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Impact of forest fires In Bromo National Park: Analysis of the environment and recovery efforts

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ABSTRACT

Background: Forest fires represent natural disasters that often stem from environmental conditions, including events like El Niño or extreme climatic situations. Rainfall, a crucial factor, plays a role in influencing extreme climate occurrences. In Indonesia, human activities predominantly contribute to forest fires, exacerbated by extreme climatic conditions. Areas with high potential for forest fires encompass conservation zones closely linked to human activities. An illustrative example is the Bromo Tengger Semeru National Park (TNBTS), which serves both as a conservation and tourist area. The presence of human tourists or visitors in these conservation zones creates conditions conducive to forest fires, particularly when supported by extreme climatic conditions. **Method:** This study used field observation methods, satellite data analysis, and interviews with authorities and environmental experts. The data collected included the area affected, the plant types, and the environmental conditions after the fire. **Findings:** TNBTS experiences a specific rainfall pattern, with the lowest precipitation observed in May-Jun-Jul-Aug-Sept and the highest in Nov-Dec-Jan-Feb-Mar. During periods of low rainfall, TNBTS becomes susceptible to fires, necessitating preventative measures in the month leading up to the dry season. Initiating preventative actions at the onset of the dry season, notably in May, is crucial for controlling forest fires. Analyzing hotspot data of fire incidents from 2001 to 2020 reveals peak occurrences among other nationalities in 2001, 2014, and 2019. Identification based on data indicates that not all hotspots signify fire incidents; some result from heat emanating from Mount Semeru's crater at the TNBTS location. **Conclusion:** This article concludes the importance of cooperation between authorities, environmental organizations, and communities in forest fire prevention and recovery efforts in Bromo National Park. It emphasizes the need for increased preventive and responsive measures to protect similar conservation areas in the future. **Novelty/Originality in this article:** This study also offers a new perspective in the interpretation of hotspot data by distinguishing between forest fires and volcanic activity and identifying May as a critical period for initiating preventive action analysis based on long-term rainfall patterns.

KEYWORDS: community-based tourism development; Curug Dhuwur Waterfall; SWOT analysis; community involvement; tourism sustainability.

1. Introduction

Mount Bromo (2.3329 m above sea level) is an active volcano so it has a crater that is also very fascinating to see. This crater has a diameter of approximately 800 meters (North-South) and 600 meters (east-west). To be able to enjoy the view of this crater up close, you can walk or ride a horse. Then, you will climb the stairs which are 250 in total. Only then can you get near the crater and enjoy its charm firsthand (BBTNBTS, 2019).

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A long time ago, based on folklore, the Mount Bromo tengger tribe originated from Mount Tengger with an altitude of 4,000 m above sea level, the highest mountain in its time after Mount Semeru (3,676 m above sea level). Because of the frequent occurrence of small eruptions that eventually become a powerful eruption that creates a caldera with a diameter of more than 8 km. As a result of the eruption, new mountains such as Mount Bromo, Widodaren, Watangan, Chair, and Mount Batok have emerged that you can see until now.

Bromo National Park, located in Indonesia, is known for its unique natural beauty and diverse ecosystem. However, forest fires have become a serious threat to the sustainability of this national park (Cahyono et al., 2015; Fadli et al., 2019). Forest fires can destroy endemic plants, threaten the sustainability of flora and fauna, and result in ecosystem degradation (Balasubramanian 2019; Bruno et al., 2019; He et al., 2019).

Forest fires are a disaster that almost occurs every year, especially when supported by favorable climate or weather conditions such as El Nino (Anggraini & Trisakti, 2011; Bhatt & Sachan, 2004; Bhattarai et al., 2020). Mora et al. (2019) stated that forest fires generally occur when conditions are favorable, namely a dry climate, available fuel and a fire source. One area that is prone to forest fires is conservation areas such as national parks (Wasist et al., 2019). National park areas are natural conservation areas that have original ecosystems, managed using a zoning system that are used for research, science, education, supporting cultivation, tourism and natural recreation purposes (UU 41 of 1999 concerning forestry).

