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Historical Patterns of Mount Merapi Eruptions: Understanding the Century Cycle and Its Implications for Community Preparedness Education, 1768-2010

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Abstract: Mount Merapi is one of the most active volcanoes in Indonesia, yet public understanding of its long-term eruption pattern remains limited. Most people are more familiar with short-term volcanic activity than with the possibility of major eruptions recurring within a longer historical cycle. This study aims to analyze the historical eruption pattern of Mount Merapi from 1768 to 2010 and to examine its implications for community preparedness education. The study uses the historical method, including heuristic data collection, source criticism, interpretation, and historiography. Primary and secondary historical sources on Merapi's eruptions were critically reviewed and synthesized to identify long-term patterns and their social impacts. The findings show that Merapi's major destructive eruptions tend to appear within a century-scale cycle, particularly the eruptions of 1930 and 2010, both of which caused severe casualties and widespread damage. The 2010 eruption was widely regarded as unexpected, but historical evidence suggests that it was part of a recurring long-term pattern. These findings reveal a gap between historical knowledge and public disaster awareness. This study contributes to Indonesian disaster historiography by offering a long-term interpretation of volcanic disasters and by emphasizing the importance of integrating historical eruption records into disaster risk reduction and community preparedness education.

Abstrak: Gunung Merapi merupakan salah satu gunung api paling aktif di Indonesia, tetapi pemahaman masyarakat tentang pola erupsi jangka panjangnya masih terbatas. Masyarakat umumnya lebih mengenal aktivitas vulkanik jangka pendek daripada kemungkinan terjadinya erupsi besar yang berulang dalam siklus sejarah yang lebih panjang. Penelitian ini bertujuan untuk menganalisis pola erupsi historis Gunung Merapi dari tahun 1768 hingga 2010 serta mengkaji implikasinya bagi pendidikan kesiapsiagaan masyarakat. Penelitian ini menggunakan metode historis yang meliputi heuristik, kritik sumber, interpretasi, dan historiografi. Sumber-sumber sejarah primer dan sekunder mengenai erupsi Merapi ditelaah secara kritis dan disintesiskan untuk mengidentifikasi pola jangka panjang serta dampak sosialnya. Hasil penelitian menunjukkan bahwa erupsi besar yang merusak di Merapi cenderung muncul dalam siklus skala abad, terutama pada erupsi tahun 1930 dan 2010 yang menimbulkan korban jiwa besar serta kerusakan luas. Erupsi 2010 selama ini dianggap tidak terduga, padahal bukti historis menunjukkan bahwa peristiwa tersebut merupakan bagian dari pola jangka panjang yang berulang. Temuan ini menunjukkan adanya kesenjangan antara pengetahuan sejarah dan kesadaran bencana masyarakat. Kajian ini berkontribusi pada historiografi bencana Indonesia dengan menawarkan pembacaan jangka panjang atas bencana vulkanik serta menegaskan pentingnya integrasi catatan erupsi historis ke dalam pengurangan risiko bencana dan pendidikan kesiapsiagaan masyarakat.

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INTRODUCTION

Volcanic disasters have long shaped human–environment interactions in the Indonesian archipelago, a region situated along the Pacific Ring of Fire. Among Indonesia's most active volcanoes, Mount Merapi occupies a distinctive position due to its high eruption frequency, long historical record, and dense human settlement on its slopes. Written documentation of Merapi's eruptions dates back to the early Dutch colonial period in the seventeenth century, while earlier eruptions are reconstructed mainly through relative dating and geological evidence. Available data indicate that between approximately 3000 and 250 years ago, at least 33 eruptions occurred, including seven major events, suggesting a recurrence interval of large eruptions ranging from 150 to 500 years (Kemerling, 1920; Permana et al., 2017; DiTirro, 2018).

