Reducing the risk of potential hazard in tourist activities of Mount Bromo

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Abstract. Mount Bromo has been crowned as one of the most beautiful mountains in the world, having a particular landscape uniqueness. Not only volcano, Bromo also has savanna, sea of sands, and culture of Tengger tribe. Its panoramic landscape has attracted a large number of tourists, both domestic and foreign, despite the threat of eruption. To ensure tourists safety and satisfaction, the potential hazard, both from eruption and other features should be managed carefully. The study objective was to identify and map hazard potentials and identify the existing hazard management. It was carried out in Mei – June 2017. Lava, tephra, eruption cloud, ash, earthquake, land sliding, extreme weather, slope, transportation modes (jeep, motorcycle, and horse), human, and land fire were found as potential hazards in Mount Bromo. Five locations had been identified as hazard area in the tourism areas, i.e. savanna, sea of sand, Bromo caldera and Pananjakan I trail and viewing point. Early warning system should be developed as part of hazard management in the area. Capacity building of local stakeholders and visitors would be needed to reduce risk of the hazard.

1. Introduction

Hazard is defined as any source that has the potential to cause harm, accident or adverse health impact on something or someone [1]. An older definition states hazard as physical events, phenomenon, or human activity with destructive potentials that may cause loss of life or injury, property damage, social and economic disturbance or environmental damage [2]. There are two causes of hazard: (1) nature, which include lightning, cliff, landslide, vegetation, wildlife, volcano activities, waves, current, rapids, troughs, and floods, and (2) human activities, which include unmaintained buildings, design of roads/lanes, and landscapes that have been changed [3]. Natural hazards such as volcano eruption, earthquakes, landslide, avalanche in high mountainous area, high waves, torrential rain and storm in coastal areas, can affect tourists’ activities and tourism destinations, and can substantially changes the landscape of an area [4]. Hazard potentials in tourism destination may also cause risk for destination manager and visitors.

Risk is defined as possible adverse consequences or predicted loss (death, injury, financial loss, disturbance on livelihood and economic activities, and environmental damage) resulted from interaction between natural or human induced hazard and vulnerability [2] or the combination of hazard and vulnerability [5]. Risk can be calculated as the product of disaster likelihood multiplied by vulnerability, and divided by capacity to respond adequately [2].
Recreational opportunity in tourism destination is generally contain hazard, and therefore the manager should be responsible to carry out hazard management actions in reducing the likelihood of accidents or loss occurrence on visitors [3]. Such condition can also be found in Mount Bromo, an active volcano that recently erupted in 2016. Mount Bromo area is part of Bromo Tengger Semeru National Park located in East Java Province. The site is acknowledged as one of the most beautiful mountains in the world. It has various attractions, which include the scenic mountainous view, sunrise view, sea of sands, savanna, volcano and the culture of Tengger Tribe. Its panoramic and scenic beauty has attracted high number of visitors, both domestic and foreign, over the years. However, behind its magnificent beauty lies potential hazards threatening the safety of tourists visiting the site. Natural hazard in tourism area of Mount Bromo include volcanic activities of Mount Bromo, gorge/cliff, landslide, weather, fire, lightning, wind, earthquake, and various diseases associated with the respiratory tract [6].

During January 2016 – April 2017, eighteen cases of accidents in Mt. Bromo area has been recorded for insurance claims, and more might have happened that had not been reported. Visitors who had negative experience will have lower satisfaction and lower option of return visit [7]. There is significant relation between visitors’ safety and destination’s image, and that the image of the destination affects visitors’ motivation to visit the destination [8]. While visitors to protected area should be limited based on its carrying capacity, a decrease of visitor number caused by such bad image would not be acceptable. Therefore, hazard/risk management is required. Risk management should be developed based on different types of client and travel [9]. Risk management stages includes planning risk management, risk assessment, risk control, risk financing, and risk monitoring and evaluation [10]. There are at least two approaches in developing hazard/risk management plan, i.e. job safety analysis/JSA [11] and tourism risk assessment developed by Wilks and Moore for APEC in 2004 [12], which later was also adopted by UNEP [2]. The APEC/UNEP approach is widely used in tourism hazard management researches. This research aimed at identifying and assessing potential tourism hazard and risk in Mount Bromo and providing its management recommendation, using the Wilks and Moore/APEC/UNEP approach.

