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Multiple Predicaments and Optimization Pathways in Enhancing Local Government Emergency Management Effectiveness - A Case Study of the 2016 Wuhan "7·6" Extreme Rainstorm Disaster

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Abstract: Improving disaster prevention, mitigation and relief capacity, together with the capacity to handle major and urgent public emergencies, has been placed at the core of the national security system and has become a key indicator of progress in modernizing China's governance system and governance capacity. From 30 June to 6 July 2016, under the influence of a strong El Niño event, Wuhan experienced an exceptionally persistent rainstorm. Cumulative rainfall over the seven-day period reached 560.5 mm, the highest weekly total since meteorological records began; at some stations in Jiangxia District the seven-day total reached 733.7 mm, exceeding the 100-year return period. At the peak of the event, 162 waterlogged sites appeared within the built-up area, expressways and arterial roads were cut off, dikes in the outlying districts of Huangpi and Xinzhou were endangered, and 864,000 residents were affected, with 172,900 person-times emergency relocated, 14 people killed and one missing. The disaster provides a representative case for examining how a large riverside city governed by a local government responds to cumulative, long-duration rainfall rather than to a single short peak.

This study constructs a mixed-method framework of "case thick description – comparative analysis – mechanism extraction". Process tracing is used to reconstruct the full cycle from rainfall onset and warning issuance to emergency response, waterlogging clearance and post-disaster recovery, so as to identify critical decision points and response gaps. An embedded comparison of Wuhan, Changsha and Hefei examines how three provincial capitals in the middle reaches of the Yangtze handle comparable persistent rainfall. Social network analysis is used as an analytical lens for the structure of government–enterprise–society interaction, fuzzy-set qualitative comparative analysis (fsQCA) for the configurations of conditions associated with effective response across Wuhan's 13 administrative districts, and latent Dirichlet allocation (LDA) topic modelling for the focus of public attention in news and social media texts. Given the constraints on data access in an undergraduate research project, the last three methods serve mainly as analytical perspectives rather than as fully executed quantitative models; the empirical core rests on process tracing and comparative case analysis based on public reports and secondary textual materials.

Four predicaments are identified. The technological embedding predicament appears as a gap between monitoring and warning on the one hand and drainage engineering and organizational routines on the other: warnings were issued repeatedly, yet pumping stations operating at full capacity could not discharge water because of backwater from the high Yangtze and lake levels. The collaborative governance predicament consists of an institutional deficit in the interaction among government, water utilities, communication and power enterprises and social organizations, whose mobilization still depended on ad hoc administrative instruction. The spatial equity predicament reflects an uneven distribution of flood-control resources between the central districts and the outlying districts and townships, where losses and casualties were concentrated. The institutional fragmentation predicament stems from the division of river and lake regulation, urban drainage, meteorological monitoring and disaster relief among separate administrative systems, reinforced by a path dependency that favours emergency rescue over anticipatory prevention. On this basis a three-dimensional interactive model of "vision – system – capacity" is constructed: modernization of vision is the driving force that moves emergency management from post-event relief towards anticipatory risk governance; system rebuilding is the carrier that reallocates authority and integrates procedures; capacity upgrading is the visible outcome across risk assessment, resource dispatch, on-site response and recovery. The three evolve through a closed loop in which vision guides system iteration, the system supports capacity upgrading, and capacity in turn feeds back into vision.

Accordingly, optimization pathways are proposed along four dimensions: technology empowerment, government–enterprise collaboration, resilience building and integrated governance. The paper also explores an effectiveness assessment framework informed by the Capability Maturity Model (CMM), offered as a theoretical design rather than a tested tool, to support the diagnosis of emergency management weaknesses in comparable riverside megacities.

Keywords: *Emergency Management Effectiveness; Local Government; Wuhan "7·6" Rainstorm; Process Tracing; Three-Dimensional Interactive Model*

I. INTRODUCTION

Coordinating development and security is a major strategic requirement for the long-term stability of the state. Under global climate change, extreme Meiyu rainfall and persistent rainstorms have become more frequent in the Yangtze River basin. Megacities with dense river and lake networks and highly concentrated populations face an amplified flood risk, which places heavy demands on local emergency governance. The 20th National Congress of the Communist Party of China explicitly required that disaster prevention, mitigation and relief capacity be improved, signalling a shift from reactive relief towards anticipatory and resilient governance. In practice, however, many localities still

struggle with warnings that do not reach the grassroots, blocked inter-agency coordination, misallocation of resources between urban and rural areas, and fragmented institutions. A systematic review of a representative disaster is therefore needed to clarify how these difficulties arise and what can realistically be done about them.

