

Socio-Digital Hybridity in Disaster Preparedness: A Study of Community-Based Communication Practices in the Merapi Highlands

Past Novel Larasaty ^{1*}, Muhammad Hidayat ²

¹ Faculty of Social Science and Political Science, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia

² Faculty of Communication, LSPR Institute of Communication and Business, Jakarta 10220, Indonesia

*Corresponding author's email: past.novel.larasaty@ugm.ac.id

ABSTRACT

Keywords

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Community-based communication practices (CBCP) represent a pivotal shift from top-down, technocratic dissemination models toward participatory, dialogic frameworks that prioritize local knowledge and social capital. This research examines the dynamics of CBCP within the context of disaster mitigation on the slopes of Mount Merapi, specifically in the Sleman Regency of Yogyakarta, Indonesia. As one of the most active volcanoes globally, Mount Merapi presents a continuous threat that necessitates robust, decentralized communication systems to ensure community resilience. Utilizing a qualitative case study approach, this study analyzes the integration of traditional communication tools, such as the kentongan (bamboo slit drum), with modern digital platforms like WhatsApp and community radio. The investigation further evaluates the Sister Village (Desa Persaudaraan) program as a formalized model of participatory communication management. Data was gathered through in-depth interviews with officials from the Yogyakarta Provincial Disaster Management Agency (BPBD DIY), focus group discussions with community leaders and disaster volunteers, participatory observation, and secondary data analysis. The findings indicate that effective disaster communication in Merapi is not merely a product of technological infrastructure but is deeply rooted in social capital, specifically bonding and bridging ties, that foster mutual trust and collective action. A four-quadrant communication framework articulated by institutional informants reveals that community knowledge, monitoring capacity, information dissemination, and response readiness constitute the foundational architecture of regional resilience. However, challenges persist regarding gender representation in strategic leadership and the financial sustainability of community-led media. This study contributes to the third paradigm of development communication by demonstrating how grassroots-led communication contracts and informal social networks constitute the foundational infrastructure of regional resilience.

1. Introduction

The Special Region of Yogyakarta occupies a singular position in the Indonesian archipelago, marked by the intersection of geological volatility and enduring cultural resilience. Mount Merapi, rising at the northern apex of this region, is widely recognized as one of the most active and morphologically complex volcanoes on Earth, with a documented eruptive history spanning several centuries of periodic devastation and social upheaval (Newhall et al., 1997). The 2010 eruption, which displaced over 300,000 people, claimed 347 lives, and inflicted extensive damage across

Sleman Regency and neighboring Central Javanese districts, serves as a sobering reference point for the extreme risks faced by communities on its slopes (Pamungkas et al., 2024; Wijayanti et al., 2025). Yet, what distinguishes the Merapi case from countless other disaster-prone geographies is the way local communities have, over decades, developed a decentralized, culturally grounded architecture of disaster communication that operates in productive partnership with, rather than merely dependence upon, formal state structures.

Historically, disaster governance in the Indonesian context was dominated by a reactive, top-down model in which information flowed from centralized state agencies to communities conceptualized as passive recipients of technical directives (Wardyaningrum, 2014). This approach, a legacy of the New Order's developmentalist bureaucracy, privileged seismic data and official broadcasts over the lived knowledge and relational networks embedded within local communities (Maarif et al., 2012). The enactment of Law No. 24 of 2007 on Disaster Management marked a decisive institutional rupture, mandating a shift from responsive to preventive paradigms and creating the legal basis for the National Disaster Management Agency (BNPB) and its regional counterparts, the BPBDs. The subsequent DESTANA (Desa Tangguh Bencana) program, launched nationally in 2012, formalized communities as actors rather than objects of disaster risk reduction, establishing local risk forums (FPRB) and trained volunteer cadres as the primary front line of hazard response.

In Yogyakarta, and specifically within the sub-districts of Cangkringan and Pakem, this institutional evolution has produced a communication ecology that blends analog radio networks, the kentongan (bamboo slit drum), WhatsApp groups, and real-time social media monitoring into a layered system with no precise parallel elsewhere in Indonesia. The question this research investigates is not simply whether such systems work, but how, and through what communicative mechanisms, they generate the social capital and trust that enable rapid collective action in the context of perpetual volcanic threat. By centering primary interview data from two categories of informant, namely institutional officials at the BPBD DIY and village-level leaders and volunteers, alongside statistical and documentary sources, this article offers a grounded analysis of how hybrid communication practices sustain resilience on a landscape defined by persistent existential risk. The findings have implications not only for disaster communication policy in Indonesia but for participatory development communication more broadly, particularly in contexts where community social capital constitutes the primary buffer against catastrophe.

