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Geohazard-Informed Rapid Planning for Disaster Relief Operations: Lessons from Flood Response in Sumatra

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ABSTRAK

Operasi bantuan kemanusiaan pada fase tanggap darurat banjir umumnya berlangsung dalam kondisi ketidakpastian tinggi, keterbatasan akses, serta sumber daya yang terbatas. Dalam situasi tersebut, keputusan operasional terkait penentuan prioritas, moda transportasi, dan penempatan dukungan infrastruktur sangat memengaruhi efektivitas dan keadilan respons kemanusiaan. Penelitian ini mengkaji bagaimana penilaian *geohazard* berbasis citra satelit dapat mendukung perencanaan operasional bantuan bencana pada fase tanggap darurat. Dengan menggunakan kejadian banjir di Sumatra sebagai studi kasus, analisis dilakukan melalui observasi citra satelit untuk mengidentifikasi luasan genangan, keterpaparan permukiman, gangguan akses, serta kerusakan hunian di sepanjang dataran banjir sungai. Alih-alih menerapkan pemodelan prediktif yang kompleks, penelitian ini menekankan penerjemahan observasi *geohazard* secara cepat ke dalam interpretasi operasional guna mendukung pengambilan keputusan tepat waktu, termasuk pemilihan moda transportasi, penentuan prioritas di tengah keterbatasan sumber daya, serta penempatan infrastruktur pendukung penting seperti pasokan listrik darurat. Hasil penelitian menunjukkan bahwa perencanaan berbasis *geohazard* meningkatkan kesadaran situasional dan mendukung respons kemanusiaan yang lebih terkoordinasi lintas domain intervensi, meliputi distribusi logistik, respons medis, dukungan psikososial, dan bantuan berfokus anak. Sebuah jalur konseptual disajikan untuk menggambarkan bagaimana penilaian *geohazard* memandu keputusan operasional dan menghasilkan dampak pengganda dalam operasi bantuan bencana. Penelitian ini menyimpulkan bahwa integrasi penilaian *geohazard* memperkuat efektivitas dan adaptabilitas pengambilan keputusan kemanusiaan dalam kondisi darurat.

Kata Kunci: *Analisis geohazard; Operasi bantuan bencana; Citra satelit; Pengambilan keputusan dalam respons kemanusiaan; Praktik berbasis bukti; Respons banjir*

ABSTRACT

Disaster relief operations during flood emergencies are often conducted under conditions of high uncertainty, limited access, and constrained resources. In such contexts, operational decisions regarding prioritization, transportation, and deployment of critical support infrastructure directly affect humanitarian effectiveness and equity. This study examines how satellite-based geohazard assessment can support disaster relief operational planning during the emergency response phase. Using recent flood events in Sumatra as a case study, the analysis draws on satellite imagery to observe flood extent, settlement exposure, access disruption, and housing damage along riverine floodplains. Rather than applying complex predictive or simulation-based models, the study emphasizes how rapid geohazard observation can be translated into operational interpretation to support timely decision-making, including transportation mode selection, prioritization under resource scarcity, and deployment of essential infrastructure such as emergency power supply. The findings indicate that geohazard-informed planning enhances situational awareness and supports more coherent and equitable humanitarian response across multiple intervention domains, including logistics delivery, medical response, psychosocial support, and child-centered relief. A conceptual pathway is presented to illustrate how geohazard assessment informs operational decisions and generates multiplier impacts across disaster relief activities. Beyond its operational relevance, the study highlights the role of evidence-informed learning in strengthening professional practice under uncertainty. The study concludes that integrating geohazard assessment into emergency response practices improves the effectiveness, accountability, and adaptability of humanitarian operations in flood-affected contexts.

Keywords: *Geohazard assessment; Disaster relief operations; Satellite imagery; Humanitarian decision-making; Evidence-informed practice; Flood response*

INTRODUCTION

Flood disasters remain one of the most persistent humanitarian challenges in Indonesia, particularly across Sumatra, where extensive river systems, low-lying floodplains, and settlement expansion intersect with increasing climatic variability. While floods are often perceived as recurrent and seasonal phenomena, their impacts continue to escalate due to population growth, land-use change, and the fragility of transportation, energy, and communication infrastructure. Beyond physical inundation, floods frequently generate cascading disruptions, including access failure, settlement isolation, prolonged power outages, and breakdowns in essential services, all of which significantly complicate disaster relief operations.

