From whole-of-government to whole-of-society – Digitally-transformed emergency response in Poland and Taiwan.

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Abstract. Responding to complex, existential, and cross-cutting emergencies often exceeds the capacity of public institutions acting through the Whole-of-Government (WoG) approach. This calls for a collective action by the public sector (through WoG), the private sector, civil society, and citizens to deliver a Whole-of-Society (WoS) response. Given the complexity and scale of this response, WoS is naturally enabled by Digital Transformation (DT) and Artificial Intelligence (AI). This paper examines how digitally-transformed and AI-enabled WoS Emergency Response (ER) can be conceptualized and operationalized across diverse public governance contexts, using a comparative study of Poland and Taiwan. Drawing on a scoping review of interdisciplinary literature on WoG, WoS, ER, DT, and AI, the study revisits the WoS approach to better account for digitally-transformed and AI-enabled forms of preparation, communication, coordination, and control in ER. The review identifies two persistent gaps in existing frameworks: the under-conceptualization of DT as a core governance condition and the predominance of leadership understood in individual and hierarchical terms. Based on these insights, the study proposes a conceptual refinement of the well-established WoS framework for the energy transition by Määttä (2021), treating DT and institutional capacity as cross-cutting dimensions that underpin the remaining four dimensions: crisis framing, shared responsibility, systems thinking, and inclusivity. The refined framework is then applied to analyze and compare the structures and operations of digitally transformed WoS ER in Poland and Taiwan, offering a theoretically grounded lens on ER arrangements across diverse settings. Poland and Taiwan offer instructive cases due to contrasting vulnerabilities and institutional frameworks.

Keywords. Whole-of-government, Whole-of-society, Emergency response, Digital transformation
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1. Introduction

Governments worldwide increasingly recognize the necessity of the WoS approach to disaster preparedness, response, and recovery (Clark et al., 2025). This approach emphasizes inclusive, collaborative engagement among government, business, and civil society organizations, academia, communities, and individuals (WHO, 2019; McClelland et al., 2022). Yet the specific role of digital systems in enabling WoS ER remains underexplored. Existing

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research demonstrates that Digital Transformation fundamentally reshapes disaster response by enhancing stakeholder coordination and enabling real-time data distribution (Lee et al., 2023; Sandoval & Lanthier, 2024; Wang et al., 2025). Shared data platforms, digital infrastructure, digital services, and digital competencies prove essential in cross-sectoral emergency management (Lee et al., 2023; Sandoval & Lanthier, 2024; Wang et al., 2025).

However, this literature exhibits two limitations. First, with the exception of Sandoval & Lanthier (2024), who argue that the digital divide inhibits access not only to digital technology but to disaster aid and relief, few studies systematically integrate digital technologies into WoS frameworks. Thus, they miss the critical element needed to scale up ER from the organizational to the societal level. Second, most research examines ER components in isolation rather than holistically (Lee et al., 2023; Wang et al., 2025). The system-level WoS approach is key to effective ER, where technology is used to scale up and technology-enabled institutions to coordinate societal response. Against this background, the study addresses the question: How can the WoS approach, centered on digital technology and digitally enabled institutions, be conceptualized and validated in the context of ER?

To this end, the study aims to develop a conceptual framework for a WoS-based, digitally enabled ER by extending the well-established Määttä (2021) WoS framework, originally proposed to capture countries' responses to governing the energy transition. The framework includes five dimensions: crisis framing, shared responsibility, inclusivity, leadership, and systems thinking. This study extends this framework by: 1) reconceptualizing the leadership dimension as institutional capacity of public sector organizations to coordinate collective action; 2) introducing DT as the sixth dimension to scale-up ER response from the organizational to societal level, and transforming the ER organizations themselves; and 3) positioning the institutional and technology dimensions across others, as enablers to crisis framing, shared responsibility, inclusivity, and systems thinking, and each other.

The extended framework is validated through a comparative analysis of ER arrangements in Poland and Taiwan, selected to capture variations in institutional arrangements, technological capacities, and risk profiles, as well as their overlaps. The comparative approach is relevant given the transboundary and systemic nature of contemporary ER, which requires coordinated responses across sectors, jurisdictions, systems, etc. Poland and Taiwan offer instructive cases due to contrasting vulnerabilities and institutional frameworks. While Taiwan faces high-intensity natural hazards such as typhoons, as well as geopolitical threats, Poland faces low-intensity natural hazards, such as floods, and regional and cross-border instability due to its position in Europe. Each case is instructive for understanding WoS implementation in a given context. However, comparative analysis can work across contexts, revealing which WoS mechanisms are transferable and which require localized adaptation.

This work makes some important contributions. First, we advance WoS scholarship by demonstrating that DT is a core dimension of contemporary ER, not merely a technical medium. Second, we provide adaptive response strategies grounded in empirical analysis of how digital solutions support institutional frameworks and community roles, illuminating pathways toward more responsive ERs in which technological and institutional capacity increasingly determines responses and outcomes. Both contributions are materialized in the extended framework and its application in Poland, Taiwan, and across.

The remainder of this paper is structured as follows. Section 2 presents the outcomes of the literature review covering WoG, WoS, ER, DT, and Artificial Intelligence (AI). Section 3 presents the methodology for addressing the research question. Section 4 describes theoretical findings – conceptualization of the WoS approach for ER, centered on DT and digitally enabled institutions. Section 5 describes empirical findings – validation of the proposed framework based upon the cases of Poland and Taiwan, each providing institutional structures and evidence of their use in concrete ER cases. Section 6 discusses the findings and their implications for research and practice. Section 7 provides the main findings, limitations of this research, and directions for future research.

2. Literature review

This section documents the outcomes of the literature review on the transition from WoG to WoS for ER, as well as DT's enabling role in this transition. The section is structured into four subsections: WoG to WoS (Section 2.1), WoG to WoS for ER (Section 2.2), DT in WoG to WoS for ER (Section 2.3), and AI-enabled DT (Section 2.4).

2.1. WoG to WoS

A number of articles concern combined WoG and WoS responses to the COVID-19 pandemic in Taiwan and China. Hsieh et al. (2021) examine collaborative governance implemented by Taiwan's National Epidemic Prevention Team, arguing for "an integrated system of interdepartmental, central-local, intersectoral and citizen-state collaboration" to fight COVID-19. Ning et al. (2020) summarize China's governance approach for fighting the COVID-19 pandemic, including "whole-of-government response and accountability, setting up a multi-sectoral cooperation platform, swiftly scaling up epidemic emergency capacity," and "whole-of-society actions with engagement of social organizations, and engaging citizens in the epidemic prevention and control". Li et al. (2022)

examine the implementation of the WOG-WOS approach to fighting the pandemic in Wuhan, China, where "the government and non-government stakeholders have quickly engaged in collaborative governance to address the community food supply challenges," acting in an interdependent manner.