Bromo Tengger Semeru National Park (TNBTS) experienced a forest fire in 2014. Forest fires occurred in TNBTS from 2000-2015 with the largest forest fire in 2014 covering an area of 2,415 hectares at the Tengger Laut Pasir Resort (Suprihatin, 2016; Tamin et al., 2021). Factors that can cause forest fires in national park areas include human activity. Factors that influence the occurrence of forest and land fires include climate, community activities, building density, fire fighting equipment, road networks, use of fire in land preparation, disappointment with forest management, illegal logging, animal feed, forest encroachment (Latifah et al. 2013; Rasyid 2014; Hekmatyar & Adinugraha, 2021). Fire incidents in national parks cause ecosystem disruption, such as in the Rawa Aopa Watumohai National Park (TNRAW), which results in the burning of nests where they lay their eggs, loss of food sources, destruction of shelters, and some even burn to death, such as maleo, anoa, small crested cockatoo.

Controlling forest fires to protect the Bromo Tengger Semeru National Park ecosystem can be done by preventing, extinguishing and post-fire handling. Saharjo (2016) states that fire prevention strategies can be done in 2 ways, namely 1) fuel reduction and 2) reduction of sources of risk of fire. Based on the explanation above, it is necessary to analyze forest fire patterns in conservation areas in TNBTS to be able to prevent forest fires from occurring in conservation areas.

1.1 Impact of forest fires

The impact of forest fires in Bromo National Park is very broad and detrimental. Habitat loss, biodiversity decline, and land degradation are some of the main impacts observed (Wahono et al., 2017). In addition, air quality is also affected, resulting in increased air pollution around the national park area. In addition to the tourism sector, the Ministry of Tourism and Creative Economy also said that the fire had a bad impact on environmental sustainability in the Bromo Tengger Semeru National Park (TNBTS) area. The barrage has an impact on the attraction of tourists to green tourism in the Mount Bromo area. Tourists will no longer be interested in visiting because there is no green space to be seen after the fire occurs. This can affect the tourism value of Mount Bromo.

In addition to tourism and the environment, the adverse effects of the fire were also directly felt by the local residents. Data from the East Java Regional Disaster Management Agency (BPBD) revealed that the forest and land fires in the Mount Bromo area severely damaged a clean water pipeline network spanning 11,600 meters. This pipeline network connects the clean water source in the Mount Bromo area to the residents' homes. The damaged pipes are responsible for supplying clean water to four villages in the Sukapura

District of Probolinggo, namely Ngadirejo with a clean water pipeline length of 1,600 meters, Sapikerep 3,400 meters, Ngadas 5,100 meters, and Wonokerto 1,500 meters long. Following the fire incident, the government promptly undertook repairs to the clean water pipeline network. There are 2,240 families or approximately 6,472 residents recorded as beneficiaries of the pipeline repairs.

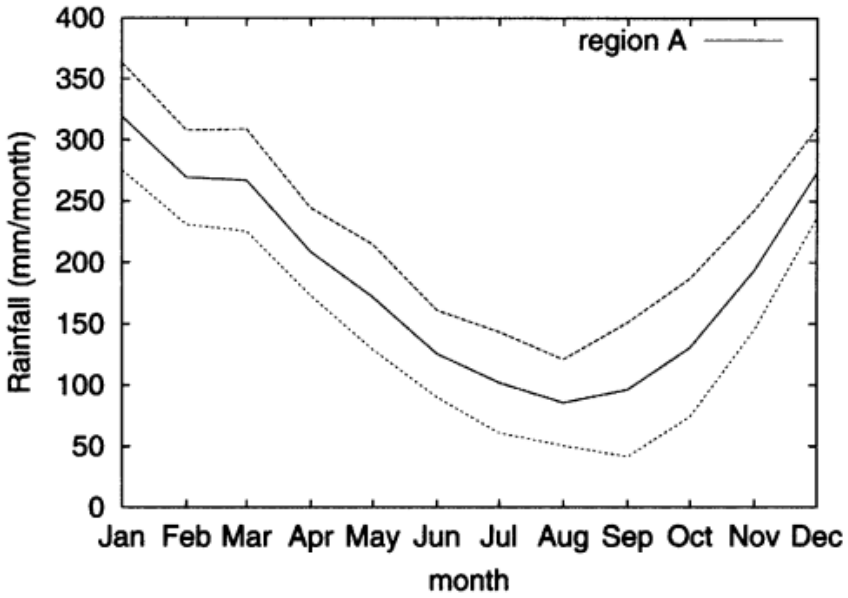

Fig. 1 Graph of rainfall per month in region A
(Aldrian & Susanto, 2003)

2. Methods

The research was carried out in a online with research locations in Bromo Tengger National Park Semeru (TNBTS). Location selection The research was carried out deliberately (purposive) with consideration that the location is one of the one area that often occurs forest fires.

