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Ecotourism Hazard Mapping in Torean Trail, Mount Rinjani National Park, North Lombok District

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Abstract

Mount Rinjani is a mountain located in Mount Rinjani National Park and is popular as a hiking tourist destination. The Torean Trail is one of 6 hiking trails on Mount Rinjani that has potential ecotourism hazards, namely physical hazards, biological hazards, and human activity hazards. The purpose of the study was to identify and assess potential hazards in hiking activities on the Torean trail based on physical, biological and human activity aspects. The type of data collected is data on potential physical, biological and human activity hazards that may pose a risk, the incidence of accidents, and the location where the hazards are found. Data were collected through literature study, field observations, and interviews. There are three kinds of hazards found in the Torean Trail, namely physical hazards, biological hazards, and human hazards. These hazards can threaten tourists when hiking through the Torean Trail.

Keyword: hazards, hiking trails, Mount Rinjani, Mount Rinjani National Park

1. Introduction

Mount Rinjani is one of the famous destinations in West Nusa Tenggara and is within the Mount Rinjani National Park area. One of the most popular tours is hiking on Torean Trail which is also associated with hazards and potential disasters. According to Muntasib et al. [1], hazards and potential disasters can befall climbers at any time. Therefore, managers need to actively plan trips and map areas that may be dangerous. Mount Rinjani is also included in the Asia Pacific volcanic chain on Lombok Island and has moderate to high seismic activity [2].

Administratively, the Torean Trail is in Loloan Village, Bayan District, North Lombok Regency, West Nusa Tenggara and is included in the National Park Management Section (SPTN) I area, precisely in the Senaru Resort. Currently, the Torean Trail has 4 temporary posts for hiking, namely the check-in post, post 1, post 2 (Birisan Nangka), and post 3. The Torean Trail is a new hiking trail that goes directly to Segara Anak Lake without having to go through the crater/Pelawangan. The advantage of this hiking trail is that there are many springs even in the dry season, so climbers will not have difficulty finding water, unlike other hiking trails. In addition, the first half of the hiking trail passes through a shady forest. The Torean Trail is used for traditional ceremonies and religious rituals at the hot springs below Gua Susu. Today, the Torean Trail is one of the most frequently travelled trails by climbers. This is because the Torean Trail offers extraordinary natural beauty. The more climbers who pass through the Torean Trail, the greater the possibility of danger on the hiking trail.

Hiking activities in the mountains, especially on active mountains, have the potential for danger, with risks ranging from minor accidents to serious accidents. A hazard is an event, phenomenon or human activity that has the potential to be physically damaging, causing injury or loss of life, damage to infrastructure, or environmental degradation [3]. Hazard management is necessary to improve safety assurance for visitors. According to Jubenville et al. [4], hazard management is an activity with a specific purpose implemented by managers to reduce the possibility of injury, death, or loss of property that occurs to participants from known or predicted causes, both natural and man-made hazards found in a tourist area. Safety issues are the main factor that visitors consider in choosing a tourist destination to visit [5]. Management of hazards that may occur in tourist areas is needed to create

confidence in visitors for their safety, thus contributing to the increase in subsequent visitors [6]. In line with Hermawan [7] which shows that increasing tourism security efforts will have an impact on increasing visitor satisfaction.

Therefore, hazard mapping is needed on the Torean Trail so that it can be used for the information for climbers who pass through the Torean Trail. The purpose of this research is to identify and assess potential hazards in hiking activities on the Torean Trail based on physical, biological, and human activity aspects.

2. Research Methods

The research was conducted at the Torean Trail, Mount Rinjani National Park, North Lombok Regency, West Nusa Tenggara Province. Data collection was conducted from April to June 2022. The tools used include Global Navigation Satellite System (GNSS) receiver, compass, thermometer hygrometer, and clinometer. The software used were Microsoft Office, Avenza Maps 3.14, and ArcGIS 10.8. Supporting tools such as stationery, digital single lens reflex cameras namely Canon EOS 200D, recording devices, and materials used in the form of maps of the Mount Rinjani area.

