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From Faults to Festivals: A Geotourism Strategy Based on Geological and Geophysical Analysis in Prambanan

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ABSTRACT

This study explores the development of geotourism in the Prambanan region of Yogyakarta by integrating geological, geophysical, and cultural data to design a strategic geotrail. Located along the Opak Fault and rich in volcanic history, Prambanan features diverse geosites such as Tebing Breksi, Lava Bantal Berbah, and Candi Abang. Through a multidisciplinary methodology combining geological mapping, gravity surveys, and cultural site assessments, six key geosites were evaluated using Kubalikova's framework. Tebing Breksi emerged as the most feasible site due to its rich pyroclastic breccia formations and cultural functions, while other sites showed moderate to high potential. Geophysical analysis using the Lacoste & Romberg gravitymeter revealed fault structures critical to infrastructure safety and disaster mitigation. The study proposes the development of integrated geotrails supported by educational panels, improved facilities, community involvement, and conservation strategies. By connecting geological significance with cultural heritage and local livelihoods, this research supports the sustainable enhancement of tourism infrastructure in Prambanan. The findings provide valuable input for policymakers, tourism planners, and educators, emphasizing the role of geoscience in destination development. Limitations include the need for deeper geotechnical and socio-economic impact studies. Future research may explore visitor engagement and smart tourism technologies for enriched geosite experiences.

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INTRODUCTION

Indonesia, situated on the Pacific Ring of Fire, possesses exceptional geological diversity due to its complex tectonic activity and volcanic history. This geological wealth offers significant opportunities for the development of geotourism, a form of sustainable tourism that emphasizes the appreciation of Earth's geological features while promoting environmental conservation, education, and local economic development. Geotourism not only enhances visitor engagement with nature but also supports communities through place-based learning and storytelling rooted in the land's formation and evolution (Koupatsiaris & Drinia, 2024; Sgobba et al., 2020).

Recent developments in geotourism have shown its potential in fostering regional development, especially in areas rich in both natural and cultural heritage (Al Farishi et al., 2025; Fatihah et al., 2025; Pegatariana et al., 2025). Studies from various countries demonstrate that integrating geological, cultural, and educational values can strengthen the tourism offering while preserving local identity (Bollati et al., 2023; Singh A & Shukla A, 2025). In Indonesia, this approach aligns with national policy, especially following the designation of 20 geoheritage sites by the Ministry of Energy and Mineral Resources in 2021. Among these, Yogyakarta's Prambanan region presents a compelling case with its combination of stratified volcanic landscapes and ancient cultural sites.

Prambanan is globally recognized for its Hindu temple complex, yet its geological significance is less explored in tourism narratives. The area contains diverse landforms such as the pyroclastic breccia of Tebing Breksi, the underwater volcanic remnants of Lava Bantal Berbah, the sedimentary and volcanic rocks of the Semilir Formation, and the red lateritic soils around Candi Abang. Moreover, Prambanan sits near two significant fault systems, the Opak and Dengkeng Faults, which not only shape the landscape but also represent zones of seismic risk (Chen, 2022; Rudolph, Melissa Ann., 2024). These geodynamic features are critical not only for geological interpretation but also for hazard-aware tourism planning

Despite these assets, the geotourism potential of Prambanan remains underutilized. Many geosites lack integrated interpretation infrastructure, signage, accessibility planning, or linkage to cultural narratives. The disconnect between

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geodiversity and visitor experience limits both educational impact and community-based tourism opportunities. While the region is already a cultural tourism hotspot, the geological dimension is rarely included in formal tourism products, leaving room for innovation through geotrail development and interpretive planning (Lestari et al., 2025; Williams et al., 2024).

This study aims to explore and enhance the geotourism potential of Prambanan by combining geological mapping, geophysical surveys using gravity methods, and cultural asset analysis. The research employs a holistic framework to evaluate geosite value based on scientific, educational, economic, and conservation parameters. It also proposes a geotrail design that connects geologically significant locations with cultural heritage sites, enabling an immersive and educational experience. The use of gravity survey data adds a unique dimension, supporting risk-informed infrastructure planning in tectonically active zones.

