

Empowering Resilient City Systems Through the Digital Economy: A Public Policy Perspective – The Case of Beijing

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Abstract. Against the background of escalating global climate crises and urban disaster risks, traditional urban governance models urgently require transformation. This essay adopts a public policy perspective, taking Beijing as its case study. Through literature review and case analysis, it systematically explores how the digital economy empowers Resilient City Systems. Findings reveal that digital technologies, through means such as digital twin systems and emergency response systems, are deeply embedded within four urban subsystems—early warning, emergency response, recovery, and learning—significantly enhancing risk response capabilities. A bidirectional relationship emerges between digital technologies and public policy: policy provides strategic direction and institutional safeguards for technological application, while technology drives iterative optimisation of policy instruments through data feedback. The study's findings offer theoretical reference and practical paradigms for resilience-building in megacities.

Keywords: public policy, digital economy, resilient city systems, bidirectional construction

1. Introduction

Against the background of the global climate crisis, urban disaster risks are showing new characteristics such as increased frequency, abnormal patterns, and extreme intensity [1], posing challenges to traditional governance models. The Chinese government has explicitly proposed building liveable, resilient, and smart cities as the core approach to modern urban governance in the new era. Beijing, grounded in the operational patterns of megacities and the capital's security development requirements, has pioneered the exploration of Resilient City development. Guided by the Beijing's Urban Master Plan (2016-2035), it has issued and implemented policy instruments such as the Guidelines on Accelerating the Building of a Resilient City (hereinafter referred to as the Guidelines) [2], gradually exploring and forming a resilient city construction paradigm with Chinese characteristics.

Academic circles have proposed the concept of “Resilient City”, conducting in-depth theoretical research into urban capacity to withstand disasters and risks [3]. This approach views cities as complex systems including natural, economic, technological, social, and cultural dimensions, enhancing resilience through scientifically planned urban layouts and well-functioning operational systems [4]. At its core, this embodies public policy governance principles, forming an urban development paradigm rooted in public policy theoretical logic [5].

As a vital productive force in the new era, the digital economy injects fresh momentum into resilience enhancement through its unique industrial penetration and policy responsiveness [6]. In 2020, the Chinese government incorporated new infrastructure development into its national strategy, driving the deep integration of digital technologies with urban governance [7] to provide technical support and policy safeguards for resilient city systems.

Therefore, this study employs literature review and case analysis methodologies, with Beijing as the research subject, to examine the systemic components of a resilient city from a public policy perspective. By investigating the positive impact of the digital economy on resilient city systems, this study contributes to enriching theoretical understanding and practical exploration of resilient cities under new technological conditions, thereby providing reference and insights for resilient city development.

2. Literature review

2.1. Conceptual connotation and theoretical framework of resilient city

The concept of the Resilient City evolved from the field of physics, where its original meaning was “the restoration to a natural initial state” [8]. Beginning in the 1970s, research on Resilient Systems initially focused on natural ecosystems, and the range of that gradually expanded over time to socio-ecological systems. By the early 21st century, the vision of Resilience found initial application within specific urban systems, giving rise to the concept of the Resilient City. Within Resilient City planning research, studies have demonstrated that spatial planning can optimize urban layouts and enhance cities' capacity to withstand natural disasters, thereby confirming that Resilient City planning helps cities cope with the negative impacts of diverse disasters [9,10].

Jing contends that Resilient City, as a strategic response to complex urban risks, embodies the tangible expression of public policy governance principles [11]. Shi proposes that Resilient City construction requires transitioning from conceptual research to practical exploration, establishing a working framework encompassing “planning resilience” and “resilient planning” across four dimensions: temporal, spatial, governance, and implementation pathways [2]. Li and Yi, examining the characteristics of the digital-intelligent era, emphasize the complexity of urban systems within the intertwined virtual and physical spaces, highlighting that resilience construction must acknowledge the duality of technology-enabled empowerment and risk paradoxes [12]. Wang further expands the system composition, proposing that in the digital-intelligent era, Resilient Systems can be enhanced through a closed-loop mechanism that combines data-driven decision-making and technological innovation [13].

2.2. Coupling mechanisms between public policy instruments and resilient city development

Regarding the functional definition of a Resilient City, the city embodies a form of public relations, and its structural layout can be viewed as a reflection of public policy. At the same time, Resilient City's functions should reflect urban development objectives [5]. Public policy serves as the core driver for Resilient City development. Beijing's Guidelines explicitly outline four-dimensional objectives—space planning, construction, management, and society—and illustrate, through the Huilongguan-Tiantongyuan “15-minute emergency zone” case, how policy instruments advance resilience through strategic design, institutional safeguards, and practical implementation [14].