Data was collected on potential physical, biological, and human activity hazards that could pose a risk, accident occurrence, and hazard location. Data were collected through literature study, field observation, and interviews. Interviews were conducted with managers, communities, and visitors, especially those involved in hazard management on Mount Rinjani, with various communities involved in the management of Mount Rinjani. Community respondents, who often climb Mount Rinjani, are involved in tourism activities and/or climbing management, and community leaders. The number of community and visitor respondents was 30 respondents each [8].

Data on physical and biological hazards were identified and analysed by referring to the risk assessment guidelines by classifying hazards based on likelihood and severity, then evaluating risks using a risk evaluation matrix [9]. Data on hazards caused by human activities were analysed based on the NHS risk assessment [10]. The risk criteria for physical and biological hazards refer to UNEP [9], namely the criteria for the probability of occurrence and severity of hazards. The likelihood level of physical and biological hazards was classified into five classes: rare (score 1), unlikely (score 2), possible (score 3), likely (score 4), and almost certain (score 5). Physical and biological hazards that only occur in extreme circumstances are classified as rare. Physical and biological hazards that sometimes occur under certain circumstances are categorised as possible. Included in the possible class if physical and biological hazards often appear in certain circumstances. While physical and biological hazards that fall into the almost certain class, usually very often appear in every situation.

Based on UNEP [9], the criteria and scores for the severity of physical and biological hazards are classified into five classes: not severe (score 2), moderately severe (score 4), moderately severe (score 6), severe (score 8), and very severe (score 10). Included in the non-severe class if there is no significant disturbance. If there is minor disruption, it is categorised as moderately severe. Then if there is a disturbance that causes serious injury, it is categorised as moderately severe. When interference sometimes causes death, it is categorised as severe. While disturbances that definitely cause death are categorised in the very severe class.

Human hazard assessment criteria and scores are also classified based on hazard likelihood and severity criteria, where each criterion is classified into five classes with the lowest score of 1 and the highest score of 5 [10]. The hazard chance level criteria classes are rare (score 1), unlikely (score 2), possible (score 3), likely (score 4), and almost certain (score 5). Human hazards that are unlikely to occur are included in the rare class. The unlikely class includes hazards that have an unpredictable but possible chance of occurrence. If a human hazard has a chance of occurring occasionally for some reason, it is categorised into the possible class. Meanwhile, human hazards that have a chance of occurring 2-3 times in a certain period of time are included in the likely class. If the hazard has the possibility of occurring very often and repeatedly, it can be grouped into the almost certain class.

The criteria for the severity of human hazards are categorised into five classes: not severe (score 1), moderately severe (score 2), moderately severe (score 3), severe (score 4) and very severe (score 5). Including the non-severe class if the impact of the hazard is felt in the form of itching and blisters. If the severity of the hazard causes prolonged pain and even causes shortness of breath, it can be categorised into the moderately severe class. Furthermore, it can be categorised as moderately severe if there is a temporary loss of consciousness. Severe class is included if the severity causes permanent disability and severe injuries. Meanwhile, hazards that cause death are categorised as very severe. The risk assessment of physical hazards, biological hazards, and human hazards is then calculated using the following formula:

$$\text{Risk} = \text{Likelihood} \times \text{Severity} \quad (1)$$

The results of the calculation of the assessment of hazard likelihood and severity criteria will obtain the level of hazard risk and be classified using a risk matrix to determine the priority of hazards that must be corrected [11]. The risk matrix of physical hazards, biological hazards, and human hazards are presented in full in Figure 1 and Figure 2. The risk of physical and biological hazards is classified into four classes, namely low risk with a value of 2-12, medium risk with a value of 13-25, high risk has a value of 26-38, while very high risk has a value of 39-50. Human hazard risk classification is also classified into four classes: low risk with values 1-3, medium risk with values 4-6, high risk with values 8-12, and very high risk with values 15-25.