By offering a model of geotourism that integrates Earth sciences, local heritage, and community participation, this study contributes to the broader discourse on sustainable destination development. It addresses current gaps in geosite utilization, supports government initiatives on geoheritage protection, and provides practical guidelines for the implementation of geotrails that balance conservation with tourism growth.

Theoretical Background

Geotourism is a branch of sustainable tourism that focuses on the appreciation, interpretation, and conservation of a region's geological and geomorphological features. More than just observing landscapes, geotourism involves an educational journey through the Earth’s history, connecting scientific understanding with public experience. According to Sharma & Tamrakar (2025) geotourism emphasizes not only the aesthetic value of geological formations but also their scientific significance, cultural context, and potential for local economic contribution. It aligns with the principles of sustainability by promoting community involvement, environmental stewardship, and long-term destination resilience.

A key theoretical foundation for assessing geotourism potential is the concept of geosite evaluation. Nocca et al. (2024) proposes a multi-criteria framework that evaluates sites based on their scientific importance, educational value, conservation needs, economic potential, and additional values such as aesthetics or cultural relevance. This approach has been widely adopted in Central Europe and adapted in other regions to assess both natural and anthropogenic features. Possenelli et al. (2024) further refines this model by introducing quantitative and qualitative indicators that can be used to classify and prioritize geosites for development or protection. These frameworks offer a structured basis for identifying which geosites are most feasible for tourism and which require investment in interpretation or infrastructure.

Another theoretical lens relevant to this study is the integration of geodiversity with cultural and ecological diversity. Sgobba et al. (2020) and Matshusa & Leonard (2024) highlight that effective geotourism goes beyond geology by embracing the interconnectedness of natural systems, historical narratives, and community practices. This integrated approach supports a broader understanding of landscape evolution, human-environment interaction, and site-based storytelling. For example, sites like Tebing Breksi and Candi Abang are not only geologically significant but also serve as cultural landmarks and community gathering spaces. Theoretical models suggest that such sites offer greater interpretive potential when physical and intangible heritage are presented together.

Geophysical methods also provide a valuable scientific foundation in geotourism planning, particularly in regions prone to geological hazards. Gravity survey techniques, as explained by El Bohoty et al. (2023) are useful for mapping subsurface structures such as faults and density anomalies. These methods contribute to understanding site stability, tectonic risks, and landscape evolution. The application of gravity methods in tourism planning is especially important in tectonically active zones like the Prambanan area, where the Opak and Dengkeng Faults influence landform development and infrastructure vulnerability. Incorporating geophysical data ensures that geotourism infrastructure such as trails, viewpoints, and visitor centers are built with safety and resilience in mind.

The concept of geotrail development is also grounded in interpretive tourism theory. According to Stolz & Megerle (2022), well-designed geotrails function as outdoor museums, connecting multiple geosites through a curated narrative. These trails enhance the visitor experience by offering structured information through panels, guides, digital tools, and physical infrastructure. Interpretation plays a crucial role in transforming raw geological features into meaningful experiences that are accessible to the public. Ozdemir & Zonah (2025) emphasize the importance of using both traditional interpretive tools and modern technologies to engage diverse visitor profiles, including students, tourists, and local communities.

In summary, the theoretical foundation of this study combines principles from geotourism development, geosite evaluation, geodiversity integration, geophysical risk assessment, and interpretive planning. This multidimensional perspective allows for a comprehensive and context-sensitive strategy for developing geotrails in the Prambanan region. It also ensures that scientific rigor, cultural richness, and community benefit are harmonized in the process of sustainable tourism development

METHODOLOGY

This study employed a multidisciplinary approach to assess the geotourism potential of the Prambanan region by integrating geological mapping, geophysical surveying, and cultural site analysis. The methodology was structured in several interrelated stages, starting from preliminary planning to data collection, analysis, and geosite evaluation.