During the emergency response phase, humanitarian actors are required to operate under severe constraints. Field access may be partially or completely disrupted, communication networks degraded, and situational information fragmented or delayed. Despite these limitations, critical decisions must be made rapidly regarding which communities to prioritize, how to reach them, what forms of assistance are most urgent, and which logistical strategies are feasible given the terrain and hazard conditions. These decisions are inherently consequential, as delays or misallocation of resources directly affect human safety, health, and dignity.

In many real-world flood responses, operational decisions are taken under extreme time pressure and informational uncertainty. Although humanitarian teams often rely on field experience and intuition, the absence of structured scientific input can result in reactive or suboptimal outcomes. Communities that are easier to reach may receive assistance earlier, while more isolated settlements—often those with greater vulnerability—remain underserved. This challenge has been widely recognized in disaster risk and emergency management literature, which emphasizes the need for decision-making frameworks capable of operating effectively under uncertainty (Alexander, 2013). Flood impacts are therefore not solely determined by hazard magnitude, but by the interaction between physical processes and social vulnerability, a relationship that has long been emphasized in hazard and disaster studies (Smith & Petley, 2009; Blaikie et al., 2014).

Scientific approaches to disaster management have traditionally emphasized pre-disaster risk assessment, hazard modeling, and long-term mitigation planning. While these approaches are indispensable, they are often poorly aligned with the immediate needs of emergency response operations. The emergency phase demands analytical approaches that are rapid, interpretable, and directly actionable. International frameworks for disaster risk reduction, including the Sendai Framework, increasingly emphasize the importance of integrating scientific knowledge into decision-making across all phases of disaster management, including response and recovery (UNDRR, 2015).

Geohazard assessment offers a practical pathway to bridge scientific reasoning and humanitarian operations during emergency response. By integrating spatial information on terrain, hydrology, and settlement exposure, geohazard analysis provides a structured understanding of how flood hazards interact with human systems. Importantly, such analysis does not require complex modeling to be operationally useful. Previous studies on satellite-based hazard mapping demonstrate that even medium-resolution imagery can provide valuable situational awareness during disaster events (Joyce et al., 2009).

This study argues that disaster relief operational planning should be grounded in geohazard-informed reasoning, particularly in flood emergencies where access and mobility are primary constraints. Using recent flood response experiences in Sumatra as a case study, this paper demonstrates how satellite-based geohazard observation can inform transportation mode selection, prioritization under resource scarcity, and deployment of critical support infrastructure such as power generation. Rather than proposing a new analytical framework, the study emphasizes lessons learned from translating spatial scientific understanding into concrete humanitarian action.

Rather than proposing a new analytical framework, this study emphasizes lessons learned from translating spatial scientific understanding into concrete humanitarian action. This study contributes to professional education and applied learning by demonstrating how scientific knowledge is operationalized in humanitarian decision-making under uncertainty.

Flood impacts are not determined solely by physical hazard intensity, but also by the social vulnerability of exposed populations, which is spatially uneven and closely linked to settlement patterns, access, and adaptive capacity (Cutter et al., 2003).

LITERATURE REVIEW

A. Floods as Spatially-Driven Geohazards

From a geohazard perspective, floods are inherently spatial phenomena shaped by interactions between hydrological processes, topography, river morphology, land use, and human settlement patterns. In lowland river systems such as those prevalent in Sumatra, floodwaters often spread laterally across broad floodplains, inundating residential areas, agricultural land, and transportation corridors simultaneously. The resulting impacts are rarely confined to a single administrative unit, instead affecting interconnected networks of villages and communities.

The operational significance of flooding lies not only in water depth or duration, but in how inundation reshapes accessibility. Roads may become impassable even under shallow flooding, bridges may be structurally compromised, and informal access routes may disappear entirely. These conditions transform the humanitarian landscape, converting what would otherwise be straightforward logistics into complex navigation challenges that demand adaptive operational strategies.

B. Disaster Relief as a Multi-Constraint Problem

Disaster relief operations can be understood as multi-constraint problems in which decisions must balance urgency, access, resource availability, and operational risk. Humanitarian actors rarely have the luxury of addressing all needs simultaneously. Instead, they must prioritize interventions based on feasibility and potential impact. In flood contexts, such prioritization is heavily influenced by spatial constraints imposed by geohazards.