Risk = Likelihood x Severity		**Severity**				
		Not severe	**Slightly severe**	**Moderately severe**	**Severe**	**Very severe**
Likelihood	**Almost certain**	10 Low risk	20 Medium risk	30 High risk	40 Very high risk	50 Very high risk
	Likely	8 Low risk	16 Medium risk	24 Medium risk	32 High risk	40 Very high risk
	Possible	6 Low risk	12 Low risk	18 Medium risk	24 Medium risk	30 High risk
	Unlikely	4 Low risk	8 Low risk	12 Low risk	16 Medium risk	20 Medium risk
	Rare	2 Low risk	4 Low risk	6 Low risk	8 Low risk	10 Low risk

Figure 1. The risk matrix of physical hazards and biological hazards

Risk = Likelihood x Severity		Severity				
		Not severe	Slightly severe	Moderately severe	Severe	Very severe
Likelihood	Almost certain	5 Medium risk	10 High risk	15 Very high risk	20 Very high risk	25 Very high risk
	Likely	4 Medium risk	8 High risk	12 High risk	16 Very high risk	20 Very high risk
	Possible	3 Low risk	6 Medium risk	9 High risk	12 High risk	15 Very high risk
	Unlikely	2 Low risk	4 Medium risk	6 Medium risk	8 High risk	10 High risk
	Rare	1 Low risk	2 Low risk	3 Low risk	4 Medium risk	5 Medium risk

Figure 2. The risk matrix of human hazards

In addition to the hazard risk assessment, spatial analysis was also conducted. Spatial analysis was carried out on the geographical coordinates of potential physical hazards, biological hazards, human hazards, the location of hiking posts, the summit of Mount Rinjani, and Segara Anak Lake that were successfully inventoried on the Torean route. The spatial analysis process was carried out using ArcGIS 10.8 software to produce a map of potential hazards. Spatial data of hazard points inventoried in the field was converted from Avenza Maps into Keyhole Markup Language (KML) format, so that it can be read in geographic information system-based software such as ArcGIS 10.8. Furthermore, the spatial data of hazard points is overlaid with data on the administrative boundaries of the area, then given information in the form of map symbology according to the potential hazards found.

3. Results and Discussion

3.1. General Conditions of the Torean Trail

The Torean Trail is one of the six hiking trails in Mount Rinjani National Park. Through SK.78/T.39/TU/KSA/3/2021 on 15 March 2021, the Torean Trail was inaugurated on April 1st 2021. Before it was inaugurated, the Torean Trail was a trail used by the Sasak Hindu and Muslim communities to carry out traditional ceremonies both at Segara Anak Lake and along the Torean Trail.

The Torean Trail has two branching trails, namely the Torean Trail and the Senanga Trail with an intersection before post 2 Birisan Nangka. In addition, this trail also has three temporary posts for hiking, then for help for hikers utilising information posts that have decent facilities. Since the Torean Trail was inaugurated until the end of 2021, there have been at least ten accident victims, seven of whom suffered sprained legs while hiking and three victims fell into the ravine. All victims were evacuated to get help. Evacuation and rescue activities on the hiking trail are carried out by the Edelweiss Medical Help Centre (EMHC).

3.2. Potential Physical Hazards

The potential physical hazards found on the Torean Trail are ravines, slippery and steep trails, low temperatures, fog, landslides, volcanic activity, and fire (Figure 3). Potential physical hazards have low, medium, and high-risk values. Accident data from the Mount Rinjani National Park Office in 2021-2022 recorded 10 accidents on the Torean Trail and 7 of them were caused by slippery and steep paths. In addition, ravines are the highest potential physical hazard factor, because the Torean Trail is a hiking trail that has many ravines with insufficient security. The temperature around the hiking trail ranges from 14-27ºC. The temperature is low enough to cause hikers to experience hypothermia on the Torean Trail. While physical hazard factors such as fog, landslides, volcanic activity, and fires are very little found.

