



Earthquake Crisis Management in Guangzhou City, Guangdong Province, People's Republic of China

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Abstract

Background and Aims: Megacities face a low-frequency, high-consequence earthquake risk characterized by dense population, infrastructure complexity, and cascading failure potential. Guangzhou, a core metropolitan center in the Guangdong-Hong Kong-Macao Greater Bay Area, exemplifies this governance challenge. This study aimed to: (1) analyze Guangzhou's earthquake crisis management system and specific risks; (2) identify challenges and gaps in the existing framework; and (3) propose innovative strategies and a guidance framework for high-density urban earthquake management.

Methodology: A qualitative case study design guided by Quarantelli disaster lifecycle theory was adopted. Four independent variables government administrative capacity, technological innovation capacity, disaster preparedness and mitigation systems, and public awareness and education constituted the conceptual framework. Data were collected through semi-structured interviews with 20 purposively selected key informants from government officials (n=6), technical experts (n=5), community representatives (n=5), and academic scholars (n=4), and analyzed using thematic analysis.

Results: Guangzhou's primary risk stems from high-density exposure and cascading lifeline failures. The central performance bottleneck is interface failure: weak translation between data and decisions, plans and actions, warnings and behavior, and resources and aid. Early warning systems are technically advanced but socially underutilized. Four integrative discoveries emerged: (1) interface failure as a crisis multiplier; (2) early warning as behavioral governance; (3) preparedness inequality as a performance driver; and (4) routine governance embedding as a resilience path. An Integrated Urban Earthquake Resilience Framework (IUER) with five strategic pathways is proposed.

Conclusion: Effective earthquake crisis management in megacities requires a shift from siloed, technology-centric approaches to humanized, interface-focused governance. Strengthening operational interoperability, embedding preparedness into routine urban governance, and





designing early warning as a behavioral system are essential pathways for building equitable resilience in high-density urban environments.

Keywords: Earthquake Crisis Management; Guangzhou City; Disaster Governance; Urban Resilience; Interface Failure

Introduction

The governance of natural disasters, particularly earthquakes, has become a central concern in contemporary public administration and disaster management research. Although earthquakes are fundamentally driven by tectonic processes, their societal impacts are shaped by human settlement patterns, infrastructure complexity, and urban exposure levels (UNDRR, 2022). International disaster databases consistently demonstrate that sudden-onset hazards generate severe human and economic losses, with earthquakes among the most destructive due to their unpredictability, rapid onset, and capacity to trigger cascading urban system failures (CRED, 2025; Daniell et al., 2017).

Modern megacities characterized by dense high-rise development, extensive underground transportation, and highly interconnected lifeline networks are particularly vulnerable to cascading effects (Pescaroli & Alexander, 2018). Earthquake risk management has consequently evolved from a narrow engineering discipline into a multidimensional governance challenge requiring integrated approaches spanning public administration, urban planning, emergency management, and community resilience (Tierney, 2019; Cutter et al., 2008).

From a geotectonic perspective, South China, including Guangdong Province where Guangzhou is located, forms part of the South China Block, a major Precambrian continental unit that experienced complex Mesozoic tectono-magmatic evolution (Vatuvu et al., 2023). Although present-day seismicity in the Pearl River Delta is moderate relative to western China, inherited fault systems continue to define the region's seismotectonic background. Understanding Guangzhou's earthquake risk therefore requires consideration not only of seismic frequency, but of the broader tectonic framework and, critically, high urban exposure.

From a disaster governance standpoint, contemporary research emphasizes that earthquake risk is determined by the interaction of hazard, exposure, and vulnerability, not hazard probability alone (UNDRR, 2022; Birkmann et al., 2013). This is especially relevant for the Pearl River Delta, where economic density and population concentration have increased dramatically. Scholars describe this as a 'low-frequency, high-consequence' risk profile typical of coastal East Asian megacities (Tierney, 2019), under which traditional reactive emergency models are insufficient; lifecycle-based crisis management frameworks integrating prevention, preparedness, response, and recovery are required (Quarantelli, 1988; Alexander, 2015).