2.1 Types and data sources

Data used in This study is quantitative data. According to Sugiyono (2018), quantitative data is a method of Research Based on positivistic (concrete data), data research in the form of numbers that will be measured using statistics as a counting test tool, related to with the problem being researched to produce conclusions. The data sources used in this study include secondary data obtained by studying literature studies both obtained from electronic newspapers, articles, previous research and the internet. Other secondary data was also obtained from the Central Statistics Agency and Ministerial Regulation Environment.

2.2 Data analysis methods

Methods used in This research is descriptive and quantitative to determine the value of resource and environmental damage according to the Regulation of the Minister of Environment of the Republic of Indonesia Number 7 of 2014 concerning Environmental Losses Due to Pollution and/or environmental damage Live. In it, it is explained that the cost of environmental losses for damage to resources and the environment is classified into five, namely losses due to the violation of Environmental Quality Standards as a result of the non-implementation of all or part of the water treatment obligations waste, emissions,

and/or B3 waste management, losses for reimbursement of settlement implementation costs environmental disputes, losses for reimbursement of countermeasure costs.

2.3 Data collection

Data collection techniques is an important part of achieve the objectives of the research true. Sugiyono (2017) stated that if the researcher does not know data collection technique, then the data obtained will not meet the standards that have been determined. Deep This research, the collection method

The data is carried out by search techniques data manually, namely by Performing secondary data searches through existing references. Data is obtained from internal data and external, i.e. data available on inside the company and outside company. Pollution and/or damage Environment and Recovery environment, ecosystem losses and community losses due to pollution and/or damage environment. However, in the case of forest fires TNBTS assessment loss is approached from loss to reimbursement for countermeasures and recovery, ecosystem loss or ecological losses, as well as losses community or economic losses. Assessment techniques or methods externalities are a function of environmental damage to the impact an economy that states The increase in the economic impact of each Environmental Damage Unit referred to as marginal losses. Components of ecosystem losses that calculated includes

3. Results and Discussion

3.1 Sanctions for pre-wedding perpetrators in Bromo

Who Sparked a Severe FireLately, natural resources can be said to be very concerned. Many incidents in the form of damage to the environment, especially in forest fires (Masthurri et al., 2023; Pasaribu & Friyatno, 2012; Wibowo, 2019; Yusuf et al., 2019). The cases of forest fires are high day by day, where the can be caused by humans or as a result of a disaster nature. In this study, the author will dissect the case of a severe fire that occurred on the hill of Teletubbis Bromo which in the case of the accident occurs due to the lack of knowledge of humans about the importance of protection environment, as well as a lack of enlightenment about regulations or penalties for those who commit negligence or crimes against the environment.

The problem related to the severe fire case that occurred in the teletubbis bromo hill is still a problem that cannot be solved just like that. As a result of this severe fire, the country experienced a loss of approximately 89 billion. Sanctions for perpetrators due to this negligence can be subject to article 99 of Law No. 32 of 2009, which is related to Environmental Protection and Management. The new Criminal Code has also explained that the criminal law snares that await for perpetrators who intentionally or unintentionally commit criminal acts in the form of forest burning are also contained in the new Criminal Code, namely in article 308 paragraph (1) and Article 188 of the Criminal Code.

Then the Law on Forestry also explains that the punishment for a person who is negligent or intentionally causes a forest fire or the environment can be subject to Article 50 paragraph (3) letter d, Article 50 paragraph (3) letter l, Article 78 paragraph (3), Article 50 paragraph (3) letter d, Article 78 paragraph (4), Article 50 paragraph (3) letter d, Article 78 paragraph (4), Article 50 paragraph (3) letter d, Article 78 paragraph (11), Article 50 paragraph (3) letter l in Law Number 41 of 1999 About Forestry.

3.2 Law enforcement against an environmental problem

There are three pillars in Law No. 11 of 2020 and Law No. 32 of 2009 concerning Environmental Management in providing environmental law enforcement, namely criminal sanctions, civil sanctions, and administrative sanctions. Criminal sanctions, according to Simons, are a suffering that already exists in the Criminal Code which is associated with a

violation of regulations, which by a judge's decision has been imposed on someone who has been found guilty. Sanctions for someone who commits a crime of environmental destruction, either intentionally or unintentionally, can be imposed through Article 97, Article 120, Article 99, Article 98, Article 100 to Article 115 of Law No. 32 of 2009 concerning Environmental Management.