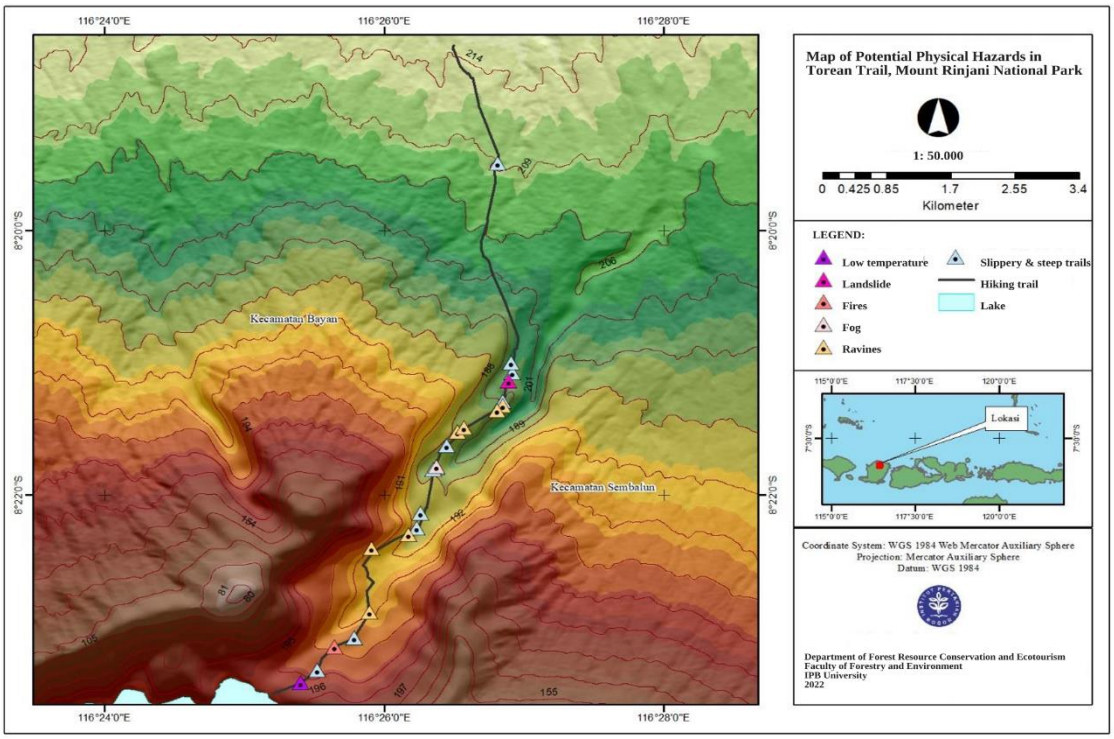

Figure 3. Map of potential physical hazards in Torean Trail, Mount Rinjani National Park

Table 1. Potential physical hazard values in Torean Trail, Mount Rinjani National Park

No.	Potential Physical Hazards	Likelihood	Severity	Value	Risk Level
1	Ravines	Likely	Severe	32	High risk
2	Slippery and steep trails	Likely	Moderately severe	24	Medium risk
3	Low temperature	Possible	Slightly severe	12	Low risk
4	Fog	Possible	Slightly severe	12	Low risk
5	Landslide	Unlikely	Slightly severe	8	Low risk
6	Volcano activity	Unlikely	Slightly severe	8	Low risk
7	Fires	Rare	Slightly severe	4	Low risk

The ravine has the highest level of danger because the chances of occurrence are quite high and have a high risk, as recorded in Table 1. Data for 2021-2022 from TNGR recorded three incidents of tourists falling into the ravine and causing injuries so that they had to be evacuated by the manager. Slippery and steep trails are the most frequent potential hazards on the Torean Trail. A total of seven incidents were reported in April 2021 - May 2022 where slippery and steep trails, especially during the rainy season, caused minor to moderate injuries, but no fatalities have been reported due to this hazard.