2. Method

2.1. Location and Time
This research was carried out in Mount Bromo. The mountain is part of Bromo Tengger Semeru National Park, which is located on 7°54' - 8°55'13” South Latitude and 112°51’ - 113°04’45” East Longitude. Administratively, Mount Bromo is located on four districts, i.e. Probolinggo, Pasuruan, Lumajang, dan Malang Districts, East Java Province. Interview to residents was carried out to residents living in two adjacent villages, i.e. Ngadas Village, Malang District, and Ngadisari Village, Probolinggo District. The field survey was conducted on May 2017.

2.2. Data Collection Method
Survey method, which include field observation and interview with Mount Bromo manager, local community, and visitors, was employed in collecting data on hazard potentials, tourism activities, accidents occurrence, and existing management actions and hazard management plan. Geographical location of potential hazards or source of hazards were marked using the Geographical Positioning System (GPS) for later used in mapping the hazard. In addition, literature and document study was also carried out to obtain the data.

Interview with the manager of Mount Bromo, local community, visitors, and local tourism agency were carried out to obtain data on hazard potentials, its risk, severity and likelihood, accidents occurrence, existing management actions, and community and visitors perception toward hazard and visitors safety services. Management key informant, i.e. the officers in charge of visitor safety services and hazard management, were selected as respondent in the interview with the manager. Interview was also carried out with 30 conveniently sampled local people/residents from Ngadas and Ngadisari Villages located adjacent to the destination. A total of 30 visitor respondents, selected using convenient
sampling, were also interviewed. Included in the questionnaire were respondents’ assessment on hazard likelihood and severity, using qualitative measures (table 1 and table 2).

2.3. Data Processing
Lists of identified hazards in Mount Bromo were developed from field observation, interview with area manager, interview with residents, and interview with visitors. The lists were then combined to develop a complete list of identified hazards in Mount Bromo, which included the likelihood and severity of each hazard potential. Since quantitative data on the frequency of occurrence and the risk incurred is lacking, qualitative data was used to explain the measures of likelihood (table 1) and severity (table 2), based on information provided by the area manager, residents, and visitors. The highest number of responses from the three groups of respondents were used in classifying hazard’s likelihood and severity, in order to minimize bias (under or over estimation of likelihood and severity).

Table 1. Qualitative measures of likelihood [12][2]

| Descriptor              | Description                                      |
|-------------------------|--------------------------------------------------|
| Almost certain          | Is expected to occur in most circumstances        |
| Likely                  | Will probably occur in most circumstances         |
| Possible/Moderate       | Frequently occur at some time                    |
| Unlikely                | Could occur at some time                         |
| Rare                    | May occur in exceptional/ extreme circumstances  |

Table 2. Qualitative measures of severity [12][2]

| Descriptor   | Description                                      |
|--------------|--------------------------------------------------|
| Insignificant| Insignificant consequences, no injury            |
| Minor        | Minor consequences/injury: first aid treatment   |
| Moderate     | Serious (permanent) injury, medical treatment required |
| Major        | Extensive injuries, with occasional death        |
| Catastrophe  | Fatalities/death                                 |

2.4. Data Analysis
Potential hazards found in Mount Bromo tourism destination was mapped using Arcmap 10.3 software. The map was derived from map of zonation of Bromo Tengger Semeru National Park and hazard geographical position obtained using GPS in field observation through digitation, data extraction using DNR Garmin 5.4.1 software and map generation process (figure 1).
Risk assessment includes risk identification to determine possible risk, analysis/evaluation to determine the magnitude/level of risk, and value judgment/appraisal to determine risk’s acceptability [10]. Risk assessment involves assessment to the identified risk based on the impact, separating the minor and acceptable risk to major risk by considering the likelihood (frequency of probability) of risk occurrence, and the impact (consequences) of the risk [12][2]. Hazard found in the destination was ranked based on its likelihood from rare to almost certain (table 1). Rank of impact severity was also assigned to each potential hazard, ranging from insignificant to catastrophe (table 2). The rank of likelihood and severity of each type of hazard was obtained from the highest number of responses given by respondents (managers, residents, and visitors).