Without structured spatial reasoning, prioritization risks becoming arbitrary or reactive. Communities that are easier to reach may receive assistance earlier, while more isolated settlements—often those with greater vulnerability—remain underserved. Geohazard-informed assessment helps counteract this bias by making isolation, exposure, and access constraints visible within the decision-making process.

C. Scientific Reasoning Under Uncertainty

Emergency response environments are characterized by uncertainty rather than data abundance. Cloud cover may obscure satellite imagery, field assessments may be delayed, and information may be inconsistent. Under such conditions, scientific reasoning must adapt to operate with partial evidence. Rather than seeking certainty, the goal is to reduce uncertainty sufficiently to enable responsible and ethically defensible action.

Geohazard assessment supports this goal by providing a coherent spatial narrative of the disaster environment. Even when data are incomplete, spatial patterns of inundation, terrain, and settlement distribution can inform decisions about where intervention is most urgently needed and how assistance can be practically delivered.

METHODS

This study adopts a qualitative, case-based approach grounded in operational experience rather than experimental design. The focus is on understanding how geohazard assessment can support disaster relief operational planning under real-world constraints.

A. Study Context

The case study draws on flood response experiences in Sumatra, with primary observations centered in Aceh Tamiang Regency. This region is characterized by extensive river networks, lowland floodplains, and settlements distributed along river corridors. During flood events, these characteristics contribute to widespread inundation and access disruption.

B. Data Sources and Interpretation

Medium-resolution satellite imagery was used as the primary data source for observing flood extent and settlement exposure. Although cloud cover and acquisition timing imposed limitations, the imagery provided sufficient spatial context to identify inundated zones, disrupted transportation routes, and potentially isolated communities.

These observations were complemented by contextual field knowledge from humanitarian activities conducted by local actors, including the Community-based Rapid Action for Sustainable Transformation (CRAST). CRAST's involvement in disaster response provided practical insights into access constraints, logistical challenges, and decision-making processes under emergency conditions.

C. Analytical Focus

Rather than performing quantitative flood modeling, the analysis emphasizes spatial interpretation relevant to operational planning during the emergency response phase. This approach reflects the realities of disaster relief operations, where data availability is limited, access conditions change rapidly, and timely interpretation often outweighs analytical precision.

Satellite imagery was examined to identify spatial patterns of inundation, settlement exposure, and access disruption across flood-affected areas. The objective of this interpretation was not to predict flood dynamics or simulate future scenarios, but to support immediate operational decision-making by humanitarian actors. Emphasis was placed on understanding how observed flood extent interacted with terrain characteristics and settlement distribution, particularly in low-lying floodplains and river-adjacent communities.

To structure the rapid geohazard interpretation, the analysis was guided by the following operational questions:

1. Which areas are likely to be isolated due to flooding?
2. How does flood extent intersect with settlement patterns?
3. What implications do these patterns have for access and logistics?

These guiding questions enabled a focused and pragmatic assessment of operational constraints, supporting decisions related to prioritization, transportation mode selection, and allocation of limited resources. By framing spatial interpretation around concrete operational needs, the analysis aligns scientific observation with humanitarian practice, ensuring that geohazard information remains directly relevant to on-the-ground decision-making under emergency conditions.

RESULT AND DISCUSSION

A. Flood Patterns and Settlement Exposure

Satellite-based observation reveals extensive inundation along river corridors, with floodwaters extending beyond the main channel into surrounding floodplains. In several observed areas, clusters of settlements are fully or partially submerged, indicating prolonged exposure and high potential for isolation. The spatial continuity of inundation suggests that flood impacts often affect multiple settlements simultaneously, reinforcing the need for area-based rather than village-by-village assessment.

Distinct exposure typologies were observed. In some areas, dense settlement clusters located within low-lying floodplains experienced widespread inundation, resulting in prolonged isolation and limited external access. In other areas, settlements followed linear patterns along riverbanks, where even narrower inundation zones intersected critical access routes. In such contexts, minor increases in water level produced disproportionate impacts on mobility and logistics.

