

GEOTOURISM PLANNING: DISASTER AND ACCIDENT RISK EDUCATION THROUGH WARNING SIGNS AT THE IJEN CRATER

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Abstract

Ijen Geopark, located in Banyuwangi Regency and Bondowoso Regency, East Java Province, was officially designated as a UNESCO Global Geopark on September 9, 2023. One of the 21 developed geological sites is the Ijen Crater, an acidic crater lake with a blue flame phenomenon. However, this area also has the potential for significant disaster and accident risks. This study aims to assess the effectiveness of geotourism safety planning through disaster and accident risk education using warning signs. Data were collected through field observation and document analysis. Qualitative methods with observation techniques were used to assess the condition of existing warning signs, as well as the obstacles faced by visitors to the information conveyed. Observations were conducted at several strategic points in the Ijen Crater. Data analysis techniques used descriptive analysis and triangulation. The results have gained from the lack of effectiveness of warning signs due to sign design and lack of lighting facilities. Some visitors ignore and do not notice the signs, especially those who hike early in the morning when it is still dark. The author recommends that it is necessary to integrate information about disaster risk in the form of warning signs that are easy to understand to increase awareness and alertness of visitors equipped with lighting facilities. The management of Kawah Ijen can collaborate with related institutions to develop a more comprehensive and attractive educational program to minimize disaster risk. This research contributes to geotourism planning and emphasizes the importance of disaster and accident risk education as part of the mitigation strategy in disaster-prone tourism areas. Balancing education with attraction is essential for establishing safe and sustainable geotourism.

Keywords: Geotourism Planning, Disaster Education, Accident Risk, Mitigation, The Ijen Crater.

A. INTRODUCTION

Geotourism is a form of nature-based tourism that prioritizes exploration and understanding of geological wealth, landscapes, and unique natural phenomena. The scope of geotourism encompasses a diverse array of geological and geomorphological features, ranging from mountains and coastlines to small rock outcrops and man-made structures (UNESCO, 2024). This includes understanding and appreciating the geological history, unique features of the earth, and natural processes that shape the landscape. Geotourism is not only a force for geoconservation but also a type of tourism that holds promise in fostering sustainable, local economic growth, and advocating for territorial sustainability (Fernandes et al., 2021). Through geotourism, tourists can appreciate natural landscapes formed over millions of years and understand the value of nature conservation and sustainability. Geotourism experiences can be found in various regions in Indonesia, especially in geoparks.

Currently, Indonesia has 10 Geoparks recognized as UNESCO Global Geoparks, namely Batur Geopark; Sewu Mountain Geopark; Rinjani Geopark; Ciletuh Geopark; Toba Caldera Geopark; Belitong Geopark; Raja Ampat Geopark; Maros Pangkep Geopark; Merangin Geopark; and Ijen Geopark. Each of these geoparks has unique geological, ecosystem, and cultural features, and plays an important role in the development of sustainable tourism in Indonesia. Ijen Geopark, located in Banyuwangi Regency and Bondowoso Regency, East Java Province, was officially designated as a UNESCO Global Geopark on September 9, 2023. One of the 21 developed geological sites is the Ijen Crater, an acidic crater lake with a blue flame phenomenon. However, this area also has the potential for significant disaster and accident risks. The dynamic volcanic activity, presence of toxic gases, and rugged terrain make the area a serious accident risk. Visitors and tourists who are unaware of these potential risks may face dangerous situations that threaten their safety.

Based on Circular Letter Number: SE.1289/K2/BIDTEK.1/KSA/07/2024 Ijen Crater is closed starting July 12, 2024, due to the increase in the status of Mount Ijen to Alert (Level II). Then the hiking was reopened starting on September 8, 2024, announced through an official circular letter from the East Java Natural Resources Conservation Center (BBKSDA) with the Number SE.1658/K2/BIDTEK 1/KSA/9/2024. After being closed for 2 months, on the first day of opening, 583 tourists visited Ijen Crater, consisting of 153 domestic tourists and 430 foreign tourists. In addition to the risk of natural disasters in the form of phreatic eruptions and toxic gas emissions, several incidents of accidents at Ijen Crater have occurred in recent years, mainly involving tourists getting too close to the crater rim area. One of the most recent cases was the death of a Chinese tourist in April 2024. The victim fell into a ravine about 75 meters deep while taking photos because she tripped over the long skirt she was wearing.