The 2016 Wuhan rainstorm is an appropriate case. Between 30 June and 6 July 2016, Wuhan received 560.5 mm of rain within a week, the highest weekly total on record, while some stations in Jiangxia recorded 733.7 mm over seven days, beyond the 100-year return period. The event was distinctive not because of a single extreme hourly intensity but because several rainfall episodes followed one another while river and lake levels were already high, leaving no window in which to lower impounded water in advance. During the event, up to 162 waterlogged sites appeared in the urban area, several arterial roads became impassable, and dikes in Huangpi and Xinzhou were endangered. A total of 864,000 people were affected, 172,900 person-times were relocated, and 14 people died with one reported missing. Power and communication lines were damaged in some areas, and pumping stations that were working at full capacity could not lower internal water because high external water levels held the discharge outlets back.

Although flood-control agencies launched successive response levels and committed substantial manpower and equipment, three weaknesses were evident. Warning information reached streets, communities and villages with a time lag and rarely reached individual households in a usable form. Infrastructure shortcomings in outlying districts were exposed sharply. And government, market and social actors had no stable mechanism for joint action, so that mobilization depended on temporary administrative orders.

Existing scholarship offers many accounts of urban flood emergency management, but most studies concentrate on a single engineering or institutional dimension. Few integrate technology, market, society and institutions into one explanation of how effectiveness is produced. This paper therefore asks three questions: What predicaments does a local government face when responding to persistent extreme rainfall? Through what mechanism are these predicaments generated? And how can emergency management effectiveness be improved through the renewal of vision, the rebuilding of systems and the upgrading of capacity?

II. RESEARCH BACKGROUND

A. A stress test for a riverside megacity

Wuhan is crisscrossed by rivers, lakes and connecting channels, and its drainage system has long operated under the backwater pressure of the Yangtze River and adjacent lakes. In 2016 the Meiyu season lasted 33 days and produced about two and a half times the normal rainfall. Successive rainfall episodes raised river, lake and reservoir levels continuously, so that the event combined storm runoff with already elevated water levels. Viewed through the crisis life cycle, four phases can be distinguished.

The incubation phase ran from 30 June to 3 July. Rainfall occurred in repeated episodes and the meteorological service issued warnings several times, with the municipal flood-control headquarters progressively activating level III and then level II drainage response. Yet some communities and townships underestimated the risk accumulated by successive rainfall, and many residents treated each episode as an ordinary summer shower rather than as part of a cumulative hazard process.

The outbreak phase covered 4 to 6 July, when the heaviest episode struck. Waterlogging spread across large parts of the urban area and main roads were cut. Dikes in Huangpi and Xinzhou developed several dangerous situations, villages were inundated and large numbers of residents had to be evacuated. Pumping stations affected by high external water levels lost much of their effective capacity, producing the characteristic situation in which pumps kept running while water levels did not fall.

The diffusion phase extended from 6 to 8 July. Rainfall weakened, but river and lake levels remained high, so secondary risks such as seepage and overtopping of dikes persisted, while shelter supply, lifeline repair and public health precautions became the dominant tasks. The resolution phase began after 8 July, when water receded and work shifted to resettlement, infrastructure repair, hazard investigation and after-action review.

Losses were distributed very unevenly in space. Central districts, with dense populations and comparatively complete pumping and pipe networks, mainly experienced short-duration street inundation. Outlying districts and counties such as Huangpi and Xinzhou, where dikes and rural irrigation and drainage facilities were built to lower standards, absorbed most of the flood damage and most of the casualties. The pattern of "urban waterlogging in the centre, flooding in the periphery" reflects a structural imbalance in infrastructure investment and in the allocation of emergency resources.

Mobilization was extensive. Tens of thousands of responders were committed, together with pumping equipment, and the armed forces, fire services, water affairs, urban management and civil affairs departments all took part, while social organizations and volunteers joined spontaneously. This large input was not fully converted into effective response. Information sharing between departments was limited, social participation lacked unified dispatch, and some grassroots communities were unable to translate warnings into concrete protective action.

B. From the "one case, three systems" framework to resilient urban governance

National policy has progressively reshaped the institutional environment for flood emergency management. The Emergency Response Law of the People's Republic of China, as revised in 2024, affirms the principle of prevention first and the combination of prevention with preparedness. The Opinions on Promoting the Safe Development of Cities require a systematic and modern urban safety framework, and the Three-Year Action Plan for "Data Elements ×" (2024–2026) treats data-enabled emergency management as a priority action. Hubei Province and Wuhan Municipality have issued successive plans for urban drainage and flood control that call for drawing lessons from major floods and remedying the shortcomings of riverside cities.

