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Research Paper

E-Government Model Design for Volcano Eruption Disaster Risk Reduction in Agam Regency, West Sumatra

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Abstract

The eruption of Mount Marapi in Agam Regency poses a high risk to public safety and requires a responsive and sustainable disaster management system. However, information dissemination and inter-agency coordination remain limited and have not optimally utilized the potential of digital technology in Disaster Risk Reduction (DRR), particularly for volcanic hazards that are complex and difficult to predict. This study aims to develop an e-government framework for diagnosing volcanic eruption disaster risk reduction and to design an e-government model based on smart governance principles. A multiple-method approach was employed, including a review of existing policies and regulations, a survey of community perceptions, and an assessment of institutional and infrastructure readiness. The findings indicate that the community supports the use of digital technology in disaster management; however, the effectiveness of information systems, training programs, and Information and Communication Technology (ICT) infrastructure remains low. The proposed e-government model consists of six main strategies: (1) regulatory strengthening, (2) digital-based public outreach, (3) stakeholder engagement, (4) technology capacity building, (5) development of integrated information systems, and (6) efficiency in fund management. This model is expected to enhance community preparedness, accelerate emergency response, and improve the efficiency and transparency of volcanic disaster risk governance in Agam Regency.

Keywords: Agam Regency; Disaster Risk Reduction; E-Government; Smart Governance; Volcano.

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1. Introduction

Indonesia is one of the countries with the highest levels of disaster vulnerability in the world due to its location at the convergence of three major tectonic plates and the presence of more than 120 active volcanoes (Adi et al., 2024). One of the regions with a high level of hazard exposure is Agam Regency in West Sumatra Province, which lies within the hazard radius of Mount Marapi eruptions. Periodic eruptions of Mount Marapi have caused significant impacts on social and economic life as well as on the daily activities of local communities through the distribution of pyroclastic materials, volcanic ash, and disruptions to mobility (Pradana, 2016). The complexity and uncertainty of volcanic eruption characteristics require disaster risk reduction approaches that are not only reactive but also preventive, participatory, and technology-based.

In the context of Disaster Risk Reduction (DRR), a holistic approach encompassing four phases of disaster management—mitigation, preparedness, emergency response, and recovery—has become both an international and national paradigm (Handayani et al., 2020). However, recent DRR documents and studies emphasize that the effectiveness of disaster risk reduction largely depends on the quality of risk communication systems, message clarity, and active community involvement in decision-making processes, rather than solely on the availability of technology (Hickey et al., 2025). In line with this, although Law No. 24 of 2007 and the Regulation of the Head of the National Disaster Management Agency (BNPB) No. 3 of 2021 mandate the integration of DRR into development planning, implementation at the local level still faces challenges, including weak inter-agency coordination, limited real-time communication systems, and low levels of community participation in digitally based disaster communication mechanisms.

The development of digital technology in recent years has shown a significant increase in disaster communication systems, including the use of digital media, online communication platforms, and community-based approaches to enhance disaster literacy and preparedness. Recent studies highlight that disaster communication in the digital era must be designed in a contextual, participatory, and community needs–based manner to ensure that risk messages are effectively understood and responded to (Rizal et al., 2025). Nevertheless, these studies also indicate that the use of digital media in disaster communication remains fragmented, has not been systematically integrated into local government governance structures, and has not been specifically tailored to high-complexity disaster contexts such as volcanic eruptions.

Digital transformation presents opportunities for the application of e-government as a strategic instrument to strengthen disaster risk management. E-government not only functions as a digital public service platform but also serves as a means to integrate data, accelerate cross-actor communication, and enhance public engagement in disaster risk management (Indrajit, 2005). E-government models such as government-to-citizen (G2C), government-to-business (G2B), and government-to-government (G2G) enable the development of information networks that support rapid, accurate, and coordinated responses during disaster events (Indrayani, 2020).

Although numerous studies have examined the use of digital technology in disaster management and e-government in general, a research gap remains in the design of e-government models specifically aimed at reducing volcanic eruption disaster risks. This gap is particularly evident in the lack of integration between enhanced digital communication systems, smart governance principles, institutional readiness, and community participation within a comprehensive governance framework, especially in disaster-prone areas such as Agam Regency. Most previous studies have tended to focus on the technical aspects of disaster information systems or infrastructure readiness assessments, without formulating a systemic model that simultaneously incorporates institutional, social, and technological dimensions (Alfayn, 2022; Wimbardana & Sagala, 2013).

Therefore, this study aims to design a smart governance e-government model within the framework of volcanic eruption disaster risk reduction in Agam Regency. The study analyzes local policies and institutional readiness, evaluates community perceptions of digital technology utilization, and integrates smart governance principles into the design of the e-government model. The findings are expected to provide both practical and conceptual contributions to strengthening regional capacity to address disasters in an adaptive, collaborative, and sustainable manner.

Therefore, with a case of Agam Regency, this study aims to design a smart governance-based e-government model in the disaster risk reduction framework for volcanic eruption. This study will analyze local policies and institutional readiness, evaluate community perceptions of digital technology utilization, and integrate smart governance principles into the model design. It is expected that the results of this study can provide practical and conceptual contributions in strengthening regional capacity to face disasters in an adaptive, collaborative, and sustainable manner.

2. Methods

This study employs a multiple approach combining statistical and qualitative descriptive aimed at designing an e-government model for volcanic disaster risk reduction in Agam Regency. The research method is structured in alignment with the problem formulation, which focuses on the current policy, the readiness of e-government aspects, and community perceptions regarding the use of digital technology in disaster risk reduction. We begin with the development of a framework for analysis based on the ideal and best practices of e-government, as well as risk reduction theories that will be further explained in the following section.

2.1. Analytical Framework

The success of e-government implementation is not solely determined by the availability of technology, but also by the presence of three key elements: support, capacity, and value (Indrajit, 2016). Support includes strong commitment and leadership from local governments as well as solid inter-agency coordination (Indrajit, 2016), which refers to the existence of enabling policies and regulations, stakeholder involvement, and effective public outreach. Capacity refers to the readiness of human resources, financial resources, and reliable information technology infrastructure (Yuhefizar et al., 2017). Meanwhile, value relates to the extent to which both the government and the public perceive the tangible benefits of using digital technology in public services, including disaster risk reduction (Setiani & Maesaroh, 2018). When these three elements are not met, e-government risks becoming merely symbolic, without producing a real impact on disaster resilience. Various challenges also hinder its implementation, ranging from low human resource capacity and limited ICT infrastructure to the lack of commitment and policy continuity (Astuti, 2005; Meijer, 2015; Susilawati et al., 2023).