During the so-called "New Merapi" period, major eruptions were recorded in the eighteenth and nineteenth centuries (1768, 1822, 1849, and 1872) and again in the early twentieth century (1930–1931). Nineteenth-century eruptions were significantly larger than those in the twentieth century, with pyroclastic flows reaching up to 20 km from the summit, indicating a possible recurrence of major eruptions approximately every 100 years (Permana, 2015). Since the seventeenth century, Merapi has erupted more than 80 times, with an average repose period of four years and intervals ranging from one to eighteen years. However, historical evidence demonstrates that longer repose periods do not necessarily correlate with eruption magnitude, as both short and long dormancy phases have preceded major and minor eruptions alike. This variability underscores the importance of magma chemistry and physical properties rather than repose duration alone in determining eruption scale (Kemerling, 1920; First et al., 2021).

From a physical perspective, Merapi's eruptions are characterized by the slow extrusion of magma, forming lava domes with volumes of up to 0.9 million cubic meters, accompanied by intense fumarolic and solfataric activity. The Garuda Peak represents one of the most prominent geomorphological features associated with recent lava dome growth and serves as a key observation point for ongoing volcanic activity (Tsai et al., 2015; Mulligan & Nadarajah, 2012; Moningka & Simanjuntak, 2024). According to records from the Sleman Regional Disaster Management Agency (BPBD), Merapi exhibits short eruption cycles of 2–5 years, medium cycles of 5–7 years, and, historically, long cycles exceeding 30 years, particularly during its early developmental phases. Since the nineteenth century, eruption records have become more continuous, reinforcing the need for heightened community preparedness, as dramatically illustrated by the 2010 eruption (Permana et al., 2017).

Despite the extensive geological and volcanological literature on Merapi, historical scholarship on disasters in Indonesia has evolved more slowly. Early studies tended to frame disasters as purely natural events, emphasizing physical processes and immediate impacts. However, since the late twentieth century, historians and geographers have increasingly conceptualized disasters as socio-environmental phenomena, shaped by long-term interactions between natural hazards, human settlement patterns, and political decision-making. In this historiographical shift, disasters are no longer seen as isolated events but as historically embedded processes that reveal changing human–environment relations (McDonald-Harker et al., 2021).

Within Indonesian disaster historiography, colonial archives have been crucial for reconstructing past volcanic activity, yet they often marginalize indigenous knowledge and the everyday experiences of local communities. More recent studies have sought to address this limitation by incorporating oral histories, local cosmologies, and community-based risk management practices. This growing body of work situates volcanic disasters within broader environmental histories, highlighting how eruptions have influenced land use, agricultural systems, demographic change, and cultural perceptions of risk over time (Ismawati & Irawan, 2023).

Historical geography provides a particularly valuable framework for analyzing volcanic disasters because it integrates spatial and temporal dimensions of change. From this perspective, Mount Merapi is not merely a site of recurring eruptions but a historically produced landscape, continually reshaped by volcanic processes and human adaptation. Settlement expansion, infrastructure development, and shifting administrative boundaries have altered patterns of exposure and vulnerability, often amplifying disaster risk despite advances in monitoring technology. Historical-geographical analysis thus enables a deeper understanding of how past land-use decisions and spatial planning practices continue to shape present-day disaster outcomes (Kemerling, 1920; Finaka, 2019).

This study is positioned within the tradition of environmental history, which emphasizes reciprocal relationships between humans and the natural environment. In the case of Merapi, eruptions have

generated both destruction and fertility, creating a paradox that has sustained long-term habitation in high-risk zones. Communities living on Merapi's slopes have developed adaptive strategies informed by historical experience, cultural beliefs, and practical knowledge of volcanic behavior. At the same time, state-led disaster management policies have increasingly formalized risk governance, sometimes producing tensions between local knowledge systems and scientific or bureaucratic approaches (First et al., 2021).

To analyze these dynamics, this study employs a conceptual framework that integrates the disaster cycle, community resilience theory, and historical-geographical approaches. The disaster cycle concept conceptualizes eruptions as recurring processes consisting of pre-disaster preparedness and mitigation, emergency response, and post-disaster recovery and reconstruction. Applying this framework to Merapi allows for an examination of how lessons from past eruptions have—or have not—been institutionalized over time (Gusti, 2024).

Community resilience theory is used to assess the capacity of local populations to absorb, adapt to, and recover from volcanic hazards. Resilience in this context extends beyond material resources to include social networks, collective memory, leadership structures, and culturally embedded knowledge of Merapi's behavior. Historical experience plays a critical role in shaping these forms of resilience, influencing how communities interpret warning signs and respond to evacuation orders (Permana & Hartanto, 2019).