The preliminary stage began with a literature review to understand the geological history, tectonic characteristics, and tourism context of the study area. Relevant geological maps, geomorphological classifications, and previous geosite inventories were examined to establish a baseline for field observation and geosite selection. This phase also included administrative preparations such as acquiring permits and coordinating with local authorities and communities.

Fieldwork was conducted across six identified geosites in Prambanan, Kalasan, and Berbah districts. Geological data collection involved surface mapping, stratigraphic description, and petrographic sampling to determine lithological composition and landform characteristics. Special attention was given to features associated with volcanic activity, sedimentary structures, and fault traces. Geomorphological observations were guided by Zuidam (1983) landform classification and supported by remote sensing data including Shuttle Radar Topography Mission (SRTM) imagery and contour overlays.

In parallel, geophysical surveys were carried out using a Lacoste & Romberg gravitymeter to map subsurface anomalies and tectonic features, particularly the influence of the Opak and Dengkeng fault systems. Gravity data were processed using standard reduction techniques and filtering methods such as Upward Continuation and Total Derivative Response (TDR). These geophysical insights were crucial for identifying fault zones, assessing geological risks, and informing spatial planning for potential geotrail development.

Cultural data were collected through direct observation and informal interviews with local residents and site managers. These interviews provided context for the cultural and historical significance of each geosite, including community use, religious functions, and past conservation efforts. Sites such as Candi Abang and Goa Jepang Sentonorejo were analyzed not only for their geological attributes but also for their heritage value and role in local narratives.

All geosites were then evaluated using a modified version of Kubalíková (2013) framework, which assesses sites based on five core parameters: scientific value, educational value, economic value, conservation value, and additional or aesthetic value. Each parameter was scored and analyzed to determine the feasibility of site development and integration into a cohesive geotrail. Supporting visual documentation, including photographs, geological maps, and site diagrams, was used to enrich interpretation and planning.

This integrated methodological design ensured that both the tangible and intangible aspects of geotourism were considered. By combining geological, geophysical, and cultural data, the study produced a holistic assessment that supports the development of safe, educational, and sustainable geotourism infrastructure in the Prambanan region.

RESULT

Geological Setting

The Prambanan area lies within the Southern Mountains Zone of Java, an uplifted volcanic arc formed during the Oligocene to Miocene periods. This region exhibits a complex geological landscape shaped by volcanic activity, tectonic deformation, and fluvial processes. Understanding its geomorphology, stratigraphy, and structural patterns is essential for evaluating its geotourism potential and guiding the development of geotrails and interpretive sites.

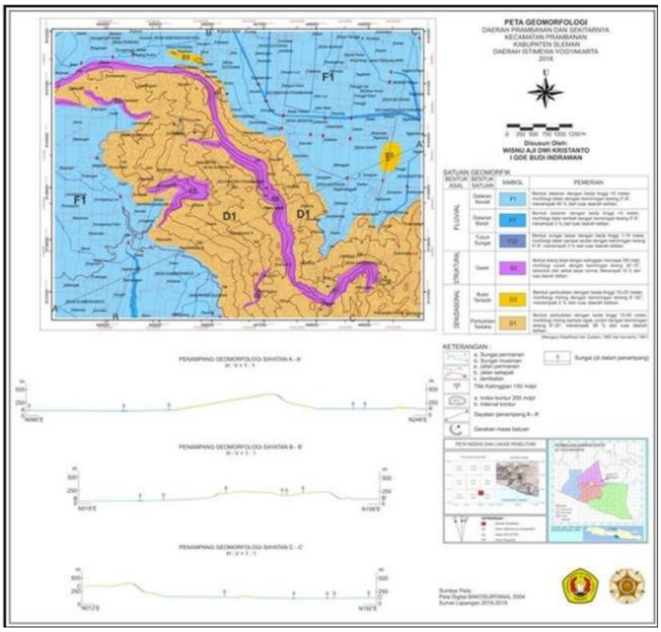

Figure 1. Geomorphological Map of Prambanan (Kristanto, 2018).