In the security arena, Brunk (2016) calls for complementing the WoG approach to peacebuilding through improved coordination among the security, diplomacy, and development sectors, and for the WoS approach in donors' home societies that "have potential to influence peacebuilding outcomes abroad". Further, Manwaring et al. (2023) recall the Australian response to "cyber-enabled foreign interference," which involves building cyber, national, and democratic resilience through WOG and WOS strategies. It also uncovers that such responses are top-down driven, treating citizens as a "passive strategic resource, rather than conceived of as a potentially substantive partner in a "joined-up" response". This message is amplified by Virta et al. (2023), who call for reconciling WoG and WoS in security governance achieved through "trust building, co-operation and resilience rather than state coercion".

More generally, Bouckaert (2022) argues for a combined society-public sector effort to "ensure an inclusive service delivery, effective crisis governance, and functional innovation", not possible with a "pure market driven" New Public Management, nor with "a pure network driven" New Public Governance, calling for a "neo-Weberian-State" where a WoG "perspective [...] is embedded in" a WoS context. Bouckaert (2024) further embraces WoG/WoS as part of a "governance structure characterised by resilience and systemic responsiveness".

2.2. WoG to WoS for Emergency Response

Määttä (2021) conceptualizes the WoS approach through interrelated dimensions of crisis framing, shared responsibility, leadership, systems thinking, and inclusivity, arguing that contemporary crises require coordinated action across institutional, sectoral, and societal boundaries. This framework highlights the limits of hierarchical command-and-control models and underscores the importance of collaborative governance in managing systemic risks. Building on this perspective, Clark et al. (2025) advocate for further action-oriented research involving populations at risk, identifying four dimensions and ten themes of disaster-resilient societies: stakeholder participation (informal leader, spontaneous volunteers, inclusive spaces), capacity building (trust, co-creation, learning), vulnerability reduction (targeted communication, diversity, agencies), and organizational change (adoptive capacity, transformation). They provide a solid framework for action-based research.

While WoS emphasizes broad societal engagement, insights from the WoG literature remain relevant for understanding institutional capacity and coordination. In their analysis of COVID-19 responses in the UK and Australia, Weiss & Thurbon (2022) identify the state's salutary capacity and its capacity to correct course in a crisis as key determinants of an effective response, alongside political choice. Their findings demonstrate that political decisions can compensate for institutional weaknesses or, conversely, exacerbate governance failures. Institutional arrangements and decision-making authority remain central even within inclusive governance.

A number of studies illustrate how WoS principles play out across different actor groups. Pineda & Corburn (2020) show that disabled residents face disproportionately higher risks during disasters due to non-inclusive policies, underscoring WoG commitments to equity within broader WoS strategies. Milton & Elkahlout's (2024) analysis of Qatar's humanitarian engagement during the Afghanistan evacuation demonstrates how non-state actors can enhance institutional agility, internal capacity-building, and societal resource mobilization, reinforcing the roles of humanitarian and civil society actors in ER ecosystems. Similarly, O'Sullivan & Phillips (2019) argue that effective WoS pandemic planning requires institutionalized spaces for citizen participation, moving beyond symbolic engagement toward asset-oriented and participatory governance.

Several studies also highlight the importance of information, coordination, and digital capacity in enabling WoS approaches. Gradon & Moy (2021) evaluate the responses of the intelligence communities during COVID-19 and the failure of the warning-policy interface, and suggest communication and information strategies based on the WoS approach, in which "government players are augmented by Non-Governmental Organizations (NGOs), health practitioners, the private sector, and general public". They also emphasized the importance of identifying misinformation and fake news earlier. Similarly, Wolf-Fordham (2020) advocates breaking down silos among governmental and non-governmental actors to strengthen local emergency and public health preparedness. To do so, it is important for public administrators to pursue education, professional development, research, and practice, especially when society faces multiple disasters.

2.3. Digital Transformation in WoG to WoS for Emergency Response

Digital technologies enable WoS ER by facilitating coordination among stakeholders, democratizing real-time data, and fostering adaptive resilience that transcends siloed actions. In cross-sectoral coalitions, shared data platforms, digital infrastructures, and digital competencies are foundational public goods for emergency prevention, preparedness, and response (Lee et al., 2023; Sandoval & Lanthier, 2024; Wang et al., 2025).

The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015) highlights the role of technology in mitigating disaster risks and enhancing community resilience, including systems to improve multi-hazard early warning, response mechanisms, and risk assessments, and reduce impacts on livelihoods, health, infrastructure, and services. It proposes Disaster Risk Reduction architectures to leverage technology for inclusive risk governance, with social media, AI-driven forecasting, and data hubs facilitating cross-sectoral coalitions. Such architectures redefine digital systems as essential co-governed infrastructures for multi-level coordination across governmental, industrial, and civic domains, rather than ancillary tools. According to UNDRR (2015), community feedback loops demonstrate 35% gains in efficacy in multi-hazard contexts.

Three diverse WoS emergency contexts are China, Singapore, and the US. China's digital health governance exemplifies the WoS paradigm, in which the State Council coordinates 12 ministries, regulatory bodies, industry associations, and academic institutions to standardize data interoperability, privacy protocols, and internet-based healthcare delivery within national emergency architectures (Wang et al., 2025). Singapore's response to the pandemic was characterized by the integration of pre-existing technology assets with bespoke digital interventions for contact tracing, quarantine enforcement, multi-channel public communication, etc. Its Smart Nation platform served to unify various government departments in addressing the challenges posed by the pandemic (Lee et al., 2023). In the US, the Federal Emergency Management Agency's Whole Community doctrine was extended to digital infrastructure governance, positing that equitable broadband access, device provisioning, and digital literacies are conditions for community-centric regulation of flood, wildfire, and pandemic risks, as network policy decisions materially shape hazard vulnerability (Sandoval & Lanthier, 2024).