Despite Guangzhou's strategic importance and rising exposure profile, important structural and operational challenges persist within the city's earthquake crisis management system. Contemporary disaster governance research stresses that effective urban resilience depends on seamless integration across the full disaster management lifecycle (OECD, 2023). However, emergency management systems in many rapidly urbanizing megacities have evolved with stronger emphasis on post-event response rather than proactive risk governance (Nakashima et al., 2014; Godschalk, 2003). Metropolitan-level implementation may still encounter coordination fragmentation among monitoring agencies, local governments, infrastructure operators, and community organizations.

Objectives

1. To analyze the earthquake crisis management system and the specific risks in Guangzhou City.
2. To identify and evaluate the challenges and gaps in the existing crisis management framework.
3. To propose innovative strategies and a guidance framework for earthquake crisis management in high-density urban areas.

Literature Review

Disaster Management Lifecycle Theory

Disaster Management Lifecycle Theory provides the dominant analytical foundation in contemporary disaster research. Quarantelli (1988) reframed disasters as socially organized processes, arguing that effective management requires systematic activities before, during, and after impact. In its contemporary form, the lifecycle comprises four interrelated phases: mitigation (prevention), preparedness, response, and recovery. Building on this foundation, Integrated Emergency Management (IEM) theory promotes an all-hazards, all-phases, and all-agencies approach emphasizing emergency management as a unified system rather than isolated sectoral responses (FEMA, 2021). The Whole-of-Government (WoG) approach further extends integration to the broader public administration system, emphasizing horizontal cross-ministry collaboration and vertical central-local alignment (OECD, 2023).

Government Administrative Capacity in Disaster Governance

Government administrative capacity is widely regarded as the institutional backbone of urban resilience. Contemporary scholarship conceptualizes it not merely as technical competence, but as the state's ability to mobilize resources, coordinate diverse actors, maintain policy coherence, and sustain operational legitimacy under extreme uncertainty (Howlett &



Ramesh, 2023). Core components include policy formulation and integration, inter-agency coordination, rapid resource mobilization, and organizational learning. In megacities, the 'fragmented authority paradox' is a persistent challenge: nominally centralized systems experience coordination friction due to functional silos and limited real-time data sharing (Comfort et al., 2010). Strengthening horizontal integration and closing the plan-execution gap are consistently identified as critical priorities.

Technological Innovation Capacity and Smart Emergency Management

Technological innovation has emerged as a central pillar of earthquake crisis management. Smart emergency management integrates advanced ICTs, artificial intelligence, big data analytics, and sensor networks across the full disaster lifecycle (Kopanov et al., 2024). Key components include Earthquake Early Warning Systems (EEWS), AI-based rapid damage assessment, integrated emergency command platforms, and UAV-assisted rescue. However, the literature consistently highlights a 'technology governance gap': advanced digital systems exist but are not fully embedded into decision-making workflows or inter-agency coordination routines, limiting their operational impact (Lagap, 2024; Nakashima et al., 2014).

Disaster Preparedness and Mitigation System

Preparedness and mitigation constitute the most cost-effective components of the disaster management lifecycle. Mitigation encompasses long-term structural measures including seismic zoning, earthquake-resistant building codes, and infrastructure hardening. Preparedness focuses on developing effective response capacity through contingency planning, inter-agency drills, early warning dissemination, and public education (UNDRR, 2022). Preparedness effectiveness depends not only on plan existence but on plan operability, whether plans are regularly exercised, updated, and integrated across agencies. Community-level preparedness, including household emergency supplies, evacuation knowledge, and mutual aid networks, is recognized as decisive for outcomes during the first hours after an earthquake (Tierney, 2019; Godschalk, 2003).

Public Awareness, Education, and Community Participation

Public awareness and community participation are central pillars of contemporary earthquake risk governance. The Sendai Framework for Disaster Risk Reduction 2015–2030 explicitly emphasizes a people-centered approach, highlighting public risk literacy and stakeholder participation (UNDRR, 2022). In earthquake scenarios, the first minutes after ground shaking are critical, and community self-organization plays a decisive role. Contemporary research highlights social capital, trust networks, community cohesion, and mutual aid as critical determinants of disaster resilience (Zhao, 2024; Cutter et al., 2008). Inclusive risk communication strategies are essential for reaching vulnerable populations, including elderly residents, migrant communities,

and digitally excluded groups (World Bank, 2024). The 'last-mile communication gap' remains a persistent challenge in diverse urban environments.