The geomorphology of the region was classified using Zuidam (1983) framework, which categorizes landforms based on origin, slope characteristics, and formative processes. The area is predominantly composed of volcanic plains (52 percent) with flat to gently sloping topography, shaped by past eruptions and lava flows. Structural ridges, covering about 21 percent of the area, are characterized by steeper slopes and were formed through tectonic uplift and faulting. Denudational ridges (5 percent) exhibit moderate slopes resulting from long-term erosion of older rock units. Fluvial basins (5 percent) represent the youngest landforms, consisting of low-lying zones formed by weathering, sedimentation, and river activity. These landform types reflect the interplay between volcanic activity, tectonic movements, and erosional dynamics that define the landscape of Prambanan (Table 1; Figure 1).

Table 1. Geomorphological Classification by Zuidam (1983)

Origin	Landform Type	Topography & Area	Formation Process	Dominant Features	Flow Pattern
Structural	Ridge	Gentle to steep slopes (2%–60%) Area: 21%	Uplift and faulting	Homoclinal hills, plains, river slopes	Subdendritic
Volcanic	Plains	Flat to gentle slopes (0%–2%) Area: 52%	Volcanic activity	Volcanic plains, remnant hills, rivers	Subdendritic
Denudational	Ridge	Gentle to moderate slopes (2%–30%) Area: 5%	Erosion and uplift	Remnant hills, plains	Subdendritic
Fluvial	Basin	Gentle slopes (0%–2%) Area: 5%	Weathering, erosion, sedimentation	Fluvial basins	Not classified

Stratigraphically, the region consists of four primary lithostratigraphic units arranged from oldest to youngest: the Kebo-Butak Sandstone Unit, the Semilir Batulapili Unit, the Merapi Volcanic Unit, and the Alluvial Deposition Unit. The Kebo-Butak Unit comprises deep marine sandstones and volcanic breccias deposited during the Late Oligocene to Early Miocene. Overlying this is the Semilir Unit, composed of pyroclastic materials such as tuff and batulapili, deposited during the Early to Middle Miocene. These two units record the volcanic and sedimentary evolution of the Southern Mountains (Figure 2). The Merapi Unit represents Holocene volcanic deposits dominated by andesitic lava and pyroclastic flows, distributed across slopes and lowlands. The youngest layer is the Alluvial Unit, composed of unconsolidated sediments from recent erosion, mainly occupying the central and western lowlands of Prambanan. This vertical succession reflects the region's transformation from deep marine to terrestrial volcanic environments, contributing to its geodiversity.

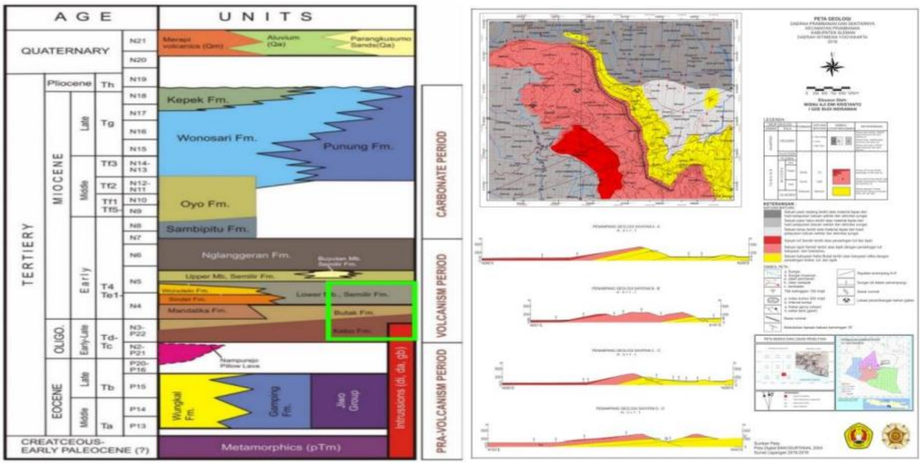

Figure 2. Geological Map of Prambanan and Stratigraphy of Southern Mountains
Source: Kristanto (2018) and Surono (1992)