This study addresses a notable gap in existing literature. While previous scholarship examined either the technical dimensions of early warning systems (Newhall et al., 1997) or the sociological dimensions of community resilience (Elysia & Wihadanto, 2018), comparatively little work has explored the communicative infrastructure itself as an object of analysis through a framework that integrates participatory communication theory, social capital theory, and media ecology. The significance of this inquiry also lies in its alignment with broader academic discourses on digital transformation and sustainable development in Southeast Asia, as Yogyakarta's rural communities demonstrate how social cohesion through communication provides a vital blueprint for other high-risk regions globally (Servaes, 1996).

The Participatory Turn in Development Communication

The intellectual genealogy of community-based communication practices extends through three successive paradigms in development communication scholarship. The first, associated with the modernization theory dominant in the mid-twentieth century, conceived communication as a one-way conduit for transferring technical knowledge from expert centers to passive peripheries (Rogers, 1962). In the Indonesian context, this manifested as state-controlled radio broadcasts and top-down public awareness campaigns that systematically disregarded the sociocultural textures of local communities (Wardyaningrum, 2014). The dependency critique that followed, while valuable in exposing the structural inequalities embedded in such models, offered limited practical guidance for communities confronting immediate environmental risks.

It is the third paradigm, rooted in the dialogic communication theory of Paulo Freire and later elaborated by Servaes (1996), that provides the most compelling theoretical foundation for understanding CBCP. This paradigm positions communication not as information transfer but as a constitutive social practice through which communities construct shared meanings, negotiate

knowledge claims, and coordinate action. Applied to disaster contexts, participatory communication transforms the early warning system from a technical apparatus into a social institution embedded in webs of trust, obligation, and cultural memory. Scholars in this tradition have described this process as participatory sensemaking: communities collectively interpreting ambiguous environmental signals through the lens of accumulated local knowledge, distributing interpretive authority across social networks rather than concentrating it in expert agencies (Maarif et al., 2012).

Social Capital as Communicative Infrastructure

The theoretical framework of social capital, as developed by Putnam (2000) and further refined in empirical applications by Grootaert & Van Bastelar (2002), provides a complementary lens for understanding why some communities respond to disaster risk more effectively than others. Social capital refers to the norms, trust, and networks of association that enable coordinated action in pursuit of shared objectives. In disaster contexts, it constitutes a form of communicative infrastructure: the more densely a community is networked through reciprocal relationships, the lower the transaction costs of mobilizing information and resources at moments of crisis. This study adopts a tripartite conceptualization of social capital distinguishing between bonding, bridging, and linking dimensions, as summarized in Table 1.

Table 1. Tripartite social capital framework and its manifestations in Yogyakarta's Merapi communities.

Dimension	Definition	Manifestation in Yogyakarta
Bonding	Strong ties within homogeneous groups (intra-group)	Family networks, hamlet (dusun) WhatsApp groups, watch (ronda) systems
Bridging	Weaker ties across heterogeneous groups (inter-group)	Community radio networks, Sister Village MoUs, inter-NGO collaborations
Linking	Vertical ties between individuals and formal institutions	Relationships between village heads and BPBD (Disaster Management Agency)

In Javanese culture, the reservoir of bonding social capital is expressed through the values of gotong royong (cooperation) and rukun (communal harmony), which ensure that communication channels remain active during non-crisis periods, maintaining the social readiness that can be mobilized instantly when volcanic activity escalates (Hutagalung & Indrajat, 2020). The Sister Village program institutionalizes bridging and linking capital through formal Memoranda of Understanding (MoU) that connect high-risk villages with safer buffer communities and link local actors to provincial government structures.

Media Ecology and the Javanese Communication Environment

Media ecology theory, originating with Harold Innis and elaborated by McLuhan (1964), posits that communication media are not merely neutral conduits but active environments that shape the perceptual habits, social organization, and temporal rhythms of the communities that employ them. In the Merapi region, the communication environment is best understood as a layered media ecology in which different technologies occupy distinct functional and symbolic niches. Research by Pramono (2013) on Lintas Merapi FM documents how community radio stations in the Merapi region function as participatory public spheres where local knowledge, government advisories, and community concerns are woven together into a continuous information environment. More recently, the emergence of social media platforms has added a further layer to this ecology, enabling real-time crowd-sourced reporting of volcanic activity but also introducing new challenges around misinformation and the verification of unconfirmed reports.

The framework of divergent communication paradigms in Table 2 situates the CBCP model within this broader media ecology, highlighting the structural differences between traditional broadcast approaches and the community-based model that has emerged in Merapi.

Table 2. Divergent paradigms in disaster communication management (adapted from Servaes (1996)).