Seismic Risk Context of Guangzhou and the Greater Bay Area

Guangzhou lies within the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), within the South China Block, characterized by intraplate seismicity rather than major plate boundary activity (Vatuvu et al., 2023). Most historical earthquakes in Guangdong are of moderate magnitude, and the region is not among China's highest seismic hazard zones. However, the GBA is among the world's most densely urbanized and economically integrated regions, with extreme population density, extensive high-rise development, complex underground infrastructure, and globally significant supply chains. Even moderate earthquakes in such settings can produce disproportionate disruption due to infrastructure interdependence and systemic risk propagation (Pescaroli & Alexander, 2018). The low-frequency, high-impact risk profile creates vulnerability to preparedness decay and investment complacency over time (Sherman-Morris et al., 2021).

Conceptual Framework

This study develops a conceptual framework to examine determinants of earthquake crisis management effectiveness in Guangzhou City. The Success of Earthquake Crisis Management is specified as the dependent variable, influenced by four independent variables: Government Administrative Capacity, Technological Innovation Capacity, Disaster Preparedness and Mitigation System, and Public Awareness and Education. The framework is informed by disaster lifecycle theory, urban resilience theory, and public administration perspectives on integrated risk governance.

H1: Government Administrative Capacity positively influences the Success of Earthquake Crisis Management.

H2: Technological Innovation Capacity positively influences the Success of Earthquake Crisis Management.

H3: Disaster Preparedness and Mitigation System positively influences the Success of Earthquake Crisis Management.

H4: Public Awareness and Education positively influences the Success of Earthquake Crisis Management.

Methodology

This study adopted a qualitative case study design focusing on Guangzhou City as a representative high-density metropolitan area facing low-frequency but potentially high-impact seismic risks. The qualitative approach is particularly suited to exploring governance effectiveness,



institutional coordination, technological integration, and community preparedness within real-world urban contexts.

Key Informants

Purposive sampling was used to select 20 key informants possessing specialized knowledge and practical experience in earthquake crisis management in Guangzhou. To ensure data triangulation and multidimensional perspectives, informants were drawn from four stakeholder groups: (1) government and emergency management officials (n=6), including senior or mid-level officers from municipal emergency management bureaus and related governmental units; (2) technical and professional experts (n=5), including specialists in seismology, smart emergency systems, GIS, and early warning technology; (3) community-level representatives (n=5), including neighborhood committee leaders, community emergency volunteers, and grassroots disaster prevention coordinators; and (4) academic scholars and policy specialists (n=4), including university researchers and policy advisors in public administration, emergency management, and urban resilience. Participants were selected based on direct involvement in disaster management, a minimum of five years of professional experience, familiarity with the Guangzhou emergency governance context, and voluntary willingness to participate.

Research Instruments and Data Collection

The primary research instrument was a semi-structured interview script aligned with the research objectives and conceptual framework. Data collection was conducted between January 2025 and December 2025 using two methods: (1) document analysis of national and municipal emergency management policies, earthquake contingency plans, and smart-city reports; and (2) in-depth semi-structured interviews with the 20 key informants. Interviews were conducted face-to-face or via secure telephone, each lasting approximately 45–60 minutes, and were audio-recorded with permission.

Data Analysis

Qualitative data were analyzed using thematic analysis following a five-stage process: (1) verbatim transcription and data familiarization; (2) initial open coding of meaningful text segments; (3) axial coding to group codes into broader analytical categories; (4) cross-case comparison across stakeholder groups; and (5) selective coding to synthesize themes in relation to the conceptual framework.



Results

The thematic analysis yielded findings organized around the four conceptual dimensions and three research objectives. Table 1 summarizes core findings by stakeholder group, highlighting convergent perspectives and stakeholder-specific insights.