Tectonically, the Prambanan area is influenced by major fault systems including the Opak Fault and its subsidiary structures such as the Sambirejo and Sengon Faults. Field observations and topographic analysis indicate the presence of strike-slip movement, particularly left-lateral displacement along these faults. These faults are aligned in north–south and southwest–northeast directions, consistent with regional tectonic trends. The activity of these faults contributes to the rugged terrain, local seismicity, and the exposure of older rock units at the surface. Understanding these structures is crucial for both geotourism planning and disaster risk reduction, especially in areas frequented by visitors or with planned infrastructure.

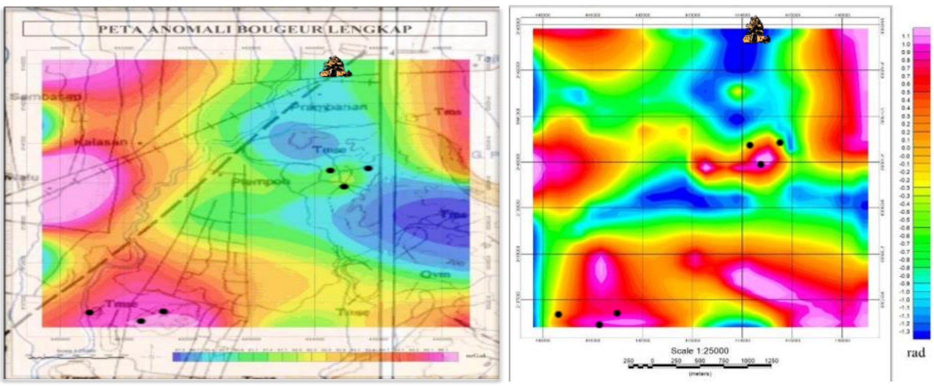

Figure 3. Tilt Derivatve, Overlay Geological, and Complete Bouger Anomaly Map
Source: Modified from Surono (1992)

Geophysical investigations using gravity surveys further support the geological interpretation. The Complete Bouguer Anomaly Map reveals contrasting density zones, with low anomalies corresponding to thick alluvial deposits and high anomalies indicating denser bedrock exposures in the ridges (Figure 3). The Tilt Derivative Map enhances the visibility of linear features such as fault lines and lithological boundaries, confirming the presence and orientation of major faults in the region (Figure 3). These subsurface insights are essential for mapping geological risks and identifying suitable zones for geotrail construction and visitor facilities.

Altogether, the geological and geophysical setting of Prambanan reveals a diverse and dynamic natural system. Its volcanic, tectonic, and sedimentary features not only form the scientific foundation for geotourism but also offer interpretive opportunities for education and sustainable development. The integration of surface mapping and subsurface analysis provides a robust basis for geosite assessment and strategic planning for tourism infrastructure in the region.

Geosite Identification and Evaluation

The Prambanan region presents a diverse array of geological, cultural, and ecological features that qualify as potential geosites. Based on field observations, community insights, and supporting geophysical data, six geosites were selected for evaluation: Tebing Breksi, Lava Bantal Berbah, Candi Abang, Goa Jepang Sentonorejo, DAM Sambirejo, and Tebing Banyunibo. Each site was assessed using a modified version of Kubalikova's (2013) framework, which evaluates geosites across five parameters: scientific and intrinsic value, educational value, economic potential, conservation value, and additional or aesthetic value.

Tebing Breksi emerged as the most prominent geosite, scoring the highest across all five evaluation parameters. This site exhibits well-exposed pyroclastic breccia formations, clear stratification, and strong aesthetic appeal. Its transformation from a former mining area into a public park also adds cultural and economic dimensions, making it a flagship model for geotourism development in the region. High interpretive value and established infrastructure further elevate its potential as a key node in any future geotrail network.