In addition, low temperature conditions are also a cause of tourist hypothermia on the Torean Trail. Hypothermia is common when hiking closer to Segara Anak Lake. Temperature measurements on the Torean Trail ranged from 16-27ºC. The Torean Trail is also often foggy which can potentially obscure the view of tourists. Bad weather conditions that occur are one of the factors that fog often appears. Fog does not pose a great risk of danger because it appears only at specific times. Landslides have occurred at several locations on the hiking trail but were never officially recorded by officials. The landslide occurred when the hiking trail was closed, so there was no record of casualties. The impact of the landslide was the disruption of the trail when the hike was reopened. In contrast to what happened on Mount Everest, the main cause of death of hikers was caused by avalanches.

Mount Rinjani's volcanic activity is still active. This is because Mount Rinjani has a subsidiary mountain that is still active, namely Mount Barujari. Volcanic activity in the form of eruptions recorded from 1846 - 2016 occurred 12 times, namely in 1846, 1884, 1901, 1906, 1909, 1915, 1944, 1966, 1994, 2004, 2009 and 2016 [12]. Eruptions due to volcanic activity of Mount Rinjani are mostly centred in the caldera, so that the flow of lava and volcanic dust is not directly felt by the surrounding community. While the fire incident on the hiking trail has occurred 5 times. Fires can occur due to weather factors and also from the activities of visitors and porters/guides who light fires carelessly. According to [13]fires on hiking trails can be caused by the activities of hikers who make campfires and throw cigarette butts without turning them off first.

3.3. Potential Biological Hazards

Potential biological hazards found on the Torean Trail are transverse branches, nettles, and long-tailed macaques (*Macaca fascicularis*). Transverse branches are quite often found along the Torean Trail due to the tropical forest vegetation that has many trees and plants. In 2022 a tourist was injured when his foot got caught in a tree branch, requiring evacuation. Jelatang (*Laportea pterostigma*) also one of the plants often found along the Torean Trail, this plant can cause itchiness which can reduce comfort while hiking. Long-tailed macaques are rarely encountered along the Torean Trail and rarely injure tourists.