To address these challenges, the concept of smart governance emerges as a governance approach that emphasizes participation, collaboration, data transparency, and the use of technology in public decision-making (Meijer & Bolívar, 2016). Smart governance also integrates good governance principles such as accountability, transparency, responsiveness, and equity, all of which are essential in strengthening public trust, especially during times of crisis.

Therefore, to comprehensively understand how e-government implementation can contribute to disaster risk reduction, this study employs an analytical framework that integrates the three main elements (support, capacity, and value) within the context of e-government, combined with the principles of smart governance as a foundation for adaptive and participatory digital governance. This framework enables the exploration of the interconnection between structural factors (such as policy and infrastructure) and social factors (such as community participation and perceived benefits of technology), while also highlighting existing challenges and opportunities. The visualization of this analytical framework is presented in Figure 1 below.

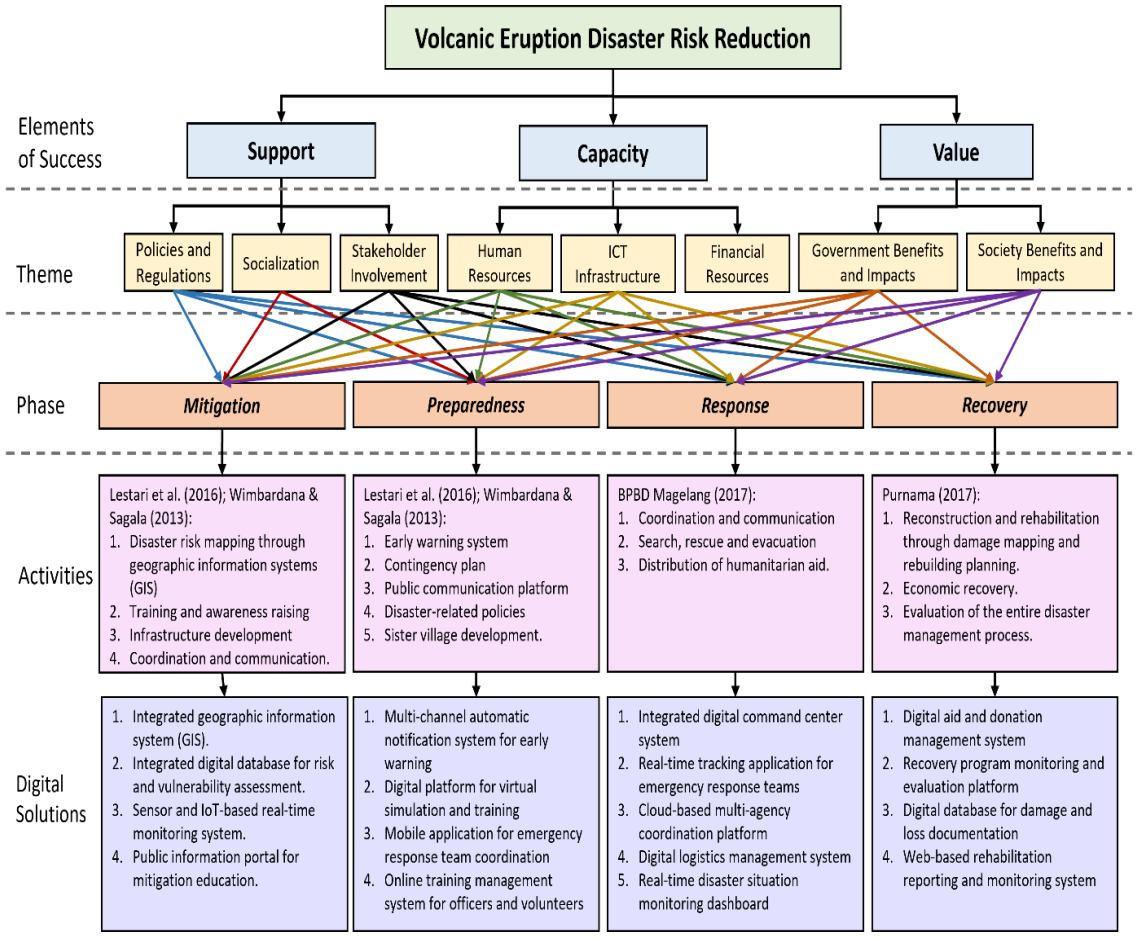


Figure 1. An Analytical Framework for E-government Model in Disaster Risk Reduction

2.2. Instruments and Data Collection Techniques

Primary data were collected using three main instruments: non-participant observation, in-depth interviews, and structured (closed-ended) questionnaires. Field observations were conducted to observe the conditions in the field with limited researcher engagement with community activities. Face-to-face interviews were carried out to gather information from key informants, including government officials who have relevant knowledge of the study topic. These interviews were conducted with the Secretary of the Regional Disaster Management Agency (BPBD), the Head of the E-Government Services Division at the Department of Communication and Information (DISKOMINFO), and the Head of the Legal Division at the Regional Secretariat (Setda). Meanwhile, closed-ended questionnaires were used to obtain structured data on the perceptions of the community and volunteers, with predefined answer choices to facilitate analysis. The questionnaires measured community and volunteer perceptions of the use of technology in disaster management. Secondary data were obtained from official documents such as national laws, local regulations, standard operating procedures (SOPs), budget reports, as well as policies and regulations from BPBD, Diskominfo, and the Legal Division.

2.3. Sampling Methods

For individual respondents, we employed cluster sampling based on disaster-prone areas affected by volcanic eruptions. The five sub-districts selected as sample clusters were Banuhampu, Baso, Canduang, Ampek Angkek, and Sungai Pua. The individual sample size was calculated using Slovin's formula with a 90% confidence level and a 10% margin of error, resulting in a sample size of 100 respondents, consisting of 90% general public and 10% volunteers. Sampling was conducted randomly within each cluster. The sample distribution details are also presented in Table 1.