Table 1 Summary of Key Findings by Stakeholder Group

Dimension	Government Officials (GOV, n=6)	Technical Experts (TEC, n=5)	Community Representatives (COM, n=5)	Academic Scholars (ACA, n=4)
Risk Perception	High-density exposure; cascading lifeline failures; 'stacked vulnerability'	Site amplification; underground uncertainty; secondary hazard potential	Space scarcity; narrow lanes; vulnerable group mobility constraints	System interdependency; planning efficiency vs. safety redundancy
Coordination Bottlenecks	Information chimneys: plan-action disconnect; unclear vertical interfaces	Non-unified data standards; inconsistent GIS layers; permission barriers	Upward-only reporting; command-need mismatch; unclear local authority	Structural mismatch; symbolic planning; blame-avoidance incentives
Warning-to-Action	Parameters without action scripts; long approval chains; weak automation	Closed-loop failure; network congestion; lack of scenario cues	No behavioral scripts; no location-based guidance; weak collective broadcast	Need for humanized design; equity-sensitive differentiation; crowd behavior management
Preparedness Constraints	Shelter scarcity in old districts; uneven distribution; vulnerable group barriers	Risk-based placement needed; logistics under disruption; offline navigation essential	Formalistic drills; weak household reserves; one-to-one support missing	Social capital integration; functional recovery metrics; volunteer system formalization
Innovation Priorities	Integrated GIS platform; time-sequenced SOPs; community capability building	Secondary hazard simulation; resilient communications; unified GIS picture	Micro-renovation; community app; gamified drills; volunteer protection	Resilience governance framework; recovery-oriented standards; behavioral governance

GOV = Government Officials; TEC = Technical Experts; COM = Community Representatives; ACA = Academic Scholars

Table 2 Cross-Dimensional Analysis of Key Findings

Dimension	Main Findings	Representative Quotes	Link to Dependent Variable
Government Administrative Capacity	Fragmented situational awareness due to "information chimneys"; plans lack time-sequenced execution protocols; unclear vertical interfaces between city and communities	GOV-1: "Departments maintain separate platforms...real-time interconnection is limited." COM-1: "Information must be reported upward."	Response effectiveness; recovery efficiency; public satisfaction



Dimension	Main Findings	Representative Quotes	Link to Dependent Variable
Technological Innovation Capacity	Warning-to-action translation gap; network congestion vulnerability; lack of interoperability standards; weak automation linkage	GOV-2: "Messages arrive as technical parameters. Residents need actionable instructions." TEC-1: "Early warning must be evaluated as a closed-loop system."	Casualty reduction; response speed; secondary hazard mitigation
Preparedness and Mitigation System	Shelter scarcity in old districts; uneven resource distribution; formalistic drills; "preparedness inequality" across districts	GOV-3: "Shelter scarcity is a core risk in older areas." COM-3: "Many families have no emergency kits, no plan."	Casualty reduction; economic loss reduction; recovery speed
Public Awareness and Education	Low risk perception in low-frequency environment; weak household preparedness; social capital as critical first-hour resource; vulnerable groups need targeted support	COM-2: "Residents generally think big earthquakes will not happen; low risk perception leads to low participation." ACA-1: "Social capital shapes whether communities can self-organize."	Public satisfaction; system resilience; reduced panic and congestion

DV = Dependent Variable

Integrative Findings: Four New Discoveries

Cross-stakeholder comparison revealed four integrative discoveries that extend beyond any single stakeholder group perspective (Table 3).

Table 3 Integrative Discoveries and Evidence Convergence

New Discovery	Cross-Group Convergence Pattern	Implications
1. Interface Failure as Crisis Multiplier	GOV: plan-action gaps; TEC: interoperability failures; COM: capillary breakdown; ACA: structural mismatch	Crisis escalation is driven by failures at interfaces between systems, not isolated subsystem weaknesses
2. Early Warning as Behavioral Governance	GOV: action scripts missing; TEC: closed-loop design needed; COM: no location-based guidance; ACA: crowd behavior management	Warning effectiveness depends on end-to-end behavioral outcomes, not detection accuracy alone
3. Preparedness Inequality as Performance Driver	GOV: district disparity; TEC: disrupted access; COM: vulnerable groups; ACA: equity lens	Unequal preparedness across districts and populations is a core determinant of casualties and dissatisfaction
4. Routine Governance Embedding as Resilience Path	GOV: daily-life education; TEC: platform integration; COM: repeated drills; ACA: institutional standards	High-density conditions make emergency-only strategies insufficient; preparedness must be embedded into routine urban governance

Innovative Strategies and Proposed Integrated Urban Earthquake Resilience (IUER) Framework

Addressing Objective 3, cross-stakeholder data analysis and integrative findings were synthesized into five strategic pathways constituting the Integrated Urban Earthquake Resilience



(IUER) Framework for high-density urban contexts. The IUER Framework operates across the full disaster lifecycle and is designed to address the four integrative discoveries identified above.