Figure 1. The rim area of the Ijen Crater is borderless.

Source: researcher, 2024

Figure 1 shows the rim area of Ijen Crater without a safety barrier. This location is one of the places where tourists see the main attraction of Ijen Crater and take pictures of the scenery. If tourists are not vigilant, there is a risk of slipping into the steep and slippery ravine. The importance of safety planning in geotourism in Ijen Crater is becoming increasingly relevant along with the high interest of tourists who visit and the high risk of disaster and accident risks. Education about disaster and accident risks to tourists is one of the key strategies for reducing potential hazards and increasing preparedness. In the context of geotourism, disaster, and accident risks are important issues that must be considered. Education about potential hazards in Ijen Crater is needed so that tourists not only enjoy the beauty of nature but also understand and comply with safety regulations.

Effective geotourism planning requires collaboration between many stakeholders, including local authorities and conservation groups. Stakeholders play an important role in developing policies and implementing safety measures to protect tourists and the environment (Wahyuningtiyas & Iskandar, 2023).

One effective method to provide risk education is installing warning signs in strategic locations in the area. These warning signs not only serve as danger markers but also as an educational medium for tourists to better understand the potential risks that exist. This study aims to assess the effectiveness of geotourism safety planning through disaster and accident risk education using warning signs. With clear and informative warning signs, tourists are expected to understand the risks of disasters and accidents that may occur. In addition, this planning also plays a role in improving visitor safety and supporting the image of safe and responsible tourism.

B. RESEARCH METHOD

Data were collected through field observation and document analysis. Qualitative methods with observation techniques were used to assess the condition of existing warning signs, as well as the obstacles faced by visitors to the information conveyed. Qualitative research is an approach to exploring and understanding the meaning that exists and is given by individuals or groups of individuals to social or human problems. Qualitative research occurs in natural settings, where human behavior and events occur naturally. Direct observation is a method of data collection in research in which the researcher directly observes the subject or phenomenon in the field without intervention or manipulation of the situation that occurred. Observations were conducted at several strategic points in the Ijen Crater, such as at the starting point of the hike, the hiking trail, and around the crater rim where tourists see the main attractions of Ijen Crater. Documents analyzed were government circulars, guidebooks or Indonesian National Standard documents, scientific publications, and related documents. Data analysis techniques used descriptive analysis and triangulation. Descriptive research describes certain circumstances as fully and carefully as possible (Rasyid, 2022). Its main advantage lies in its simple and flexible method, focusing on clear descriptions of experiences and events, and sticking closely to the data (Hall & Liebenberg, 2024). Descriptive analysis provides a basic overview of the data, while triangulation is used to ensure the validity and reliability of the data through comparison of various sources.

C. FINDINGS AND DISCUSSION

Ijen Geopark, located in Banyuwangi Regency and Bondowoso Regency, East Java Province, was officially designated as a UNESCO Global Geopark on September 9, 2023. One of the 21 developed geological sites is the Ijen Crater, an acidic crater lake with a blue flame phenomenon. Ijen Crater is also known for its traditional sulfur mining activities. Local miners manually collect chunks of sulfur from the crater and carry them down to the foot of the mountain. Tourism activities that visitors can do include hiking to the top of Ijen; enjoying the blue fire phenomenon; seeing the Ijen acid lake; observing the activities of sulfur miners; landscape photography; enjoying the sunrise at the summit; observing endemic flora and fauna; visiting other geosites around Ijen Crater such as Kali Pait, Blawan Waterfall, and Wurung Crater; camping in the Paltuding area; and learning about the geology and ecology of Ijen. Various attractions and activities can be done in Ijen Crater according to tourists preferences.