2.3. Practical pathways for digital intelligence technologies to empower resilient city

Digital intelligence technologies inject new momentum into resilient city development. Scholars including Wang propose that such empowerment should unfold across a four-tiered framework encompassing theoretical optimisation, data governance, technological innovation, and equipment management [14]. Beijing's Sub-centre organically integrates GIS and BIM to establish a City Information Model (CIM), forming a “city brain” through digital platforms that enhances overall monitoring and early warning capabilities, thereby effectively boosting urban resilience [14]. Li cautions against the “paradoxical traps” of digital technologies, such as algorithmic black boxes and the digital divide, proposing that systemic coordination and environmental observation mechanisms are needed to balance technological benefits and drawbacks [12].

2.4. Institutional design and optimisation pathways for multidimensional resilient systems

In October 2021, Beijing issued the Guidelines, pioneering institutional design for Resilient City development among China's provincial-level administrative units. This framework establishes systematic arrangements for Resilient City development across four dimensions: spatial resilience, engineering resilience, managerial resilience, and social resilience [15]. Building upon this, scholars such as Tan expanded the framework to include environmental resilience, organisational resilience, and economic resilience, thereby refining the top-level design of Resilient City planning, conducting in-depth research into the current status and challenges of Resilient City development in Beijing [14]. Jing conceptualises Resilient City as a complex dynamic system, categorising it into four subsystems: early warning, emergency response, recovery, and learning. Guided by corresponding public policies, each subsystem addresses potential urban disasters while continuously enhancing the city's resilience through this dynamic process [11].

2.5. Research gaps

Current research predominantly focuses on the technical deconstruction of resilience concepts or the digital upgrading of disaster warning tools, failing to address the core governance logic of resource allocation, risk-sharing, and institutional coordination under public policy leadership.

Moreover, existing literature seldom constructs a causal chain linking “policy instruments—digital empowerment—resilience efficacy.” On one hand, top-level design research remains inadequate, failing to elucidate how public policy can systematically guide the allocation of digital economy elements towards resilience objectives. On the other hand, explorations of cross-departmental coordination mechanisms remain superficial, lacking solutions to policy implementation bottlenecks like data silos and misaligned responsibilities. This hinders the systematic integration of multi-dimensional resilience goals.

3. Case analysis

This section will examine how digital technologies, supported by public policy, empower Resilient City Systems. It will embed case studies of Beijing's current digital economy technologies within the application of four subsystems: early warning systems, emergency response systems, recovery systems, and learning systems [11].

3.1. Early warning system

From a public policy perspective, mitigating the impact of urban disasters and achieving rapid recovery necessitates the accurate prediction of various potential hazards and risks [16].

Beijing Oubeier's Smart Water Digital Twin System has established a dynamic disaster risk early warning technology framework. By creating a 1:1 dynamic digital twin of physical water treatment plants, it integrates multi-source indicators—including water quality, flow volume, and equipment status—via IoT technology. Historical data informs predictive modelling for monitoring abnormal fluctuations and optimising process parameters. Algorithms then generate tiered early warning information and emergency response plans, enabling comprehensive, end-to-end visual monitoring of the water supply system. This significantly enhances the efficiency of dynamic resource allocation prior to disasters.

Concurrently, the system establishes a policy-technology synergy mechanism with specific governmental directives. By integrating flood forecasting models with torrential flood identification algorithms, the Beijing government achieves an 89% accuracy rate for gully flood warnings, demonstrating the targeted allocation capability of the digital economy towards the goal of a Resilient City under policy impetus.

3.2. Emergency response system

In the Resilient City emergency system development, Beijing's Smart Emergency Response strategy has become a practical paradigm.

This system has developed a multi-tiered technical closed-loop framework in practice. At the front end, the Emergency Individual System establishes real-time communication networks between grassroots disaster informants and command centres, forming a 15-minute emergency response zone. At the mid-tier, satellite networks and wide/narrowband ad-hoc networks underpin forest fire command and dispatch systems, enabling visualised fire scene assessments and one-click command issuance. The back-end integrates multi-source alert data via a big data platform to generate occupational safety risk heatmaps, providing decision support for early warning analysis. During the 2025 Fangshan District flash flood incident, the system transmitted real-time footage through converged communication networks. Decision-makers utilised dynamic simulation models to formulate evacuation plans, ultimately achieving zero casualties, underscoring the emergency system's pivotal role in maintaining social order and stability.

Beijing Municipality employs the Guidelines as its policy framework, driving orderly interdepartmental coordination in disaster response through technology-enabled collaboration. Following a report of a sinkhole hazard via the Emergency Individual System in Dahongmen Street, Fengtai District, the command centre promptly activated cross-departmental coordination mechanisms. This facilitated a joint response by water management, transport and other departments, demonstrating the policy tool's capacity to overcome data silos and misalignments in responsibilities and authority.