The mobilization of digital technologies across heterogeneous contexts is facilitated by WoG/WoS paradigms. In particular, Singapore is utilizing integrated platforms for surveillance, tracing, telehealth, and economic continuity (Lee et al., 2023). China integrates electronic health records, big-data analytics, and AI-augmented insurance platforms to facilitate epidemic surveillance, clinical triage, and service resilience (Wang et al., 2025). More broadly, digital information ecosystems and infodemic management are intrinsic parts of epidemic governance (Purnat et al., 2023). In the US, the city of San Jose utilizes a range of technologies, including river-gauge telemetry, hydrological dashboards, and the Internet of Things for dam-flood forecasting. The efficacy of these measures is undermined by digital communication asymmetries, underscoring the need to integrate sensor-derived data with inclusive broadband and alerting within floodplain governance (Sandoval & Lanthier, 2024).

In particular, households without internet access face systematic limitations in accessing digitally mediated warnings, aid coordination, and recovery pathways. This "disaster divide" amplifies exposure among vulnerable groups, particularly those susceptible to flood, fire, and pandemic-related hazards (Sandoval & Lanthier, 2024). Low income, disability, senescence, and linguistic diversity are key factors contributing to exclusion in hazard-prone locales (Wang et al., 2025), as are persistent disparities in rural-urban connectivity and geriatric digital illiteracy. According to Sandoval & Lanthier (2024), subsidy mechanisms and device-access initiatives operationalize connectivity for at-risk demographics, enabling warning reception, data interpretation, and response actuation. Targeted broadband expansions helped sustain telehealth (Wang et al., 2025), while augmenting digital literacy and implementing multilingual interfaces helped democratize access to sensor feeds, dashboards, and emergency applications (Sandoval & Lanthier, 2024).

Digital technologies exhibit phase-specific affordances within WoG/WoS architectures. For instance, the prevention phase leverages predictive analytics and sensor arrays to issue early warnings. The preparedness phase operationalizes vulnerability mapping and literacy interventions. In the response phase, tracing/compliance apps, along with telehealth, are mobilized to contain the issue. The recovery phase sustains data platforms to orchestrate aid and audit resilience (Sandoval & Lanthier, 2024; Lee et al., 2023; Wang et al., 2025). **Tab. 1** summarizes the digital technologies introduced in this section.

Tab. 1 – Digital technology for WoS/WoG emergency response.

Technology employed	Key case example	WoS/WoG	Source
Data ecosystems and health data platforms	Real-time surveillance resource arbitrage, EHR-insurance-pharma federation	12 ministries, industry, academia	Wang et al., 2025
Big-data analytics	Hazard forecasting, epidemiological allocation for hydrologic flood alerts, etc.	Whole Community	Sandoval et al., 2024
AI-driven forecasting	Hazard modeling, susceptibility mapping, mass movement susceptibility maps	Multi-stakeholder coalitions	UNDRR, 2025
Secure and privacy utility	Secure cross-institutional data utility for privacy-preserving medical data sharing	Government-private data coalitions	Wang et al., 2025

Hazard sensor arrays	Adaptive telemetry, perimeter tracking for river gauges, wildfire cameras	Whole Community (sensor networks)	Sandoval et al., 2024
Vulnerability cartographies	Risk overlay mapping in San Jose digital divide-floodplain geospatial analysis	City-water district, civic input	Sandoval et al., 2024
Drones/Satellite telemetry	Real-time surveillance, hazard mapping for WMO Kenya flood/drone monitoring	Public-private-community	WMO, 2024
Tracing/Compliance applications	Cluster delineation, venue logging in TraceTogether (Bluetooth), SafeEntry (QR)	National taskforce orchestration	Lee et al., 2023
Tele-epidemiology platforms	Remote diagnostics, e-prescribing in China's "Internet Plus Health Care"	Government-industry standards	Wang et al., 2025
Infodemic management tools	Authoritative dissemination, sentiment arbitrage, social listening	WoG (centralized info ecosystem)	Lee et al., 2023
Mobile early warning through social media	Inclusive alerts, community feedback on social platforms	Civic feedback loops	UNDRR, 2025; Fischer, 2024

2.4. AI-enabled digital transformation in WOG to WOS for Emergency Response

AI plays a transformative role in modern disaster and risk response. According to the World Economic Forum (2026), as climate-induced disasters intensify, the traditional reliance on legacy systems must give way to a systemic transformation powered by AI, enabling precise infrastructure mapping, integration of mutual aid resources, and real-time automated guidance. This vision is mirrored by Ramiah (2024), who posits that AI is evolving into a vital "digital co-pilot" for crisis resilience, reshaping response mechanisms through real-time impact mapping, optimized personnel deployment, and a strategic shift toward pre-emptive risk management. By aligning these technological pillars, a unified, AI-driven architecture is essential to replace fragmented efforts with a coordinated and proactive global response framework.

The success of AI in ER depends not only on technical development but on the "alignment problem", i.e., ensuring that AI decision-making remains consistent with human values, objectives, and intentions. The core challenge lies in value judgment. For instance, in post-disaster resource allocation, should priority be given to areas with the most severe damage, regions with the highest property value (which may be wealthier), or impoverished communities with the fewest resources for reconstruction? These decisions are ethical and policy choices, rather than mere data problems (Roberts, 2025). Ultimately, a successful ER cannot rely solely on "perfect" models; it must maintain human oversight and clear accountability within complex multi-agent systems to ensure that technology can effectively navigate the chaotic realities of the ER. **Tab. 2** summarizes four use cases of AI-enabled DT in WoG/WoS for ER introduced in this section.

Tab. 2 – Use cases of AI-enabled digital transformation in WoG/WoS for emergency response.

Use case, AI role	Examples	Source
Prediction and risk mapping; AI identifies hazards before they occur, enabling proactive planning	*Early warning systems*: ML models analyze satellite data and climate patterns to predict extreme weather events. *Risk mapping*: AI-powered geospatial analysis identifies high-risk zones, such as earthquake-prone regions, helping communities and planners prioritize preparedness efforts.	Jain et al., 2023; Huntingford et al., 2019; Rehan, 2022; Richardson, 2021
Response and resource allocation; AI improves speed, coordination, and accuracy during crisis response	*Responder routing*: AI optimizes emergency vehicle routes by analyzing traffic, infrastructure damage, and hazard zones. *Resource deployment*: AI-driven outbreak tracking systems helped hospitals allocate ventilators and other equipment based on infection trends and regional needs.	Henchey et al., 2014; Zhang et al., 2025; Beg et al., 2021
Communication and public safety; AI supports fast, accurate information sharing and public engagement	*Crisis monitoring*: Emergency responders and dispatch centers use AI tools to scan social media and emergency calls to detect emerging incidents, misinformation, or urgent needs. *Chatbots and alerts*: AI chatbots assist the public with evacuation	Khallouli, 2024; Erokhin et al., 2024; Pavani et al., 2025; Abid et al., 2025

	information or shelter locations.	
Recovery and damage assessment; AI assesses damages, builds awareness	*Aerial damage assessment*: After disasters, drones analyze photos of unsafe or difficult-to-access affected areas. *Infrastructure rebuilding*: AI models recovery scenarios, based on resource availability and community priorities.	Ishiwatari, 2024; Bashir et al., 2024; Vedanth et al., 2024

3. Methodology

To address the research question "How can the WoS approach, centered on digital technology and digitally enabled institutions, be conceptualized and validated for ER?" this study adopts a twofold qualitative research design combining 1) a scoping literature review to conceptualize a DT-enabled WoS ER framework, and 2) a comparative analysis of two case studies structured according to the framework and serving to validate it.