These documents imply a change in the standard against which local governments are judged. The relevant question is no longer whether a response was launched, but whether it was timely and effective, whether the system proved resilient, and whether coordination actually functioned. Such a standard requires an assessment framework and a realistic account of the pathways through which effectiveness can be improved.

C. From single-factor analysis to multi-system coupling

Research on emergency management abroad moved from an engineering-technical paradigm to an organizational-

institutional one, and recent work focuses on multi-actor collaborative networks and information flow. Chinese scholarship has extended the "one case, three systems" framework in several directions. Wang and Zheng, analysing the Zhengzhou "7·20" disaster, argue that local government effectiveness is a function of the quality of vision, system and capacity and of the way the three interact, and they generalize a model of how effectiveness evolves from open systems theory[2]. Other studies examine the structural tension in the allocation of authority and the isolation of information between agencies.

Two gaps remain. First, much of this work treats technology, market, society or institutions separately, and offers no integrated account of their co-evolution. Second, descriptions are largely static, and the causal process through which effectiveness is generated during a disaster is rarely reconstructed. This paper adopts open systems theory, treating local emergency management as a dynamic open system that exchanges resources and information with its environment, in order to address both gaps with evidence from a single, deeply documented case.

III. RESEARCH METHODS, FRAMEWORK AND SIGNIFICANCE

A. Research methods

A mixed-method strategy of triangulation is adopted so that conclusions rest on more than one kind of evidence. At the case level, process tracing reconstructs the sequence from 30 June to 8 July, following the issuance of warnings, the adjustment of response levels, the clearance of waterlogged sites, dike emergency operations and the evacuation of residents. Attention is paid to the interaction between the evolving hazard and the timing of government action, because the decisive question in a cumulative rainfall event is not whether a warning was issued but whether it was issued and acted upon before the accumulated risk crossed a threshold.

An embedded comparison places Wuhan alongside Changsha and Hefei, three provincial capitals in the middle reaches of the Yangtze that face comparable persistent rainfall. The comparison is based on public reports and party newspaper texts from the three cities, and examines warning lead time, the level of leadership attention, the scale and speed of mobilization, and the treatment of urban and rural areas. Its purpose is to distinguish features specific to Wuhan from those shared by cities in the same river basin, and thus to strengthen causal inference beyond a single narrative.

At the data-analysis level, three further methods are introduced as analytical lenses. Social network analysis is used to describe the relationships among government departments, water and utility enterprises, power and communication companies, social organizations and the media. Fuzzy-set qualitative comparative analysis takes Wuhan's 13 administrative districts as units, with leadership attention, resource input, coordination level and information infrastructure as condition variables and response effectiveness as the outcome, in order to identify configurations associated with strong performance. Latent Dirichlet allocation is applied to news and social media texts to capture the focus of public attention and its evolution during the event.

A methodological note is necessary. Constrained by the conditions under which an undergraduate research project is conducted, fsQCA, social network analysis and LDA are used here primarily as analytical perspectives. The empirical material consists of official reports, statistical communications, news coverage and published research rather than a large-scale program of first-hand interviews or web crawling. No configuration solution, network metric or topic model result is reported as if it had been computed from data that were not obtained. This limitation is stated explicitly because the credibility of a case study depends on the reader being able to see where evidence ends and inference begins.

B. Research framework

The study follows the sequence of theoretical construction, case description, mechanism extraction and pathway design. First, a review of the literature on emergency management effectiveness and on open systems theory provides the basis for a three-dimensional interactive model of "vision – system – capacity". Second, the Wuhan case is reconstructed from public reports, official communications and news coverage, and four predicaments are identified. Third, the model is used to explain how the predicaments are generated and how the three dimensions interact over the course of the event. Fourth, pathways are derived along the four dimensions of technology, collaboration, resilience and integrated governance, and an assessment framework informed by the Capability Maturity Model is outlined.

C. Research significance

The theoretical contribution lies in applying open systems theory to flood emergency management in a riverside megacity and in extending the "vision – system – capacity" model to a case of persistent rather than sudden-onset rainfall. The case also adds a documented middle-Yangtze example to a literature dominated by coastal cities and by the Zhengzhou "7·20" event. Practically, the analysis identifies weaknesses that recur in cities with similar topography, and the proposed assessment framework offers a way for local governments to locate their own shortcomings. Methodologically, the study illustrates how process tracing, structured comparison and textual analysis can be combined within the resource limits of a small research team, and it shows the value of stating those limits openly.