Strategic Pathway 1. Operational Interoperability Engineering: The framework requires the establishment of citywide interoperability standards for emergency data exchange covering earthquake monitoring outputs, infrastructure status, shelter capacity, and community field reports. This includes a Unified GIS Operations Dashboard integrating micro-geological risk layers, building vulnerability data, lifeline status indicators, and community field reports on a single, role-based platform. Time-sequenced, scenario-based Standard Operating Procedures (SOPs) replace general contingency plans, converting policy intent into actionable operational doctrine. All informant groups converged on the centrality of this pathway: 'Without real-time data fusion across departments, command remains fragmented even when plans exist' (TEC-2).

Strategic Pathway 2. Closed-Loop Behavioral Warning System: The framework reframes early warning from a technical detection function to a behavioral governance system. Warning messages are redesigned to include short, behaviorally legible action scripts tailored to building type, floor level, and population characteristics, disseminated through multi-channel systems (mobile alerts, public address, building-level alarms, and community staff relays). A satellite backup and drone-relay communication architecture ensures system continuity under network congestion scenarios. This pathway directly addresses Discovery 2, translating 'warning-as-notification' into 'warning-as-command.' Academic informants emphasized equity-sensitive differentiation: 'Warning design must account for how elderly residents, non-native speakers, and mobility-limited populations receive and process messages' (ACA-2).

Strategic Pathway 3. Equity-Sensitive Preparedness Infrastructure: To address preparedness inequality (Discovery 3), the framework mandates risk-based resource placement rather than equal distribution by district. This includes vulnerability mapping integrated into shelter planning, community micro-reserves in older districts, household readiness subsidy programs prioritizing vulnerable households, and micro-renovation programs creating distributed safe spaces within constrained urban morphologies. Technical experts consistently identified old-district shelter scarcity as a 'structural liability' that no amount of warning optimization can overcome (TEC-3).

Strategic Pathway 4. Routine Governance Embedding: The IUER Framework positions preparedness as a dimension of routine urban governance rather than an emergency-activated function. This includes integrating earthquake preparedness into urban renewal planning and land-use governance, embedding terrain-based micro-drills into school curricula and workplace safety protocols, formalizing community volunteer systems with legal recognition and liability protection, and establishing preparedness performance metrics within municipal governance evaluation systems. Community representatives identified formalistic, infrequent drills as a



primary barrier: 'People forget what to do because drills happen once a year and never match actual conditions' (COM-4).

Strategic Pathway 5. Inclusive Community Resilience Network: The framework institutionalizes social capital as a formal resilience asset by establishing community emergency volunteer networks with standardized training, equipment access, and mutual aid protocols; deploying community-specific emergency mobile applications with offline capability; and creating one-to-one support systems for vulnerable residents (elderly, migrants, mobility-limited individuals). Academic scholars emphasized that 'social capital functions as a first responder before institutional help arrives; its systematic neglect in planning represents a major unrealized resilience asset' (ACA-3).

Table 4 Integrated Urban Earthquake Resilience (IUER) Framework Strategic Pathways

Strategic Pathway	Core Interventions	Integrative Discovery Addressed	Expected Outcome	Implementation Horizon
1. Operational Interoperability	Unified GIS dashboard; time-sequenced SOPs; citywide data exchange standards	Interface Failure as Crisis Multiplier (D1)	Unified situational awareness; reduced coordination delays	Short-term (0–2 yrs)
2. Closed-Loop Behavioral Warning	Action-oriented warning messages; multi-channel dissemination; satellite backup	Early Warning as Behavioral Governance (D2)	Higher protective behavior uptake; reduced panic	Short-term (0–2 yrs)
3. Equity-Sensitive Preparedness	Risk-based shelter placement; community micro-reserves; vulnerability mapping; household subsidy programs	Preparedness Inequality as Performance Driver (D3)	Equitable outcomes; reduced preventable casualties	Medium-term (2–4 yrs)
4. Routine Governance Embedding	Preparedness in urban renewal; micro-drills in schools and workplaces; formal volunteer systems	Routine Governance Embedding (D4)	Skill internalization; improved procedural memory	Medium-term (2–4 yrs)
5. Inclusive Community Resilience	Volunteer networks; community apps with offline mode; one-to-one vulnerable resident support	All four discoveries (cross-cutting)	Faster first-hour stabilization; reduced external dependency	Medium/Long-term (2–8 yrs)