Lava Bantal Berbah is another high-potential geosite, distinguished by rare pillow lava formations that represent ancient submarine volcanic activity. Scientifically, it offers educational value related to underwater volcanism and tectonic processes. The site also has conservation significance due to its vulnerability to weathering and potential disturbance, suggesting the need for protective measures in future tourism planning.

Candi Abang and Goa Jepang Sentonorejo are examples of sites where cultural and geological narratives converge. Candi Abang, a lateritic hill with archaeological remains of a red-brick Hindu temple, represents both volcanic sedimentation and ancient religious activity. Goa Jepang, a man-made cave from the World War II era, illustrates human interaction with geological formations and can serve as a focal point for historical and cultural interpretation. Both sites scored moderately high in cultural and educational value but require investment in accessibility, signage, and community involvement to reach their full potential.

DAM Sambirejo and Tebing Banyunibo scored in the moderately feasible category. While these sites lack the dramatic geological exposures of other locations, they contribute to important landscape elements and ecological diversity. DAM Sambirejo supports local water management and farming, while Tebing Banyunibo forms part of a broader heritage cluster near the ancient temple of Banyunibo. Their integration into a geotrail can enhance route continuity and provide resting points or interpretive stops that connect major geosites.

Table 2. Geosite Evaluation Summary

Geosite	Total Score (%)	Feasibility
Tebing Breksi	92	Feasible
Lava Bantal Berbah	88	Feasible
Candi Abang	79	Moderately Feasible
Tebing Banyunibo	61	Moderately Feasible
DAM Sambirejo	56	Moderately Feasible
Goa Jepang Sentonorejo	58	Moderately Feasible

Geosite feasibility was classified into five categories: very feasible, feasible, moderately feasible, not feasible, and very not feasible. Based on the scoring results (see Table 2), only Tebing Breksi and Lava Bantal Berbah are currently in the "feasible" category. The remaining four sites are classified as "moderately feasible," indicating that while they possess considerable potential, they require targeted improvements in infrastructure, interpretation, or environmental management.

This evaluation confirms that geotourism development in Prambanan should adopt a cluster-based approach, integrating multiple geosites into a single narrative journey. Rather than treating each geosite as an isolated attraction, this strategy emphasizes the thematic continuity between natural history, cultural heritage, and community life. Prioritizing investment in high-potential geosites while gradually improving moderately feasible ones can support the phased growth of a sustainable and educational geotrail system across the region.

DISCUSSION

The geosite evaluation in Prambanan reveals not only the presence of diverse geological and cultural features but also a clear hierarchy in their readiness for geotourism development. Sites such as Tebing Breksi and Lava Bantal Berbah emerged as highly feasible geosites, while others like Candi Abang, DAM Sambirejo, Goa Jepang, and Tebing Banyunibo were classified as moderately feasible. This stratification provides a foundation for strategic geotrail planning and resource prioritization.

The high ranking of Tebing Breksi aligns with findings from similar studies on repurposed quarry landscapes. For instance Williams et al.(2024) emphasize that sites formerly used for extraction can become flagship geotourism destinations when supported by community involvement and multifunctional use. Like Breksi, the Bombo Headland Quarry in Australia has been transformed into a tourist attraction that integrates geological education and cultural programming. Tebing Breksi exemplifies this model by hosting cultural performances and local festivals while maintaining its geological identity. To sustain this balance, enhancement strategies should include anti-vandalism campaigns, improved interpretive signage, and geological conservation zones, as recommended by Brilha (2016) in his geosite management framework.

