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Dealing with Hazards in Harmony: Participatory Mapping of Flood and Landslide Evacuation Routes in Sompok, Imogiri, Bantul, Indonesia

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Abstract This study aimed to strengthen disaster resilience in Sompok Hamlet, Imogiri, Bantul Regency, Indonesia, through the implementation of Community-Based Disaster Risk Reduction strategies. The study developed flood and landslide hazard maps using participatory mapping, field surveys, and focus group discussions and used these outputs to design evacuation routes and supporting signage for community use. The case study was situated in the post-disaster context of the 2017 Cempaka Cyclone, which triggered severe flooding and landslides in the area. The study produced a maximum flood inundation map, delineated landslide-affected zones, and identified a safe evacuation route. These maps will be very useful in improving the communities' capacity to deal with disasters in the future. The integration of the Sipendil landslide early warning system and the flood and landslide hazard maps into community-based disaster education and local tourism management is also expected to improve preparedness in Sompok. These findings provide practical evidence for localized disaster risk reduction and may offer a transferable model for similar hazard-prone communities.

1. INTRODUCTION

Sompok Hamlet is located on the floor of the Oyo Valley, which separates the Baturagung Mountain Range, and the hamlet has distinctive natural and cultural resources. Administratively, Sompok Hamlet is part of Sriharjo Village, Imogiri Sub-district, Bantul Regency, Special Region of Yogyakarta, Indonesia (Figure 1). The Sompok community is exposed to multiple natural hazards, including flooding, landslides, and extreme weather, and these risks are intensified by climate change (IPCC, 2022). In this context, the concept of living in harmony with disaster is particularly relevant for Sompok. This concept recognizes that disasters cannot be fully prevented, but their impacts can be reduced through preparedness and adaptive capacity. The approach integrates local culture, traditional knowledge, and contemporary risk reduction measures into a coordinated strategy. Rather than emphasizing post-disaster emergency response alone, it prioritizes sustainability and community-based disaster risk reduction by involving residents throughout disaster planning, preparedness, and response (Soetanto et al., 2022).

A practical application of living in harmony with disaster is the planning of effective evacuation routes. Participatory mapping enables residents to identify safe and feasible routes that reflect local topography, exposure, and hazard-prone zones. Evidence from mitigation programs in India indicates that participatory mapping can increase disaster risk awareness and support decision-making during emergencies (Samaddar et al., 2022). Related work in the

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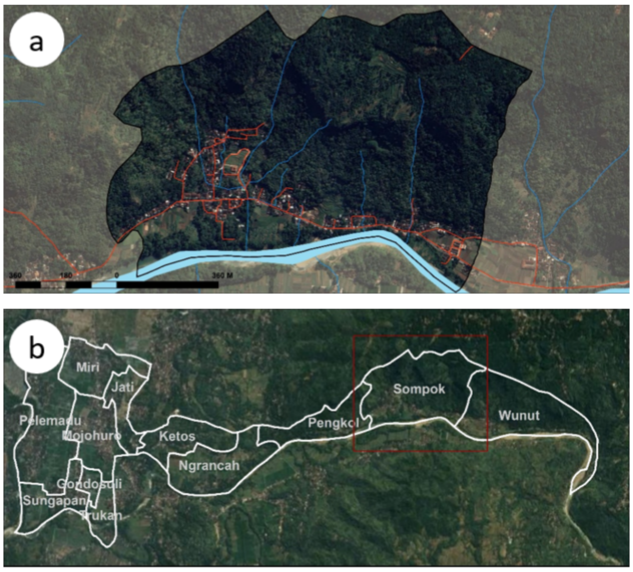

Figure 1 . Sompok Hamlet, (a) location of the hamlet, (b) setting within the Oyo River valley, Bantul Regency, Indonesia.

densely populated urban area of Kotagede, Yogyakarta, shows that community engagement in mapping can help address disaster risks in settings where risk reduction is closely linked to cultural heritage (Hizbaron et al., 2015). Applying a comparable approach in Sompok Hamlet could support the development of safer and more efficient evacuation routes, strengthen local understanding of hazard exposure, and improve preparedness. Clearly defined and well-communicated routes may shorten evacuation time, support coordination, and reduce potential losses and casualties.