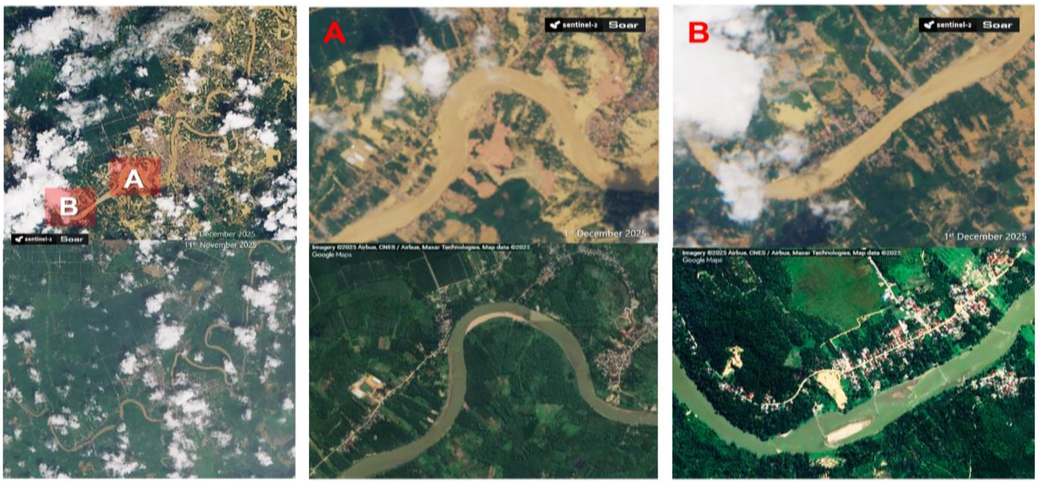

Figure 1. Satellite-based observation of flood extent and settlement exposure along the Tamiang River. The overview map highlights two observed areas (A and B), while detailed views illustrate extensive inundation affecting multiple settlements and access

Area A represents a flood-affected zone spanning multiple administrative boundaries along the Tamiang River. Satellite imagery reveals extensive inundation across low-lying floodplains, where several settlements are located in close proximity to the river channel. The spatial pattern indicates that floodwaters have expanded beyond the main river course, submerging residential areas and agricultural land. The density and continuity of inundated zones suggest that multiple villages within this area were simultaneously affected, resulting in widespread settlement isolation.

Area B exhibits a similar exposure pattern, characterized by linear settlement distribution along the riverbank, where even narrower inundation zones intersect critical access routes, amplifying mobility disruption.

B. Transportation Mode Selection

One of the most critical operational decisions in flood response concerns the selection of transportation modes. Geohazard assessment plays a decisive role in this process by revealing where land-based access is no longer viable. In several observed areas, flood conditions rendered four-wheeled vehicles impractical, while access by motorcycle remained possible in limited corridors. In other cases, complete reliance on water-based transport was unavoidable.

Understanding these spatial constraints enabled relief teams to make informed choices regarding transportation. Motorcycles were prioritized for rapid delivery of lightweight supplies to partially accessible areas, while boats were allocated for fully isolated settlements. Without geohazard-informed assessment, such decisions risk inefficiency, delays, or exposure of teams to unnecessary risk.

C. Prioritization Under Resource Constraints

Resource scarcity is a defining feature of emergency response. Geohazard assessment contributes to prioritization by highlighting areas where isolation, exposure, and vulnerability intersect. In practice, this meant directing limited resources first to communities that were both severely affected and least accessible, rather than those that were simply easiest to reach.

Spatial understanding also informed decisions regarding the sequencing of interventions. Initial efforts focused on life-sustaining assistance, followed by targeted support addressing emerging needs as flood conditions evolved. This staged approach reflects how geohazard-informed reasoning supports adaptive planning rather than static response.

D. Critical Infrastructure Support: Power Generation

Beyond consumable logistics, flood response often depends on the availability of functional infrastructure, particularly power supply. In flood-affected areas, electricity outages severely constrain medical services, communication, and basic community functions. The deployment of portable generators therefore represents a critical component of disaster relief operations.

Geohazard assessment informed decisions regarding generator deployment by identifying areas where prolonged inundation coincided with infrastructure failure and high population exposure. By prioritizing these locations, relief teams ensured that limited power resources were allocated where they could support medical care, lighting, communication, and other essential services.

E. Housing Damage, Prolonged Exposure, and Secondary Health Risks

Beyond inundation extent and access disruption, satellite imagery also indicates widespread damage to residential structures in flood-affected areas. In several observed locations, prolonged submergence and repeated exposure to floodwaters resulted in visible degradation of housing clusters, including roof displacement, wall collapse, and structural deformation. These patterns suggest not only immediate displacement risks but also longer-term habitability challenges for affected households.