IV. FOUR PREDICAMENTS IN LOCAL GOVERNMENT EMERGENCY MANAGEMENT

The reconstruction of the Wuhan event points to four predicaments. They are presented separately for analytical clarity, but in practice they overlapped and reinforced one another, and it is this interaction that explains why a well-resourced response still fell short.

A. Technological embedding: warning without conversion into action

Meteorological and hydrological monitoring is now widely deployed, but the tools are not adequately embedded in engineering systems and organizational routines. During the event the meteorological service issued warnings repeatedly and hydrological stations tracked river and lake levels in real time, yet warnings moved down the hierarchy to streets, communities, townships and villages with a delay, and rarely reached individual households in a form that told people what to do. Urban waterlogging sensors were numerous and pumping stations ran at full load, but high external water levels prevented discharge, so that the binding constraint lay not in sensing or in pumping capacity but in the relationship between the drainage network and the receiving water body.

This separation between hard sensing technology and the softer engineering-institutional complex is the core of the predicament. During the event, power and communication lines failed in some outlying townships, interrupting

monitoring exactly when it was most needed. Some smart platforms remained at the level of display and provided little support for decisions taken on site by frontline staff, who often had to rely on telephone calls and personal experience. Technology, in other words, was present but not embedded: it informed the top of the system more than the bottom, and it described the hazard more accurately than it changed the response.

B. Collaborative governance: an institutional deficit among government, enterprises and society

Flood response involves water affairs, meteorology, urban management, state-owned water utilities, power and communication companies, and social organizations, yet no standing framework binds them together. In Wuhan, the resources of utility and infrastructure enterprises were committed mainly through temporary administrative instruction rather than through pre-established emergency contracts that specify obligations, priorities, cost sharing and compensation. Enterprises complied, but their own operating constraints and cost exposure were not addressed, which weakens the durability of the arrangement across events.

Social participation displayed the familiar tidal pattern. Volunteers and organizations rushed to affected areas during the crisis and dispersed quickly afterwards. Without registration, information matching and task assignment before the event, willing helpers duplicated effort in some places and were absent where need was greatest. Meanwhile, hydrological data on river and lake levels, urban waterlogging data held by urban management, and displacement data held by civil affairs remained in separate systems, so that each department acted on a partial picture.

The root cause is not a lack of goodwill but a lack of institutional design. Where authority and responsibility are unclear and where incentives are not aligned, coordination depends on personal relationships and on the intensity of leadership attention at a given moment, which is precisely what fails under the workload of a prolonged event.

C. Spatial equity: the urban–rural divide amplifies risk

Damage was distributed with strong spatial inequality. Central districts had received sustained investment in pumping stations, pipe networks and monitoring, whereas dikes and small irrigation and drainage facilities in Huangpi, Xinzhou and other outlying areas were built to lower standards and maintained with fewer resources. Facing the same rainfall, the centre suffered short-term inundation while the periphery suffered dike emergencies, inundated villages and large-scale evacuation.

Emergency supplies and professional rescue teams were concentrated in the urban core. Township-level stockpiles were thin and specialized personnel scarce, so local government had to request support from the centre while the roads connecting them were themselves affected. Differences in infrastructure investment were thus converted directly into differences in disaster risk, and residents of peripheral areas bore a disproportionate share of loss. This is a question of spatial equity in emergency governance, not merely of engineering standards, because it concerns who is protected first and whose protection is deferred.

D. Institutional fragmentation and the rescue-first path dependency

China's emergency management system is organized on the principles of unified leadership, administration at different levels and territorial responsibility. In practice, however, functional segmentation persists. Water authorities manage rivers, lakes and dikes; urban management manages drainage; the meteorological service manages monitoring and warning; civil affairs manages displacement and relief. Each reports through a different chain. For a compound rain–waterlogging–dike event, no standing joint command structure matches the structure of the hazard, and the coordination required to pre-release reservoir and lake storage before the storm involves bargaining costs that are hard to absorb within a short warning window.

Alongside fragmentation there is a path dependency that favours rescue over prevention. Once a disaster occurs, large resources can be mobilized quickly and visibly; before it occurs, investment in hazard inspection, dike reinforcement in rural areas, community drills and public risk education is less visible and easier to postpone. The result is a recurrent cycle of disaster, emergency response, reconstruction and the next disaster, in which each stage appears rational while the sequence as a whole is costly.

V. OPTIMIZATION PATHWAYS

The four predicaments are not independent failures to be corrected one by one. They are manifestations of a system in which vision, structure and capacity are misaligned. The pathways below are therefore organized around the three-dimensional model, with each pathway addressing one predicament while contributing to the same underlying realignment.