Discussion

The findings align with and extend existing disaster governance literature. The emphasis on cascading risk and interdependencies reinforces the work of Pescaroli and Alexander (2018), who argue that modern urban disasters are defined by chain reactions across coupled systems. In Guangzhou's context, crisis management must move beyond protecting individual structures to ensuring the resilience of system-wide functions, particularly lifelines.

The identification of interface failure as the core performance bottleneck validates concerns in public administration literature about the fragmented authority paradox (Comfort et al., 2010). The study demonstrates that formal plans and institutions are insufficient without interoperable data platforms, shared operational procedures, and real-time information fusion supporting Whole-of-Government approaches (OECD, 2023).

The persistent warning-to-action gap corroborates the socio-technical view of early warning systems (Allen & Melgar, 2019). While technically proficient, Guangzhou's system fails as a closed-loop system because it does not reliably translate detection into protective behavior. This underscores the need to redesign early warning as a behavioral governance tool, consistent with World Bank (2024) guidance on humanized, equity-sensitive warning communication.

The concept of preparedness inequality extends the social vulnerability literature (Tierney, 2019; Cutter et al., 2008), providing empirical evidence that disparities in shelter access, drill realism, and household readiness across districts and demographic groups are fundamental performance drivers. This supports calls for equitable resilience frameworks prioritizing vulnerable populations (Agrawal et al., 2024). The proposed IUER Framework synthesizes these insights into an actionable governance architecture, moving beyond problem identification toward structured strategic pathways grounded in stakeholder evidence.

International Comparative Analysis

To contextualize Guangzhou's performance, Table 5 presents a comparative analysis with Tokyo (Japan), Mexico City (Mexico), and Istanbul (Turkey), major cities sharing high-density, low-to-moderate seismic risk profiles.

Table 5 International Comparative Analysis: Earthquake Crisis Management in High-Density Cities

Dimension	Guangzhou (Current Study)	Tokyo, Japan	Mexico City, Mexico	Istanbul, Turkey
Seismic Risk Profile	Low-frequency, high-consequence; intraplate	High frequency; well-documented subduction zone	Moderate-to-high; soft soil amplification	High; proximity to North Anatolian Fault
Early Warning System	Technically advanced but socially	J-Alert + broadcaster integration; high public compliance	SASMEX; message comprehension	Infrastructure developing; EU framework integration





Dimension	Guangzhou (Current Study)	Tokyo, Japan	Mexico City, Mexico	Istanbul, Turkey
	underutilized; weak action scripts		challenges; false alarm issues	
Governance	Fragmented	Centralized with strong	Complex multi-level	Centralized AFAD
Coordination	"information chimneys"; plan-action gaps	municipal-agency coordination; regular joint drills	governance; cross- borough coordination challenges	coordination; improvements post- 1999
Key Gaps	Interface failures; preparedness inequality; warning-to-action translation	Aging infrastructure; over-reliance on public compliance	Uneven building code enforcement; poverty- vulnerability linkages	Rapid informal urbanization; enforcement gaps
Lessons for Guangzhou	-	Embed drills into routine school/workplace culture; strengthen building code enforcement	Leverage historical experience; integrate community networks formally	Use post-disaster reform windows; align governance with international standards

Sources: Guangzhou findings from current study; Tokyo, Mexico City, and Istanbul based on published comparative disaster governance literature.

Recommendations

Policy Formulation

1. Institutionalize Cross-Department Interoperability: Mandate citywide standards for emergency data exchange covering earthquake monitoring outputs, infrastructure status, resource inventories, traffic conditions, shelter capacity, and community field reports, with legal frameworks for data sharing and audit mechanisms.