The scoping literature review was conducted using the methodological framework by Arksey et al. (2005). It aimed to identify, systematize, and extend existing DT-enabled WoG/WoS ER frameworks. To this end, a search was conducted in Scopus on 20.01.2026 using article titles, abstracts, and keywords. For WoG, the search used the synonyms "whole-of-government" OR "joined-up government" OR "all-of-government", identifying 1,008 results, including 562 in social sciences. For WoS, the search used the synonyms "whole-of-society" OR "all-of-society" OR "entire-society" OR "whole-of-nation", identifying 2,484 results, including 996 in social sciences. To narrow down the search to ER, the WoG and WoS terms were combined with the synonyms "emergency response" OR "crisis response" OR "disaster response" OR "humanitarian response" OR "relief response", identifying 20 results, 6 in social sciences for WoG, and 16 results, 5 in social sciences for WoS. This confirmed the limited integration of WoS/WoG with ER in general, let alone with DT. To overcome this limitation and complement the scholarly literature, policy/analytical reports were also searched. The outcomes described in Section 2 informed the development of the DT-enabled WoS ER conceptual framework documented in Section 4.

The comparative case study analysis applied the WoS ER framework to Poland and Taiwan, following Eisenhardt's (1989) replication logic. Such analysis is particularly suitable for studying WoS ER, as contemporary crises are transboundary and require coordination across institutional, sectoral, and technological boundaries. The cases of Taiwan and Poland were selected for their contrasting institutional settings, risk profiles, and digital capacities, while both making significant investments in digitally supported ER. Taiwan's ER context is characterized by high exposure to natural hazards and advanced digital coordination infrastructures, whereas Poland operates within the European civil protection and security architecture and faces cross-border and cascading crisis risks. In both contexts, the data sources included publicly available policy documents, institutional reports, system descriptions, and secondary analyses of DT- and AI-supported ER mechanisms. The analysis serves to validate the proposed WoS ER framework, and the outcomes are described in Section 5 and discussed in Section 6.

4. Theoretical framework

In line with the main research question and the methodological decisions outlined in Section 3, this section proposes a digitally enabled WoS framework for ER. The framework is built on the scoping literature review documented in Section 2, particularly the framework proposed by Määttä (2021). This framework conceptualizes collective emergency response through crisis framing, shared responsibility, inclusivity, systems thinking, and leadership dimensions. To address contemporary governance conditions and the enabling role of technology for ER, the framework is extended in three ways. First, by introducing a new DT dimension that recognizes the enabling role of digital infrastructures, data systems, and computational tools in coordinating WoS responses to ER. Second, by reconceptualizing the leadership dimension into an institutional dimension, shifting the emphasis from individual and hierarchical authority to organizational, governance, and regulatory capacities for sustained coordination across sectors, actors, and levels. Third, both the DT and institutional dimensions are treated as cross-cutting; they underpin the functioning of the remaining dimensions. The resulting digitally-enabled WoS framework for ER is depicted in Figure 1, and its six dimensions are described below.

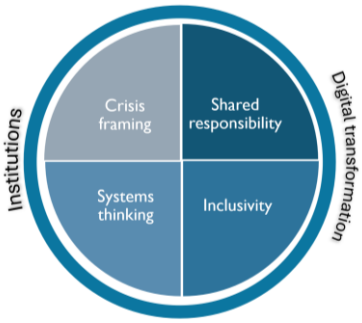

Fig. 1. Digitally-enabled WoS framework for emergency response

Crisis framing: Määttä (2021) identifies crisis framing as fundamental to the WoS approach, providing context and justification for society-wide mobilization. It justifies drastic measures and the subordination of sectoral interests to the systems-wide approach. In the ER, crisis framing motivates actors to overcome institutional silos, commit resources, and accept rapid decision-making amid uncertainty. The risk is suppressing alternative views and legitimate dissent in the name of ER, potentially framing challenges as everyone's personal problem to secure compliance. The approach has been deployed in many contexts, from peacebuilding and disaster management to pandemics and health emergencies, all of which are systemic challenges with cross-cutting impacts.

Shared responsibility: refers to the mobilization of actors and resources across society, recognizing that complex crises affect all sectors and cannot be addressed by any single entity (Määttä, 2021). In ER, shared responsibility entails a structured distribution of roles, capacities, and obligations across individual, local, national, and international levels. In particular, it entails citizens and businesses acquiring ER knowledge and capacities. However, as stakeholders have different interests, deliberation and power balance are important, as are genuine interests, recognition, equal collaboration, trust in government, and situational awareness.

Inclusivity: recognizes that the capacity to cope with crises is uneven across society (Määttä, 2021). The WoS approach emphasizes sharing efforts and benefits fairly and "leaving no one behind". This requires mitigating losses, increasing participation capacity, and caring for the vulnerable – the elderly, people with disabilities, those in poverty, and workers in affected sectors. These measures apply at all levels, from individuals to nations (Määttä, 2021, p. 3). In the ER contexts, inclusivity is not only a normative principle but a functional requirement, as unequal access to resources directly affects response outcomes. Inclusivity helps manage conflict through collaborative action toward shared goals. It can be genuine or merely symbolic.

Institutions: In the Määttä (2021) framework, leadership refers to the government's role in coordinating and guiding WoS responses. To capture the structural and organizational foundations of ER, we reconceptualize this dimension in terms of institutions, encompassing political authority, administrative capacity, legal frameworks, and operational readiness. Institutions facilitate sustained collective action by issuing guidance, adjusting laws, reallocating resources, and removing coordination barriers, and by maintaining 24/7 operational capacity and pre-established mechanisms. The WoG approach is integral to this leadership and requires collaboration across policy domains and government sectors, as well as outward to non-governmental actors. This distributed leadership model contrasts with traditional hierarchical structures by emphasizing coordination over control.