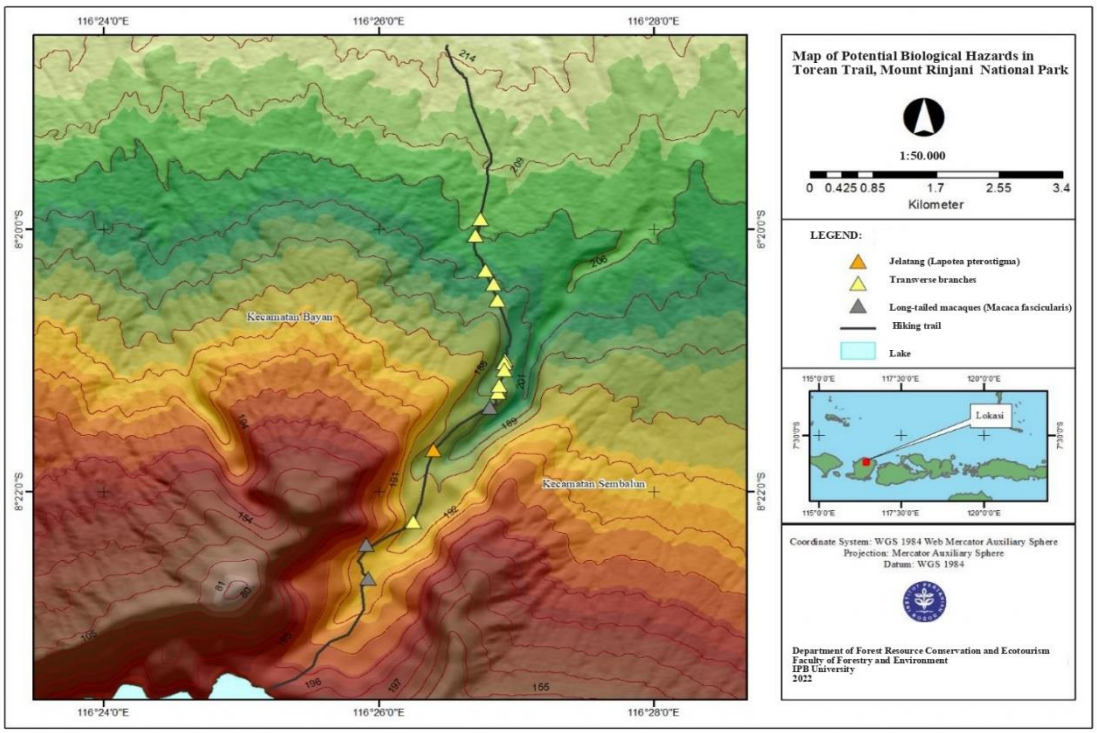

Figure 4. Map of potential biological hazards in Torean Trail, Mount Rinjani National Park

Table 2. Potential biological hazard values in Torean Trail, Mount Rinjani National Park

No.	Biological Hazards	Likelihood	Severity	Value	Risk Level
1	Transverse branches	Possible	Moderately severe	18	Medium risk
2	Jelatang (*Lapotea pterostigma*)	Possible	Slightly severe	12	Low risk
3	Long-tailed macaques (*Macaca fascicularis*)	Rare	Slightly severe	6	Low risk

Along the hiking trail there are many transverse branches, especially during the rainy season, there are more transverse branches due to fallen trees, increasing the potential for danger on the Torean Trail. Transverse branches can potentially cause danger, especially for climbers who do not pay attention to the condition of the path when walking. Jelatang also have the potential to be a biological hazard, this plant is found near Segara Anak Lake. Jelatang has spiny and poisonous green leaves, if accidentally touched the skin experiences pain and stinging, feels like burning and reddish itching [14].

Potential wildlife hazards such as long-tailed macaques are found at several points along the hiking trail, such as in Pelawangan Senaru, Pelawangan Sembalun, and around Segara Anak Lake. According to Saputra et al. [15], long-tailed macaques can be aggressive towards visitors with food grabbing behaviour, potentially causing injury to visitors. Heriyanto and Muhtar [16] added that long-tailed macaques are primates that often forage during the day, so they often disturb and attack humans, especially during the day.