Before participatory mapping is implemented, the disaster risk scope should be defined to provide a basis for mitigation planning. In Bantul Regency, including Imogiri and Sompok, the primary hazards include flooding, landslides, and extreme weather (IFRC, 2023). Historical records indicate recurrent damaging events, including the 2017 flood that displaced hundreds of residents and a landslide in 2022 that damaged homes. Defining the hazard scope is necessary for identifying risk drivers, mapping vulnerable locations, and developing mitigation measures that enable timely and effective community response (Maskrey, 2011).

Strengthening disaster risk management under recurrent threats also requires engagement across stakeholders. Training, simulations, and technical guidance can enhance community capacity to recognize risks, plan evacuations, and manage hazard impacts (Gaillard & Mercer, 2013). Community-Based Disaster Risk Reduction programs can further support local awareness and resilience (Wisner et al., 2012). In Sompok, collaboration with local tourism groups, such as Pokdarwis (tourism awareness group), is also relevant for integrating risk reduction with the development of nature- and culture-based tourism. This integration can reduce risk while supporting local livelihoods and economic resilience (Cutter et al., 2008).

The need for assistance and strengthening of disaster mitigation in Sompok is vital for ensuring community sustainability and well-being. Implementing community-based disaster risk reduction (CBDRR) initiatives is crucial for building a resilient community that can effectively reduce the impacts of disasters. By empowering local residents and integrating disaster risk reduction into local development plans, Sompok could serve as a model for sustainable, disaster-resilient communities. This community service-based research aims to (1) create a flood and landslide hazard map through participatory mapping, FGD, and field survey; and (2) develop evacuation routes based on flood and landslide hazards, together with signage infrastructures. This research is expected to provide new insights into the development of disaster risk reduction (DRR) strategies at a very local scale.

2. METHOD

Community-Based Disaster Risk Reduction (CBDRR) activities were implemented in Sompok Hamlet, Sriharjo Village, Imogiri Sub-district, Bantul Regency, from July to October 2024. Participatory mapping was used to identify potential hazards, including landslides and floods. In addition, the safest evacuation route was developed based on mapped flood- and landslide-prone areas. The road dataset was derived from the RBI (Rupa Bumi Indonesia) topographic map at a scale of 1:25,000. However, evacuation routes were mapped through on-screen tracing and field verification to ensure suitability for the Sompok Hamlet mapping scale, with a minimum target scale of 1:10,000.

2.1 Data acquisition

Potential hazards were identified and evacuation routes were determined through two main stages, focus group discussion (FGD) and validation through a field survey. FGD is a participatory method used to explore and gather information about a social phenomenon within small groups (Kumer & Urbanc, 2020; O.Nyumba et al., 2018). In this study, 18 participants took part in the FGD, representing local leaders, farmers, women's groups, and youth organizations. The FGD guided participants to (1) recall past disaster events; (2) identify areas affected by floods and landslides; (3) discuss existing evacuation practices; and (4) propose potential assembly points. Participants annotated base maps with their local knowledge, and these annotations were subsequently digitized for spatial analysis. FGD activities emphasized participatory mapping, in which participants delineated flood inundation and landslide locations on the provided map. During the FGD, community members served as primary informants with firsthand knowledge of conditions in Sompok Hamlet. The data collected included the maximum flood inundation extent and areas that had experienced landslides.

The preliminary flood and landslide hazard maps then informed the field survey and validation. The field survey was used to verify mapped hazard locations, identify high-risk areas requiring attention, and select safe and efficient