Furthermore, civil sanctions are the result of compensation for actions that have been carried out, which in Law No. 32 of 2009 concerning Environmental Management is stated in Article 84, which allows the resolution of environmental disputes by demanding compensation. Settlement of this dispute can be done through litigation or non-litigation, which are respectively regulated in Article 87 and Article 93 for litigation, and Article 85 and Article 86 for non-litigation. Administrative sanctions, which can be in the form of fines, written warnings, and revocation of certain permits, aim to create peace, order, and welfare in society. Administrative sanctions for criminal acts of environmental damage can be imposed through Articles 76 and 83 of Law No. 32 of 2009 on Environmental Management and Management. For example, law enforcement related to the fire case that occurred on Mount Bromo on September 6, 2023, which was caused by flares used by six people during a pre-wedding photo shoot. In the viral video, it can be seen that even though the fire had engulfed the land at the photo shoot location, the six people did not try to extinguish the fire, which actually grew bigger and spread. As a result of this fire, tourism activities on Mount Bromo had to be temporarily closed to prevent similar incidents. From this case, Andrie Prabowo Eka Pradana is threatened with a sentence of 1.5 years in prison and a fine of IDR 1.5 billion.

3.3 Chronology of the fire

After learning of the disaster, the joint team of Bromo Tengger Semeru National Park (TNBTS) immediately inspected the scene of the incident. However, when they arrived at the location, the forest and land on Teletubbies Hill had already been burned. The joint team continued to try to extinguish the fire that burned the national park area, but they encountered obstacles due to strong winds. Therefore, the fire extinguishing process lasted quite a long time (Suprihatin et al., 2016).

The fire has damaged the flora and fauna land in the Bromo Tengger Semeru National Park (TNBTS). In addition, carbon emissions around the fire area are also increasing. As a result of the disaster, the government through regulation number PG.08/T.8/BIDTEK/9/2023 closed the total tourism of Mount Bromo as of Wednesday, September 6, 2023 until an undetermined time. After that, the Probolinggo Police secured six people involved in the pre-wedding photo using flares. One of the six people was named as a suspect. She is the manager of the wedding organizer with the initials AWEW. In addition to violating the rules for lighting beacons, AWEW also violated because they did not have a permit to enter the converse area of Bromo Tengger Semeru National Park (TNBTS). As a result of the violation committed, AWEW was subject to Article 50 paragraph 3 letter D jo Article 78 paragraph 4 of Law No. 41 of 1999 concerning Forestry as amended in Article 50 paragraph 2 letter b Article 78 paragraph 5 of Law No. 6 of 2023 concerning the Determination of Government Regulations. The replacement of Law No. 2 of 2022 concerning Ciptaker became a law and or article 188 of the Criminal Code. The man from Lumajang received a threat of imprisonment with a maximum duration of 5 years and a fine of up to IDR 1.5 billion.

3.4 Countermeasures and prevention efforts

The forest fire in the Bromo Tengger Semeru National Park (BTS) in 2023, which was allegedly caused by human activities such as the use of flares, has raised serious concerns due to its wide-ranging environmental impacts. Here are the potential consequences of the forest fire in Bromo caused by flare use in Table 1.