Table 1: Volcanic Disaster Risk Areas of Mount Marapi in Agam Regency and Sample Distribution

No.	Sub-District	Large Area		Population Number	Sample Size (people)		Total
		Hectares	(%)		Public	Volunteers	
1	Banuhampu	118.15	1.65	38,528	20	2	22
2	Baso	64.62	0.90	37,838	19	2	22
3	Canduang	4,034.76	56.47	25,717	13	1	15
4	Ampek Angkek	261.21	3.66	45,377	23	3	26
5	Sungai Pua	2,666.33	37.32	27,612	14	2	16
	Total	**7145.07**	**100**	**175,072**	**90**	**10**	**100**

Source: Dinas Pekerjaan Umum dan Penataan Ruang, 2021 and Author's analysis, 2025

2.4. Data Analysis Method

Data were analyzed through three main stages. First, a review of policies and regulations was conducted descriptively on documents such as laws, regional regulations, SOPs, and organizational structures. The goal was to evaluate the effectiveness of the regulations and to identify institutional strengths and weaknesses.

Second, the implementation of e-government was analyzed using the GAP analysis approach, a method of evaluation used to assess the performance or competency of an organization, particularly in efforts to deliver good public services (Kim & Ji, 2018). This analysis compares the actual condition with the ideal condition in six aspects: (1) policies and regulations, (2) socialization and disaster literacy, (3) stakeholder involvement, (4) human resource readiness, (5) ICT infrastructure, and (6) financial support. This analysis also examined the public's understanding and participation in disaster socialization programs.

Third, the results of the two previous analytical stages were used as the basis for designing an integrative and contextual e-government model. The overall research methodology is illustrated in Figure 2. This model is directed to strengthen coordination among stakeholders, increase public participation, and support a technology-based early warning system. The resulting model is expected to be sustainably implemented in all phases of disaster management, from mitigation, preparedness, and emergency response to recovery, in order to strengthen regional resilience against volcanic eruptions.

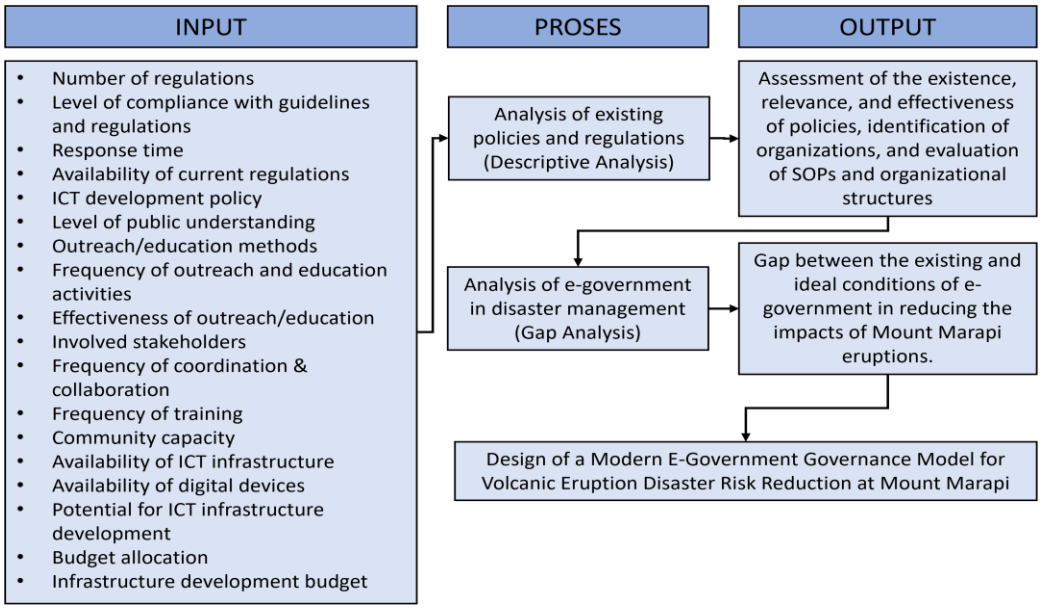


Figure 2. Flowchart of the research methodology

3. Results and Discussions

3.1. The Existing Policy and Regulatory Analysis

The disaster management policy and regulatory framework for volcanic eruption risk reduction in Agam Regency is structured across three governance levels: national, provincial, and regional. As presented in Table 2, these regulations comprehensively cover all phases of disaster management, including mitigation, preparedness, emergency response, and rehabilitation and reconstruction. The alignment of policies across governance levels reflects the implementation of a multi-level disaster governance approach, which is essential for ensuring consistency, authority, and operational clarity in disaster risk reduction (DRR) (Hickey et al., 2025).

Table 2: Policies and Regulations by Governance Level

Phase	POLICIES AND REGULATIONS BY GOVERNANCE LEVEL		
	National Level	**Provincial Level**	**Regional Level**
Mitigation	• Law No. 24/2007: mitigation through spatial planning, education, and public participation. • Government Regulation (GR) No. 23/2008: international institution support for risk studies. • Ministerial Regulation of Energy and Mineral Resources No. 15/2011: technical guidance for geohazard mitigation.	• West Sumatra Regional Regulation No. 5/2007: risk mapping and spatial planning. • Governor Regulation of West Sumatra (2016): volcanic contingency plan.	• Agam Regional Regulation No. 2/2016: community-based mitigation • Regent Regulation No. 44/2022: mitigation budget and early warning system.
Preparedness	• BNPB Regulation No. 10/2008: command and simulation guidelines. • Law No. 24/2007: training and public outreach.	• Governor Regulation of West Sumatra (2016 & No. 15/2021): SOPs, simulations, and cross-sector coordination.	• Agam Regional Regulation No. 1/2010: simulations and public training. • Regent Regulation No. 44/2022: evacuation facilities budget.
Emergency Response	• Government Regulation No. 21/2008: emergency status, posts, and logistics. • Government Regulation No. 22/2008: funding and aid distribution.	• West Sumatra Regulation No. 5/2007: authority to establish posts and evacuation. • Governor Regulation No. 15/2021: logistics and SAR team.	• Agam Regent Decree No. 188/2024: posts, evacuation, and logistic aid. • Agam Regional Regulation No. 2/2016: community involvement
Rehabilitation & Reconstruction	• Law No. 24/2007: social, economic, and infrastructure recovery. • Government Regulation No. 21/2008: rehabilitation planning based on sustainable development.	• Governor Regulation No. 15/2021: long-term recovery and strategic infrastructure.	• Governor Regulation No. 15/2021: long-term recovery and strategic infrastructure.