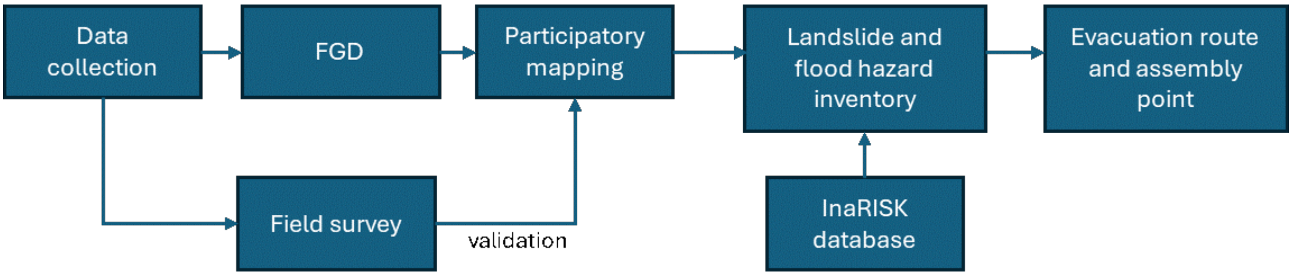

Figure 2 . Workflow of this research

evacuation routes. The survey also assessed the accessibility of roads and bridges to determine whether proposed routes could be used during emergencies. The field survey produced a dataset of verified evacuation routes for dissemination to residents.

2.2 Data processing and analysis

The study employed a Public Participatory Geographic Information System (PPGIS) approach. PPGIS represents a collaborative approach between cartographers and local communities (Sieber, 2006) and is operationalized at the community level through participatory mapping. Participatory mapping is widely used for disaster mapping and for documenting local knowledge related to hazard experience and response practices (Cadag & Gaillard, 2012; Klonner et al., 2021; Reichel & Frömming, 2014).

The spatial data integrated within the PPGIS framework included houses, maximum flood inundation areas, landslide-affected areas, and the road network. A comparison with InaRISK was also conducted to validate and contextualize community-based findings. InaRISK hazard maps were obtained from the official BNPB platform (`https://inarisk.bnpb.go.id/`) and provide national-scale classifications of flood and landslide hazards. In this study, InaRISK served as a reference layer within the methodological framework, while differences between InaRISK and community-based mapping are presented in the Results section. Mapping scale and technical procedures were tailored to the hamlet context. Road network data were derived from the RBI topographic map at a scale of 1:25,000, while evacuation routes were mapped through direct field surveys from residential areas to designated assembly points, supported by GPS tracking. The routes were refined to a scale of 1:10,000 to improve local positional accuracy. All datasets were integrated to produce hazard maps, evacuation routes, and proposed locations for evacuation signage. Figure 2 summarizes the methodological workflow.

3. RESULT AND DISCUSSION

3.1 Hazards Inventory

The government, through InaRISK, has produced regional risk maps that include flood and landslide information (`https://inarisk.bnpb.go.id/`). The landslide map is broadly consistent with local topography, as the hilly area is classified as a high-hazard zone, and nearly half of Sompok is categorized as high hazard by InaRISK. However, InaRISK does not classify Sompok as susceptible to flooding. A comparison of the two hazard-mapping approaches in Sompok indicates that regional maps are not sufficient as a basis for DRR at a very local scale (Figure 3). In this context, PPGIS is a valuable tool for strengthening local DRR strategies, particularly because it captures community experience as direct evidence of past events. Similar findings were reported by Bullen & Miles (2024) and Ariza-Álvarez & Soria-Lara (2024), who showed that PPGIS can bridge gaps between official hazard modelling and community perceptions, while supporting scenario planning in disaster management.

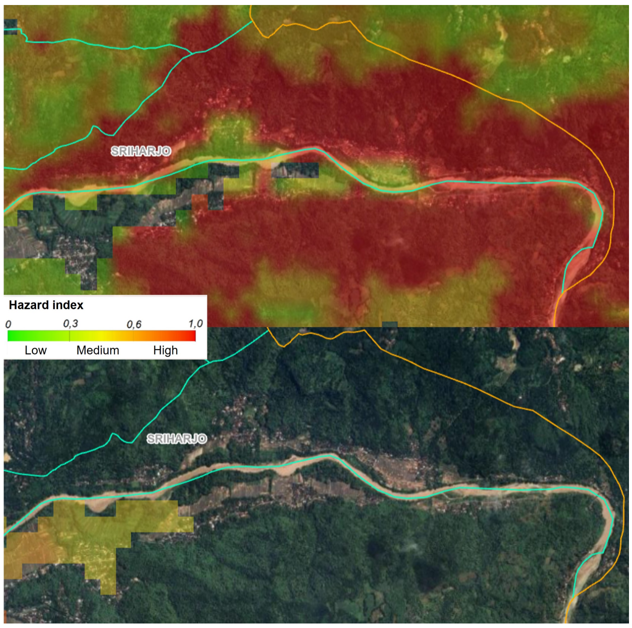

Figure 3 . Landslide and flood hazards in Sompok based on InaRISK

While InaRISK identifies Sompok as highly susceptible to landslides but not to floods (Figure 3), PPGIS indicates that both floods and landslides occurred and remain salient in community memory. Comparison of InaRISK (Figure 3) with PPGIS outputs (Figure 4 and Figure 5) illustrates how regional hazard models may underrepresent local-scale variability. In contrast, participatory mapping yields finer-grained information grounded in residents' lived experience, which can provide a stronger basis for community-based DRR.