Lava Bantal Berbah, with its rare submarine volcanic features, holds strong scientific and educational value. Pillow lava structures have been used in other UNESCO Global Geoparks such as Azores Geopark (Portugal) and Jeju Island (South Korea) as central attractions due to their rarity and visual distinctiveness (Woo et al., 2013). However, accessibility and fragility remain common issues. Similar to recommendations by Sgobba et al. (2020), *Lava Bantal* requires controlled visitor access, explanatory panels, and promotion through academic and digital platforms to attract specialized interest groups such as geology students and eco-travelers.

Candi Abang represents a geocultural hybrid site, where the hill's lateritic geology intersects with religious and archaeological significance. This dual identity is comparable to Mount Popa in Myanmar and Gunung Padang in Indonesia, where volcanic hills are both sacred spaces and geological features. Kubalíková et al. (2021) argue that such hybrid geosites offer high interpretive value if managed with cultural sensitivity. Development at Candi Abang should therefore prioritize interpretive narratives that connect the temple’s construction to its geomorphological setting, while respecting local customs and spiritual functions.

Goa Jepang Sentonorejo offers historical and anthropogenic layers of interpretation, echoing findings from Mushynsky, J. (2021) who emphasize the value of war-time caves and shelters as cultural geosites when linked to national history. In Western Australia, similar sites have been transformed into educational trail stops with historical reenactments and interactive guides. Goa Jepang could benefit from such approaches by integrating wartime narratives into geotourism interpretation, supported by safety improvements and guided experiences.

Moderately feasible sites such as Tebing Banyunibo and DAM Sambirejo add ecological and recreational value to the proposed geotrail network. These findings are consistent with Stojanovic et al. (2023), who argue that secondary sites can serve as “support nodes” to reduce pressure on high-traffic geosites. Enhancing these locations with rest areas, ecological interpretation panels, and access routes will diversify the visitor experience and promote local economic inclusion.

The proposed strategy for geotourism development in Prambanan supports a cluster-based geotrail model, similar to successful practices in the Langkawi Geopark (Malaysia) and the Bohemian Paradise Geopark (Czech Republic), where spatial continuity among diverse geosites enhances tourist mobility and interpretation flow (Kubalíková, 2013; Sgobba et al., 2020). By linking high-potential geosites with moderately feasible ones, the region can offer a multi-sensory learning journey through volcanic history, tectonic evolution, cultural expression, and ecological adaptation.

Interpretive planning is central to this model. Brilha (2016) recommend a combination of physical interpretation tools (e.g., panels, maps, geological gardens) and digital media (e.g., mobile apps, QR codes, AR/VR content) to support learning and engagement. These tools should be tailored to different visitor profiles, including school groups, researchers, casual tourists, and cultural pilgrims.

In conclusion, the Prambanan geosite network has the potential to become a model of integrated geotourism in Indonesia. The findings align with global best practices and support the notion that sustainable geotourism must combine geological authenticity, cultural resonance, and participatory planning. Prioritizing site protection, narrative enrichment, and inclusive infrastructure will allow the region to attract diverse visitors while preserving its natural and cultural capital for future generations.

Geotourism Development Concept

The development of geotourism in the Prambanan region requires a holistic and integrated strategy that aligns geological and cultural assets with sustainable tourism principles. The region’s diverse geosites, ranging from volcanic breccia formations and submarine lava flows to archaeological temple complexes and historical caves, provide a strong foundation for designing a geotrail system that is educational, environmentally responsible, and economically inclusive.

The core concept centers around the creation of a cluster-based geotrail network that connects six primary geosites: Tebing Breksi, Lava Bantal Berbah, Candi Abang, Goa Jepang Sentonorejo, DAM Sambirejo, and Tebing Banyunibo. This model prioritizes thematic continuity, spatial coherence, and visitor flow management. High-potential sites such as Tebing Breksi and Lava Bantal Berbah can serve as flagship destinations, while moderately feasible sites function as supporting nodes for rest, reflection, and ecological engagement.