The spatial distribution of damaged housing often overlaps with areas experiencing prolonged inundation, indicating that structural damage is not uniformly distributed but concentrated in low-lying and poorly drained zones. Such conditions increase the likelihood that residents remain exposed to damp, unsanitary living environments for extended periods, even after floodwaters recede. From an operational perspective, this observation is critical, as housing damage directly influences both shelter needs and health risks.

Prolonged exposure to damaged housing environments contributes to a range of secondary health impacts. Persistent moisture, stagnant water, and compromised sanitation increase the risk of skin infections, respiratory problems, and waterborne diseases. These risks are particularly pronounced among children, the elderly, and individuals with pre-existing health conditions. Importantly, these impacts tend to intensify over time, shifting the humanitarian burden from acute injury management toward longer-term public health concerns.

Geohazard-informed observation of housing damage therefore provides an essential link between physical flood impacts and evolving health vulnerabilities. By identifying areas where residential damage and prolonged exposure coincide, humanitarian actors can anticipate secondary health risks and adjust medical, psychosocial, and shelter-related interventions accordingly. This reinforces the value of satellite-based geohazard assessment not only for access and logistics planning, but also for anticipating downstream humanitarian needs that emerge beyond the initial emergency phase.

These observations highlight how physical damage to housing serves as a critical link between geohazard exposure and the emergence of longer-term health and psychosocial vulnerabilities, which are further examined in the Discussion section.

DISCUSSION

The Discussion section synthesizes the operational implications of geohazard assessment observed in the flood response case. Rather than treating geohazard analysis as a purely technical or analytical output, this section examines how spatial understanding shaped real-world humanitarian decisions across logistics, medical response, psychosocial support, child-centered relief, and infrastructure deployment. In line with established perspectives on disaster risk and vulnerability (Smith & Petley, 2009; Blaikie et al., 2014), the discussion emphasizes how hazard processes intersect with social exposure, access constraints, and institutional capacity during emergency response.

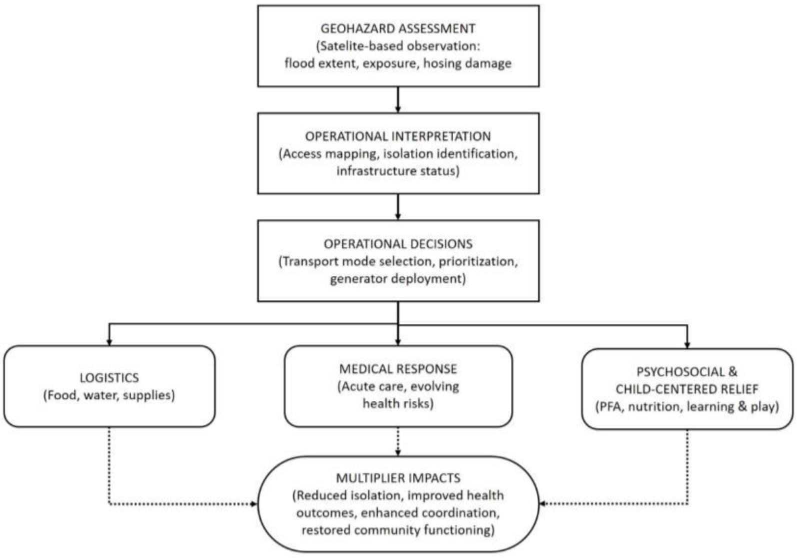

Figure 2. Conceptual Linkage from Geohazard Assessment to Multiplier Impacts in Disaster Relief Operations.

Consistent with principles articulated in disaster risk reduction and emergency management literature, the discussion is structured progressively. It begins with foundational operational roles of geohazard assessment, then examines how scientific reasoning can be integrated into humanitarian practice under uncertainty, and finally considers the broader applicability of geohazard-informed operational planning across disaster contexts (Alexander, 2013; UNDRR, 2015). In doing so, the section positions geohazard assessment not as an abstract analytical exercise, but as a practical decision-support mechanism embedded within the realities of humanitarian action.

A. Geohazard Assessment as an Operational Decision-Support Tool

The findings demonstrate that geohazard assessment, even when based on limited data availability, can function as an effective operational decision-support tool in disaster relief contexts. Rather than serving as a predictive or modeling exercise aimed at producing precise hazard metrics, geohazard analysis provides a structured lens through which emergency conditions can be interpreted. This interpretive function enables humanitarian actors to reduce uncertainty during critical decision-making moments, particularly when time, access, and information are severely constrained.