Finally, a historical-geographical approach underpins the spatial analysis of disaster impacts and adaptation strategies. By tracing changes in settlement patterns, hazard zonation, and land-use practices across different historical periods, this approach reveals how vulnerability and resilience are unevenly distributed across space and time. Integrating these perspectives enables a more comprehensive understanding of Merapi's eruptions as both natural events and historically contingent disasters.

By combining long-term eruption records with historiographical analysis and an interdisciplinary conceptual framework, this study contributes to international debates on environmental history and disaster studies. It demonstrates the value of historical-geographical perspectives for understanding volcanic risk in densely populated regions and offers insights into how historical experience can inform more socially grounded and sustainable approaches to disaster risk reduction in Indonesia and beyond.

METHOD

This study employs a historical approach to critically and systematically reconstruct past events. The historical method is applied to transform verified historical facts into a coherent, analytical, and academically accountable narrative. The temporal scope of this research spans from 1768 to 2010, which is divided into several analytical phases to capture continuity and change across periods. The methodological framework consists of four interrelated stages: heuristics, source criticism, interpretation, and historiography.

The heuristic stage focuses on identifying and collecting relevant historical sources. Data were obtained through an extensive literature review encompassing both primary and secondary sources. Primary sources include authoritative works and interpretations by historians from Universitas Gadjah Mada, particularly Prof. Djoko Suryo, whose scholarship provides firsthand academic insight into the historical context under study. In addition, official government documents, archival materials, and contemporaneous records were consulted to support empirical accuracy.

Secondary sources consist of peer-reviewed journal articles, academic books, research reports, and newspaper publications relevant to the research theme. Source selection was guided by criteria of relevance, temporal proximity, academic credibility, and thematic alignment with the research objectives.

Source criticism was conducted to ensure the authenticity, reliability, and validity of the collected data. This process involved both external and internal criticism. External criticism examined the origin, authorship, publication date, and material integrity of each source to confirm its authenticity. Internal criticism assessed the credibility of content by evaluating consistency, objectivity, potential bias, and coherence within and across sources.

Cross-referencing between primary and secondary sources was systematically employed to verify factual accuracy and to minimize interpretative distortion. Sources deemed irrelevant, inconsistent, or methodologically weak were excluded from the analysis.

The interpretation stage involved analyzing and contextualizing verified historical facts within broader social, political, economic, and cultural frameworks. Historical data were not treated as isolated events but were examined in terms of causali-

ty, structural patterns, and historical continuity and transformation over time.

A contextual analytical framework was applied to interpret relationships among events and to explain historical dynamics within the period under study. This approach enables a nuanced understanding of both short-term developments and long-term structural changes.

The final stage, historiography, consists of synthesizing interpreted data into a structured historical narrative. The narrative is organized chronologically and thematically to ensure analytical clarity and coherence. Emphasis is placed on integrating empirical evidence with critical analysis, in accordance with international standards of scholarly historical writing.

The historiographical presentation aims to balance analytical rigor with narrative clarity, allowing historical processes to be articulated as an interconnected and meaningful account rather than a mere compilation of facts.

ERUPTION HISTORY

This study examines the historical sequence of Mount Merapi eruptions from 1768 to 2010 and their socio-cultural impacts, focusing on four distinct periods: Early Colonial (1768–1830), Late Colonial (1830–1930), Post-Independence (1945–1998), and Reform Era (1998–2010). Data were derived from BPBD records, archival documents, and semi-structured interviews with local stakeholders, particularly volunteers involved in the 2010 eruption (Kemerling, 1920; Permana et al., 2017; DiTirro, 2018).

According to records from the Sleman Regional Disaster Management Agency (BPBD) in Yogyakarta, Mount Merapi erupts in short cycles, occurring every 2–5 years, while medium cycles erupt every 5–7 years. The longest recorded cycle occurred after a hiatus of >30 years, particularly during the early days of its existence as a volcano. Entering the 19th century, records of Mount Merapi's activity became continuous, requiring communities in the Mount Merapi area to be more prepared and alert.