After the rank of likelihood and severity was assigned to each type of hazard, the likelihood and severity of each hazard was then mapped into a qualitative matrix of risk analysis (table 3). Thus, a level of risk can be assigned to each potential hazard, ranging from low risk (acceptable risk) to extreme risk. For example, when the likelihood is moderate, and the severity is major, then the level of risk would be extreme, which would require immediate action.

Table 3. Qualitative Risk Analysis Matrix – Level of Risk [12]

| LIKELIHOOD       | SEVERITY/CONSEQUENCES |
|-------------------|-----------------------|
|                  | Insignificant | Minor | Moderate | Major | Catastrophe |
| Almost Certain    |               | H     | H        | E     | E           | E         |
| Likely            | M              | H     | H        | E     | E           | E         |
| Moderate/Possible | L              | M     | H        | E     | E           | E         |
| Unlikely          | L              | L     | M        | H     | E           | E         |
| Rare              | L              | L     | M        | H     | E           | H         |

Legend: E: Extreme risk, immediate action required; H: High risk, senior management attention needed; M: Moderate risk, management responsibility must be specified; L: Low risk, manage by routine procedures.

After the level of risk were identified, the management option could be determined. For tourism operators and destinations, management option for treating risk include accepting, avoiding, transferring
or reducing risk (figure 2). After determining the management option, management actions could also be developed.

![Risk Evaluation Matrix](image)

**Figure 2.** Risk evaluation matrix [12][2].

3. Result and Discussion

3.1. General Condition of Mount Bromo Tourism Area

Mount Bromo is located on the north part of Bromo Tengger Semeru National Park, in the use zone of Cemorolawang-Mentigen. Mount Bromo lies on the caldera of Tengger Mountainous Area, which most people known as Mount Bromo Area, along with several other mountains. Mount Bromo is surrounded by extensive sea of sand (around 5,290 ha) hemmed by high caldera wall forming high and steep cliff. The view of this caldera with sea of sand, Mount Bromo and other Mountain inside of it has attracted high number visitors to this area. Visitors watch the view from Mount Pananjakan, and recently new sites (Bukit Kingkong/kingkong hill and Bukit Cinta/love hill), had been developed to increase the capacity of the destination to accommodate visitors. In addition to the view, the area also has savanna, various flora and fauna, and cultural attraction of Tengger tribe. Tengger people also plays important role in providing accommodation and in site transportation for the visitors, i.e. horses and jeep. The people firmly hold their tradition, and still continue to carry out traditional ceremonies such as *Yadnya Kasada* in which the people offers sacrifices into the crater of Mount Bromo. Other ceremonies include *Karo, Unan-unan, Entas-entas, Pujan Mubeng*, etc. The ceremonies often also attracts visitors to the area. Visitors were mostly involved in recreational activities such as enjoying the scenery, capturing sunrise from Mount Pananjakan, exploring the sea of sand, hiking the trail to Mount Bromo crater, and enjoying the scenery in Teletabies savanna and hill. They also took pictures in the objects. In order to reach the objects, visitors used rent jeep, rent horse, or motorcycles.

3.2. Hazard Potentials in Mount Bromo Tourism Area

Hazard potentials found in Mount Bromo Tourism Area included physical, biological, and socio-cultural hazards. Physical hazard potentials included cliff and steep topography, land/soil condition, fog, low temperature, wind, volcanic ash, fire, and eruption (figure 3; wind, fog and temperature were identified in the map as physical hazard). Biological hazard found were horses used as transportation mode for the tourist, while socio-cultural hazard included visitor behavior, residents’/local people’s behavior, and local myth which causes accidents (figure 3).
3.2.1. **Cliff and Steep Topography.** Cliff and steep topography could be found in several location in Mount Bromo Tourism Area, particularly in Mount Bromo itself (figure 3). Visitors might fall off the cliff during their activities. However, this hazard would pose higher risk when combined with human negligence/behavior. Steep and winding roads also posed threat to visitors who bring their own vehicles without proper knowledge of the area. Accidents often occurred on the road from the nearest village to the area.

