

Geotourism for Sustainable Development in Kedung Kayang Waterfall

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Abstract

This research highlights the potential of geotourism for sustainable development in Kedung Kayang Waterfall, Central Java, Indonesia. Geotourism integrates geological, environmental and cultural aspects to promote sustainable tourism. The research emphasizes the importance of community engagement and environmental education in enhancing visitor experience and conservation efforts. Key findings include Kedung Kayang's unique geological features, such as a young fluvial landscape and diverse rock formations, which can attract tourists while supporting the local economy. A SWOT analysis was used to identify strengths, weaknesses, opportunities and threats related to geotourism development in the area. Recommendations for sustainable management strategies are provided, emphasizing a balance between tourism, environmental management, and economic growth for local communities. Overall, this research positions Kedung Kayang as a model for the integration of tourism with conservation and community development.

Keywords: Geotourism; Sustainable Development; Geological Features; Environmental Conservation

A. INTRODUCTION

Geotourism is a part of the tourism sector that has emerged as an innovative approach in the development of tourist attractions. This field has developed into a significant component in tourism studies (Yazdi et al., 2014). Geotourism as a form of alternative tourism that can be done both in natural and urban areas. This tourism activity prioritizes sustainability by utilizing the geological landscape as a tourist attraction. The main focus is to explore geological features and natural landscapes (R. K. Dowling & Newsome, 2006). Through geotourism, visitors not only travel but also contribute to the preservation of geodiversity and can deepen their understanding of earth science. This is realized through various activities such as independently visiting geological sites, exploring geo-trails and scenic viewpoints, taking guided tours, participating in geology-based activities, and visiting geological information centers at tourist sites (Ólafsdóttir, 2019). Thus, geotourism combines recreation with education about geological and natural phenomena.

Geotourism has several key characteristics that make it unique in the tourism industry (R. Dowling & Newsome, 2018). Based on geological aspects, geotourism plays an important role in conserving geoheritage and promoting understanding of earth science through the interpretation of geological phenomena. More than just a tourist activity, geotourism contributes to the sustainable development of an area through the economic and social benefits generated (Frey, 2021). This positive impact can be seen from the opening of employment opportunities for local communities, such as becoming tour guides and staff managing geotourism facilities. The accommodation sector also provides a multiplier effect for local communities through employment opportunities, organizing events, developing retail businesses, and providing various tourism support services (Ólafsdóttir & Dowling, 2014). Thus, geotourism not only focuses on nature conservation, but also on improving the welfare of communities around the destination.

Waterfalls, as one of the geological phenomena, have great potential to be developed into geotourism objects because of their distinctive and interesting geological formation characteristics. However, in the context of tourism, the appeal of waterfalls lies not only in their visual aesthetic aspects, but also in the need for visitors to obtain more in-depth information about the geological processes that formed them, the origins of the waterfalls, and the factors that contributed to the formation of the unique landscape (Ortega-Becerril et al., 2019). Kedung Kayang, located in Magelang Regency, Central Java, has been widely recognized as a nature tourism destination (Angelica et al., 2021). Valued as nature tourism, Kedung Kayang Waterfall can also potentially have a positive impact on the economic development of the local community (Adhitama, 2012). However, this development has not been maximized because there are still many facilities and infrastructure that are inadequate in providing comfort and safety for tourists (Abqa et al., 2022). From a geotourism standpoint, Kedung Kayang possesses considerable potential for further growth. However, limited awareness and insufficient support from various stakeholders, such as academics and government entities, have constrained its optimal development. This study seeks to explore the geotourism potential of Kedung Kayang and offer recommendations to enhance its integration as a geotourism destination.

B. RESEARCH METHOD

This research used a descriptive qualitative approach, with data collected through observations and interviews with the management of Kedung Kayang to obtain the latest information on the biological condition of the area (Creswell & Creswell, 2018). Additional data was obtained from a literature review, including archives and previous research, which aimed to validate the potential of Kedung Kayang as a geotourism site. Potential evaluation was conducted using SWOT analysis to identify aspects of strengths, weaknesses, opportunities, and threats in developing the area as a geotourism destination (Wheelen et al., 2018). Furthermore, the results of the SWOT analysis were further analyzed through the IFAS and EFAS methods by giving weight to each factor, which was then used to develop strategic recommendations to support the sustainable development of geotourism in the Kedung Kayang Waterfall area.