The eruption of Mount Merapi is characterized by magma slowly escaping from the volcano's body and accumulating at the summit, forming a lava dome with a volume of 0.9 million cubic meters. Within the lava dome and its surroundings, volcanic gases and water vapor are manifested as solfatar/fumarole fields. Garuda Peak, a lava product resembling a Garuda bird, is the highest point of Mount Merapi and a good place to view the still-active lava dome.

Mount Merapi eruptions always follow a lengthy process, beginning with dome formation, incandescent lava flows, and pyroclastic flows, which, by definition, mark the onset of an effusive eruption. The Regional Disaster Management Agency (BPBD) recorded 16 eruptions between 1822 and 2010. The consequences of a Merapi eruption are fatalities.

According to an interview conducted by researchers with Mr. Wawan, a volunteer from the Sleman Regional Disaster Management Agency (BPBD) in Yogyakarta, who served as a volunteer during the 2010 Merapi eruption, Mr. Wawan explained:

> The Merapi eruption occurred on Tuesday, October 10, 2010, and on Friday at 12:15 a.m. Many residents of the Cangkringan area did not expect such a large eruption. Their experience with the 2006 eruption indicated that the eruption was not directed toward Cangkringan, but toward the Kelaten area.

Natural events cannot be prevented, and we never know when they will occur. If Mount Merapi is committed to keeping its promises, it will not break them. Although Mount Merapi had already given warnings before the very large eruption, on Wednesday, October 8, 2010, it emitted a pyroclastic flow and three loud rumbling sounds (gludug gludug).

Throughout history, Mount Merapi eruptions have resulted in fatalities and injuries. Records from the Sleman BPBD regarding the number of casualties throughout Mount Merapi's eruptions can be seen in Table 1.

During the evacuation, many volunteers were trapped by hot clouds, as the 2010 eruption of Mount Merapi was unpredictable and its magnitude could not be measured. Volunteers panicked as everything was in disarray. The bunkers built by the government for the community failed to function as intended, sheltering the population, but instead served as mass burial sites for many trapped residents (Permana et al., 2017).

The 2010 Mount Merapi eruption resulted in 347 deaths and 258 injuries. According to Mr. Wawan, the victims were mostly men, as they were already in evacuation centers on Saturday, but many returned to Merapi to check on their relatives. Previous Merapi eruptions in 2001 and 2006 were less dangerous, with many people trapped by the pyroclastic flows because they outran them. The 2010

Table 1. Eruption of Mount Merapi

No	Year of Eruption	Number of Deaths	Number od Injured
1.	1822	100	None
2.	1832	32	None
3.	1872	200	None
4.	1904	16	None
5.	1920	35	None
6.	1930	264	None
7.	1954	64	57
8.	1961	6	None
9.	1969	3	None
10.	1976	29	2
11.	1994	66	6
12.	1997	None	None
13.	1998	None	None
14.	2001	None	None
15.	2006	2	None
16.	2010	347	258

Source: BPBD Sleman Document, 2016

Mount Merapi eruption claimed a significant number of lives. Data from the Sleman Regional Disaster Management Agency (BPBD) recorded 258 injuries and 347 deaths (BPBD Sleman, 2010).

The sudden eruption caused the volunteers tasked with providing early warning by sounding the sirens for signs of disaster to fail, as panic swept through Cangkringan, forcing the entire Cangkringan community to flee. The gongs (gongs) used by the community to warn of danger also failed, as people scrambled to save their belongings (Permana et al., 2017).

Mr. Wawan, a member of the Merapi Eruption Volunteer Team, recounted how his fellow volunteers, tasked with retrieving Mbah Maridjan, became trapped on their way to retrieve him. Mbah Maridjan's attitude is worthy of emulation, as he demonstrated a strong sense of responsibility to the community, refusing to descend until everyone else had. Therefore, the volunteers focused on rescuing the community first, as Mbah Maridjan had instructed them to descend after everyone else had.

At the time, Mbah Maridjan had warned the community to descend immediately, but according to Mr. Asih, some refused to listen; instead, the volunteers and community sat and watched the eruption. They failed to realize that a Merapi eruption could occur at any time, and there was no way to prevent it. We can only strive to remain vigilant as early as possible.