Systems thinking: asserts that addressing modern challenges requires holistic, integrated, and collaborative interventions designed to transform the systemic environment rather than just treating isolated symptoms. A foundational component of WoS, systems thinking is operationalized through continuous evaluation, flexible policymaking, evidence-based decision-making, transparency-driven accountability, and other mechanisms. For ER, systems thinking involves a unified response to a crisis, moving beyond isolated reactions and treating the disaster landscape as a dynamic network of interconnected parts (infrastructure, public health, social capital), enabling emergency managers to foster adaptive strategies that remain effective as the crisis evolves. It also ensures that ER actions do not inadvertently create new vulnerabilities elsewhere.

Digital transformation: While Määttä (2021) does not explicitly identify technology as a distinct WoS dimension, DT's role as an infrastructural condition of WoS ER is critical. For example, Taiwan established the National Science and Technology Center for Disaster Reduction to address the "shortage of disaster prevention technology" (Bosner & Chang, 2020). However, technology alone is insufficient without addressing coordination and integration challenges (ibid.). In this study, DT is conceptualized as a cross-cutting enabler of WoS ER. It includes integrated data platforms for real-time information sharing, digital communication, multi-stakeholder coordination, and AI-supported decision-making. DT supports crisis framing through rapid information dissemination, operationalizes shared responsibility through transparency, enhances inclusivity through accessible communication, and strengthens institutional capacity by enabling coordination.

5. Findings

This section applies the theoretical framework from Section 4 to the cases of Poland and Taiwan. This is done in two steps. First, the WoG/WoS structures for ER in Poland and Taiwan are described in Sections 5.1 and 5.2, respectively. Second, the ER operations carried out through such structures are described in Sections 5.3 and 5.4, respectively. The framework is explicitly applied to ER operations, subsuming structures under the institutional dimension. The comparison between structures and operations in Poland and Taiwan is conducted in Section 6.

5.2. Emergency response in Poland – Structures

The ER system in Poland comprises the Crisis Management Body, responsible for initiating ER; the Advisory and Consultative Body, responsible for coordinating ER; and the Crisis Management Center, maintaining 24-hour readiness to take action. All three components are present at different levels – national, ministerial, voivodeship, district, and commune, with the exception of commune-level Crisis Management Centers (Pietrek, 2011).

The main entities responsible for ER at the national level are Council of Ministers – exercises general crisis management, approves plans and coordinates actions; Prime Minister – directs activities, including through the advisory and consultative Government Crisis Management Team (RCZK); Government Security Centre (RCB) – provides support to RCZK, acts as the national ER center; Minister for Internal Affairs – takes over management in urgent cases; as well as civilian experts, service officers and Polish Armed Forces.

The Government Security Center, a state unit subordinate to the Prime Minister, plays a special role, providing services to high-level officials and serving as the national crisis management center. RCB coordinates the crisis prevention process and, in the event of a crisis, the process of minimizing its effects. It assesses risks to national security, standardizes threat perceptions across ministries, and generally enhances the ability of relevant services and public administration bodies to handle difficult situations. It operates at an inter-ministerial level.

At the voivodeship level, the Voivod (voivodeship governor) is the authority for crisis management, responsible for monitoring threats, planning responses, and addressing the consequences throughout the voivodeship, with support from the Voivodeship Crisis Management Team (WCZK). WCZK is an auxiliary body of the Voivod, which assesses threats, plans actions, and manages crises on an ongoing basis. WCZK consists of the Voivod, the head of WCZK, and representatives of the army, the police, the fire brigade, and other inspection services. The Voivod subordinates local government bodies and other units in the voivodeship to ensure an efficient response. Similar structures and responsibilities serving their respective areas exist at the district and commune levels.

RCB is the main administrator of the National Security Geoinformation System (GISBN). Originally, the system was limited to reports on COVID-19 vaccinations and SARS-CoV-2 infections published on the gov.pl portal. Currently, the system consists of two components. The first is accessible to users in the crisis management area, where maps and dashboards are published for selected threats. Part of this environment is an application that monitors threats and crisis situations, and collects information on forces and resources in accordance with the National Crisis Management Plan. The second is the publication of the RCB Daily Reports on websites and via SMS, which contain warnings about meteorological, hydrological, epidemiological, and other types of threats.

5.2. Emergency response in Taiwan – Structures

Following the 1999 Chi-Chi Earthquake, which killed 2,471 people and exposed critical coordination failures, Taiwan enacted the Disaster Prevention and Protection Act in 2000 (Bosner & Chang, 2020).

According to this Act, Taiwan's ER operates through a three-tier structure: the Central Disaster Prevention and Protection Council sets policies; the Central Emergency Operation Center (CEOC) coordinates responses; and the National Rescue Command Center handles tactical coordination. Institutional responsibilities are distributed between the Disaster Prevention and Relief Office for natural disasters, the National Security Council for man-made disasters, and the National Science and Technology Center for Disaster Reduction (NCDR) for technology integration. NCDR implements disaster-prevention science and technology plans, focusing on hazard-mitigation technologies, risk-assessment methodologies, and data analytics (Bosner & Chang, 2020).

Taiwan assigns disaster responsibilities based on hazard types: the Ministry of Interior handles earthquakes; the Ministry of Economic Affairs manages floods and pipeline failures; the Council of Agriculture addresses debris flows; the Ministry of Transportation responds to crashes; the Environmental Protection Administration handles toxic chemicals; the military assists when requested (Bosner & Chang, 2020). This single-hazard approach creates confusion for complex disasters. A function-based, all-hazards approach would assign agency responsibility for specific functions, such as transportation or public health, rather than for disaster types (Bosner & Chang, 2020).

Local ER centers function at the central, county, and township levels, but only Taipei City mirrors the central CEOC structure. Other localities use bureau-based divisions, risking inconsistent command. A national incident management system is lacking. The National Fire Agency and its search-and-rescue teams provide operational

response, but non-fire agencies with ER responsibilities lack 24/7 operational capacity. Local agencies responsible for socioeconomic welfare rarely participate in planning or exercises. The National Fire Agency Training Center trains firefighters but focuses on technical operations rather than ER. A national emergency management curriculum and multi-jurisdictional coordination at annual disaster exercises are missing (Bosner & Chang, 2020).

Taiwan has developed WoS mechanisms, including the Disaster-Resistant Community (DRC), which engages 368 local communities through coproduction with citizens and Non-Profit Organizations (NPOs) such as the Tzu Chi Foundation and the Red Cross, contributing to ER. These initiatives are local and not systematically integrated across all hazard types and government levels. The Kaohsiung pipeline explosion incident revealed that private infrastructure operators possess critical information but lack protocols for emergency data sharing. While NCDR contributes technological capabilities, it is oriented toward research and has no operational capacity for coordination or stakeholder integration across the ER system (Bosner & Chang, 2020).