In emergency flood response, the primary value of geohazard assessment lies in its capacity to translate spatial patterns—such as inundation extent, terrain constraints, and settlement exposure—into actionable operational insights. These insights support rapid situational awareness without imposing unrealistic analytical or computational demands. As such, geohazard-informed reasoning is especially well suited to the early response phase, where decisions must be taken quickly and with incomplete information, yet still require a rational and defensible basis.

B. Bridging Scientific Reasoning and Humanitarian Practice

Building on its role as an operational decision-support tool, geohazard assessment also serves as a bridge between scientific reasoning and humanitarian practice. A key contribution of this study lies in illustrating how scientific thinking can be embedded within humanitarian operations without distancing practitioners from field realities. By translating geohazard observations into operationally meaningful insights, relief actors are better equipped to make decisions that are transparent, accountable, and grounded in evidence rather than intuition alone.

This bridging function is particularly critical in disaster contexts, where scientific tools are often perceived as too technical, slow, or detached from urgent humanitarian needs. The findings demonstrate that geohazard assessment can instead operate as a mediating framework—one that allows scientific knowledge to inform humanitarian practice in ways that are pragmatic, interpretable, and directly applicable to operational planning. In doing so, geohazard-informed approaches help align scientific rigor with the practical constraints of emergency response.

C. Applicability to Broader Disaster Contexts

Although this study focuses on flood response, the conceptual approach outlined here extends beyond hydrological hazards. Landslides, earthquakes, and other geophysical disasters similarly generate access constraints, infrastructure disruption, and spatially uneven impacts on affected populations. In each of these contexts, humanitarian actors face comparable challenges related to uncertainty, limited access, and the need for rapid operational decisions.

Integrating geohazard understanding into disaster relief operations therefore enhances the capacity of humanitarian actors to respond effectively across a range of hazard scenarios. The transferability of this approach suggests that geohazard-informed operational planning represents a broadly applicable principle rather than a hazard-specific technique. By emphasizing spatial reasoning as a foundation for decision-making, this approach offers a flexible framework that can be adapted to diverse disaster environments while retaining its core operational value.

D. Multi-Dimensional Nature of Disaster Relief Operations

Disaster relief operations are inherently multi-dimensional and extend far beyond the delivery of basic logistical supplies. While food, water, and shelter are often viewed as the primary components of emergency response, effective humanitarian action requires the coordination of multiple intervention domains, including medical assistance, psychological support, child protection, and the provision of essential tools and equipment.

Each of these dimensions is influenced by spatial constraints and hazard conditions. In flood-affected environments, physical characteristics such as water depth, flow velocity, and inundation duration directly shape the feasibility of medical outreach, psychosocial interventions, and child-focused activities. Without an understanding of terrain and access constraints, humanitarian actors risk misallocating resources or failing to reach populations most in need.

Geohazard assessment therefore functions as an integrative operational layer, aligning diverse humanitarian interventions within a coherent and spatially informed framework.

E. Operational Decision-Making, Access Constraints, and Transportation Modes

One of the defining characteristics of emergency flood response is the presence of severe resource and access constraints. Humanitarian actors are rarely able to reach all affected communities simultaneously, particularly during the early phase of a disaster when information remains incomplete and mobility is restricted.

Access constraints in flood-affected regions are often highly heterogeneous. Some communities remain reachable via partially submerged roads, narrow embankments, or elevated paths, allowing limited access by motorcycles or light vehicles. Other communities are entirely cut off from land-based transportation, necessitating water-based access such as boats.

By interpreting satellite imagery and spatial patterns of inundation, humanitarian teams can make informed decisions regarding transportation mode selection. In practice, this enables relief planners to assign motorcycles for rapid delivery of lightweight supplies to partially accessible areas, while reserving boats for fully isolated settlements. Such differentiation is essential for maximizing operational reach and minimizing delays under constrained conditions.

F. Prioritization Logic and Ethical Considerations

Prioritization in disaster relief is not merely a logistical challenge but also an ethical one. Decisions regarding which communities receive assistance first inherently involve judgments about vulnerability, exposure, and feasibility. In the absence of structured assessment, prioritization may be influenced by convenience, visibility, or proximity rather than by actual need.