The 2010 Merapi eruption was the largest of Mount Merapi's eruptions, surpassing the 2001 and 2006 eruptions. While natural disasters cannot be prevented, the number of casualties can be minimized if the community is prepared for the threat of an eruption, as it can strike at any time, and its magnitude is unpredictable (Permana et al., 2017).

The 2001 eruption was categorized as minor because it only reached the Timangti area, or the first climbing post, and did not reach residential areas. The 2006 eruption was categorized as moderate because, according to informants, the eruption reached residential areas in Petung Hamlet. Meanwhile, the 2010 eruption of Mount Merapi was categorized as major because almost the entire subdistrict was affected (Permana et al., 2017).

Many people did not anticipate the magnitude of the 2010 eruption, as in previous years, in 2001 and 2006, Mount Merapi had only produced small eruptions. When the 2001 eruption occurred, it was small in scale, and the community was already on alert and had already gone to evacuation centers.

Mount Merapi has become a vital part of the lives of the surrounding communities. Nature has provided so much for them that the traditions of each village, such as traditional ceremonies honoring nature, reflect their perspective on nature and all its contents. As actors in their lives, the community consistently places itself under the will of the Almighty Creator of Nature.

The community prioritizes harmony with nature to achieve safety and well-being. Culture, as a guideline for community life, also contains knowledge for interpreting the natural and social environments around them.

Many did not anticipate the magnitude of the 2010 Mount Merapi eruption, as the community experienced less severe eruptions in 2001 and 2006. The 2010 eruption came suddenly, causing panic and leaving many unprepared for safety measures and stranded. The community's experience over the years has been limited to small-scale eruptions.

The 2010 Merapi volcano eruption devastated residential areas, sending residents into panic, as no one had anticipated such a large eruption. Consequently, everyone panicked and scrambled to get down. Many were trapped because the arrival of the pyroclastic flow could not be prevented or predicted.

The aftermath of the Merapi volcano eruption left the affected communities without a foun-

dation for their livelihoods, from jobs and homes to basic necessities such as transportation, as lava flows cut off roads. The displaced people fled their homes and sought refuge in safer areas.

The Cangkringan area, before the 2010 eruption of Mount Merapi, was pristine and beautiful. Agriculture was the primary commodity, as the eruption of Mount Merapi brought blessings, particularly in the form of fertile soil.

The devastating eruption of Mount Merapi in 2010 left many residents of the Cangkringan area homeless and jobless. Residents who lost their homes were accommodated in evacuation shelters, including Gondang 1, Gondang 2, and Gondang 3 (BPBD Sleman, 2010).

Each shelter unit was built at a cost of between six and seven million rupiah, with a building area of 36 square meters, cement floors, bamboo walls, bamboo main pillars, and a zinc roof. Each unit consisted of two bedrooms and a living room and was equipped with bathrooms, washing facilities, and six lighting points. The establishment of these temporary shelters significantly assisted the homeless victims of the Mount Merapi eruption (BPBD Sleman, 2010).

The Mount Merapi eruption brought about significant environmental changes. These environmental changes occurred rapidly, as the community had to quickly adapt to new environmental conditions, which automatically altered the community's way of life.

Social change also occurred rapidly, causing confusion and culture shock. Social changes affecting the community's livelihoods include the development of tourism, as agricultural land cannot yet be reused.

The community always prioritizes harmony with nature to achieve safety and well-being. Culture, as a guide for community life, also contains knowledge for interpreting the natural and social environments around it.

In addition to the devastating impacts of the 2010 Merapi eruption, which caused significant losses in social, health, environmental, and material terms, the eruption also resulted in the loss of livestock, farmland, plantations, and jobs. The community had to find a way to meet their needs, so they switched careers to become lava tour developers.

The 2010 eruption of Mount Merapi was quite catastrophic. Many people died as a result of the eruption. Mbah Maridjan, a man assigned to be the caretaker of Mount Merapi, also died from exposure to the pyroclastic flow. During the eruption, residents living near Mount Merapi's slopes were asked to evacuate to avoid pyroclastic flows and prevent further casualties. The victims were sheltered in government-run evacuation centers (BPBD Sleman, 2010).