3.2.2. **Soil/land condition.** Eroded area with landslide potentials could be found in several locations (figure 3). Landslide might harm and cause accidents for both visitors and the locals. The sea of sands was also identified as hazard potentials in this category. Frequent changes to soil condition in the sea of sands caused by water streams occurred during heavy rainfall might harm the visitors who were not familiar with the area. Visitors traveled across the sea of sand using jeep, horse, or motorcycle. Those who used their own vehicles and unaccustomed to the area might skid, slip and fall down that caused minor to major injuries to fatalities. The flood in sea of sands could also dragged the vehicles down, causing accidents.

3.2.3. **Fog.** Fog, which occurred almost every morning and afternoon in the area, limits the visibility of the area for the visitor. It would be difficult to see the road ahead, which might cause accidents, such as lost, fall, slip and stuck, and collision.

3.2.4. **Low temperature.** Air temperature in Mount Bromo Tourism Area was varying from a minimum range of 3°C- 5°C and maximum range of 20°C- 22°C. In mountain slopes, mountain peaks, and
highland area, the temperature was relatively low and the air was thin. Visitors with rather poor physical condition or those who did not wear proper clothing might exposed to the risk of hypothermia.

3.2.5. Wind. Wind added to the risk of hypothermia in addition to structural damage toward physical and biological features of the area. The wind brought chill to the visitors. There were only two occurrence of physical and biological damaged caused by strong wind during 2012 – 2016 [13].

3.2.6. Volcanic ash. Volcanic ash is one of parent material of soil mass in sea of sand. The ash might cause disturbance to visitors’ respiratory system, eye symptoms, skin irritation, and other indirect effect [14].

3.2.7. Fire. Fire occurred in the Teletabies savanna might cause harm to visitors. Fire usually occurred in dry season, mostly caused by human negligence.

3.2.8. Eruption. Mount Bromo is one of the most active volcanoes in Indonesia, considering its periodical eruption [15]. The most recent eruption occurred in 2016, when small eruption occurred. Apparently, despite its potential risk, the eruption also provided attraction for tourists, and benefit for the local people. Eruptions were usually accompanied by earthquake.

3.2.9. Horse. Horses were used as transportation mode for the visitors visiting Mount Pananjakan, Sea of Sand, and Mount Bromo crater. Horse might cause accidents for those who could not ride well, and risk of being kicked and collision. Poorly managed feces were still found in the area, which caused the feces fell in to the land, and though the feces might smell bad, it did not pose real threat to human health [16] unless the feces entered human body [17].

3.2.10. Human negligence: visitors’ behavior, residents’ behavior, and local myth. Visitors were often observed showing behavior that put risk to their own safety, such as climbing and trespassing safety fences put up by the area management to prevent visitors from falling off of the cliff. Such behavior is related to visitor perception toward the activity [18]. They perceived the activities as having more benefit than risks. By climbing and trespassing the fence, visitors might have a better look on the Mt. Bromo scenery, which they might think as the benefit of their action. Human behavior/negligence may also be associated with the lack of their knowledge of the environment. This was often observed in visitors’ behavior in using transportation modes and other tourism activities. An increase number of accident cases occurred to visitors using automatic transmission motorcycle. There was a case of accident that cause death of visitor, in which a visitor with acute asthma neglected the hiking requirements. In addition, high number of visitors and local people that packed the crater’s edge of Mount Bromo during Kasada ceremony posed risk of falling into the crater and gas suffocation, although the occurrence was low. Local people/the residents were involved in tourism activities, which include, but not limited to jeep driver, horse guide, food and souvenirs vendors. Their tradition to wear sarong as part of their attires might be risky during jeep driving. The sarong might get tangled, making the vehicles lose control and causing accidents. However, a more harmful threat would be from lack of maintenance of the vehicle and lack of safety equipment of the jeep. Lack of maintenance might cause engine breakdown or other damages, which would cause accidents when happened in steep road or vehicles-packed road, such as the road to Mount Pananjakan. The local people believed in the myth that anyone who visits Mount Bromo should be polite, both in their behavior and speech, and those who violated the rules might be suffering some consequences. There were two foreign tourists who got lost after carelessly urinated in the area. They could not find their way back, and just walked around in circles until they were found by the search team. The locals believed that their careless behavior caused the incident.
3.4. Residents’ and Visitors’ Perception of Hazard
Residents/local people and visitors had different perception of hazard potentials in Mt. Bromo. Hazard perceived by the residents include water stream/rain, fog, steep slope combined with human negligence, eruption, sea of sands, landslide, and human negligence. Quite a high percentage of residents’ (28%) perceived steep slope combined with human negligence as potential hazards in this area, while the lowest percentage was sea of sands. The residents knew the area very well, that only a lower percentage of them perceived water stream/rain, fog, eruption, sea of sands and landslide as hazard. Apparently, the interaction between the local people and the volcanic environment is multifaceted and complex, in which people choose to live with the hazard, and exposed to its adverse impact but also enjoyed the benefits from the environment [15]. There were a higher number of hazard perceived by the visitors. Most visitors perceived human negligence as the cause of accidents, however there were still a large percentage of visitors (more than 40%) who confessed their lack of knowledge about accidents or hazard. Their lack of knowledge might be the cause of their negligence toward hazard. This led to a conclusion of the need of visitors’ education about hazard.