Source: Author's Analysis, 2025

Coordination Stakeholders

In disaster management efforts in Agam Regency, cross-sectoral coordination is a key element in ensuring a rapid and effective response. This was demonstrated during the response to the cold lava flash flood disaster following the eruption of Mount Marapi in 2024. The Agam Regency Government established an Emergency Response Command Post through Regent Decree No. 124 of 2024. This post was strategically organized with a membership structure that reflects a collaborative approach among government elements, national technical agencies, community organizations, and volunteers.

At the regency level, relevant departments such as the Regional Disaster Management Agency (BPBD), Public Works Office (DPU), Social Affairs Office (DINSOS), and Health Office (DINKES) played important roles in emergency response operations, logistics, and basic services. Local coordination was strengthened through the roles of sub-district heads *(camat)* and village leaders *(walinagari)*, who served as communication bridges between local government and affected communities. Meanwhile, technical support from national agencies such as the Geophysics, Climate, and Meteorology Office (BMKG) and the

National Search and Rescue Office (BASARNAS) was crucial in providing early warnings, risk analysis, and rescue operations.

The involvement of community-based organizations such as Indonesian Red Cross (PMI), Indonesian Radio Organization (e.g. ORARI, RAPI), as well as local NGOs and volunteers, served as vital support elements in field operations, including communication services, healthcare, and aid distribution. The community also participated actively, both as beneficiaries and as actors in disaster response and evacuation management.

This coordination structure was designed to ensure that each stakeholder had clear duties and functions according to their respective roles and capacities. However, the effectiveness of field implementation largely depended on the speed of decision-making, smooth communication among agencies, and operational coordination during emergency situations. The strength of this cross-sectoral approach lies in its ability to unify various elements—government, society, and support organizations—into an integrated response system that is adaptive to the dynamics of disaster events.

Effectiveness of Disaster Management Standard Operating Procedures (SOPs)

The effectiveness of Standard Operating Procedures (SOPs) is a key indicator in measuring the success of disaster risk reduction policies. The SOPs prepared by the BPBD of Agam Regency cover the stages of prevention, preparedness, emergency response, and rehabilitation and reconstruction, aiming to ensure structured, measurable, and efficient disaster handling.

Emergency response SOPs such as Disaster Area Monitoring and Early Warning have shown relatively good effectiveness, with an initial response time of approximately 1–2 hours after a report is received. This is supported by an integrated communication system, the use of disaster information, and coordination with the military force (TNI) and police (POLRI), and BASARNAS. However, communication disruptions during major disasters remain a challenge (Putra et al., 2023).

Logistics distribution, regulated by the SOP for Warehouse Management and Equipment Distribution, typically requires 1–2 days for easily accessible areas and up to 3 days for remote regions. Despite geographical and infrastructure constraints, the SOPs have ensured that the basic needs of the affected communities are met. Cross-sectoral coordination between BPBD, TNI, POLRI, DINKES, and volunteer organizations has demonstrated strong synergy. Nevertheless, procedural differences between agencies during emergencies still pose challenges, highlighting the need for improved coordination mechanisms.

The SOP for Rehabilitation and Reconstruction provides guidance for post-disaster recovery. Areas with minor damage recover more quickly, while severely damaged areas require more time. Challenges such as limited budgets and administrative complexity persist, but consistent implementation of SOPs helps maintain the smooth progress of the recovery process.

3.2. Evaluation of E-Government Readiness Aspects

This evaluation adopts the smart governance framework developed by the Harvard Kennedy School of Government (Indrajit, 2016), which emphasizes three core elements of e-government implementation: support, capacity, and value, applied across the four phases of disaster risk reduction (e.g. mitigation, preparedness, emergency response, and recovery). The results indicate that digital implementation remains very limited across several aspects in each phase.

Mitigation Phase

In the mitigation phase, policies and regulations have been directed toward the development of ICT infrastructure that supports disaster data management. However, implementation has not yet been fully structured. The absence of specific regulations regarding the integration of technology into disaster mitigation is a major challenge. This has impacted the slow development of digital infrastructure and cross-sectoral coordination. The Head of Information System Integration at the Department of Communication and Information stated:

> *"Regulations that promote the development of communication networks, stable internet access, and data centers are the key foundations to support e-government in disaster risk mitigation."*

On the other hand, outreach efforts in collaboration with NGOs, universities, and monitoring posts have strengthened the dissemination of mitigation information to the public. Digital approaches have also begun to be applied, such as the use of QR codes and WhatsApp, although their utilization is still uneven. Inter-agency coordination is currently carried out through physical command posts and online groups, but is not yet supported by an integrated and real-time digital platform. The Secretary of the Regional Disaster Management Agency (BPBD) of Agam Regency noted:

> *"This system is quite effective, but we hope for an integrated application platform that enables faster and more efficient communication and coordination."*

Capacity building for human resources, particularly the Disaster Preparedness Groups (KSB), has been conducted through basic mitigation training, but faces challenges such as low public awareness and limited use of technology. Meanwhile, the ICT infrastructure that supports disaster monitoring and information dissemination remains limited. Warning Receiver System (WRS) and radio communication networks are already in use, but have not yet been complemented with systems that allow real-time data management.

Lastly, financial support remains a cliché constraint that limits the scope of public education and capacity-building efforts. Existing mitigation activities tend to rely on limited routine funding allocated by BPBD. Although various readiness elements have been developed, the integration of policy, technological enhancement, and adequate funding remains a critical need for e-government to function optimally in the disaster mitigation phase in Agam Regency. Table 3 shows that during the mitigation phase, the use of technology has begun to emerge, especially in outreach activities and stakeholder involvement. However, the coordination system and database infrastructure have not yet been fully integrated, resulting in mitigation efforts that are not as effective as expected.