The eruption of Mount Merapi has had numerous impacts, both positive and negative, triggering social change. The negative impacts of this eruption include the loss of jobs, homes, and other necessities for people living near Mount Merapi. Their homes and belongings were razed to the ground by the pyroclastic flow.

The victims of the Mount Merapi eruption not only suffered material losses, but many also felt grief and even depression due to the loss of loved ones who died due to the pyroclastic flow (Finaka, 2019). Furthermore, many children missed school due to school closures.

Another negative impact of the 2010 Mount Merapi eruption was the loss of livestock and livelihoods for many residents. Currently, the government has provided temporary housing for the victims of the eruption and has replaced livestock lost or killed during the eruption. Despite the various negative impacts on the community, the Cangkringan area has brought its own blessings, even after Mount Merapi devastated its land. They believe that Mount Merapi will restore life by replacing the damage many times over. The positive impacts they are now experiencing include natural resources such as sand and stone, and their area has become a popular tourist destination.

Period I: Early Colonial Era (1768–1830)

During the early colonial era, Merapi's eruptive activity was not systematically recorded, but available historical sources indicate recurring dome-forming eruptions and pyroclastic flows consistent with modern Merapi behavior. Colonial administration responses were primarily oriented toward maintaining territorial control and economic stability, rather than addressing community resilience (Kemerling, 1920; Permana et al., 2017; DiTirro, 2018).

The impact of volcanic activity on forced agricultural systems was significant. In particular, volcanic disturbances exacerbated the already coercive cultivation system (*cultuurstelsel*), intensifying food insecurity and labor exploitation. Thus, the early colonial period shows a pattern of disaster-induced socioeconomic strain where volcanic hazards compounded colonial coercion rather than prompting protective governance. The findings align with earlier research that argues colonial administrations

prioritized resource extraction and governance over local welfare during natural disasters.

Period II: Late Colonial Era (1830–1930)

The late colonial era is marked by a transition from sporadic documentation to more systematic volcanic observation. This period also witnessed the development of early volcanological knowledge among colonial authorities, enabling better recording of eruption frequency and impact (Kemerling, 1920; Permana et al., 2017; DiTirro, 2018).

The 1930 eruption thus served as a critical benchmark demonstrating that Merapi's potential for major eruptions exceeded previous expectations. The event also highlighted the importance of integrating scientific knowledge with local vulnerability and social structure in disaster preparedness.

However, the most significant event of this era was the 1930 eruption, which stands as the largest recorded eruption of Merapi in the twentieth century. The eruption produced extensive pyroclastic flows and resulted in 264 fatalities. The scale of the disaster exposed the limitations of colonial disaster management, which remained largely reactive and insufficiently grounded in local risk perception. This aligns with the broader historical pattern of colonial risk governance, in which the state's capacity to manage natural hazards remained limited by technological constraints and institutional priorities.

Period III: Post Independence Era (1945–1998

Post-independence governance introduced formal institutional mechanisms for disaster management, including early warning systems and evacuation protocols. Despite these developments, Merapi's social context remained shaped by local cosmology and cultural resilience (Gunn, 2018).

During this period, the role of traditional authority, particularly the figure of Mbah Maridjan, became central in shaping local responses to volcanic threats. Mbah Maridjan's position as the guardian of Merapi's spiritual gate reflects the cultural integration of volcanic hazards into the local worldview, where ritual practices and community obedience are considered crucial to maintaining harmony with the mountain. These cultural frameworks acted as both a protective mechanism—encouraging collective awareness and ritual-based preparedness—and a potential barrier when they conflicted with state-led evacuation orders.

The findings demonstrate that cultural beliefs remain an influential determinant of disaster response. They highlight the need for risk communication strategies that respect local cosmology while promoting safety, consistent with studies emphasizing the role of cultural values in disaster governance.

Figure 1. Impact of the 2010 Mount Merapi Eruption (Source: Merapi Museum Documents, 2026)

Period IV: Reform Era (1998–2010)

The reform era is characterized by decentralization and increased local autonomy, which reshaped disaster management in Indonesia. The establishment of regional disaster management institutions allowed more localized decision-making, but also introduced challenges in coordination and resource allocation (Oktavianti & Fitriani, 2021).