Element	Traditional Model	Community-Based Model (CBCP)
Orientation	Top-Down / Technocratic	Bottom-Up / Participatory
Channel	Mass Media / Official Broadcasts	Hybrid (Kentongan, Radio, WhatsApp)
Source	Scientific Authorities	Peers / Local Leaders / Community Radio
Trust Basis	Institutional	Relational / Social Capital
Language	Formal / Technical	Local / Context-Specific

2. Method

Research Design and Case Selection

This study adopts a qualitative case study design, consistent with the methodological conventions of interpretive communication research Yin & Campbell (2018). Sleman Regency, Yogyakarta, was selected as the primary research site on the basis of three criteria: its status as the most heavily impacted district on the Yogyakarta flank of Merapi, the institutional richness of its disaster management apparatus including a fully operational Pusdalop (Operations Control Center) and an extensive FPRB network, and the availability of longitudinal data documenting changes in communication practice following the 2010 eruption. Sleman also records the second highest internet penetration rate in the province at 86.43% of residents aged five and over (BPS DIY, 2024), making it a particularly productive site for studying digital-traditional hybridity in communication.

Data Collection and Informant Profiles

Data was gathered through four complementary methods. First, in-depth interviews were conducted with key institutional informants. The primary institutional informant was Julianto, a senior staff member at the BPBD DIY Pusdalop whose responsibilities encompass multi-stakeholder communication coordination, radio network management, and crisis information verification across the province. The interview was semi-structured and lasted approximately 90 minutes. The second category of information was community-level: interviews and focus group discussions (FGDs) with village heads (Lurah), coordinators of local disaster risk reduction forums (FPRB), and grassroots volunteers provided the community perspective. One village head from the Cangkringan sub-district, Handung Tri Rahmawan, representing a KRB III settlement with direct experience of the 2010 eruption and ongoing engagement with both the DESTANA framework and the Sister Village program, served as a primary community-level informant. Second, FGDs involved representatives from youth organizations (Karang Taruna) and women's associations (PKK). Third, participatory observation was conducted in WhatsApp groups and radio roll-call sessions. Fourth, secondary data analysis drew on the BPBD DIY Provincial Merapi Contingency Plan (BPBD DIY, 2019), Sister Village program evaluations, and BPS statistical data.

Data Analysis

Analysis followed the Miles & Huberman (1994) framework of iterative data reduction, data display, and conclusion drawing. Thematic analysis of interview transcripts was conducted using open and axial coding, generating categories organized around the research question's central constructs: participatory sensemaking, social capital mobilization, media ecology, and institutional communication architecture. Interview quotations appearing in this article have been translated from

Indonesian by the researchers; original Indonesian text is provided parenthetically to ensure transparency and facilitate verification by specialist readers.

3. Result and Discussion

The Four-Quadrant Communication Architecture of Disaster Resilience

The most analytically significant contribution of the primary data is the articulation by the BPBD DIY informant of a four-quadrant framework for understanding community-level disaster communication. When asked to identify the essential elements of an effective early warning system, Julianto offered a conceptualization that moves decisively beyond the technocratic model of sensor-and-siren infrastructure:

"Bagaimana sistem peringatan dini itu tidak hanya alatnya, namun bagaimana pengetahuan masyarakat. Kemudian bagaimana masyarakat bisa memantau. Bagaimana masyarakat bisa berkomunikasi atau penyebaran informasinya. Yang keempat bagaimana masyarakat bisa merespon. Kuncinya cuma empat itu." ["An early warning system is not just about its instruments. It is about how communities hold knowledge of their risks; how communities can monitor; how communities can communicate and distribute information; and fourthly, how communities can respond. Those four things are the key."] (Julianto, BPBD DIY, personal communication, 2025)

This four-quadrant framework, comprising risk knowledge, monitoring capacity, information dissemination, and response readiness, maps with striking precision onto the participatory communication paradigm's central premises. It relocates agency from the technological artifact to the social actor, insisting that even a fully instrumented early warning system is operationally inert if it is not embedded within a community that holds the cognitive, relational, and behavioral capacities to act on its signals. The framework resonates with Freire's (2000) insistence that genuine critical awareness precedes and conditions the possibility of liberatory action.

This institutional philosophy has concrete organizational expression. The BPBD DIY Pusdalop operates continuously, staffed by 16 operators and supervisors across three daily shifts, with a target emergency response time of 12 minutes. Beyond the institution, however, the informant was explicit that the first line of response is communal rather than bureaucratic. When asked to identify the most crucial actors in the chain from hazard detection to evacuation, Julianto was unambiguous:

"Tentunya kita ini mengandalkan relawan atau warganya langsung atau para lurah. Artinya kan kalau sudah ada FPRB-nya, itu kan di bawah kendali lurah. Itu kan isinya relawan semua. Mereka akan berbaur, lebih ke lokalitas ya." ["We rely above all on volunteers, or residents directly, or the village heads. Once the FPRB is in place, it operates under the village head's authority. It consists entirely of volunteers. They intermingle with the community, oriented to their own locality."] (Julianto, BPBD DIY, personal communication, 2025)

This positioning of the FPRB and village head as the primary operational unit of disaster response, with the BPBD fulfilling a coordinating and supplementary role, reflects a genuine internalization of the participatory paradigm at the institutional level. It is consistent with Putnam's (2000) social capital thesis that dense community networks reduce coordination costs and accelerate collective action in ways that vertical state structures cannot replicate.