5.3. Emergency response in Poland – Operations

Several natural and man-made emergencies have faced Poland in recent years, triggering its emergency response system, exposing its weaknesses, and prompting organizational and policy reforms. Most emergencies and over 40% of natural disaster losses are due to floods, especially in the largest river basins (Odra, Vistula), caused by heavy rainfall, snowmelt, storms in the Baltic Sea, and climate change. Here are some examples.

The 1997 flood caused 56 deaths and damaged or destroyed nearly 700,000 houses. Before the next flood in 2010, essential infrastructure improvements, such as dry retention basins, had been implemented. Since then, it became clear that while floods cannot be effectively prevented, an effective ER system must be put in place. A system of mutually cooperating entities – state and local authorities, other institutions, and the public (Walczykiewicz, 2025). In 2024, prolonged and intense rainfall triggered a flood in south-western Poland, with rapid runoff, high-water levels, and flood waves on the Vistula and Odra rivers, resulting in exceedances of warning and alert levels (PGWWP, 2025). The flood resulted in 9 deaths, the evacuation of 238,045 people, the destruction of 10,522 buildings, and the flooding of 3,144 farms, affecting 29,000 ha of crops. In addition, two water reservoir failures occurred, increasing losses and the extent of damage (PGWWP, 2025). In the sequel, we apply the theoretical framework from Section 4 to examine Poland's response to such emergencies.

Crisis framing: Despite a number of changes, both infrastructural and organizational, introduced after previous floods, the 2024 flood highlighted the limitations of Poland's multi-level ER system. While based on a clear division of competences and cooperation between central and local authorities, as described in Section 5.1, the floods revealed a lack of coordination, delayed decision-making, and communication tensions between institutions, which translated into an image of systemic failure. It also became clear that an effective ER requires coordinated actions at the site of the damage (Kotras et al., 2025).

Shared responsibility: During the flood ER, two systems operated concurrently: the institutional system and the spontaneous community system, primarily comprising residents from the flood-affected areas. This dualism hindered effective communication and coordination, occasionally leading to conflicts. Strengthening resilience must rely on coordinated, proactive, routine, and repetitive collaboration between these systems, as well as on prevention (Kotras et al., 2025). On the institutional side, the division of competencies among central and local authorities, the state water holding, Polish Waters, and local governors led to fragmented decision-making, diluted responsibility, and a lack of coherence among institutions. On the local level, local authorities are the closest to local needs and bear primary responsibility for preparing the local community. However, as they often lack sufficient personnel, many of whom are affected themselves, they have to build partnerships for the ER, where state institutions, rescue services, and social organizations share responsibility for carrying out tasks and coordinating actions. In particular, social organizations should be an integral part of the ER, formally recognized in ER structures and the state's resilience-building system, and properly funded.

Inclusivity: During the floods, rescue operations, medical treatment, medical evacuation, sanitary transport, etc., were provided by the State and Volunteer Fire Services, and the Border Defense Forces, a military organization. Those affected by the 2024 floods also received emergency benefits and flood assistance (up to 10,000 PLN) as well as additional social assistance for the poor. Low-interest rebuilding loans, financial support for farmers and entrepreneurs who had to discontinue their agricultural or business operations, psychological support to victims, and a one-off bonus for social workers were also provided. In responding to immediate needs, the state was complemented by volunteers, highlighting the local community's capacity to cope with crises and the need to integrate state actions with grassroots civic engagement at the policy and operational levels (Kotras et al., 2025).

Institutions: Governmental institutions are the main actors in WoG and are also essential for WoS. They facilitate communication and cooperation processes without imposing ready-made solutions (Kotras et al., 2025). During the 2024 floods, thousands of soldiers, police officers, and firefighters were deployed for ER. The authorities also attempted to coordinate NGO relief efforts, e.g., through cooperation between provincial governors and the Great Orchestra of Christmas Charity, not dominating but supporting and coordinating the relationships. The Flood Protection Operations Centers worked continuously, in coordination with the Institute of Meteorology and Water

Management, local authorities, and other ER units. The state immediately released hundreds of millions of zlotys in emergency aid to those affected. However, a long-term strategy combining emergency aid with spatial planning and flood risk management was lacking (Kotras et al., 2025).

Systems thinking: During the 2024 floods, information flow problems emerged. No institution acted as a 'communication filter' to release reliable, relevant, and prioritized information to the public, so the public had to verify the accuracy and importance of the information themselves. A communication error occurred on 17 September 2024, when news stations reported inconsistent fatality numbers, relying on local government reports rather than police data. There was a lack of a systematic approach to communication and warnings, with residents not being warned in a timely manner, and the messages were incomprehensible. While crisis communication is coordinated by RCB, local authorities should have the right to publish hydrological warnings independently.

Digital transformation: Information systems for forecasting and crisis management include applications that integrate hydrological, topographical, and meteorological data to support risk modelling, real-time monitoring, and public warnings. The National Protection Information System (ISOK) aims to support institutions responsible for preventing crisis situations, preparing to take control through planned actions, and responding when they occur. ISOK provides Flood Hazard and Flood Risk Maps to support spatial planning and crisis management. It is accessible to citizens via a website and a mobile application, allowing them to check whether they live in a flood-prone area and, if so, what the risk level is. During the 2024 floods, public communication occurred through social media, press conferences, and broadcasts of crisis management meetings, but was often inconsistent or delayed, leading to misinformation and hindering an effective response at the scene.

5.4. Emergency response in Taiwan – Operations

Several natural and man-made emergencies have faced Taiwan in recent years, triggering its emergency response system, exposing its weaknesses, and prompting organizational and policy reforms. Here are some examples.

The 1999 Chi-Chi Earthquake, which killed 2,471 people, exposed critical failures in ER coordination (Bosner & Chang, 2020). During the 2014 Kaohsiung pipeline explosion, which killed 32 people, officials spent critical hours determining the lead agency's responsibility while firefighters lacked access to essential pipeline maps (Bosner & Chang, 2020). The 2009 Typhoon Morakot, which killed 681 people, further exposed these weaknesses through effective crisis framing that mobilized reform (Wu, 2020). In Laiyi, professionals could not conduct rescue operations for days because the only connecting bridge was damaged, highlighting how fragmented single-hazard approaches fail during compound disasters in which flooding, infrastructure damage, and community isolation converge. The 2025 Matai'an Creek landslide dam breach killed 19 people within 70 minutes, demonstrating that despite post-Morakot reforms, fragmented governmental responsibilities persist. In the remainder of this section, we apply the theoretical framework from Section 4 to examine Taiwan's response to such emergencies.