Behind the various tourist attractions of Ijen Crater, this area also has the potential for significant disaster and accident risks. Ijen Crater has various disaster and accident risks that

tourists, local communities, and authorities should be aware of. As an active volcanic area with an acidic crater lake, there are potential natural hazards that can affect safety. Here are some of the disaster risks and accident risks in Ijen Crater:

1. **Toxic Gases.** Ijen Crater emits toxic gases such as sulfur dioxide (SO₂) and hydrogen sulfide (H₂S) that can cause respiratory irritation, shortness of breath, and even fainting if inhaled in large amounts. Travelers and sulfur miners often use gas masks to protect themselves.
2. **Phreatic Eruption.** Phreatic eruptions or gas and vapor eruptions can occur without warning. These eruptions throw hot material into the air and cause dangerous gas jets. The potential for phreatic eruptions usually increases when there are temperature changes or volcanic activity in the crater lake.
3. **Crater Cliff Landslides.** The cliff structure around the crater is more steep and prone to landslides, especially during high rainfall. Landslides can result in rock material falling into the lake or hiking trails and pose a risk to visitors.
4. **Acid Lava Flood.** Ijen Crater has a highly acidic crater lake. In the event of extreme rainfall or high volcanic activity, this lake has the potential to overflow and flow into the river, creating acidic lava flows that damage the environment and threaten the safety of residents downstream.
5. **High Acid in Crater Water.** The crater lake at Ijen is one of the most acidic in the world, with a pH close to zero. This lake water is dangerous in case of direct contact, either with the skin or corrosive metal objects.
6. **Volcanic Activity.** As an active volcano, Ijen Crater always has the potential to erupt. Although there are no records of major eruptions in recent decades, volcanic activity can change at any time and needs regular monitoring by authorities.
7. **Dangerous Hiking Terrain.** The trail to Ijen Crater is challenging, steep, and slippery, especially at night when tourists hike to see the blue flames. There is a risk of falling or slipping which can jeopardize the safety of hikers.
8. **Heat Exposure from Blue Flame.** The blue flame phenomenon is caused by burning sulfur gas. In addition to toxic gases, the heat from blue flames is also dangerous if tourists get too close or are not careful when viewing them.

Disaster risk mitigation plays a crucial role in safeguarding the sustainability and security of tourist destinations and the tourism industry as a whole. The more tourists visit attractions, the greater the risks they may encounter (Suryadi et al., 2024). It is important to know and understand the risks involved in traveling to Ijen Crater. Risk prevention and avoidance should commence at the outset of exploring volcanic geosites, providing visitors with suitable safety information and guidelines (Erfurt, 2022). To reduce the risk of disaster in the Ijen Crater, several preventive and safety measures can be taken:

1. **Monitoring and Early Warning.** Volcanologists monitor Mount Ijen's activity regularly and provide warnings if there is a dangerous increase in activity.
2. **Gas Masks.** Travelers are encouraged to bring or rent gas masks to avoid the adverse effects of toxic gases.
3. **Access Restrictions.** As volcanic activity increases, hiking trails are temporarily closed to protect the safety of travelers.
4. **Safety Signs and Instructions.** Signs on hiking trails and dangerous areas help travelers stay on safe paths.

The process of submitting Ijen Crater as a UNESCO Global Geopark began with the submission of a Letter of Intent (LOI) to the UGGp secretariat through the decision of the Indonesian National Geopark Committee (KNGI) on July 30, 2020. Previously, the local government, together with experts and academics, had worked together to collect data and prepare an initial proposal to meet UNESCO criteria. After a long preparation and various proposal revisions, as well as field evaluation by the UNESCO team, Ijen Crater was successfully recognized as a UNESCO Global Geopark in 2023. The management of Ijen Geopark for the period 2023-2024 is stated in the Decree of the Governor of East Java Number 188/144/KPTS/013/2023. Although public and expert interest in geoparks is increasing, only several studies have examined changes in tourism facilities after becoming a global geopark (Sihombing et al., 2024). Along with the rise in tourism activities, the potential for disasters in the geopark zone has also escalated (Agastya et al., 2024).

Tourism infrastructure and facilities are essential for supporting visitor management, enhancing experiences, interpreting, and carrying out conservation efforts. One of the features available at UGGp's and geosites is signage. Signage is a component of the UGGp's soft infrastructure. It consists of informative panels which encompass general maps, safety guidelines, and regulations, interpretive panels, and directional signs (UNESCO, 2024). Based on the Head of the National Disaster Management Agency Regulation Number 7/2015, Article 6 paragraph 1, disaster signs consist of disaster guidance signs; disaster warning signs; and disaster prohibition signs. Furthermore, in Article 14 paragraph 1, disaster information boards consist of information boards on types of hazards; information boards on disaster events; information boards on entering disaster-prone areas; information boards on disaster evacuation routes; and information boards on place markers. The researcher observes signs and information boards for disasters and accidents, at several strategic points in the Ijen Crater, such as at the starting point of the hike, the hiking trail, and around the crater rim where tourists see the main attraction of Ijen Crater.