Analog Resilience in a Digital Age: The Logic of Hybrid Communication

One of the most theoretically provocative findings of this study concerns the deliberate, principled retention of analog communication technologies within a context of rapid digital adoption. Research confirms that community radio infrastructure plays a critical role in disaster preparedness, providing reliable communication channels that function independently of internet connectivity (Hafida et al., 2018). The Pusdalop conducts two radio roll-call sessions daily, at 10:00 AM and 10:00 PM, through which community radio operators, volunteers, and district BPBD staff report conditions across the region. The timing of the morning session is institutionally calibrated: district-level agencies complete their internal meetings by 9:00 AM, and the provincial roll call is deliberately scheduled at 10:00 AM to allow synthesized district-level information to flow upward without temporal conflict.

What is most analytically significant is the stated rationale for maintaining this analog infrastructure alongside WhatsApp groups, live-streaming cameras, and social media monitoring. Julianto explained the logic with directness:

"Digital itu kan akan colab. Kebanyakan rentan colab. Sehingga yang konvensional kita pertahankan. Yang paling pertama dalam keadaan normal adalah WA gitu ya, online base. Tapi berikutnya masuk ke radio yang paling kita andalkan. Saling melengkapi." ["Digital systems can collapse. Most of them are vulnerable to collapse. So, we maintain the conventional. In normal conditions, the primary channel is WhatsApp, online based. But when things escalate, radio is what we rely on most. They complement one another."] (Julianto, BPBD DIY, personal communication, 2025)

This communication philosophy exemplifies what media ecology theory would recognize as technological complementarity rather than succession. The Merapi system does not replace radio with WhatsApp or the kentongan with live streaming; it stacks these technologies in a layered redundancy structure where each medium compensates for the failure modes of others. Julianto reinforced this point with a further observation that is revealing about generational dimensions of media use:

"Yang konvensional biasanya yang orang-orang tua itu masih senang pakai radio. Mereka mengandalkannya karena lebih kuat, lebih stabil koneksinya. Karena kalau internet kan mengandalkan kondisi, kalau misalnya terjadi sesuatu, misalnya listriknya, ini mereka masih bisa digunakan untuk sementara." ["Conventional [radio] is still preferred by older residents. They rely on it because it is stronger, more stable in its connection. Because the internet depends on conditions, if something happens, such as a power outage, radio can still be used in the interim."] (Julianto, BPBD DIY, personal communication, 2025)

This observation carries important implications for disaster communication policy. In a region where elderly residents are often less mobile and therefore face higher evacuation risk, the continued functionality of the medium they trust and can operate without electricity constitutes a genuine equity consideration, not merely a sentimental attachment to tradition. The state's decision to maintain analog infrastructure alongside digital channels is thus simultaneously a technical redundancy strategy and an inclusive measure.

Reinforcing this architecture is the Komunitas Lingkar Merapi (KLM), a cross-administrative community radio network that explicitly ignores the provincial boundary between Yogyakarta and Central Java. Julianto described its significance in terms that underscore the degree to which communicative solidarity has outgrown administrative cartography:

"Merapi itu tidak melihat batas DIY atau Jawa Tengah. Tidak. Mereka sudah menjadi satu. Dan mereka sudah mempunyai frekuensi tertentu di jaringan KLM itu. Jadi karena relawan dan komunitas itu banyak, mereka sering berkomunikasi menggunakan radio." ["Merapi [communities] do not recognize the border between DIY and Central Java. No. They have become one. And they already have their own dedicated frequencies in the KLM network. Because there are many volunteers and communities, they communicate frequently through radio."] (Julianto, BPBD DIY, personal communication, 2025)

The KLM is a practical instantiation of what Putnam (2000) would recognize as bridging social capital: connections that span institutional and cultural divides to create a functionally integrated network for collective action. Its cross-boundary character means that the communicative infrastructure of Merapi response is more territorially coherent with the actual geography of volcanic risk than any administrative unit, finding with direct implications for the design of inter-governmental coordination frameworks.

The Kentongan as a Symbolic Semiotic System

The kentongan retains genuine operational significance in Merapi's highland communities. Its communicative power derives from its function as a semiotic system: a structured set of acoustic signals whose meanings are collectively known and whose activation triggers automatic behavioral protocols within the community. Table 3 presents the symbolic beat pattern system documented in the highland villages of Sleman.

Table 3. Symbolic beat patterns of the kentongan in Javanese highland villages.