3.5. Risk Level of Hazard in Mount Bromo
Risk assessment was carried out to identify the risk that might occurred from each hazard potentials based on its likelihood of occurrence and severity. Qualitative measures were used in this research due to lack of quantitative data (such as accidents data). In this research, respondents were asked for their assessment of hazards’ likelihood and severity. The highest number of responses were used to classify hazard’s likelihood and severity. Risk level for each type of hazard was then determined based on the likelihood and severity. For example, even though cliff and steep topography are unlikely to cause accidents (could occur at some times), when it does cause accidents, the consequences would be major (extensive injuries with occasional death), and therefore the level of risk is high according to the qualitative risk analysis matrix. Indeed, falling off of a cliff would cause extensive injuries, and might even cause death.

The assessment toward each potential hazards in Mount Bromo showed that the level of risk from hazard found in this area ranged from low to high risk, without extreme/very high risk. Cliff and steep topography, fog, low temperature, and human negligence had high risk, while soil condition, volcanic ash and fire had moderate risk, and the other hazards had low risk (table 4).

| No. | Hazard                                           | Severity | Likelihood  | Risk Level |
|-----|--------------------------------------------------|----------|-------------|------------|
| 1   | Cliff and steep topography                       | Major    | Unlikely    | High       |
| 2   | Soil condition/landslide potential               | Minor    | Moderate    | Moderate   |
| 3   | Fog                                              | Minor    | Likely      | High       |
| 4   | Low temperature                                  | Minor    | Likely      | High       |
| 5   | Wind                                             | Minor    | Rare        | Low        |
| 6   | Volcanic ash                                     | Minor    | Moderate    | Moderate   |
| 7   | Fire                                             | Moderate | Rare        | Moderate   |
| 8   | Eruption (and earthquake)                        | Minor    | Unlikely    | Low        |
| 9   | Horse                                            | Minor    | Rare        | Low        |
| 10  | Human negligence: visitors’ behavior, residents’ behavior, and myth | Major    | Unlikely    | High       |

3.6. Existing Hazard Management in Mount Bromo Area
The manager of Mount Bromo Tourism Area, the Office of Bromo Tengger Semeru National Park, had already implemented hazard management action. The management had already implement various
hazard management effort, which included the provision of insurance for visitors, routine patrol to control fire and monitor visitors’ activities, cooperation with various stakeholders in handling cases, increasing residents’ and visitors’ awareness of hazard, documenting accident cases. Insurance fee was included in the entrance ticket fee paid by the visitors. Investment in insurance is usually performed by business operators who understand the potentials of loss that may be incurred by hazards, but do not have the physical resources needed to overcome the hazard [19]. The national park management indeed had limitation of resources and lack of flexibility in managing financial source in implementing hazard management in particular, and tourism management in general.

Community and visitor education programs included extension program for the residents in relation to fire management, the use of volcanic status stamp to notify visitor of alert status regarding volcano, announcement made by ticketing officer to notify visitor about fog occurrence, and putting up written announcement about landslide occurrence and web announcement of automatic transmission motorcycle prohibition to the area. Despite all measures that had been taken by the management, there was still lack of hazard warning signs in the area. A study in the Alpen Mountainous area in Austria found that most of its visitors perceived that the lack of risk information means that there was not any risk in the area [20]. This indicated the need of hazard information services for the visitors.