Figure 2. Disaster warning signs at Ijen Crater hiking starting point.
Source: researcher, 2024

Figure 2 shows that several signs have been installed around the Ijen Crater. The disaster warning sign at the starting point of the Ijen Crater trek contains information that the location is prone to volcanic eruptions. The sign is rectangular in shape, the background of the sign is yellow, the writing is black, also equipped with additional information and a symbol of a mountain eruption image. The caption is written in Bahasa Indonesia and English and contains information such as (1) Hazard Zone II: Potentially affected by pyroclastic flow eruption rain, rain lahar, and possibly volcanic debris avalanches. (2) Identify the nearest evacuation route and location. On BEWARE

status, people immediately evacuated. The researcher made observations to see tourist responses to the warning signs. Some tourists just glanced at it without reading, some passed the sign and did not realize the existence of the warning sign. This could be because tourists are too excited at the starting point of the hike so they walk too fast; the information listed on the sign is quite long; the writing is relatively small; visibility is limited, and around the sign, there are no lighting facilities.



Figure 3. Evacuation signage on the Ijen Crater hiking trail.

Source: researcher, 2024

Figure 3 shows evacuation direction signs on the Ijen Crater hiking trail. The sign is in the form of a directional arrow, the background of the sign is green, the writing is white, equipped with a symbol of a picture of a person running during a mountain eruption. It is written 'Evacuation Route' in Bahasa Indonesia and English. Some tourists stop for a moment to look at the sign, while others pass by the sign and do not realize its existence. Some visitors ignore and do not notice the signs, especially those who hike early in the morning when it is still dark. This could be due to the position of the sign which is too close to the tree so that most of the signpost is covered with heavy leaves and the green background color of the sign which is almost similar to the color of the leaves. Around the signs, there are no lighting facilities or coloring materials on the evacuation route signs that can reflect light. Fatigue during the hike can also cause tourists not to pay much attention to these directions.



Figure 4. Warning signs on the rim of Ijen Crater.

Source: researcher, 2024

Figure 4 shows warning signs on the rim of the Ijen Crater mounted on the guardrail. The sign is made of a banner, blue sign background, red writing, equipped with a 'stop' symbol, and a photo of the Ijen Crater view. The warning sign contains an appeal written only in Bahasa Indonesia, containing the sentence Appealed to all visitors to the Ijen Crater Natural Tourism Park: (1) Do not take photos on dead/living trees close to ravines. (2) To not climb dead/living trees. (3) Do not take pictures close to the cliff. (4) Do not approach the active crater. (5) Do not litter. (6) Always use standard mountaineering clothing and equipment (Do not use long dresses, bikinis, or shoes other than mountain shoes/sandals). Based on the researcher's observation, some tourists stopped for a moment to look at the sign, while others passed the sign. This could be because the information listed is quite a lot, the writing color is too contrasting and relatively small, and only uses Bahasa Indonesia so it is not understood by foreign tourists.

Although several signs have been installed, there are still several cases of tourist accidents due to a lack of awareness of the risks that threaten the Ijen Crater. This indicates that tourists lack of understanding of the risks or education from the management is not optimal. There are several challenges in implementing disaster and accident warning signs in Ijen Crater, including (1) Funding and Maintenance of Signs: Costs required for installation and maintenance of warning signs; (2) Traveler Compliance: Challenges in getting tourists to comply with existing signs; (3) Cooperation with Related Parties: The role of the government, tourism managers, and local communities in the sustainability of the warning sign program. Over the past few decades, advancements in geoeducation and geotourism have led to notable improvements in the textual and graphical design of informational panels. These developments reflect extensive research and have incorporated new media, engaged visitors more effectively, and considered the principles of heritage interpretation (Stolz & Megerle, 2022). Geotourism safety planning through disaster and accident risk education using warning signs in the Ijen Crater is quite effective considering the small number of cases but it still needs to be improved.