Geohazard-informed planning introduces a more transparent and defensible basis for prioritization. By identifying areas where flood exposure, isolation, and population vulnerability intersect, humanitarian actors can justify prioritizing communities that are both severely affected and difficult to reach. This approach mitigates the tendency to favor easily accessible locations and supports a more equitable distribution of assistance.

Operational experience from CRAST illustrates how this prioritization logic was applied in practice. When resources were insufficient to cover all affected areas simultaneously, geohazard assessment informed decisions to prioritize villages that were entirely isolated and lacked alternative coping mechanisms, ensuring that limited humanitarian resources were directed toward communities with the greatest immediate need.

G. Energy Infrastructure as a Critical Operational Enable

Energy availability represents a frequently overlooked yet critical component of disaster relief operations. Flood events often result in prolonged power outages, particularly in low-lying and rural areas where electrical infrastructure is vulnerable to inundation. The absence of electricity has cascading effects, constraining medical services, communication, lighting, and community coordination.

The deployment of portable generators therefore constitutes an essential intervention during flood response. However, generators are typically scarce and logistically demanding assets, requiring careful planning regarding placement, fuel supply, and operational oversight. Geohazard assessment contributes to generator deployment decisions by identifying areas where prolonged inundation coincides with high population density and essential service needs.

In the Sumatra flood response, generator placement was guided by spatial understanding of flood persistence and access constraints. Priority was given to locations supporting medical activities, coordination hubs, and community shelters, enhancing operational effectiveness and enabling sustained humanitarian engagement.

H. Integrated Health, Psychosocial, and Child-Centered Response

Medical assistance, psychological first aid (PFA), and child-centered relief constitute interconnected dimensions of disaster response, particularly in flood contexts where physical, psychological, and social vulnerabilities overlap.

Health risks evolve over time during flood events. In the immediate aftermath, injuries related to submerged debris and evacuation processes are common, while prolonged inundation increases the prevalence of skin infections, waterborne diseases, and allergic reactions. Geohazard-informed planning supports medical response by linking spatial patterns of inundation with anticipated health risks, enabling adaptive allocation of medical personnel and supplies.

Psychological First Aid plays a critical role in addressing emotional distress, especially among children and families experiencing displacement and isolation. Access constraints often limit psychosocial outreach, making spatial prioritization essential. CRAST's experience demonstrates that focusing PFA efforts on isolated communities identified through geohazard observation enhances effectiveness and reach.

Child-centered relief further contributes to restoring normalcy through nutritional support, educational activities, and opportunities for play. Field observations from CRAST highlight how simple interventions—such as distributing books, facilitating reading sessions, and providing child-friendly food—generate significant emotional relief and contribute to psychological recovery and community resilience.

I. Integrated Operations, Coordination, and Transferable Lessons

The multi-dimensional nature of disaster relief underscores the need for integrated operational planning. Logistics, medical care, psychosocial support, child protection, and infrastructure support must be coordinated within a shared spatial understanding of hazard and access constraints.

Geohazard assessment provides a common reference point that facilitates coordination among diverse humanitarian actors. By aligning interventions within a geohazard-informed framework, humanitarian operations can reduce duplication, minimize gaps in coverage, and enhance overall effectiveness. This integrative role is particularly important in complex flood responses involving multiple organizations operating under severe constraints.

The lessons derived from this study demonstrate that geohazard-informed operational planning functions not as a technical add-on, but as a unifying logic that connects scientific reasoning with humanitarian action. These insights are transferable to other disaster contexts and underscore the broader value of integrating spatial hazard understanding into emergency response practice.

Taken together, the findings presented in this discussion demonstrate that geohazard assessment functions not as a technical add-on, but as a unifying operational logic that connects access, prioritization, resource allocation, and humanitarian ethics. This synthesis underscores the central argument of the study: effective disaster relief requires scientific reasoning that is operationally grounded, ethically defensible, and responsive to real-world constraints.

CONCLUSION

This study demonstrates that integrating geohazard assessment into emergency response practices strengthens the effectiveness, accountability, and adaptability of disaster relief operations. Using flood response in Sumatra as a case study, the analysis shows how even limited satellite-based observations can support situational awareness and guide operational decision-making under uncertainty.

Beyond its operational implications, this study highlights the importance of evidence-informed learning processes in humanitarian education and professional capacity building.

While focused on flood response, the conceptual approach outlined here is transferable to other disaster contexts characterized by access constraints and rapid decision-making requirements.

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