In this study, PPGIS provided a more representative depiction of post-disaster conditions following the 2017 event. The 2017 Cempaka Cyclone was selected as the case study because it was the most recent event that produced severe impacts in Sompok Hamlet. Residents recalled the chronology and impacts in detail, and in several locations, visible traces of landslides and flood impacts remained. These events damaged settlement infrastructure and agricultural land. Following the event, several houses in Sompok Hamlet were relocated. The settlement subsequently became more concentrated in the hamlet center, forming a linear pattern along the main road.

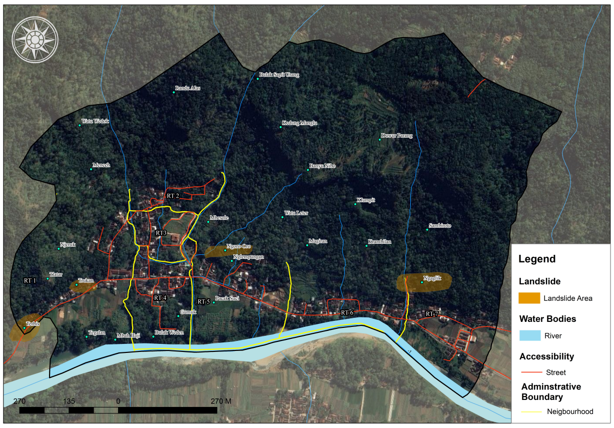

Figure 4 . Areas affected by landslides following the 2017 Cempaka Cyclone

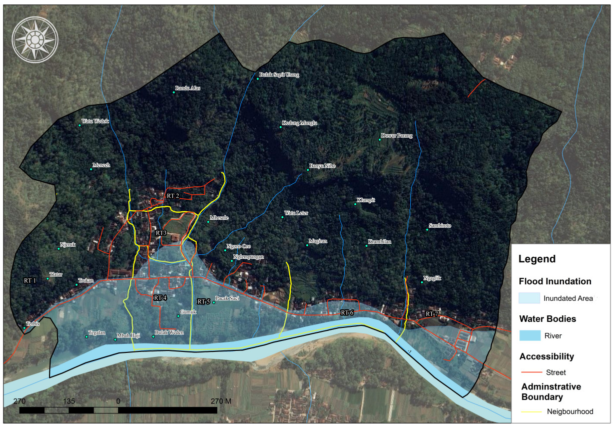

Figure 5 . Areas affected by flooding following the 2017 Cempaka Cyclone

Based on community narratives, four zones were affected by landslides in 2017 (Figure 4). These zones, including Terbis, Trukan, Ngoro-Oro, and Ngaglik, are located in the transition area between the foothills of the Baturagung Mountain Range and the Oyo River valley. The observed landslide types were primarily debris flows and rockfalls. Among the four zones, Terbis and Trukan remained densely populated residential areas where landslide susceptibility was still high, which implied continued risk to housing and local infrastructure.

The flood inundation associated with the 2017 Cempaka Cyclone extended across the Oyo River valley, which is dominated by settlements and croplands (Figure 5). The maximum inundation reached approximately 250 m from the river, affecting houses and agricultural fields. Although river levels receded rapidly, physical signs of inundation remained. Community accounts also recalled a similar event more than 30 years earlier. At that time, houses were located closer to the river, and the inundation was perceived as more severe. Following those experiences, residents relocated houses farther from the river. However, in 2017, inundation still extended to considerable distances and affected many homes. To strengthen preparedness, one proposed DRR measure is the provision of inflatable boats for emergency use.