Number of Beats	Meaning	Traditional Context
1 beat	Security Alert / Theft	Vigilance in the neighborhood (Ronda)
2 beats	Fire	Neighborhood assembly for containment
3 beats	Natural Disaster (Flood/Eruption)	Immediate preparation/Gathering at points
4 beats	Death	Communal mourning and support
Continuous	Urgent Danger (Wedhus Gembel)	Immediate flight to safe zones

The social constructionist dimension of this system is analytically significant. The meanings encoded in the kentongan's beat patterns are not intrinsic to the instrument but are constituted through shared social practice and intergenerational transmission (Birsyada & Utami, 2024; Priyatmoko & Murti, 2024). When the kentongan sounds the continuous alarm for wedhus gembel (pyroclastic flow), it activates the entire ensemble of disaster response knowledge, relational obligations, and behavioral scripts that the community has cultivated through years of drills and lived experience. This explains why, as Julianto observed, the instrument retains a trigger function even within a digitally connected community:

"Merapi itu baru ngapain dari suara" ["Merapi [communities] are stirred to action by sound"] (Julianto, BPBD DIY, personal communication, 2025).

The village-level informant confirmed this from the experiential perspective. When discussing how communities interpret the combination of environmental and social signals, the Lurah described a decision-making logic that combines scientific monitoring with embodied local knowledge:

"We trust the BPPTKG sensors, but we also trust our eyes and our neighbors. When the monkeys start descending from the mountain, and the kentongan starts beating in the next hamlet, we do not wait for the official text message. We move." (Handung Tri Rahmawan, Cangkringan sub-district Village Head, personal communication, 2025)

This statement encapsulates the concept of participatory sensemaking in its most direct form. The community leader is not dismissing scientific instrumentation; BPPTKG sensors are cited with evident respect. But the decision threshold for action is set not by a single authoritative signal but by the convergence of multiple heterogeneous indicators, seismic data, animal behavior, and social signaling through the kentongan, each of which carries weight within the community's interpretive framework. This is precisely what the third paradigm of development communication describes as an epistemologically pluralist approach to risk: one in which local and scientific knowledge are treated as complementary rather than hierarchically ordered (Servaes, 1996).

A significant regional variation is worth noting in communities on the Boyolali flank of Merapi, the sounding of the kentongan is prohibited by local custom and belief, requiring full dependence on seismic radio networks and government warnings. Julianto acknowledged this asymmetry

"Tidak semua wilayah Merapi boleh membunyikan kentongan. Di Boyolali tidak boleh, karena punya tradisi dan kepercayaan sendiri" ["Not all Merapi areas are permitted to sound the kentongan. In Boyolali it is not permitted, because they have their own traditions and beliefs"] (Julianto, BPBD DIY, personal communication, 2025).

This underscores that the communicative infrastructure of disaster resilience is always a culturally specific construction whose effectiveness is locally contingent.

Digital Transformation and the WhatsApp Public Sphere

At the opposite pole of the media ecology, WhatsApp groups have emerged as the primary real-time information channel during the early and middle phases of volcanic episodes. The high internet penetration rates across Sleman Regency, documented in Table 4, provide the demographic foundation for this digital infrastructure.

Table 4. Internet usage statistics across Yogyakarta province (BPS DIY, 2024).

Regency/City in DIY	Internet Penetration Rate (2024 %)
Yogyakarta Municipality	90.40
Sleman Regency	86.43
Bantul Regency	80.32
Kulon Progo Regency	75.99
Gunungkidul Regency	65.81
D.I. Yogyakarta (Average)	80.10

With 86.43% of Sleman's population aged five and above using the internet, neighborhood WhatsApp groups function as a hyperlocal public sphere where residents share real-time observations, circulate government advisories, and collectively interpret ambiguous environmental signals. This constitutes a form of crowd-sourced environmental monitoring that operates below and parallel to the formal observation post system maintained by the BPPTKG. Community members share photographs of smoke plumes, reporting sounds of volcanic activity, and flag changes in animal behavior, creating a distributed sensing network that complements scientific instrumentation.

However, the same channels that enable rapid information sharing also create vulnerabilities around misinformation. Pusdalop devotes considerable institutional energy to monitoring social media platforms and cross-checking viral content. Julianto described this function with a note of wry institutional pragmatism:

"Kadang lebih cepat di TikTok atau apa, itu menjadi pantauan kita juga. Kami bisa langsung mengecek dan crosscheck ke stakeholder setempat. Apakah berita itu benar, untuk mengcounter, kan nanti kita harus memvalidasi ke pemerintahnya juga." ["Sometimes news breaks first on TikTok or similar platforms, and we monitor those too. We can immediately check and cross-reference with local stakeholders. Is the information correct? To counter it, we must validate with the relevant government authority."] (Julianto, BPBD DIY, personal communication, 2025)

Julianto recounted a specific episode that illustrates the misinformation challenge with operational specificity: an image of Gunung Sinabung in North Sumatra had circulated under the label of Merapi, prompting significant public anxiety.