Table 1. Potential consequences of the forest fire in Bromo

No.	Potential consequences	Spesific potentions
1	Ecosystem damage and loss of biodiversity	• Forest Damage: Forest fires can lead to massive loss of vegetation, particularly in unique ecosystems. Bromo and its surroundings host a distinctive ecosystem that plays a critical role in maintaining ecological balance. The fire can cause long-term damage to this area. • Threat to Endangered Species: Bromo Tengger Semeru National Park is home to many endemic species, such as the Bromo orchid and wildlife like the Javan leopard and banteng. A fire can destroy their habitats and threaten their survival. • Reduction in Biodiversity: Fires reduce species diversity in the burned area and can worsen the overall condition of the ecosystem, requiring years or even decades for recovery.
2	Air pollution and poor air quality	• Carbon Emissions: Forest fires release smoke containing harmful particles (PM2.5), carbon monoxide, and other dangerous gases. This smoke can degrade air quality not only in the surrounding areas but also spread to other regions, including major cities in East Java. • Health Risks to the Public: Air pollution caused by the fire can lead to respiratory problems, asthma, and long-term health issues, especially for those with pre-existing health conditions.
3	Impact on tourism	• Damage to Tourist Destinations: Mount Bromo is one of Indonesia's most famous tourist destinations. A fire can damage the scenic views that attract visitors, reducing the region's appeal. The long-term impact could be a decline in the number of tourists visiting the area. • Economic Loss: Tourism is a major livelihood source for many local communities around Bromo. Environmental damage and the loss of natural beauty can lead to reduced tourism income, negatively affecting the local economy.
4	Social and economic impact on local communities	• Livelihoods of Farmers and Tenggerese People: The Tenggerese people, who live around Bromo, primarily depend on agriculture and tourism. A forest fire can destroy their agricultural land and cause significant economic losses. • Migration and Displacement: Large-scale fires could force nearby residents to evacuate their homes. If the fire spreads, communities near the affected areas may be displaced, leading to social disruption.
5	Climate change	• Release of Greenhouse Gases: Forest fires release significant amounts of greenhouse gases, contributing to global climate change. Bromo, which has substantial vegetation, plays a role in carbon sequestration. A fire reduces its capacity to absorb carbon, thereby exacerbating the impacts of global warming.
6	Impact on infrastructure and security	• Damage to Infrastructure: Forest fires can destroy essential infrastructure, including transportation routes, communication systems, and tourist facilities. Recovery from such damage will require substantial time and resources. • Potential for Ongoing Fires: Wildfires can lead to underground or subsurface fires, which are difficult to control. These fires can persist for a long time and threaten even larger areas. • Causes of the Fire: Flare Use Flares, or signal devices, are commonly used for various purposes, including during tourist activities or expeditions. However, if not used carefully, flares can ignite fires, especially in dry and fire-prone areas. Their use, particularly in sensitive areas like Bromo, has been identified as a leading cause of forest fires. Unintentional or negligent flare

		use can lead to large-scale fires, causing irreversible ecological damage. • Efforts for Fire Prevention and Mitigation Education and Awareness: Raising public awareness, especially among tourists, about the dangers of flare use in fire-prone areas is crucial. • Stricter Regulations: Authorities must implement stricter monitoring and regulations regarding the use of flares or fireworks in conservation areas. • Forest Fire Prevention: Enhanced fire prevention and suppression efforts should involve fire brigades, local communities, and modern technologies like satellites for early detection of fire hotspots.

Overall, the forest fire in Bromo due to flare use highlights the importance of awareness and responsibility from all parties in preserving nature, so that further damage can be minimized and the ecosystem can recover effectively.

3.5 Rocemmendations

To prevent future forest fires in areas like the Bromo Tengger Semeru National Park, it is essential to adopt a multi-pronged approach involving the local community, tourists, authorities, and modern technology. Here are key recommendations to help minimize the risk of forest fires in the future (Tabel 2).

Table 1. Recommendations to help minimize the risk of forest fires

No.	Recommendations	Recommended practices
1	Increasing security patrols and enforcement	• Enhanced Monitoring and Patrolling: Strengthen security patrols in fire-prone areas, particularly during peak tourist seasons. This includes regular foot patrols, drone surveillance, and the use of mobile units to monitor activity around sensitive zones, ensuring that fire risks are identified and controlled early. • Strict Enforcement of Fire-Related Regulations: Authorities should strictly enforce regulations prohibiting the use of fire-related devices like flares, fireworks, and campfires in vulnerable areas. This includes imposing fines or penalties for those who violate fire safety rules. Increased patrols can deter illegal activities, and authorities can act quickly to prevent fires before they spread. • Visible Signage and Fire Safety Awareness: Install clear, visible signs and warnings in high-traffic areas, such as tourist spots and popular hiking trails, to remind visitors of the risks of forest fires and the rules regarding fire usage. Proper signage can deter reckless behavior that may lead to fire accidents.
2	Public education and awareness	• Fire Safety Education Campaigns: Organize widespread educational campaigns aimed at raising awareness about the dangers of forest fires. This can be achieved through public service announcements, social media campaigns, and collaborations with local schools and communities. Focus on educating both local residents and tourists on the importance of fire safety and responsible behavior in forested areas. • Tourist Orientation and Briefing: Before visiting fire-prone areas like Bromo, tourists should be given fire safety briefings as part of their travel or tour package. This orientation should cover the risks of using flares, fireworks, and open fires, as well as the potential consequences of starting a forest fire. Making fire safety part of the tourist experience can reduce the likelihood of accidents.