C. FINDINGS AND DISCUSSION

1. Identification of Characteristics of Kedung Kayang Waterfall as Geotourism

a. Landscape Analysis

River valleys and mountains, the basin is formed from fluvial erosion of a river. Based on research conducted by (Damayani, 2017), the morphology of the landscape at Kedung Kayang

waterfall is a young stadia fluvial landscape. This is characterized by rivers that are upstream, there are waterfalls that cause vertical erosion, the river valley forms the letter "V" which is a characteristic of young stadia landscapes which can be seen from the figure below;



Figure 1. Analysis of young stadia fluvial landforms.

Source: Primary Data, 2024

b. Formation Process of Waterfall Cliffs and Rocks

Based on observations, the cliffs of kedung kayang waterfall are formed from the lava of volcanic eruptions that harden extrusively to form andesite, tuff (sediments formed from hardened volcanic ash), and breccia (Rocks consisting of broken mineral fragments or rocks cemented together by a fine-grained matrix) can be seen in the figure below;



Figure 2. Rock combination at Kedung Kayang waterfall cliffs.

Source: Primary Data, 2024

Kedung Kayang Waterfall has a height of about 38 meters with a slope of about 80°. Breccia is also found on the cliffs that are passed during trekking. The stones scattered in the river flow are andesite stones with different sizes and contents, large rocks are gray in color which indicates that the rocks come from the lava of Mount Merapi, the gray color of the rocks comes from the silica contained in the lava of Mount Merapi. However, there are also small reddish stones formed from andesite with a dominant iron content. In addition, there are other materials in the form of roof tiles found from settlements around the Pabelan River which were probably carried by flood water during the storm which can be seen from the figure below;



Figure 3. Rock Types in Kedung Kayang Waterfall Stream.

Source: Primary Data, 2024

c. Source of River Flow

Based on the results of tracing the flow of the river, the source of Kedung Kayang waterfall comes from the Pabelan river whose water source comes from springs on the slopes of Mount Merapi and Mount Merbabu. This waterfall continues to flow even during the dry season. Can be seen from the figure below;



Figure 4. Source of Flow of Kedung Kayang Waterfall.

Source: Google Earth, 2024

The water discharge at Kedung Kayang Waterfall can vary depending on the season. In the dry season, the water discharge is normal or may be smaller, while in the rainy season especially if there is rain in the eastern sky near Mount Merapi, the water discharge will be heavier and even bring flood water that can overflow into the path leading to the waterfall. This can happen even if there is no rain in the Kedung Kayang waterfall area.

Table 1. Environmental Parameters

Location	Air temperature (C)	Water temperature (C)	Altitude (MDPL)
Top of Waterfall	22,5	21,1	845
Lower Section of Waterfall	21,3	20,7	755
Downstream	21,8	21	706

Source: Qurniawan et al, 2010

According to (Qurniawan et al, 2010) Kedung Kayang Waterfall has a relatively constant temperature, air temperature measurements taken during the study averaged between 21 and 22.5

C, while the average water temperature ranged around 21 C. The relatively constant temperature can be caused by the condition that around the Kedung Kayang Waterfall area there is high vegetation, which functions as an absorber of excessive heat and a water supplier in case of drought.

d. Flora and Fauna

According to (Gusniwati, 2005) the Kedung Kayang Waterfall area is a hilly area with cool and fresh air and a calm environmental atmosphere. This area is overgrown with plants such as trees, shrubs (herbaceous) to grasses (ground cover). The type of flora in the Kedung Kayang Waterfall area can be seen in the table below;