3.7. Hazard Management Recommendation
There are four management options for tourism management, i.e. (1) retain/accept tolerable risk, when both severity and likelihood is low; (2) reduce risk, when the severity is low, but the likelihood is high; (3) transfer risk, when the severity is high, but the likelihood is low, and; (4) avoid risk, when both severity and likelihood is high, causing extreme risk/very high risk [2] [12]. Considering that the risk of hazards found in Mount Bromo were low to high level, without very high/extreme level risk, then there are three management options that can be applied in hazard management of Mount Bromo Tourism Area, i.e. accepting tolerable risk, reducing the risk, and transferring the risk. For low risk hazard, such as wind, horse and eruption which rarely to unlikely occurred, accepting tolerable risk would be the option (table 5). For moderate risk hazard, such as fire, soil condition/landslide potentials, and volcanic ash which had rare to moderate likelihood, the option was reducing risk (table 5). The high risk of cliff and steep slope, fog, low temperature, and human negligence should be transferred (table 5).

Management actions for low risk hazard should include provision of information services (putting up written and oral announcement, warning signs, etc.) that may help the visitors avoiding the areas during hazard occurrence, and patrol to make sure the visitors took heed of the warnings. In cooperation with the local community involved in tourism activity, visitors should also be informed to be careful around horses and other hazardous objects/areas.

In order to reduce the risk, routine monitoring of hazard potentials should be carried out. In addition, visitor education, providing information services and establishing a standard operational procedures (SOP) for hazard management, and standard requirement for visitors entering the area, are also suggested to reduce the risk. Tourism manager should pay attention to ‘best practice’ initiatives such as having written policies and procedures, staff training, signage, visitor briefings, and monitoring of industry standards in reducing risk [12].

In cases where visitors being injured or killed, or loss of properties incurred, tourism managers traditionally relies on insurance to transfer their financial risk to the third party [12]. This measure had also been applied by Mount Bromo manager. Therefore, transferring risk using insurance should be maintained by the management in transferring financial loss to other party, the insurance company. However, considering visitors lack of knowledge and negligence toward hazards, visitor education should be included in the hazard management action. Interpretive program and media may be the options for visitor education. Visitors showed better cognitive, affective, and behavioral outcome with the increase exposure toward interpretive media [21]. Realistic visualization of hazard can help people to develop a better understanding of the hazard [22]. This measure should also be applicable in reducing the risk of moderate level risk. As an addition, educating the local community/the residents on how to help alerting visitors of hazard potential may also be helpful in reducing risk for the visitors.
Table 5. Hazard management option and action

| No. | Risk Level | Hazard                                                                 | Management Option and Action                                                                 |
|-----|------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| 1   | High       | Cliff and steep slope, fog, low temperature, and human negligence      | Transfer risk: Insurance + visitor education (interpretive program and media), community education, |
| 2   | Moderate   | Soil condition/landslide potential, volcanic ash, fire                 | Reduce risk: Routine monitoring of hazard potentials, visitor education (installing hazard signs/interpretive media), information services, set up SOP |
| 3   | Low        | Wind, eruption (and earthquake), and horse                             | Accept tolerable risk: Information services, post-occurrence handling                          |

4. Conclusion

Hazards found in Mt. Bromo tourism area had low to high risk. Three risk management options, i.e. accept tolerable risk, reduce risk, and transfer risk, should be applicable in this area. Areas such as the steps to Mount Bromo crater, and the steep trail to Pananjakan I viewing area, had high risk for the visitors. In occurrence of fog, the whole area of Mount Bromo, from the entrance gate to sea of sand and trail to Pananjakan I, posed high risk of accidents to visitors, and therefore the management should pay extra attention during fog. The officer should already provide warning starting from the entrance gate. In case of heavy fog, a temporary closing may be applicable to reduce the risk. Considering visitors lack of knowledge and negligence, hazard management should include raising visitors’ awareness toward hazard and how to avoid and handle the risk. The management should consider to develop and implement interpretive program for visitor, install more signs and labels in the area to prevent accidents.

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