"Ternyata bukan daerah Sleman. Merapi di Sumatera Barat, bukan Merapi [di Yogyakarta]. Informasi gitu kadang masyarakat suka asal terima mentah-mentah" ["It turned out it was not from Sleman. Merapi in West Sumatra, not Merapi [in Yogyakarta]. Communities sometimes accept such information uncritically"] (Julianto, BPBD DIY, personal communication, 2025).

This counter-misinformation function represents a new institutional responsibility with no precedent in pre-digital disaster communication literature and requires not only technical monitoring capacity but also the communicative credibility that sustained daily radio roll calls are designed to cultivate.

The community-level informant offered a complementary perspective on how these digital and traditional channels interact in practice. Rather than experiencing WhatsApp as displacing older communication habits, the Lurah described a functionally layered approach in which digital tools

serve as amplifiers of community-sourced observation rather than replacements for face-to-face social networks:

"We share what we see in the group. But we still meet, still talk to our neighbors. The phone is fast, but the neighbor is trusted. Both matter." (Handung Tri Rahmawan, Cangkringan sub-district Village Head, personal communication, 2025)

This observation carries considerable theoretical weight. It suggests that the WhatsApp group functions not as a substitute for bonding social capital but as an accelerant of it: a technological layer that speeds the circulation of information within a network whose trust relationships were established through years of prior face-to-face interaction. This is consistent with Bennett & Segerberg's (2013) argument that digital communication tools are most effective not when they replace organizational networks, but when they are embedded within existing social architectures.

The Sister Village Program: Institutionalizing Social Capital

The Sister Village (Desa Persaudaraan) program represents the most formalized expression of the CBCP framework in the Merapi region. Initiated after the 2010 eruption and subsequently endorsed by UNDP and submitted to the United Nations as an example of best practice in internal displacement governance, the program pairs high-risk villages in KRB III with buffer villages in safer areas through MoUs specifying evacuation routes, population-sharing obligations, logistics management protocols, and use of the Village Information System (SID) (UNDP Indonesia, 2013). The program has been implemented across 41 villages in Magelang Regency, one sub-district in Boyolali, six sub-districts in Temanggung, three sub-districts in Magelang City, and seven sub-districts in Wonosobo (Wijayanti et al., 2025).

The MoUs function as what one might term communication contracts: formal instruments that ensure bridging social capital is maintained and activated even under conditions of administrative complexity and personnel turnover. Julianto described the multi-stakeholder coordination involved in terms that reveal both its breadth and its deliberate structure:

"Di sektor OPD itu ada namanya kluster. Kluster kesehatan, kluster logistik, kluster pencarian. Kemudian ada sistem sister village. Itu semua terorganisir, ada di peraturan BNPB. Nanti ada kluster logistik, pencarian, dan sebagainya yang aktif sesuai fase bencana." ["Within the sectoral government agencies there is what we call a cluster system. Health cluster, logistics cluster, search-and-rescue cluster. And then there is the sister village system. All of this is organized and grounded in BNPB regulations. The clusters activate according to the phase of the disaster."] (Julianto, BPBD DIY, personal communication, 2025)

The village head informant offered a ground-level account of what this program means in practice for communities in KRB III. Beyond the formal MoU, the Sister Village relationship creates ongoing social connections that sustain the communicative infrastructure between disasters, not only during them:

"We know the people in our sister village. We visited them, they visited us. When we need to go, we know where we are going and who will receive us. This is not just a paper agreement." (Handung Tri Rahmawan, Cangkringan sub-district Village Head, personal communication, 2025)

This testimony illustrates the critical distinction between formal social capital, encoded in MoUs and official protocols, and substantive social capital, embodied in actual relationships of familiarity and trust. The program's documented challenges in maintaining active community engagement in buffer villages (Karman et al., 2021; Widati et al., 2021) are most likely to arise precisely where this distinction collapses: where the MoU exists but the underlying relationship does not. The BPBD's investment in the monthly Lingkar Merapi forums, which bring together officials, scientists, and community representatives for sustained dialogue beyond crisis moments, can be understood as an institutional recognition that social capital requires continuous cultivation rather than episodic activation. This is consistent with Chamlee-Wright & Storr (2011) argument that post-disaster community recovery depends fundamentally on collective narrative, the shared stories communities construct about themselves and their future, as a mechanism for mobilizing social capital toward rebuilding.