Solutions that can be applied by Ijen Crater managers in implementing warning signs as educational media such as (1) Types of Signs Needed: Describe what warning signs need to be installed, such as signs of toxic gas hazards, cliffs, and safe zones; (2) Design and Placement of Signs: The importance of designs that are easily understood by domestic and foreign tourists and strategic locations for sign placement; (3) Language and Visuals on Signs: Utilization of symbols, images, and language (multilingual) to increase the effectiveness of risk communication; (4) Ensure appropriate visibility and equip signs with lighting facilities; (5) The management of Ijen Crater can collaborate with related institutions to develop a more comprehensive and attractive educational program to minimize disaster risk. This is in accordance with UNESCO guidelines (2024), in geotourism planning, there are several steps that must be taken to reduce risks, such as (1) Risk Assessment; (2) Safety Measures & Precautions; (3) Visitor Information & Education; (4) Crisis Management Plan; (5) Collaboration with Authorities & Stakeholders; and (6) Continuous Monitoring & Evaluation. By integrating detailed risk assessment, safety precautions, and crisis management procedures into the geotourism plan, UNESCO Global Geopark can showcase a dedicated approach to ensuring visitor safety and guaranteeing a pleasant and secure experience for travelers. Balancing education with attraction is essential for establishing safe and sustainable geotourism.

D. CONCLUSION

The results have gained from the lack of effectiveness of warning signs due to sign design and lack of lighting facilities. Some visitors ignore and do not notice the signs, especially those who

hike early in the morning when it is still dark. The author recommends that it is necessary to integrate information about disaster risk in the form of warning signs that are easy to understand to increase awareness and alertness of visitors equipped with lighting facilities. The management of Ijen Crater can collaborate with related institutions to develop a more comprehensive and attractive educational program to minimize disaster risk. This research contributes to geotourism planning and emphasizes the importance of disaster and accident risk education as part of the mitigation strategy in disaster-prone tourism areas. Balancing education with attraction is essential for establishing safe and sustainable geotourism. Suggestions for future research are to explore in more depth the perceptions and level of understanding of tourists towards signage, Ijen Geopark governance, strategic planning for education, and disaster mitigation.

REFERENCES

- Agastya, I. B. O., Paripurno, E. T., Prastistho, B., Murwanto, H., Prasetya, J. D., Nugraho, A. R. B. (2024). Model media learning for disaster risk reduction in the Batur UNESCO Global Geopark. *International Journal of Geoheritage and Parks*, 12(3), 353-366. <https://doi.org/10.1016/j.ijgeop.2024.04.005>.
- Balai Besar Konservasi Sumber Daya Alam (BBKSDA) Jawa Timur. Surat Edaran Nomor: SE.1658/K2/BIDTEK.1/KSA/9/2024 Tentang Pembukaan Kawasan Taman Wisata Alam (TWA) Kawah Ijen.
- Balai Besar Konservasi Sumber Daya Alam (BBKSDA) Jawa Timur. Surat Edaran Nomor: Se.1289/K2/Bidtek.1/Ksa/07/2024 Tentang Penutupan Kawasan Taman Wisata Alam (TWA) Kawah Ijen.
- Braga, V., Duarte, A., & Marques, C. S. (2022). *Tourism, Hospitality and Event Management – The Economics of Geotourism*.
- Drinia, H., Voudouris, P., & Antonarakou, A. (Ed.). (2022). *Geoheritage and Geotourism Resources: Education, Recreation, Sustainability*. Geosciences. <https://doi.org/10.3390/books978-3-0365-4850-0>
- Erfurt, P. (2022). Volcano Tourism and Visitor Safety: Still Playing with Fire? A 10-Year Update. *Geoheritage*, 14(2). <https://doi.org/10.1007/s12371-022-00691-y>
- Fernandes, G. P., Castro, E., & Tracana, R. B. (2021). Tourism as a Strategy for Geo-Education and Cultural Valorization of Territories: Promoting Ecocultural Values and Geoconservation in Estrela Geopark, Portugal. <https://doi:10.4018/978-1-7998-5691-7.ch007>
- Hall, S., & Liebenberg, L. (2024). Qualitative Description as an Introductory Method to Qualitative Research for Master's-Level Students and Research Trainees. *International Journal of Qualitative Methods*, 23. <https://doi.org/10.1177/16094069241242264>
- Keputusan Gubernur Jawa Timur Nomor 188/144/Kpts/013/2023 Tentang Pengelola Geopark Ijen Periode Tahun 2023-2024.
- Kompas.com. (2024, April 23). 4 Fakta Wisatawan China Meninggal Usai Jatuh ke Jurang TWA Kawah Ijen. https://www.kompas.com/tren/read/2024/04/23/173000865/4-fakta-wisatawan-china-meninggal-usai-jatuh-ke-jurang-twa-kawah-ijen#google_vignette.
- Kompas.com. (2023, September 11). Kawasan Ijen Resmi Ditetapkan sebagai UNESCO Global Geopark. <https://travel.kompas.com/read/2023/09/11/170500827/kawasan-ijen-resmi-ditetapkan-sebagai-unesco-global-geopark>.
- Miskiewicz, K. (2024). Geotourism Product as an Indicator for Sustainable Development in Poland. *Sustainability*, 16, 5516. <https://doi.org/10.3390/su16135516>
- Mouneke, N. (2024). Safety and Security Concerns in Nigeria's Tourism Sector: The Issue of Geotourism Destinations. *Information Management and Business Review*, 16(3), 616-625. [https://doi.org/10.22610/imbr.v16i3\(I\).4014](https://doi.org/10.22610/imbr.v16i3(I).4014)
- Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor 7 Tahun 2015 tentang Rambu dan Papan Informasi Bencana.