The 2006 and 2010 eruptions provide a comparative lens to understand the evolving social dynamics of Merapi hazards. The 2006 eruption, though significant, was perceived as manageable by the local population. Many residents returned to normal activities shortly after the event, and the eruption was not perceived as a long-term threat. This experience contributed to a normalization of volcanic risk among residents, which became a crucial factor in the 2010 disaster.

The 2010 eruption, however, was sudden and far larger than anticipated, resulting in 347 deaths and 258 injuries (BPBD Sleman, 2010). The eruption's unpredictability and the speed of pyroclastic flows, estimated at 60–100 km/h, overwhelmed evacuation measures and exposed critical weaknesses in the warning system. Sirens and traditional bamboo alarms (kentongan) failed to coordinate effective evacuation due to widespread panic and chaotic movement. Additionally, the collapse of government-built bunkers illustrated the limita-

tions of infrastructure-based mitigation in the face of extreme pyroclastic events (Permana et al., 2017).

The interviews with BPBD volunteers revealed that many victims were men who returned to their homes after initial evacuation, driven by familial obligations and a sense of familiarity with past eruptions. This behavior aligns with the broader theme of "risk complacency," in which repeated, smaller eruptions reduce perceived danger, leading to fatal misjudgments during major events (Permana et al., 2017).

The study also reveals that Merapi is perceived as both a source of fear and a blessing. Residents of Cangkringan, for example, describe the volcanic environment as essential to their livelihoods, as lava deposits provide sand and stones used in construction and agriculture. Traditional ceremonies and rituals, therefore, function not only as spiritual practices but also as forms of environmental knowledge and risk adaptation. This duality is consistent with prior research showing that cultural practices can support resilience by fostering community cohesion and environmental awareness (Gunn, 2018).

However, the 2010 eruption exposed the tension between cultural attachment to the mountain and the need for modern risk management. The disaster demonstrated that traditional beliefs alone are insufficient to mitigate the risks of large-scale eruptions, and that integrated approaches combining scientific monitoring, institutional coordination, and culturally sensitive communication are essential (Permana et al., 2017).

The periodized analysis reveals that Mount Merapi's eruptions have been historically shaped by evolving governance structures, scientific knowledge, and local cultural perceptions. The 2010 eruption highlights a critical shift: despite improved institutional capacity, social vulnerability remains high due to risk normalization and inadequate risk communication. Therefore, effective mitigation must integrate scientific monitoring with community-based cultural understanding to reduce casualties and enhance resilience (McDonald-Harker et al., 2021).

GOVERNMENT POLICY IN EFFORTS TO MITIGATE POST-2010 ERUPTION DISASTERS

Establishing a Disaster Preparedness-Based Indonesian Planning School. The Indonesian Planning Schools Association (ASPI) is an organization that serves as a forum for planning schools in Indonesia. ASPI is a voluntary, non-profit, and non-political organization based on mutual benefit and cooperation. ASPI was established on March 31, 2000, following an agreement reached after several planning schools through the Declaration of Establishment of the Indonesian Planning Schools Association in Yogyakarta. ASPI is headquartered at Gadjah Mada University.

ASPI aims to accelerate the development and dissemination of planning science and the profession in Indonesia. This association aims to increase the presence of planning science as a stand-alone discipline, encourage planning schools to develop planning education, and facilitate planning schools' collaboration with government institutions/agencies, the private sector, and the community, both nationally and internationally.

The association of planning schools in the Special Region of Yogyakarta, led by Gadjah Mada University, has contributed to relocation activities and the planning of permanent housing (huntap) for communities affected by the eruption, including the construction of bunkers for the Cangkringan area in preparation for the eruption of Mount Merapi. The 2010 eruption revealed that the bunkers could not withstand the heat of the flowing lava, necessitating further evaluation to prevent further casualties (BPBD Sleman, 2010).

According to the 2008 National Strategy for Mainstreaming Disaster Risk Reduction (SNP2RB), Disaster Risk Reduction (DRR) is a systematic approach. DRR aims to reduce social and economic vulnerability to disasters, increase socioeconomic capacity and resilience to disasters, and address environmental and other hazards that contribute to vulnerability (SNP2RB, 2008).