Table 3: Review of E-Government Elements in the Mitigation Phase

ASPECT	MITIGATION		
	EXISTING CONDITION	**IDEAL**	**GAP**
Policy & Regulation	No e-government policy for mitigation	E-government regulation for mitigation	Absence of policies supporting the use of technology in mitigation
Public Outreach	Use of QR Codes and WhatsApp	Public portal for mitigation education (Sha et al., 2025)	Limited access to digital information; outreach remains conventional
Stakeholder Engagement	Collaboration with NGOs, universities, and communities via WhatsApp	Digital-based coordination system (Putra et al., 2023)	No cross-sector digital coordination platform
Human Resources	Training remains conventional	Digital training management system	Training is still manual and limited in scope
ICT Infrastructure	WRS, radio communication, ORARI, national support	Integrated GIS and risk database (Fikriyah et al., 2024)	Lack of an integrated information system
Financial Resources	Budget available but limited	Dedicated budget for mitigation digitalization	Limited funds for digitalization
Government Benefits & Impact	Suboptimal mitigation data	More integrated data and monitoring	Mitigation data is not fully optimized
Society Benefits & Impact	Limited access to information	Easier public access to information	Community struggles to obtain real-time information

Source: Author's Analysis, 2025

Preparedness Phase

Disaster preparedness in Agam Regency has shown progress, particularly through strategic plans such as the 2025 contingency planning and the installation of Early Warning Systems (EWS). However, not all policies and regulations fully support the integration of technology into early warning systems. Strengthening these policies is essential as a legal foundation for developing an e-government system that is more adaptive to the needs of disaster-prone areas.

Education and public outreach efforts have been actively carried out by BPBD. Nevertheless, challenges remain, especially in terms of the effectiveness of disaster message delivery. The Secretary of BPBD Agam Regency stated:

> *"The effectiveness of the current method is facing challenges because the messages sometimes confuse the public."*

This occurs, for example, when evacuation messages for volcanic eruptions are mixed with warnings about flash floods, causing confusion in community responses. To address this issue, BPBD has collaborated with the Indonesian Institute of the Arts (ISI) Padang Panjang to produce digital educational media that is communicative and easy for the public to understand. Meanwhile, DISKOMINFO has begun to play a role in strengthening digital outreach, although its implementation remains incidental. The Head of Information System Integration at DISKOMINFO explained:

> *"Our outreach programs are tentative... we are usually invited to be resource persons when needed."*

Human resource capacity has been strengthened through joint training with BASARNAS on evacuation procedures, for both officials and the public. However, the use of digital systems at the community level remains low, requiring further education so that technology can be optimally utilized in supporting preparedness. On the other hand, ICT infrastructure readiness is still uneven. Although there has been cooperation with communication service providers to maintain network stability, remote areas still face connectivity challenges. The Head of Information System Integration added:

> *"We collaborate with third parties... if there's a network or internet connection issue, they fix it immediately."*

However, the absence of integrated digital systems, such as mobile applications or local disaster data centers, remains a major obstacle in delivering fast and accurate information.

In terms of funding, budget allocation for preparedness remains limited and tends to rely on support from the central government or third parties. This impacts the slow development of supporting infrastructure, such as emergency communication systems and evacuation equipment.

Overall, the preparedness phase in Agam Regency has demonstrated various collaborative initiatives and initial adoption of technology. However, challenges in regulatory aspects, digital infrastructure readiness, and community capacity still require serious attention. Strengthening these three areas is key to realizing a resilient and responsive e-government system in facing potential future disasters. In the preparedness phase, most activities, such as training and coordination, are still done manually. There is no digital early warning system or online training, even though both are very important to improve disaster preparedness. Table 4 outlines a summary assessment of e-government elements in the preparedness phase by highlighting the gap after comparing the existing condition and its ideal.

Table 4: Review of E-Government Elements in the Preparedness Phase

ASPEK	PREPAREDNESS		
	EXISTING CONDITION	**IDEAL**	**GAP**
Policy & Regulation	An early warning system (EWS) is installed, not yet digital	Digital-based preparedness SOPs	SOPs still manual
Public Outreach	Face-to-face outreach	Digital platform for virtual training (Sha et al., 2025)	No digital methods used in training
Stakeholder Engagement	Coordination via WhatsApp	Mobile app for emergency team coordination (Haq et al., 2024)	Coordination still relies on less effective WhatsApp communication
Human Resources	In-person training	Digital training management system (Sha et al., 2025)	Lack of technology-based virtual training
ICT Infrastructure	Not available	Digital monitoring system for preparedness (Danang et al., 2019)	No digital infrastructure for preparedness
Financial Resources	Not available	Specific funding allocation for tech-based training	No dedicated budget for preparedness
Government Benefits & Impact	Response is slow	Faster and more efficient response	Government readiness is inefficient
Society Benefits & Impact	Community is not disaster-ready	More disaster-ready community	The public is not optimally prepared

Source: Author's Analysis, 2025

Emergency Response Phase

In the emergency response phase, Agam Regency has established a strong regulatory foundation, particularly through the mechanism of disaster status declaration formalized by the Regent's Decree. This process is facilitated by the Legal Division of the Regional Secretariat, which acts as the key unit in drafting the regulation. As stated by the Head of the Legal Division:

> *"The Legal Division serves as a facilitator in drafting the Regent's Decree regarding disaster status in Agam Regency."*

This decree provides a binding legal basis for all regional apparatuses and related agencies to take coordinated emergency actions. In terms of strengthening the emergency response system, the application of e-government is increasingly being considered a strategic solution. A centralized digital platform is seen as capable of enhancing cross-sector coordination, accelerating reporting and documentation, and supporting real-time monitoring of logistics distribution. The Head of the Legal Division emphasized:

> *"With the use of e-government, reporting and documentation can be done digitally, which facilitates audits and evaluations."*

Nevertheless, the effectiveness of the response relies not only on regulations and technology but also on the readiness of human resources and community capacity. Coordination between BPBD, volunteers, and residents during emergency response is generally conducted via emergency posts and WhatsApp groups. While this approach aids in quick communication, its accessibility and efficiency are still limited, especially in affected areas where technology has not been optimally utilized. The Secretary of BPBD stated:

> *"There are still limitations in the community's ability to use digital technology effectively during emergencies."*

This condition highlights the need for a more structured, e-government-based communication system that can reach citizens directly and provide fast and accurate information. Moreover, increasing the capacity of Disaster Preparedness Groups (KSB) and local volunteers is crucial for enabling communities to be more proactive in evacuation and initial post-disaster response.