Figure 6 . (a) Sanggar Seni Budaya Tamansari as an assembly point with a large field behind (b) Road conditions along selected evacuation routes (c) Community-based installation of evacuation signage

3.2 Mapping the evacuation route

All roads in Sompok were mapped, and an overlay analysis was conducted between the road network and areas affected by landslides and floods following the Cempaka Cyclone. Evacuation routes were then identified to avoid hazardous zones. The overlay analysis was also used to select an assembly point at Sanggar Seni Budaya Tamansari (Figure 6), which includes a large open field and a multipurpose building.

Figure 7 presents the evacuation routes and the designated assembly point, illustrating the spatial relationship among hazard zones, road networks, and safe gathering points. Routes were surveyed in the field using GPS tracking to establish direct connections from residential areas to the assembly point and to support safe and efficient evacuation. Sompok Hamlet has also experienced tourism development, with new attractions including homestays, camping, riverside cycling, and a riverside playground. The evacuation map supports dissemination of essential information to visitors, enabling those engaged in tourism activities to identify evacuation routes and the nearest assembly point in the event of an emergency. In addition, maps produced through PPGIS can serve as tools for disaster education for tourists and the wider community (Figure 7).

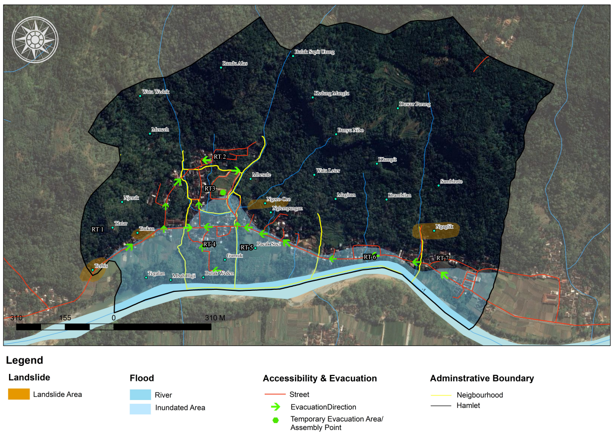

Figure 7 . Evacuation route map in Sompok designed based on past flood and landslide events

The installed Sipendil landslide early warning system (Figure 8) represented another key output of this study. Sipendil operates using rainfall thresholds through a simple mechanism intended to be easily understood. When rainfall recorded by the gauge exceeds a predefined threshold, an alarm is activated to warn residents. The system is also equipped with LED lights that automatically turn on when the threshold is exceeded, enabling people with hearing impairments to recognize the warning. When integrated with PPGIS hazard maps and evacuation routes, Sipendil strengthens community response capacity by linking real-time monitoring with established evacuation procedures.

Recent studies have shown that optimized evacuation routes and community participation can reduce evacuation time and improve overall safety (Mizumura et al., 2024; Zikeloglou et al., 2024), and highlighted the added value of co-creating DRR strategies with multiple stakeholders (Vollmer et al., 2025). In addition, integrating early warning systems with community-based mapping requires inclusive governance as well as technical capacity. Lempert et al. (2023) reported that a participatory co-design process in Sitka, Alaska, produced a decentralized landslide warning system aligned with local needs and values, which strengthened technical functionality and increased community trust and ownership.

Figure 8 . Community-based installation of Sipendil. Sipendil is a rainfall-threshold landslide early warning system based on rainfall scenarios

4. CONCLUSION

The implementation of Community-Based Disaster Risk Reduction (CBDRR) activities in Sompok Hamlet produced findings that strengthened community resilience and preparedness. By mapping hazard-prone areas based on the impacts of the 2017 Cempaka Cyclone and developing safe evacuation routes, this research supported residents in understanding and reducing flood and landslide risks. The integration of the Sipendil landslide early warning system and the dissemination of evacuation maps to the local tourism sector further enhanced preparedness. Participatory mapping was central to this process because residents hold detailed knowledge of local environmental conditions and risk patterns. This participatory approach fostered community ownership of disaster risk reduction strategies and positioned Sompok as a model for integrating disaster resilience into community development, particularly as a reference for other hamlets in Yogyakarta. Overall, the findings provide a practical framework for other areas facing similar hazards and contribute to efforts to develop sustainable, disaster-resilient communities.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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