Infrastructure development is a key component of this strategy. Trail signage, interpretive panels, resting shelters, parking areas, and sanitation facilities must be provided at each geosite, tailored to both its geological sensitivity and anticipated visitor volume. For example, fragile sites such as Lava Bantal require controlled access and protective barriers, while public gathering spaces at Tebing Breksi can accommodate amphitheaters, guided tour stations, and visitor centers. Universal design principles should be adopted to ensure accessibility for people of all ages and abilities.

Interpretation and education play a central role in shaping visitors' experience. Drawing on recommendations from Brilha (2016) and Newsome et al. (2012), each geosite should include explanatory panels that connect scientific content with local culture and narratives. Complementary media such as mobile apps, virtual guides, and QR-linked video content can extend interpretive depth and language inclusiveness. The development of school-geosite partnerships, citizen science activities, and field-based learning modules would further enhance the educational value of the trail network.

Community engagement is essential for both operational sustainability and cultural authenticity. Residents should be actively involved as site stewards, trail guides, craft producers, and hospitality providers. Capacity-building programs can equip communities with skills in interpretation, conservation, and tourism management. The economic benefits of geotourism through entrance fees, guided tours, homestays, and souvenir sales should be distributed equitably to reinforce community ownership and reduce external dependence.

Environmental conservation is another pillar of the development concept. Each site should be assessed for carrying capacity and zone according to sensitivity. Strategies such as controlled access paths, revegetation programs, waste management systems, and regular monitoring are necessary to maintain the integrity of geological and ecological features. Integrating conservation education into interpretive content can also build environmental awareness among visitors and locals.

A critical feature of the Prambanan development concept is the integration of geophysical risk mitigation, particularly in areas influenced by the Opak and Dengkeng Faults. The use of gravity data in site planning ensures that infrastructure placement avoids seismic risk zones and unstable terrain. Early warning systems, evacuation signage, and structural design standards should be part of the long-term resilience framework.

Promotion and partnerships are required to position Prambanan as a geotourism destination both nationally and internationally. Collaboration with universities, local governments, and heritage agencies can support research, training, and content development. Strategic marketing through digital platforms, tourism fairs, and educational tourism channels can attract diverse visitor segments, from geoscience enthusiasts to school groups and cultural travelers.

In summary, the geotourism development concept for Prambanan is built on the principles of integration, interpretation, inclusion, and innovation. It envisions a network of accessible and well-managed geosites that together offer immersive experiences rooted in geology, history, and community identity. When fully implemented, this approach has the potential to transform the region into a model of sustainable geotourism, balancing education, economic benefit, and environmental stewardship.

CONCLUSION

This study demonstrates that the Prambanan region holds significant potential for geotourism development through the integration of geological, geophysical, and cultural resources. The evaluation of six geosites, Tebing Breksi, Lava Bantal Berbah, Candi Abang, Goa Jepang Sentonorejo, DAM Sambirejo, and Tebing Banyuniborevealed a diverse range of scientific, educational, and cultural values. Tebing Breksi and Lava Bantal emerged as highly feasible geosites, while others offer opportunities for gradual development within a cohesive geotrail framework. The use of Kubalikova's evaluation model and supporting gravity data provided a robust basis for site classification, infrastructure planning, and hazard mitigation.

A strategic geotourism development concept was proposed, emphasizing thematic integration, community participation, environmental conservation, and risk-informed infrastructure. This approach aligns with global best practices of global and supports sustainable destination planning that benefits both visitors and local communities.

However, studying has several limitations. It did not include quantitative visitor perception data, detailed cost analysis, or in-depth community impact assessments. Furthermore, some geosites remain under-researched in terms of biodiversity and archaeological potential.

Future research should focus on participatory planning with local stakeholders, visitor experience studies, and the integration of smart technologies such as augmented reality for interpretation. These efforts will help realize a more dynamic, inclusive, and resilient geotourism system for the Prambanan region.

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Conflict of Interest

The authors declare no conflict of interest related to the publication of this study.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contribution

All authors contributed equally to the design, data collection, analysis, and writing of this manuscript. All authors have read and approved the final version of the paper.

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