A. Technology empowerment: aligning technology with institutions

The first requirement is a cross-departmental data platform for flood response that links meteorological, hydrological, drainage, power and communication data, so that river and lake levels and urban waterlogging points can be read together rather than in separate systems. Such a platform should be designed around the decisions that frontline staff actually make, not around display requirements.

The second requirement is a tiered warning call-and-response mechanism. Issuing a warning should trigger a defined set of actions by named responsible persons in streets, communities, townships and villages, with feedback confirming that the message was received and acted upon. For riverside cities, scenario exercises should explicitly incorporate backwater from high river and lake levels, so that the limits of the drainage system are known before the event rather than discovered during it.

The third requirement is an assessment routine for the performance of technical systems themselves. Procurement is easy and maintenance is difficult; without periodic evaluation of whether platforms, sensors and models improve field decisions, investment tends to accumulate at the visible layer while the operational layer remains unchanged.

B. Government–enterprise collaboration: from ad hoc mobilization to institutionalized cooperation

Government should move from being the sole consumer of emergency resources to being the organizer of a multi-actor system. A first step is to conclude framework agreements with water, power and communication enterprises that specify obligations during flood seasons, standby capacity, priorities for restoration, cost sharing and post-event compensation, converting temporary instruction into a standing contractual relationship.

A second step is to design a mechanism that recognizes and rewards emergency contributions by enterprises, social organizations and individuals, for example through a quantified social value credit that can inform procurement preferences, tax treatment or public recognition. This proposal is a theoretical design; it would require fiscal and regulatory support before it could operate, and its feasibility depends on how contribution is measured and how disputes over attribution are resolved.

A third step is a unified platform for social forces, with registration, capability profiles and contact arrangements completed before the flood season, and task assignment and information sharing during the event. Pre-registration is what allows spontaneous goodwill to be used where it is needed instead of where it happens to arrive.

C. Resilience building: closing the urban–rural gap and strengthening local self-reliance

Differences in standards between the centre and the periphery should be addressed directly. Outlying dikes and rural irrigation and drainage facilities need differentiated upgrading, and lifeline systems need redundancy so that a single failure does not interrupt power and communication across an entire township during the critical hours of an event.

Resilient communities are the second element. Township and community stockpiles of basic supplies, regular evacuation drills, and grid-based hazard inspection are low-cost measures with high returns in the first hours of a disaster, when external assistance has not yet arrived. Public risk education should explain cumulative rainfall hazard in terms that residents can act on, since the Wuhan experience shows that repeated warnings do not by themselves produce protective behaviour.

D. Integrated governance: renewing vision to drive system and capacity

Modernization of vision is the driving force. Flood risk assessment should be incorporated into spatial planning and land use decisions, so that development in flood-prone areas is weighed against the cost of protection, and so that the safety of peripheral areas is not systematically deferred behind urban expansion.

System rebuilding requires a standing cross-departmental flood command body with the authority to request data, convene agencies and coordinate the timing of river, lake and drainage operations. Without such authority, joint command exists only on paper during ordinary times and is improvised under pressure.

Capacity upgrading can be supported by an assessment framework informed by the Capability Maturity Model, organized around the maturity of vision and risk awareness, of institutional arrangements and procedures, and of operational response. The framework proposed here is a design for diagnosis, not a validated instrument: its indicators would need testing against actual performance records before they could be used for accountability. Its value lies in making explicit what a mature local system should be able to do, and in giving local governments a structured way to identify where they stand.

VI. LIMITATIONS AND FUTURE RESEARCH

Several limitations should be acknowledged. This is a single-case study of persistent Meiyu rainfall in a large riverside city in the middle Yangtze basin, and the findings cannot be transferred directly to mountainous cities or to regions where flood risk is dominated by short-duration cloudbursts. The evidence base consists mainly of public reports, official communications and news coverage, supplemented by published research; it does not include a large-scale programme of first-hand interviews with responders or affected residents, and it does not include the computational results that fsQCA, social network analysis and LDA would produce if applied to a complete dataset. The optimization pathways, including the social value credit mechanism and the maturity assessment framework, are theoretical proposals whose implementation would require supporting fiscal rules and administrative authorization.

Future work should extend the comparison to a larger set of cities across different topographic and climatic settings, and should collect first-hand interview and operational data so that the three-dimensional model can be tested rather than illustrated. Refining the maturity indicators into a usable diagnostic instrument, and examining how local governments actually use such instruments, would be a further step towards turning the analysis in this paper into practical guidance.

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