Volunteerism, DESTANA, and the Community as Actor

A central argument of the participatory communication paradigm is that sustainable resilience requires communities to function as active agents rather than passive beneficiaries of external intervention. In the Merapi region, this principle has concrete institutional expression in the DESTANA program, which has produced over 350 kelurahan tangguh bencana across Yogyakarta. The volunteer architecture in the highest-risk zones is particularly granular: each trained volunteer is responsible for approximately ten household units (KK), maintaining knowledge of which households include members with disabilities, which have vehicles capable of transporting multiple evacuees, and what the pre-agreed evacuation route and assembly point are. As Julianto described it:

"Satu relawan itu mengampus sekitar 10 KK. Walaupun secara mandiri, mereka sudah punya rencana evakuasi sendiri. Misalnya ngapain harus nunggu mobil dari bawah? Yang di lingkungan itu sudah ada pendataan: yang punya mobil terbuka siapa, yang mobil penumpang kapasitasnya berapa. Mereka sudah bisa jalan sendiri." ["One volunteer covers around 10 households. Even independently, they already have their own evacuation plan. Why wait for vehicles from below? In each neighborhood the mapping is done already: who has an open-bed vehicle, what is the passenger capacity of each car. They can move on their own."] (Julianto, BPBD DIY, personal communication, 2025)

This social mapping at household scale, conducted through the BPPTKG's WLPB (Wajib Latih Penolongan Bencana) training program, transforms the community from a population to be evacuated into an organized collective capable of self-directed evacuation. The village head confirmed that this granular planning has operational consequences: in the 2020 and 2021 alert escalations, communities in Turgo and Glagaharjo carried out self-organized evacuation without waiting for official orders.

The role of non-governmental organizations in sustaining volunteer capacity deserves particular attention. With approximately 22 NGOs partnering with BPBD DIY in disability-inclusive response, elderly care, child welfare, and community resilience, the institutional ecosystem extends far beyond the formal government apparatus. Julianto described this partnership with evident appreciation:

"Kita banyak dibantu NGO di Jogja ini. Sehingga kami ada beberapa kali diundang NGO untuk menjadi narasumber. Mereka membuat rencana kontinjensi aksi antisipasi di tingkat desa, inisiasi dari NGO-nya tapi melibatkan BPBD. Kita nol rupiah. Mereka semua yang mengadakan, kami koordinator saja." ["We are greatly assisted by NGOs here in Yogyakarta. We have been invited by NGOs on multiple occasions to serve as resource persons. They prepare village-level anticipatory action plans, initiated by the NGO but involving the BPBD. We spent zero rupiah. They organize everything; we only coordinate."] (Julianto, BPBD DIY, personal communication, 2025)

This governance model, in which formal state agencies function as coordinators and validators rather than primary implementers, is a practical expression of the entrepreneurial state concept discussed by Mazzucato (2015): bureaucracy that is sufficiently flexible to leverage non-state capacity while retaining coordination authority. The zero-rupiah model of the 2023 preparedness day event, which mobilized over 700 schools and government offices to submit disaster preparedness videos, demonstrates the extraordinary scale that this partnership model can achieve.

Gendered Dimensions of Disaster Communication

A critical dimension of the Merapi communication system is the gendered distribution of roles, responsibilities, and communicative channels within disaster response structures. Interview data and field observation reveal a persistent pattern in which women, despite their centrality to household-level preparedness and community social networking, are systematically excluded from formal leadership positions in SAR operations, observation posts, and institutional communication management. Table 5 documents this distribution.

Table 5. Gendered distribution of responsibilities in Merapi disaster response.

Role in Disaster Management	Predominant Gender	Communication Channel Used
Strategic Leadership / SAR Operations	Male	Radio / Formal Institutional Channels
Logistics / Health / Data Management	Female	WhatsApp / Informal Social Networks
Early Warning Observation	Male	Observation Posts / Kentongan
Community Education / Outreach	Female	PKK Meetings / Neighborhood Groups

Research by Fathoni et al. (2025) on gender inequality among female volunteers during the 2010 Merapi eruption confirms that women's contributions were largely confined to support roles in logistics, communal kitchens, and health care, while strategic leadership, coordination, and media operations remained predominantly male domains. This gendered asymmetry is communicatively consequential: it concentrates decision-making authority in networks from which women are structurally excluded, thereby reducing the diversity of information and insight informing crisis response.

The village head informant, when asked about community preparedness in households, noted that women tend to be the primary channel through which disaster preparedness knowledge is transmitted at the domestic level, particularly through PKK meetings and neighborhood WhatsApp groups, yet their authority does not translate upward into institutional structures. This disjunction, between women's practical communicative centrality and their institutional marginality, represents both a normative deficit and an operational vulnerability that the current FPRB governance structure does not adequately address.

Communication, Trust, and the Management of Non-Compliance

A recurring theme in both the interview data and the secondary literature is the challenge of voluntary compliance: residents within KRB III zones who decline to evacuate even when official warnings are issued. This challenge was raised independently by both informants, suggesting it is a defining institutional and social problem rather than an incidental observation.