In terms of ICT infrastructure, efforts to strengthen network reliability are being made through cooperation with service providers. However, challenges persist in disaster-prone areas that frequently experience signal disruptions. The Secretary of BPBD added:

> *"We hope the application of e-government will bring significant changes... reporting, monitoring, and decision-making can be conducted more quickly and accurately."*

From a financial perspective, Unexpected Expenditure Budget (BTT) serves as the main funding source during the emergency response phase. This fund is managed by the Regional Financial Agency (BAKEUDA). However, bureaucratic procedures in fund disbursement often hinder rapid field response. As noted by the Secretary of BPBD:

> *"In emergencies, we use the BTT fund. But administrative procedures can sometimes delay the quick disbursement..."*

Overall, the emergency response system in Agam Regency has been built with adequate structure and regulation. However, its implementation effectiveness still needs to be strengthened through the digitalization of coordination systems, enhancement of human resource capacity, development of a reliable communication infrastructure, and financial policy reform to be more adaptive to crisis conditions. Transitioning to a responsive and integrated e-government-based emergency response system is a crucial step toward accelerating holistic and efficient disaster management. In the emergency response phase, communication still relies on messaging apps such as WhatsApp and radio communication tools. Agam Regency has not yet established a digital command center or dashboard capable of monitoring and responding to incidents in real-time. Table 5 describes a summary assessment of e-government elements in the emergency phase by highlighting the gap after comparing the existing condition and its ideal.

Table 5: Review of E-Government Elements in the Emergency Response Phase

ASPECT	EMERGENCY RESPONSE		
	EXISTING CONDITION	**IDEAL**	**GAP**
Policy & Regulation	Disaster status set manually through Regent's Decree	Regulation for a digital command center (Polii, 2021)	No digital command center regulation
Public Outreach	No automatic warning system	Multi-channel notification system	No real-time monitoring system
Stakeholder Engagement	Communication via post and WhatsApp	Real-time monitoring dashboard (Putra et al., 2023)	Coordination still relies on WhatsApp
Human Resources	Not available	Emergency team tracking app (Pratama & Zaky, 2025)	No real-time tracking system
ICT Infrastructure	Radio and WhatsApp communication	Integrated IT infrastructure (Purbasari et al., 2020)	IT infrastructure remains manual
Financial Resources	Emergency funds accessible	Digitally managed emergency fund	Disbursement is still slow
Government Benefits & Impact	Slow response	Faster decision-making	The government is less responsive
Society Benefits & Impact	Aid often delayed	Communities receive aid more quickly	Aid delivery to communities is delayed

Source: Author's Analysis, 2025

Recovery Phase

The post-disaster recovery phase in Agam Regency emphasizes the critical role of cross-sector synergy among local government, NGOs, and communities. This collaboration forms the foundation for infrastructure rehabilitation, socio-economic recovery, and psychosocial support for disaster-affected residents. However, the effectiveness of recovery remains highly dependent on clear regulations, responsive coordination systems, and the readiness of human resources, particularly in ICT-enabled disaster governance. One major challenge is the gap between policy and implementation, especially concerning the integration of the e-government system. Additionally, interagency interoperability and the availability of IT-skilled personnel remain suboptimal, slowing down digital recovery efforts.

From the community's perspective, the most prominent challenge lies in local economic recovery and strengthening community capacity. Empowerment programs such as skills training, MSME support, and microbusiness assistance are urgently needed to support long-term post-disaster economic resilience. Unfortunately, limited digital access in affected areas also hampers the effectiveness of information and aid distribution.

Strengthening ICT infrastructure has become an urgent need to support this phase. The development of regional data centers, increased internet access, and the provision of integrated digital platforms would enable accurate, fast, and integrated disaster information management. Without such infrastructure, the recovery system risks becoming unresponsive to field dynamics and community needs.

Financial management is another critical concern during recovery. Budget limitations and administrative rigidity often delay program implementation. The digitalization of disaster fund management offers opportunities for faster budget disbursement and greater public accountability. The Secretary of BPBD Agam Regency stated:

> *"We hope that implementing e-government can accelerate fund disbursement and improve transparency in disaster budget management."*

Thus, the implementation of e-government in the post-disaster recovery phase holds great potential for improving service efficiency, accelerating aid distribution, and ensuring transparency in public fund utilization. Furthermore, strengthening digital regulations, ICT infrastructure, IT human resources, and flexible financial policies are strategic elements to build a more adaptive and sustainable disaster recovery system in Agam Regency. In the recovery phase, the use of technology remains very limited, especially in monitoring aid and recovery processes. There is no transparent and publicly accessible digital platform to track aid distribution and fund utilization. Table 6 outlines a summary assessment of e-government elements in the recovery phase by highlighting the gap after comparing the existing condition and its ideal.

Table 6: Review of E-Government Elements in the Recovery Phase

ASPECT	RECOVERY PHASE		
	EXISTING CONDITION	IDEAL	GAP
Policy & Regulation	No recovery digitalization policy	Regulation for transparent aid distribution via digital means	No specific policy for digital-based recovery
Public Outreach	No recovery program evaluation	Recovery evaluation platform (Gupta et al., 2022)	No digital evaluation platform
Stakeholder Engagement	WhatsApp is used for coordination	Web-based monitoring system (Putra et al., 2023)	No web-based monitoring system
Human Resources	No systematic reporting	Digital documentation database (Gupta et al., 2022)	Reporting is still done manually
ICT Infrastructure	Not available	Digital rehabilitation system	No IT system for recovery
Financial Resources	Recovery fund lacks transparency	Digital budgeting system	Weak transparency in fund management
Government Impact	Difficulty monitoring recovery	More structured recovery process	Government struggles to monitor recovery effectiveness
Society Impact	Aid is often delayed	Aid is distributed more fairly and quickly	Aid is often not equitably distributed

Source: Author's Analysis, 2025

To sum up, only 1–2 aspects in each DRR phase in Agam Regency currently support a smart e-government approach. The percentage of digital readiness for mitigation and emergency response remains at 25%, while preparedness and recovery are even lower at only 12.5%. Table 8 summarizes the readiness of Agam Regency in responding to a volcanic eruption disaster from the e-government dimension.