Crisis framing: Typhoon Morakot caused the most serious flood in over half a century. The associated damages prompted the government to accelerate efforts to enhance communities' disaster relief capacity. To improve community resilience for disaster preparedness and prevention, Taiwan adopted the concept of Disaster Resilience Communities (DRCs) to work with NPOs and citizens across 368 local communities, e.g., Laiyi's Community Resilience Program, to assist the evacuation of the elderly and disabled. However, this WoS approach remains localized rather than systematically integrated across all hazard types and government levels. DRCs emphasize making disaster risk information available to the public in ways that enable them to understand the threats they face (Chen, Liu & Chan, 2006; Wu, 2020). Through community residents' and NPOs' participation in disaster prevention, governments began adopting proactive preparedness models (Wu, 2020) and working with local NPOs or representatives to co-plan or co-design disaster preparedness and prevention plans.

Shared responsibility: After Typhoon Morakot, the Ministry of the Interior established the Disaster Management Capacity Building program for high-risk townships and districts to partner with universities in order to strengthen their disaster resilience. For 135 townships and districts, the outcomes include revisions to disaster-related plans, production and dissemination of disaster maps, establishment of emergency operations centers, assessment of emergency shelters, and education and training. The Water Resource Agency collaborated with local governments and academic institutions to identify where floods are most likely to occur, pinpoint flood-prone communities in these areas, and enhance residents' capacity to respond through flood and disaster prevention plans, installation of evacuation indicators, and organizational measures. Meanwhile, the community capacity development is co-produced with NPOs. For instance, the Red Cross is empowering its volunteers in community-based disaster risk reduction. The Tzu-Chi Foundation, supported by many Buddhists, serves as a facilitator of local disaster prevention and relief (Han, 2013). However, because each program targets different types of disasters, the design is inefficient at enabling a comprehensive system to address compound disasters, i.e., chains of disasters arising from multiple hazards. This became a key issue after Typhoon Morakot.

Inclusivity: Typhoon Morakot damaged Laiyi and several other villages, destroying over 100 houses and prompting the area to be designated a safety concern. One of the designated NPOs for the reconstruction was the Chinese

Communication Analysis Association, which established the Laiyi Reconstruction Service Center in Laiyi. The organization discovered a severe shortage of resources for elderly care and advocated empowering local tribal members to independently establish solutions for disaster prevention and preparedness. As residents of Laiyi belong to the Tja lja av us Gala Avus tribe, which values interpersonal relationships among tribe members and symbiotic relationships with nature, the Ministry of Culture's Community Spiritual Companionship Project – Reading and Cultural Reconstruction Network is integrated into the disaster management system.

Institutions: During Typhoon Morakot, the top authority responsible for ER was the Executive Yuan. The system also included the Central Disaster Prevention and Response Council, in charge of a disaster prevention plan and monitoring disaster management by the central and local governments; the Central Disaster Prevention Response Committee, responsible for planning and coordinating tasks among the central and local governments; and the Office of Disaster Management (ODM), responsible for assisting the Committee. Different ministries were responsible for different types of disasters, e.g., the Ministry of Economic Affairs for flood disaster management. Also, local governments formulate regional plans with their ODMs, ensuring they align with their capabilities and local context. During Typhoon Morakot, the central and local governments established Emergency Operation Centers (EOCs), and relevant agencies set up their ER teams. For the central government, the most relevant ministry or agency is responsible for establishing the EOC and ER team. For local governments, the task forces are commanded by the mayor. However, because township-level ER competency is often lacking, an EOC is rarely established locally. Instead, Community Resilience Programs (CRPs) build local capacities by engaging local actors and residents in disaster preparedness, prevention, and relief, and by establishing township-level EOCs.

Systems thinking: It is operationalized through continuous evaluation, flexible policies, evidence-based decision making, and transparency for accountability (Määttä, 2021). In Taiwan, disaster prevention development emphasizes community capacity. In addition to projects adopted by the central and local governments, prevention projects are planned in line with local conditions and the appropriate use of local resources, enabling residents to fully engage in disaster prevention and relief efforts when facing evacuation and other challenges.

Digital transformation: The main function of NCDR is to serve as a boundary spanner, working with universities, NPOs, and public agencies to apply technologies to enhance the effectiveness of disaster prevention and response operations. For instance, in 2010, NCDR played a crucial role in implementing CRPs to build resilience capacity through technologies such as satellite remote sensing imagery, numerical computer models, real-time monitoring systems, dynamic simulation analysis, emergency decision-support systems, and disaster risk databases (Liu & Tseng, 2015). However, for communities to apply such technologies and related knowledge, they must be translated into forms that the general public can understand and use (Liu & Tseng, 2015).

6. Discussion

The revision and application of Määttä's (2021) WoS framework allowed this study to better understand how digitally enabled ER operates across different institutional, natural, and social contexts in Poland and Taiwan.

First, both cases reveal persistent tensions between formal institutional architectures and the operational demands of complex ER, though these tensions manifest differently. Taiwan's emergency management system operates under a legally codified single-hazard ministerial assignment, in which different disaster types are assigned to designated authorities, creating jurisdictional confusion during compound disasters such as the 2014 Kaohsiung pipeline explosion or the 2025 Mataian Creek landslide. This fragmentation persists despite reforms, constraining shared responsibility to professional silos, with the National Fire Agency dominating operational response. In Poland, the 2024 flood exposed fragmentation rooted in the top-down, hierarchical division of competencies across territorial levels, as well as in how state, local, and community institutions operate in both the civil and defence sectors. Despite deploying thousands of firefighters, police, and soldiers, and rapidly releasing emergency aid, the government lacked a systematic communication strategy to filter, validate, and prioritize information flows, with local authorities not allowed to publish hydrological warnings independently.

Second, across both cases, the study observed a diffusion of responsibility, manifested in situations where no actor felt empowered to take decisive action or where responsibilities overlapped between actors. While Taiwan's fragmentation stems from hazard-specific legal categorization, Poland's emerges from multi-level territorial and functional divisions that create coordination gaps. Crisis framing played an important role in legitimizing emergency measures and mobilizing resources, but the framing also influenced coordination dynamics. In Taiwan, crisis framing reinforced expert-driven response structures, prioritizing technical management within designated authorities. In Poland, crisis framing emphasized scale and urgency, but the lack of a clear communication hierarchy contributed to information overload and public confusion. Inclusivity was realized unevenly in both contexts. In Poland, warnings were often communicated in technical or unclear language, limiting accessibility, particularly for elderly populations and rural communities. In Taiwan, the effectiveness of digital systems depended on intermediary actors translating complex information into actionable knowledge for citizens. In both cases, digital tools increased access to information, but were ineffective in reaching vulnerable groups.