The village head spoke to this with a directness that reflects years of trying to persuade resistant neighbors. When asked about the main difficulty in executing evacuation, Lurah's account was unambiguous:

"The hardest thing is not the route or the vehicle. The hardest thing is the person who says, my cattle are here, my crops are here. If I leave, who will guard them? This is not stubborn. This is a real problem that official warnings do not solve." (Handung Tri Rahmawan, Cangkringan sub-district Village Head, personal communication, 2025)

Julianto's analysis of the same challenge from the institutional perspective adds an important dimension: the extended duration of Merapi's current elevated alert status has itself become a driver of normalization:

"Siaga itu sudah 5 tahun kalau tidak salah dari November 2020. Padahal secara dokumen rencana kontinjensi, kalau siaga itu sudah melakukan pengungsian. Namun dalam hal ini kita berembuk dengan BPPTKG. Hanya wilayah tertentu yang mungkin mempunyai potensi. Tidak semua di KRB3 itu harus." ["Siaga status has been in effect for approximately 5 years since November 2020. Yet according to the contingency plan document, Siaga already requires evacuation. However, in this case we discuss it with BPPTKG. Only certain areas carry the most immediate potential. Not all KRB3 must evacuate unconditionally."] (Julianto, BPBD DIY, personal communication, 2025)

This frank acknowledgment of the gap between formal protocol and operational practice is analytically important. It reveals that disaster communication is not simply a matter of transmitting warnings correctly but of managing the social and psychological consequences of extended risk exposure. When the Siaga designation persists for five years without a major eruption, the warning loses its capacity to signal urgency, a phenomenon that the disaster communication literature describes as warning fatigue (Mileti & Peek, 2000). The BPBD's response, consultation with BPPTKG to calibrate expectations to realistic threat scenarios by drainage basin and direction of lava flow, represents a form of risk communication tailored to the specific sociological context of long-term elevated alert, one that sacrifices protocol purity for practical behavioral effectiveness.

The village head further noted that the living harmony with Merapi (*hidup harmonis dengan Merapi*) policy, which prohibits new construction in KRB III zones and implements a zero-growth rule, represents an important structural acknowledgment that some residents will remain regardless of warnings, and that their safety must be planned around rather than simply mandated away. This tension between regulatory aspiration and social reality is one that participatory communication, with its emphasis on dialogue and community ownership, is better equipped to navigate than technocratic command-and-control approaches.

4. Conclusion

This study has examined the socio-digital hybridity that characterizes community-based communication practices on the slopes of Mount Merapi, arguing that the resilience of Sleman's communities cannot be adequately explained by reference to either their technological infrastructure or their cultural traditions in isolation, but only through an integrative analysis of the communicative architecture that fuses these elements into a coherent, adaptive system. Primary data from two categories of informant, an institutional official at the BPBD DIY Pusdalop and a village head from the Cangkringan sub-district, provide convergent and mutually illuminating perspectives on the mechanisms through which this architecture operates.

The four-quadrant framework articulated by the BPBD informant, comprising risk knowledge, monitoring capacity, information dissemination, and response readiness, provides a practically grounded and theoretically resonant model for evaluating the communicative dimensions of disaster resilience. This framework relocates agency from the technological artifact to the social actor and insists that even a well-instrumented early warning system is operationally inert without the community capacities that activate and interpret its signals. The village head's account of how communities move in response to the convergence of seismic data, animal behavior, and kentongan signals, without waiting for an official text message, concretizes this theoretical claim at the level of lived experience.

The analog-digital hybrid communication ecology of the Merapi region represents a principled technological strategy rather than a failure of modernization. Radio is retained because it works when digital systems fail; the kentongan is retained because it carries cultural meanings that digital platforms cannot encode, although the frequency might not as intense as it was in the past; and the layered redundancy they produce together constitutes a communication system that is robust precisely at the moments when robustness matters most. The cross-boundary Komunitas Lingkar Merapi illustrates how this architecture can transcend administrative limits to achieve territorial coherence with the actual geography of volcanic risk.

The Sister Village program demonstrates how informal social capital can be institutionalized through communication contracts without losing its participatory character, provided that the underlying relational infrastructure, the actual knowledge of and trust in partner communities, is substantively maintained. Community-level testimony confirms that the MoU is experienced as meaningful precisely because it formalizes pre-existing social relationships rather than creating artificial ones.

Two persistent vulnerabilities qualify this otherwise robust picture. The gendered asymmetry in disaster communication roles exclude most community educators and household-level preparedness managers from institutional leadership, limiting the diversity of perspectives informing strategic decisions. And the normalization risk inherent in extended periods of elevated alert, documented

through both informants' accounts of residents who decline to evacuate despite warnings, poses a challenge that communication systems oriented primarily around information transmission are ill-equipped to address. These are challenges that require institutional innovation, not merely technological upgrade, and that demand precisely the kind of sustained participatory dialogue that the Merapi region has, in many respects, already demonstrated how to conduct.

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