Table 1: Digital Readiness Evaluation

No.	Aspect	Mitigation	Preparedness	Emergency Response	Recovery
1	Policy & Regulation	✗	✗	✗	✗
2	Public Outreach	✓	✗	✗	✗
3	Stakeholder Engagement	✓	✓	✓	✓
4	Human Resources	✗	✗	✗	✗
5	ICT Infrastructure	✗	✗	✓	✗
6	Financial Resources	✗	✗	✗	✗
7	Government Impact	✗	✗	✗	✗
8	Society Impact	✗	✗	✗	✗
Total Digital Aspects		2	1	2	1
Total Aspects		8	8	8	8
Digital Readiness (%)		**25%**	**12,5%**	**25%**	**12,5%**

Source: Author's Analysis, 2025

These results indicate that disaster management in Agam Regency remains largely conventional. ICT infrastructure is insufficient for emergency communication, GIS/IoT-based early warning, and integrated inter-agency data systems. Training and awareness activities are dominated by manual approaches, emphasizing the need for strategic integration of technology, policy, and capacity development.

3.3. Public Perception of Digital Technology Utilization in Volcanic Eruption Disaster Risk Reduction

A survey conducted among communities in high-risk areas around Mount Marapi revealed strong support for digital technology as a medium for disaster information dissemination. Approximately 75% of respondents believe that the government should actively provide information through digital channels, such as official websites or dedicated applications (Figure 2). However, only 38% perceive current government digital communications as highly effective in delivering early warnings, while 4% consider them completely ineffective. The remaining respondents indicated that the effectiveness of digital information dissemination requires significant improvement.

On the other hand, about 24% of respondents stated they had never received any socialization or outreach related to disaster mitigation and preparedness from the Agam District Government. These findings highlight the urgent need for local government to improve systematic outreach, particularly

through an e-government approach, to ensure that disaster information is more widely and inclusively accessible to the public.

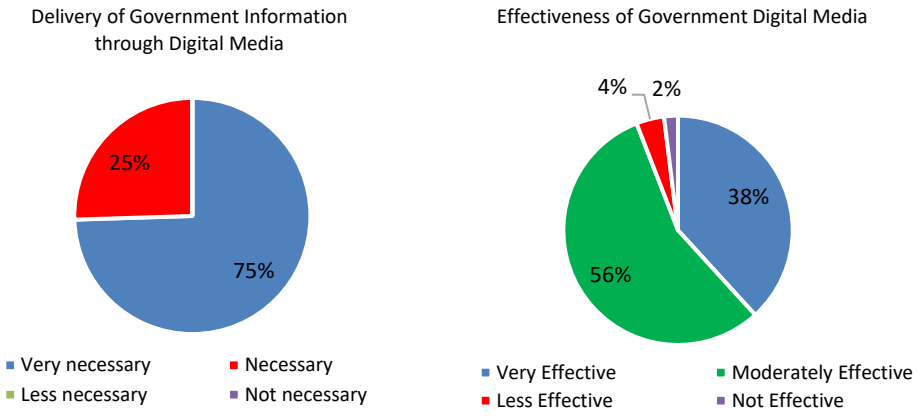


Figure 3. Effectiveness of Government Digital Media in Disaster Information Dissemination

Furthermore, 75% of respondents stated that an e-government system is crucial to enhance communication and coordination between the government and the public during disaster events. This reflects the high expectations of the community regarding the role of technology in bridging the information gap during emergencies (Figure 3).

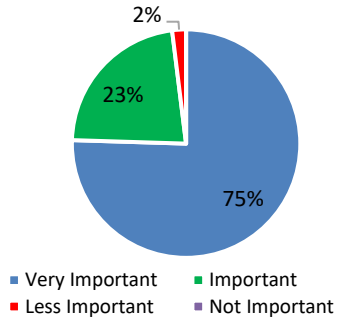


Figure 4. Public Opinion: E-Government for Communication During Eruptions

Community preparedness was also a key concern in the survey, as presented by Figure 4. While 67% of respondents believe that regular training from the government is essential to improve community capacity in facing disasters, 60% reported they had never participated in such training. When asked whether they would participate if the training were delivered digitally—via mobile applications or video tutorials—44% expressed confidence in joining, while 52% were uncertain but showed interest in participating. These findings suggest a promising opportunity to utilize digital technology as a more flexible and accessible educational medium.

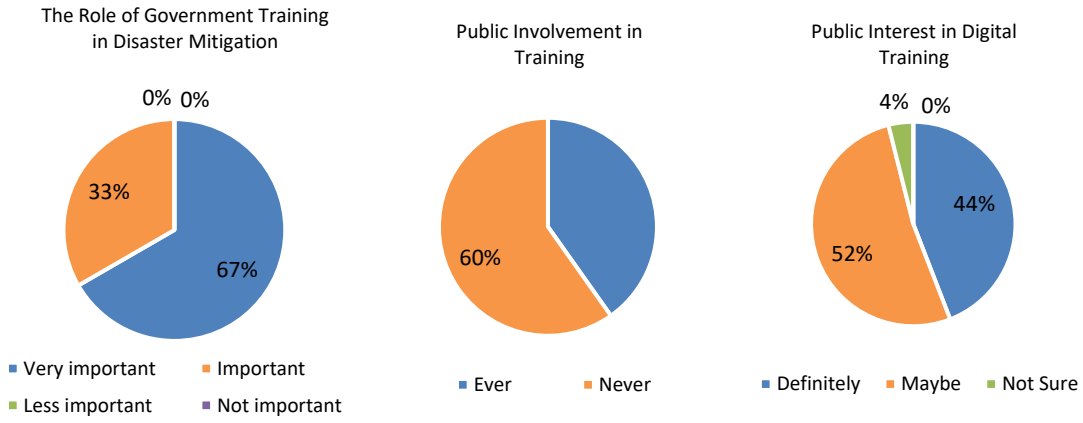


Figure 5: Role of Government Training and Community Participation Interest

The availability of ICT infrastructure is also a critical factor in the successful implementation of e-government for disaster risk reduction. Figure 5 shows that about 29% of respondents reported that internet access in their area is not consistently stable, which could hinder timely and reliable information dissemination during emergencies. While 75% of the population already owns sufficient digital devices, 24% feel their devices are inadequate, and 2% do not own any digital devices at all. In response to this, 59% of respondents stated that the government needs to improve digital infrastructure—including internet networks, disaster-related applications, and official information portals—as part of efforts to strengthen technology-based mitigation systems.