- Rasyid, F. (2022). Metodologi Penelitian Kualitatif dan Kuantitatif – Teori, Metode, dan Praktek. IAIN Press Kediri.
- SNI 8289:2016 Jalur dan rambu evakuasi erupsi gunungapi.
- Sabila, F.S.N., Abdurrachman, M., Saepuloh, A., Kurniawan, I.A., Baraas, A., Yudiantoro, D.F., & Kusdaryanto, H. (2024). Geology, Archaeology, and Historical Studies of the Late 16th Century Plinian Eruption of Raung Volcano: A Potential Case for Disaster Geotourism in Ijen UNESCO Global Geopark, East Java, Indonesia. *Geosciences*, 14. <https://doi.org/10.3390/geosciences14110284>
- Sihombing, F. V. BR., Suryadi, M. I., & Putra, D. H. A. S. (2024). TRANSFORMASI FASILITAS PARIWISATA KALDERA TOBA PASCA PENETAPAN SEBAGAI UNESCO GLOBAL GEOPARK. *Warta Pariwisata*, 22(1), 38-45. <https://doi.org/10.5614/wpar.2024.22.1.06>
- Stolz, J., & Megerle, H. E. (2022). Geotrails as a Medium for Education and Geotourism: Recommendations for Quality Improvement Based on the Results of a Research Project in the Swabian Alb UNESCO Global Geopark. *Land*, 11(9). <https://doi.org/10.3390/land11091422>
- Suryadi, M. I., Enzelluthfiah, L., Amalia, H.S., & Pratiwi, W. D. (2024). DAMPAK PARIWISATA DI KAWASAN PANTAI PADANG TERHADAP MANAJEMEN RISIKO BENCANA GEMPA DAN TSUNAMI. *Jurnal Darma Agung*, 32(4), 343 - 353. <https://doi:10.46930/ojsuda.v32i4.4527>
- Susetyo, S. H., Abidin, A. U., Nagaya, T., Kato, N., & Matsui, Y. (2024). Environmental health risk assessment and acute effects of sulfur dioxide (SO₂) inhalation exposure on traditional sulfur miners at Ijen Crater Volcano, Indonesia. *Toxicology Reports*, 13. <https://doi.org/10.1016/j.toxrep.2024.101772>
- Undang-Undang Nomor 24 Tahun 2007 Tentang Penanggulangan Bencana.
- UNESCO. (2024). *GEOTOURISM FOR UNESCO GLOBAL GEOPARKS: A TOOLKIT FOR DEVELOPING AND MANAGING TOURISM*.
- Wahyuningtiyas, L., & Iskandar, D. A. (2023). Peran Stakeholder dalam Pengelolaan Kawasan Taman Wisata Alam Kawah Ijen. *Journal of Regional and Rural Development Planning*, 7(2). <https://doi.org/10.29244/jp2wd.2023.7.2.166-178>