3.3. Recovery systems

In developing Resilient City recovery systems, Beijing has established a post-disaster recovery framework of exemplary value.

Regarding technological integration, the Western Suburb Rainwater Storage Project leveraged the urban flood monitoring network, consolidating facility data, and employing hydrological and

hydrodynamic modelling to issue flash flood warnings for mountainous areas and urban channels. Subsequently, digital twin technology simulated reconstruction plans to optimise resource allocation pathways. Finally, a smart construction site platform enabled cross-regional project coordination, utilising water storage and regulation techniques to significantly replenish groundwater.

The Beijing government issued relevant guidelines permitting disaster-affected projects to proceed with ‘construction first, approval later’ to rapidly restore lifelines. Recovery efforts following the 2023 Mentougou floods leveraged this policy-supported fast-track approval process, substantially reducing water supply system restoration times in affected areas. This quantitatively demonstrated how policy instruments amplify technical effectiveness.

3.4. Learning system

Practical exploration of Beijing's Resilient City learning system continues to deepen. The Guidelines establish a dynamically adaptive disaster prevention framework through the three-dimensional spatial layout principles of relocation, prevention, and evacuation. For instance, Pinggu District addressed electric bicycle charging hazards exposed in the 2025 fire case study by implementing policy-guided fixed charging point installations. Combined with networked smoke detector technology, this case forms a composite governance model integrating institution and intelligence.

In July 2025, Beijing conducted comprehensive flood emergency drills simulating extreme rainfall triggered by a typhoon remnant vortex. Leveraging real-time monitoring data from the smart water management system, 23 multi-departmental exercises were coordinated, demonstrating the redundant safeguarding capabilities of distributed lifeline infrastructure during disasters.

Such practices validate the intricate interplay mechanisms within Resilient City subsystems, demonstrating that Beijing is forging a Chinese-characteristic model of Resilient Cities through the deep integration of institutional innovation and technological application.

4. Discussion

This study reveals the intrinsic logic of building Resilient City Systems through the bidirectional construction of policy instruments and the digital economy. Beijing has deeply embedded digital technologies within Resilient City subsystems through institutional innovation. The implementation of the Smart Emergency Response strategy during the Fangshan District flash flood incident demonstrates the policy design's capacity for targeted technological deployment. This approach challenges the traditional assumption of technological neutrality in resilience research, offering a new paradigm for studying the integration of the digital economy and urban governance.

The feedback loop where technology drives policy innovation is particularly pronounced in Beijing's practice. The city's enhancement of early warning capabilities through the digital economy, alongside the establishment of standards for risk monitoring and early warning systems, exemplifies how technological application reciprocally shapes policy optimisation. This bidirectional relationship is also evident in international comparisons: New York achieved synchronous policy-technology evolution through its Decade-long Resilient City Project catalogue, while London leveraged its London Data Hub to build a transparent, shared decision-support system. These examples collectively demonstrate Beijing's leading position in this domain, validating the institutional advantages of megacities in resource integration.

The core contribution of this study lies in revealing the essential nature of public policy within Resilient City Systems: it not only regulates technological application but also creates technological efficacy. Through policy innovation, digital technologies significantly enhance urban risk response

capabilities via dynamic resource allocation and the construction of citywide sensing networks. However, caution is warranted regarding the potential impact of Beijing's unique characteristics as a megacity sample on the generalisability of these conclusions. While the policy analysis focuses on institutional texts and implementation outcomes, future research could further integrate the methodology of politics for comparison and expand longitudinal tracking across multiple urban cases.

5. Conclusions

This study, adopting a public policy perspective and using Beijing as its empirical case, systematically elucidates how the digital economy profoundly integrates into four urban subsystems—early warning, emergency response, recovery, and learning—significantly enhancing the risk management capabilities of the Resilient City. Findings reveal a bidirectional relationship between digital technologies and public policy: policies provide strategic direction and institutional safeguards for technological application, while technologies drive iterative optimisation of policy instruments through data feedback. The theoretical contribution lies in challenging the assumption of technological neutrality by establishing a causal chain linking policy instruments—digital technologies—resilience efficacy. Practically, case studies such as Beijing Oubeier's Smart Water Digital Twin System and Smart Emergency Response strategy validate the linkage mechanisms between policy design and technological implementation. Limitations of the study include the specificity of Beijing as a megacity sample, insufficient depth in policy analysis, and inadequate exploration of governance pain points. Future research may extend to longitudinal tracking across multiple cities, deepen matching models between policy instruments and technologies by using the methodology of politics, and introduce emerging tools like algorithmic auditing to enhance institutional empowerment. This study offers a new paradigm for integrating the digital economy with urban governance, creating significant reference value for resilience-building in megacities.

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