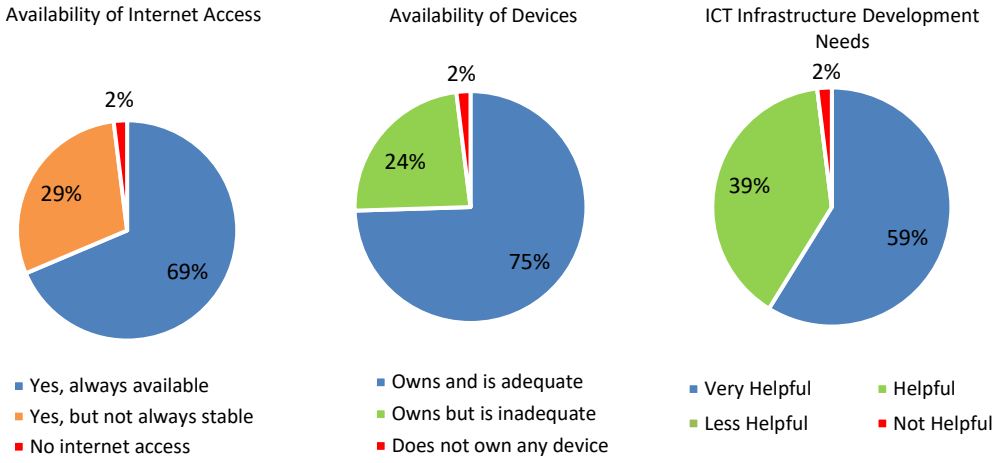


Figure 6. Availability of Digital Devices and ICT Infrastructure Needs

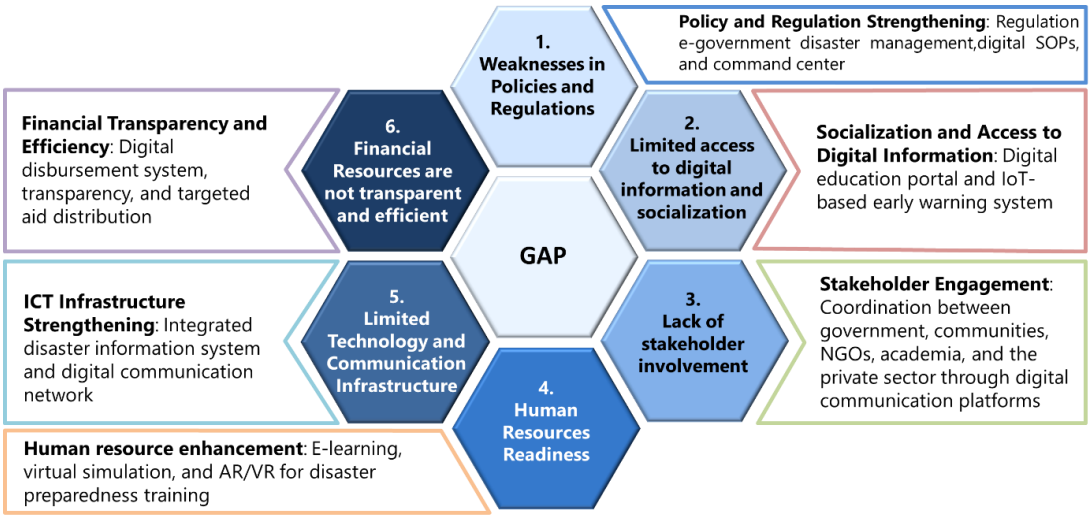
3.4. Design of the E-Government Model for Volcano Eruption Disaster

The e-government model for reducing volcanic eruption risk at Mount Marapi in Agam Regency is developed based on an integrative analysis of existing policies, regulatory frameworks, ICT infrastructure readiness, and real field conditions. The primary aim of this model is to establish a disaster management system that is responsive, integrated, and digitally oriented, thereby improving the effectiveness of mitigation, preparedness, emergency response, and post-disaster recovery.

However, the implementation of e-government in the disaster management sector still faces various obstacles. The main issues identified include the absence of specific regulations governing the digitalization of mitigation and emergency response processes, the lack of digital-based Standard Operating Procedures, and weak governance regarding the use of command centers and cross-sector coordination. In addition, access to disaster information remains limited due to the reliance on conventional outreach methods, the unavailability of adequate digital platforms for two-way communication between the government and the community, and the low utilization of technology in disaster training, which results in limited capacity among volunteers and residents in facing potential eruptions.

Another significant challenge is the limited ICT infrastructure and the lack of an integrated disaster information system, which hinders coordination and emergency response efforts. Disaster fund management is also not running efficiently, as digitalization is not yet a priority, fund disbursement is slow, and budget transparency remains low.

In response to these challenges, the proposed e-government model needs to comprises six main strategies namely: (1) strengthening digital disaster regulations; (2) developing digital access to information and outreach based on IoT and mobile platforms; (3) enhancing stakeholder engagement through an integrated communication platform; (4) implementing technology-based human resource training such as e-learning and virtual simulations; (5) building ICT infrastructure and integrated disaster information systems; and (6) digitalizing disaster fund management to improve transparency and efficiency. Figure 6 further outlines key elements of each strategy.



Source: Author's Analysis, 2025

Figure 6. Governance Model Design of Modern E-Government for Volcanic Eruption Disaster Risk Reduction in Mount Marapi

Conclusion

This study highlights the importance of implementing e-government in reducing the risk of volcanic eruption disasters. The study presents a framework that can be applied universally. The analysis reveals that despite institutional commitment and several regulatory initiatives, the use of digital technology in disaster management still faces various challenges, including the lack of technical regulations, limited cross-sector integration, and uneven ICT infrastructure. The evaluation of local government readiness also indicates that mitigation and preparedness efforts remain conventional, while digital systems have not yet been optimally implemented across all phases of disaster management.

A survey of the community reveals strong public expectations for the role of digital technology in information dissemination, improved preparedness, and communication during disaster events. However, limitations in the effectiveness of government digital media, lack of technology-based outreach and training, and uneven digital infrastructure are major obstacles in building an inclusive and responsive mitigation system. In response to these findings, this study proposes an e-government governance model that includes six key strategies: strengthening disaster digitalization regulations; developing digital access to information and outreach; increasing stakeholder involvement through an integrated communication platform; implementing technology-based human resource training; building ICT infrastructure and integrated disaster information systems; and digitalizing fund management. This model is expected to enhance the region's capacity to face volcanic eruption risks in a more adaptive, collaborative, and modern manner. This study has a limitation as it only focused on a single case in Agam Regency, which may limit the generalizability of the findings. Therefore, testing the proposed analytical framework for volcano eruption disasters in other prone areas warrants further investigations.

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