3.4. Potential Human Hazards

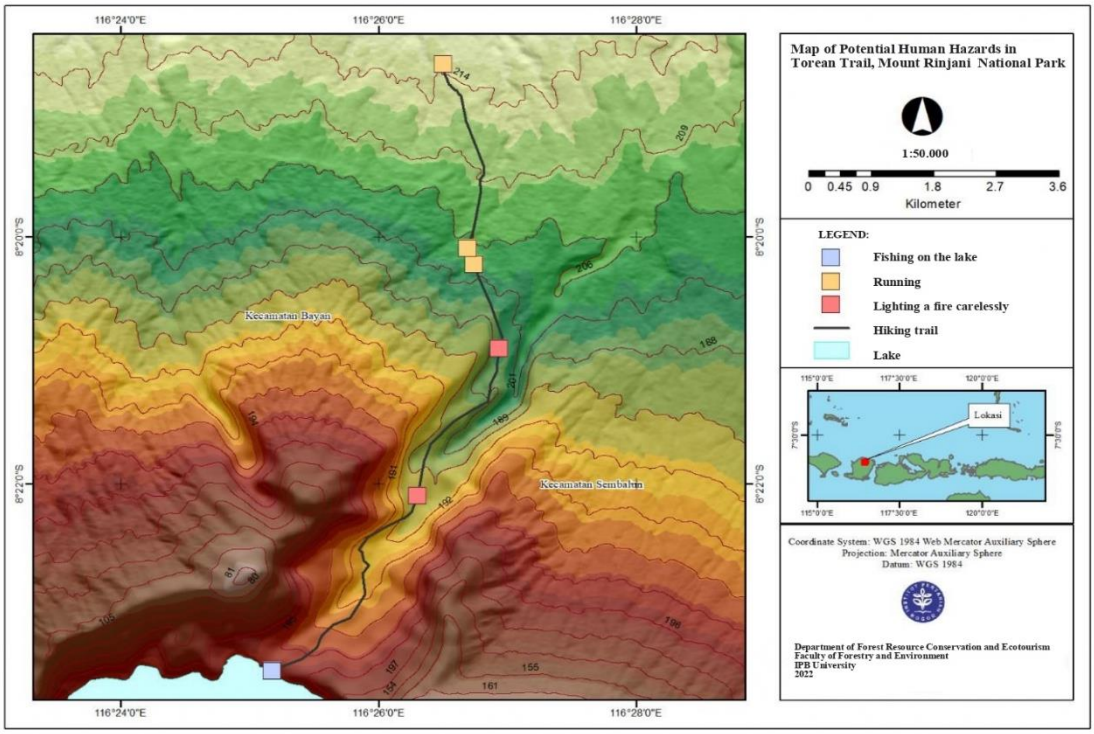

Figure 5. Map of potential human hazards in Torean Trail, Mount Rinjani National Park

Table 3. Potential human hazard values in Torean Trail, Mount Rinjani National Park

No.	Human Activities	Risk of Potential Harm	Value	Risk Level
1	Running	Fall/injury/bone fracture/fatalities	16	Very high risk
2	Lighting a fire carelessly	Fire/fatalities	10	High risk
3	Fishing on the lake	Drowning/fatalities	3	Medium risk

Potential human hazards on the Torean Trail include running, careless fire lighting and fishing in the lake. Running on the Torean Trail is particularly dangerous as there are many slippery and steep trails, making injury a possibility. Carelessly lighting fires on the Torean Trail also has the potential to increase the occurrence of hazards on the hiking trail.

Running is an activity that can be dangerous for tourists, because the slippery and steep condition of the hiking trail makes this path should not be used for running. Balance when hiking can be done by walking with small steps, adjusting breathing movements and not forcing footsteps that are too wide to save energy so as not to get tired quickly [17]. The Torean Trail currently has 3 temporary posts that are used by tourists to rest or to build a camp. Most of them bring portable cookstoves or firewood to cook or keep body warm, but it is still common to find tourists who do not turn off the fire so that it can cause a fire in the post area or burn tourist objects found in that place.

Fishing activities in Segara Anak Lake are often carried out by local residents and through the Torean Trail. Based on data from TNGR in 2021-2022, there has never been a case of a hikers having an accident or drowning while fishing. However, before the Torean Trail was officially opened, there were angler accidents, but they were not recorded because they were still illegal. According to Gitapala [18] a hikers must be sensitive to the environment and surroundings as a way to be aware of the threat of danger that can come at any time.

4. Conclusions

The Torean Trail has three potential hazards: physical hazards, biological hazards, and human hazards. The physical hazards recorded on the Torean Trail have a high risk of ravines, a medium risk of steep and slippery trails, and low risk factors including low temperature, fog, landslides, volcanic activity, and fire. Biological hazards have three hazard factors: transverse branches have a medium risk, Jelatang plants, and long-tailed macaques have a low risk. Human activity hazards have three hazard factors: running activity, lighting fires, and fishing in Segara Anak Lake.

Author Contributions

EKSHM: Conceptualization, Metodology, Supervision, Writing - Review & Editing; **MDA:** Data Collection, Software, Data Visualization, Writing - Original draft preparation; and **RS:** Supervision, Metodology, Writing - Review & Editing.

Conflicts of interest

There are no conflicts to declare.

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