The 2008 National Strategy for Disaster Risk Reduction (SNP2RB) defines Disaster Preparedness Education (PSB) in Indonesia as a body of knowledge related to risk-reduction efforts, including preparation, support, and community rebuilding (responsiveness) in the event of a disaster. This also includes mitigating the impacts of disasters, fostering preparedness, and emergency response to save communities (SNP2RB, 2008).

"Disaster Risk Reduction Policy in Education" is as follows. Firstly, The Indonesian Disaster Management Society (MPBI), which has taken the initiative to become a policy advocacy platform for implementing comprehensive disaster education. The MPBI explains that the goal of disaster education is to shift the public's perspective on disaster management from an emergency response perspective to comprehensive disaster management (MPBI, 2008).

Secondly, the Strategic Center for Disaster Risk Reduction (SC-DRR), based on a survey conducted among grassroots teachers and schools, found that they strongly support disaster education. In contrast, at the grassroots (decision-makers) levels, positive changes have also gradually been observed. Therefore, efforts to establish a platform and standardize disaster education materials should be undertaken simultaneously, considering that SC-DRR is currently inventorying various aspects of disaster management in the region (legal, formal, local government, schools, etc.) (SC-DRR, 2008).

Thirdly, KERLIP Foundation (Keluarga Peduli Lingkungan). Disaster education should be used as an advocacy tool for school resilience (for example, the Ministry of National Education already has standards for facilities and infrastructure, which can be promoted through disaster education). The vision of the National Strategy for Mainstreaming Disaster Risk Reduction (SNP2RB) (2008) is: "The realization of a culture of safety and preparedness for disasters through a decentralized education system capable of supporting disaster risk reduction through vulnerability reduction and capacity building in the education sector" (SNP2RB, 2008).

Therefore, universities, as the highest educational institutions, have been given the right to regulate their own education systems capable of supporting disaster risk reduction through vulnerability reduction and capacity building efforts. Therefore, concrete efforts to achieve this include reducing vulnerability and increasing capacity in the education sector through integration into the higher education system, including: (1) integrating DRR education into courses, thesis topics, and student activity units; (2) facilitating the development of DRR research in universities that can be utilized by district/city and provincial governments; (3) facilitating the development of disaster study centers at several universities. A simple understanding is that to transfer a complete substance to an object, it must begin with a source/subject filled with ready-made substance. Therefore, integrating DRR education into courses is important, as an initial step in efforts to reduce disaster risk into the higher education system.

CONCLUSION

Since 1768, Mount Merapi has experienced over 80 eruptions, of which several were classified as major events (VEI ≥ 3) occurring in the 19th century (1768, 1822, 1849, 1872) and the early 20th century (1930–1931). Historical records indicate that 19th-century eruptions were more intense, while 20th-century eruptions were more frequent. Large eruptions are estimated to occur approximately once every 100 years and are often explosive, producing pyroclastic flows reaching up to 15 km from the summit.

The spatial pattern of eruptions has shown significant temporal shifts. Between 1872 and 1931, eruptions were predominantly directed toward the west–northwest. After the major 1930–1931 eruption, the dominant flow direction shifted to the southwest, persisting until the 2001 eruption. Notable exceptions include the 1994 eruption, which flowed southward toward the upper Boyong River, and the 2006 eruption, which shifted southeastward, forming a crater opening toward the Gendol River. These observations highlight the dynamic nature of Merapi's eruptive behavior over time.

This study contributes to the historiography of volcanic disasters in Indonesia by providing a long-term perspective on eruption frequency, magnitude, and directional trends. By integrating historical records with geological observations, it establishes a critical baseline for understanding hazard patterns and informs adaptive risk mitigation strategies.

Future research should focus on: (1) detailed analyses of factors influencing directional changes in pyroclastic flows, including subsurface geological structures and crater morphology; (2) integration of archival, oral, and geological data to improve spatial and temporal resolution of past eruptions; (3) hazard modeling that incorporates historical eruption patterns to refine risk assessment; and (4) assessment of community adaptation strategies in response to changing eruption behaviors. These approaches can enhance predictive capacity and support more effective disaster preparedness in the Mount Merapi area.

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