Table 2. Types of Flora in Kedung Kayang Waterfall Area

No.	Flora	Latin Name
1	Bamboo	<i>Gigantochloa apus</i> Z.
2	Waru	<i>Hibiscus tiliaceus</i> L.
3	Banana	<i>Musa paradisiacal</i> LINN.
4	Cloves	<i>Eugenia aromatica</i>
5	Acacia	<i>Acacia nilotica</i>
6	Coconut	<i>Cocas nucifera</i> LINN.
7	Pine	<i>Pinus merkusii</i>
8	Kerinyu	<i>Eupatorium palascens</i>
9	Tembelekan	<i>Lantana camara</i> LINN.
10	Reeds	<i>Imperata cylindrica</i> Beauv.
11	Banyan	<i>Ficus benyamina</i> LINN.
12	Yellow Bamboo	<i>Bambusa vulgaris</i>

Source: Gusniwati, 2005

Typical types of fauna are not found. The types of fauna that are often found in the Kedung Kayang area are insects, reptiles and birds, which can be seen in the table below;

Table 3. Types of Fauna in Kedung Kayang Waterfall Area

No.	Fauna	Latin Name
1	Butterflies	<i>Taides</i> sp.
2	Crickets	<i>Acheta domesticus</i>
3	Dragonfly	<i>Libellula quaroma culata</i>
4	Grasshopper	<i>Valanga</i> sp.
5	Snake	<i>Phyton</i> sp.
6	Lizard	<i>Mabouya multifasciata</i>
7	Chameleon	<i>Goneocephalus</i> sp.
8	Frog	<i>Rona</i> sp.
9	Owl	<i>Tyto alba</i>
10	Starling	<i>Pycnonotus aurigaster</i>
11	Black Eagle	<i>Ictinaetus malayensis</i>
12	Long-tailed Macaque	<i>Macaca fascicularis</i>
13	Mountain Cekakak	<i>Halcyon cyanoventris</i>
14	Cipoh	<i>Aegithina tiphia</i>

Source: Gusniwati, 2005

The distribution of vegetation in the kedung kayang area, in the trekking area is mostly overgrown with bamboo and wild plants, while on the cliffs in the form of moss and ferns. As for the edge of the cliff opposite the waterfall, pine trees were planted by the landowner community which is now used to build photo spots.

2. Development of Kedung Kayang with the concept of Geotourism

(Ólafsdóttir & Runnström, 2009) Revealed, to achieve sustainability in tourism development in vulnerable areas, tourism must be carefully managed so as not to cause negative impacts on the environment, culture, society, and the local economy. If managed with sustainable principles, geotourism has the potential to provide long-term benefits to the region that have a direct impact on people's lives. A deep understanding of the relationship between biodiversity, conservation and tourism development is essential for sustainable geotourism management. Research is needed to find the ideal balance between these three elements. Achieving sustainability will improve the quality of life and experiences for local people and tourists, and strengthen the development of the region that impacts the community (Ólafsdóttir & Dowling, 2014).

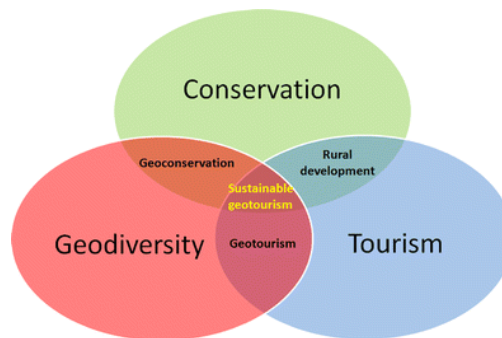


Figure 5. The relationship between biodiversity, conservation and tourism

Source: Ólafsdóttir & Dowling, 2014

From the elements previously described, the next step is to conduct a more in-depth analysis using the IFAS (Internal Factor Analysis Summary) and EFAS (External Factor Analysis Summary) approaches to evaluate the internal and external factors that affect the development of geotourism at the location. Through the identification of strengths, weaknesses, opportunities and threats (SWOT) factors, this analysis aims to provide a comprehensive picture of the current position of the geotourism destination to be developed. The IFAS analysis will focus on identifying internal factors that can support or hinder the development of geotourism, such as the quality of natural resources, infrastructure, and the capacity of destination managers. Meanwhile, EFAS will explore external factors, including tourism market potential, government policies, and emerging sustainable tourism trends. By integrating the results of both analyses, the right strategy can be obtained to optimize destination potential and overcome existing challenges, so that geotourism development can run on the principle of sustainability. This is important to ensure that the destination is not only attractive to tourists today, but also able to survive in the long term by maintaining environmental integrity and local wisdom.