Third, the study shows that digital technologies can serve as both enabling and revealing mechanisms within WoS

ER. Taiwan's NCDR serves as a boundary-spanning organization that deploys satellite remote sensing, real-time monitoring systems, emergency decision-support systems, and disaster risk databases to bridge information gaps between ministries, local governments, universities, and communities. The effectiveness of these technologies, however, depends on intermediary work that translates specialized knowledge into concepts the general public can understand and act upon. Similarly, Poland's ISOK provides Flood Hazard and Flood Risk Maps, accessible via websites and mobile applications, extending hydrological and topographical data into everyday risk awareness. Yet the 2024 floods demonstrated that communication between the government and the public occurred primarily through social media and broadcast crisis meetings, resulting in inconsistent messaging, competing casualty figures, and delayed warnings delivered in incomprehensible language, all worsened by fake news. The absence of unified communication filters and a clear message hierarchy meant that digital channels amplified coordination problems, unable to compensate for unclear lines of responsibility and untested communication protocols. Tab. 3 summarizes the outcomes of the analysis of the digitally enabled WoS ER in Poland and Taiwan.

Tab. 3 – Use cases of AI-enabled digital transformation in WoG/WoS for emergency response

Dimensions	Poland	Taiwan
Crisis framing	Limitations of the multi-level ER system, lack of coordination, delayed decision-making, communication tensions perceived as systemic failure	Critical coordination failures and mobilized reform, crisis framing accelerating Disaster Resilience Communities development
Shared responsibility	Institutional and community systems operating in parallel, central-local authority division of competency, fragmented decision-making, diluted responsibility; social organizations not formally integrated in ER structures	Disaster responsibilities are assigned by hazard types, universities partner with high-risk townships, NPOs co-produce disaster prevention and relief, programs target different disaster types, limiting comprehensive system integration
Inclusivity	Rescue by the State and Volunteer Fire Services and military units, emergency aid and rebuilding support, warnings delayed and incomprehensible	Disaster-Resistant Communities engage 368 communities, NPOs assist elderly and disabled evacuation, community participation is emphasized but localized
Systems thinking	Information flow problems, no institution as a communication filter, inconsistent numbers and delayed warnings, a strategy combining aid and spatial planning is lacking	Community capacity development emphasizes preparedness and prevention, projects are planned in line with local conditions, no national incident management
Institutional	Three-tiered governance structure operating at different territorial levels, clear division of competences, coordination gaps	Three-tiered structure distributed by hazard types, single-hazard approach, confusion in multiple-hazard disasters.
Digital transformation	Closed environment with maps, dashboards, and monitoring, open dissemination of reports and warnings, communication through social media and press conferences with inconsistent messaging	Satellite remote sensing, real-time monitoring, emergency decision-support systems, disaster risk databases, translation for the public is needed, NCDR has research but no operational coordination authority

7. Conclusions

This study set out to examine how digitally enabled emergency response can be incorporated into an established WoS framework. The objective was to move beyond treating digital technologies as merely technical support tools and instead to analyze the constitutive role of digital transformation in contemporary emergency governance. The Määttä's (2021) framework was chosen. By extending this framework and applying the result to the comparative cases of Taiwan and Poland, the study aimed to develop a more comprehensive conceptual and empirical understanding of digitally enabled WoS emergency response.

The research question "How can the WoS approach, centered on digital technology and digitally enabled institutions, be conceptualized and validated for emergency response?" was addressed through a scoping literature review and a comparative analysis of institutional structures and concrete emergency responses observed in Poland and Taiwan. The findings demonstrate that digital transformation can be incorporated into the WoS framework as a cross-cutting dimension that shapes and conditions other dimensions, i.e., crisis framing, shared responsibility, inclusivity, systems thinking, and institutional coordination. In both cases, digital systems played an important role in information sharing, monitoring, and coordination, but their effectiveness depended on existing institutional arrangements. In Taiwan, advanced digital and scientific capacities supported expert-driven response

but were constrained by a single-hazard institutional structure that limited coordination during multi-hazard disasters. In Poland, digital systems disseminating emergency information increased public access to data, yet the absence of clear communication hierarchies and responsibility structures reduced their effectiveness during emergencies. These findings show that digital technologies alone cannot ensure an effective WoS emergency response; they must be embedded within coherent institutional structures and clear lines of responsibility.

By reconceptualizing leadership as institutional and coordination capacity, introducing digital transformation, and positioning both as cross-cutting dimensions, this study advances the WoS research in two important ways. First, it shows that institutional arrangements are central to enabling coordination across multiple actors in ER. Second, it demonstrates that digital transformation is not only an infrastructure but an organizational process that influences participation, inclusivity, and shared responsibility. The extended framework, therefore, provides a more suitable tool for analyzing emergency response in digitally advanced and institutionally complex settings. The comparative findings suggest that effective digitally enabled WoS ER requires alignment between digital capacities and institutional design. Both Taiwan and Poland illustrate that when institutional responsibilities are fragmented or communication protocols are unclear, digital tools may amplify rather than reduce confusion. Conversely, when digital systems are supported by clear coordination mechanisms and intermediary actors who translate information for different audiences, they can strengthen collective action and resilience.

This study has three main limitations. First, it is based on two qualitative case studies, which limits the generalizability of the findings. Second, the analysis relies on documented responses and secondary sources, which may not fully capture informal coordination processes or real-time decision-making dynamics. Third, the study focuses on ER rather than long-term recovery and preparedness, both of which are central to WoS ER governance.

Future research could apply the extended WoS framework to additional countries and crisis types to further test its robustness across different institutional and cultural contexts. Comparative studies involving low- and middle-income countries or transboundary crises could provide additional insights into the role of digital transformation under resource constraints. Further work could also examine how AI, automated decision-support systems, and platform governance influence accountability, trust, and inclusivity in WoS ER over time.

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During the preparation of this work, the authors used Grammarly and Perplexity in order to make grammatical and spelling corrections. After using this tool/service, the authors reviewed, edited, made the content their own, validated the outcome as needed, and took full responsibility for the publication's content.

Conflict Of Interest (COI)

There is no conflict of interest.

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