2. Convert Plans to Operational Doctrine: Require contingency plans to be translated into time-sequenced, scenario-based Standard Operating Procedures (SOPs) defining triggers, responsibilities, and handoffs for the first minutes and hours following an earthquake event.

3. Reframe Early Warning Policy: Shift policy focus from warning provision to action enablement. Mandate that warning messages include short, behaviorally legible action scripts tailored to building type, location, and population characteristics.

4. Embed Preparedness in Urban Renewal: Integrate shelter and evacuation feasibility into urban renewal and land-use governance, particularly in old districts. Fund micro-renovations for distributed safe spaces and establish community micro-reserves.

5. Adopt Equity-Sensitive Preparedness Governance: Explicitly address vulnerable populations through vulnerability mapping integrated into shelter planning, resource placement, and volunteer support systems.

**Table 6** Policy Recommendation Matrix for Guangzhou Earthquake Crisis Management

Category	Specific Intervention	Horizon	Lead Actors	Expected Impact	Feasibility
Interoperability	Mandate citywide emergency data exchange standards	Short (0–2 yrs)	Emergency Management Bureau; Municipal Government; IT Dept	Unified situational awareness; reduced delays	High
Operational Doctrine	Convert plans to time-sequenced SOPs with drill integration	Medium (2–4 yrs)	Emergency Management Bureau; All response departments	Predictable execution; reduced overlap and delay	Medium
Early Warning Design	Action-oriented, context-tailored warning messages	Short (0–2 yrs)	Seismic Monitoring Center; Media/Communications Dept	Higher protective behavior uptake; reduced panic	High
Preparedness Embedding	Micro-renovations for shelter spaces in old districts	Long (4–8 yrs)	Urban Planning Bureau; Housing Authority; District Govts	Improved evacuation feasibility; reduced inequality	Medium
Equity Governance	Vulnerability mapping and one-to-one support systems	Medium (2–4 yrs)	Social Services; Community Affairs; Civil Affairs Bureau	Equitable outcomes; reduced preventable casualties	Medium
Community Micro-Reserves	Establish community-level emergency supply points	Medium (2–4 yrs)	District Govts; Neighborhood Committees; Volunteer Orgs	Faster first-hour stabilization	High
Drill Reform	Terrain-based, repeated micro-drills with skill testing	Short (0–2 yrs)	Emergency Mgmt. Bureau; Education Dept; Community Orgs	Skill internalization; improved procedural memory	High
Communication Resilience	Satellite backup and drone-based relay systems	Medium (2–4 yrs)	Communications Dept; Technology Vendors	Maintained command under network failure	Medium

Practical Application

1. Build Unified GIS Operations Dashboard: Develop a shared, role-based dashboard integrating micro-geological risk layers, building vulnerability information, underground space layouts, lifeline status indicators, shelter capacity, and community field reports.
2. Operationalize Closed-Loop Early Warning: Implement multi-channel warning dissemination combined with clear, scenario-based action scripts and behavioral response monitoring.
3. Strengthen Last-Mile Preparedness: Establish community micro-reserves in older districts with routine inventory checks. Support household readiness programs through subsidies for emergency kits, prioritizing vulnerable households.





4. Redesign Drills for Realism: Shift from formalistic drills to terrain-based, repeated micro-drills focusing on skill internalization and realistic physical constraints (narrow streets, stairwells, vertical mobility).

Further Research

1. Develop Interface Performance Metrics: Operationalize and validate measurable indicators such as time-to-fused situational awareness, interoperability latency, warning reception and comprehension rates under stress, and time-to-resource delivery for vulnerable households.

2. Investigate Behavioral Response: Conduct mixed-method studies combining surveys, behavioral experiments, and mobility analysis to understand how disaster literacy, trust, building type, and social norms shape protective action.

3. Model Cascading Hazard Chains: Develop scenario simulations integrating lifeline infrastructure data, underground space maps, and urban morphology to predict secondary hazard propagation.

4. Evaluate Integrated Interventions: Pilot and evaluate IUER Framework interventions using pre-post designs and cross-neighborhood comparisons to generate evidence for scalable implementation.

5. Comparative Governance Analysis: Extend the IUER Framework to other Greater Bay Area cities and compare governance outcomes to strengthen the framework's generalizability to similar high-density, low-frequency seismic risk contexts.

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