Table 4. IFAS (Internal Factor Analysis Summary)

Internal Factor	Description	Weight	Rating	Score
Strengths				
1. Interesting Geological Diversity	Unique rock formations (andesite, breccia, tuff) formed from volcanic activity provide its own attraction as an educational geotourism object.	0.20	4	0.80
2. Local Awareness of Conservation	Local community awareness about the importance of maintaining ecosystems and	0.15	3	0.45

	geodiversity is starting to increase with community initiatives.			
3. Community Involvement in Management	The surrounding community can be involved in management as guides, restaurant managers, and other small businesses.	0.15	3	0.45
4. Popularity as a Tourism Destination	Kedung Kayang is already known and is a potential tourist destination to increase tourist visits.	0.10	4	0.40
Total Score Strength				2.10
Weaknesses				
1. Lack of Environmentally Friendly Infrastructure	Inadequate tourism infrastructure to support the conservation concept, such as the lack of special trails and cleaning facilities.	0.15	2	0.30
2. Limited Resources and Knowledge	The community and tour managers have limited knowledge related to geotourism management based on conservation and education.	0.10	2	0.20
3. Readiness of Safety Support Facilities	The availability of tourist facilities is still limited, such as security equipment at the top viewing point and railing facilities on stairs that are damaged.	0.05	2	0.10
4. Dependence on Weather for Visitors	The number of visitors is strongly influenced by weather conditions, especially in the rainy season, which reduces the attractiveness of the tour.	0.10	2	0.20
Total Score Weakness				0.80
Total Score IFAS				2.90

Source: Author's Analysis, 2024

Table 5. EFAS (External Factor Analysis Summary)

External Factor	Description	Weight	Rating	Score
Opportunities				
1. Increased Tourist Interest in Ecotourism	The global trend of ecotourism is increasing, especially among environmentally conscious travelers, providing an exciting opportunity for Kedung Kayang.	0.20	3	0.60
2. Government Support for Sustainable Tourism	The government encourages the development of sustainable and environmentally friendly tourism, especially in areas that have high conservation potential.	0.15	4	0.60
3. Cooperation Opportunities with Ecological Institutions and NGOs	Opportunities to work with environmental organizations and NGOs in maintaining geological diversity and supporting educational programs for tourists.	0.10	3	0.30
4. Potential for Geological Education and Interpretation	Kedung Kayang has the potential to be developed into a geological educational tour site that can increase visitor knowledge.	0.10	3	0.30
Total Score Opportunity				1.80
Threats				
1. Competition with other Ecotourism Destinations	Competition with other sustainable tourism destinations that may have better	0.15	2	0.30

	infrastructure and more professional management.			
2. Potential Environmental Damage due to Overcrowding	An increase in the number of visitors without good management can cause damage to the ecosystem and geology at Kedung Kayang.	0.15	3	0.45
3. Environmental Uncertainty and Extreme Weather	Extreme weather or natural disasters, such as landslides or flooding, could damage the area and endanger visitors.	0.10	3	0.30
4. Dependence on External Funding	The sustainability of the program depends on external funding, which could disrupt management activities if funding is unstable.	0.05	2	0.10
Total Score Threat				1.15
Total Score EFAS				2.95

Source: Author's Analysis, 2024

The IFAS score (2.90) indicates that internally, Kedung Kayang has quite strong potential in terms of geological diversity, local community involvement, and increasing conservation awareness. However, there are still some weaknesses related to infrastructure, limited knowledge, and dependence on weather conditions.

The EFAS score (2.95) indicates that externally, Kedung Kayang has significant opportunities especially in terms of increased tourist interest in ecotourism and government support for sustainable tourism development. However, threats in the form of competition with other destinations, potential environmental damage, and environmental uncertainty need to be anticipated.

The strategic recommendations based on the results of the IFAS and EFAS analysis can be described as follows:

1. Maximizing geological diversity as the main attraction is an important step, where geological education and interpretation programs are developed through guided tours and information boards that explain the unique rock formations and natural processes at Kedung Kayang. This strategy enhances the appeal of educational tourism and provides a more immersive experience for visitors.
2. Preserve the environment, it is necessary to build environmentally friendly and conservative infrastructure such as protected trekking trails, waste management facilities, and sanitation that support sustainability. This step can be realized through government support or partnerships with conservation organizations, so that the environment is maintained and comfortable for visitors.
3. Local community involvement is key. By providing training in tourism services, conservation and geological education, local communities can play an active role as tour guides, homestay managers and small businesses that support geotourism. This not only improves the local economy but also raises public awareness of the importance of preserving the environment.
4. Strengthen resources, take advantage of government support and cooperation with conservation organizations, so that tourism management can be maximally supported through financial assistance, training and promotion. In addition, geotourism promotion targeting ecotourism and educational tourists is an important strategy. With a campaign that highlights the uniqueness of Kedung Kayang as an educational and conservative destination, tourists who are environmentally conscious and value sustainability can be attracted to visit this destination.
5. In order to prevent environmental damage due to overcrowding, management of the number of visitors is done through an online ticket booking system and restrictions on visitors at peak

times. This strategy allows for better management of the number of tourists, maintains comfort, and prevents environmental damage.

6. Anticipating the impact of extreme weather is done by preparing weatherproof facilities and mitigation plans that include evacuation routes and weather warning systems to maintain visitor safety at all times. With the implementation of these strategies, Kedung Kayang is expected to develop as a sustainable geotourism destination that benefits the ecosystem, local communities and tourists.

These findings are in line with research conducted by Noer Aini (2015) and Marswari (2015) where the Kedung Kayang area has the potential to become geotourism. Through its wealth and optimal involvement of local communities, the development of Kedung Kayang geotourism is expected to be sustainable.

D. CONCLUSION

This research analyzes the potential of Kedung Kayang Waterfall as a geotourism destination, identifies its geological and ecosystem characteristics, and formulates a sustainable development strategy using a SWOT analysis approach. The results showed that Kedung Kayang Waterfall has strong geotourism potential, especially due to the diversity of rock formations, such as andesite, breccia, and tuff formed from volcanic activity. This unique geological feature can be utilized as the main attraction in an educational geotourism program.

In addition, the SWOT analysis revealed that Kedung Kayang's internal strengths lie in its unique landscape, community involvement, and awareness of conservation practices. However, weaknesses include limited eco-friendly infrastructure and lack of local community knowledge in geotourism management. Opportunities arise from increasing tourist interest in ecotourism as well as government support for sustainable tourism development. The main threats involve environmental damage due to visitor overcapacity and the unpredictability of extreme weather conditions.

Limitation

Methodologically, this study uses SWOT analysis which is qualitative and subjective, with a lack of specific quantitative data. The research focused on one specific site, the broader geographical context and geological significance of the falls within the regional landscape was not fully explored, which limits a thorough understanding of the site's geotourism potential.

Suggestions for Future Research

This research provides a foundation for further studies that can explore more deeply the management of environmental risks in Kedung Kayang, especially related to extreme weather and the impact of overcrowding that can damage geological ecosystems. In addition, a more specific study on the socio-economic impact of geotourism development on the welfare of local communities is needed, as well as further analysis of the effectiveness of collaboration between the government, academics and conservation organizations in maintaining a balance between environmental conservation and sustainable tourism development. Future research is also recommended to develop a more interactive and high-tech geological interpretation model to increase the attractiveness of tourism and education in Kedung Kayang.

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