		• Community-Based Fire Prevention Programs: Educate local communities, especially those living close to the park, on fire prevention techniques. Train local farmers and residents on how to safely manage open burning and other activities that may contribute to forest fires. Encourage sustainable farming and land management practices that minimize fire risk.
3	Implementation of advanced technology for early fire detection	• Satellite and Drone Surveillance: Implement advanced satellite technology and drone surveillance systems to detect early signs of forest fires. By using heat sensors and infrared imaging, authorities can identify hotspots before they escalate into large-scale fires. These technologies enable rapid response and intervention, reducing the overall impact of fires. • Real-Time Fire Monitoring Systems: Invest in real-time fire monitoring systems that can alert local authorities, fire departments, and the public about fire outbreaks. These systems can be integrated with weather forecasts and data on dry conditions to predict high-risk periods, allowing for more proactive measures to prevent fires. • Community Fire Watch Programs: Set up community-based fire watch programs that use mobile apps or other communication platforms to allow locals and visitors to report suspicious activity or signs of fire. This allows for immediate action by authorities or fire brigades, improving response times and minimizing damage.
4	Strengthening local community involvement	• Training Firefighters and Volunteers: Provide local firefighters and community volunteers with comprehensive training on fire prevention and suppression techniques. Equip them with the necessary tools and knowledge to quickly respond to small fires before they spread. These community-based responders can play a key role in protecting the forest. • Involving Local Communities in Conservation: Empower local communities, including the Tenggerese people, to participate actively in forest conservation initiatives. When communities have a vested interest in protecting the forest, they are more likely to be proactive in preventing fires and other forms of environmental degradation.
5	Improving infrastructure and fire safety equipment	• Installation of Fire Suppression Infrastructure: Install fire suppression infrastructure such as water tanks, firebreaks, and fire alarms in strategic locations. These systems can be activated quickly in the event of a fire, reducing the time it takes to contain the blaze. • Create Firebreaks and Buffer Zones: Establish firebreaks and buffer zones around sensitive forested areas and along the perimeter of Bromo Tengger Semeru National Park. Firebreaks are areas cleared of vegetation, preventing fires from spreading across large areas.
6	Promote eco-friendly tourism and sustainable practices	• Encourage Eco-Conscious Tourism: Promote eco-friendly tourism practices that focus on minimizing environmental impact. Encourage visitors to follow Leave No Trace principles and avoid actions that can lead to fires, such as disposing of cigarette butts improperly or using flammable devices in high-risk areas. • Alternatives to Fire-Based Activities: For tourists who enjoy outdoor activities, provide alternative options that do not involve fire risks, such as guided nature walks, wildlife watching, and educational tours about conservation. This can help reduce the temptation to engage in fire-based activities such as lighting flares or campfires.

7	Collaboration with environmental and conservation organizations	• Partnerships with NGOs: Collaborate with environmental NGOs and other conservation groups to conduct fire prevention and awareness programs. These organizations can also help with forest restoration projects following a fire and provide additional resources and expertise in fire management. • Support Community-Based Forest Management: Strengthen community-based forest management programs that allow local communities to take the lead in protecting and managing forests. These programs can also involve monitoring and reporting fire risks, ensuring that local knowledge is integrated into fire prevention efforts.

4. Conclusions

The use of flares during prewedding photoshoots. A total of five smoke flares erupted, causing sparks that burn the savannah. Six people involved in such cases and the manager of the wedding organizer is designated as suspect. This case occurred due to negligence in the use of flares and lack of permits to enter conservation areas. The impact of the fire involving economic and environmental losses. Total losses reached IDR 8.3 billion, including blackout costs, ecosystem loss, and tourism service losses. In addition, flora and fauna are rare in Bromo National Park, such as flowers Edelweiss and eagles, potentially lost. Fires also result in a water crisis in several villages, with 600 people affected. The flora rehabilitation process takes 3-5 years and involves natural methods and tree planting. Ministry of Tourism and Economy Kreatif calculated state losses of IDR 89.7 billion, including the absence of ticket purchases and tourist expenses during the 13-day closure.

To prevent similar events, preventive measures include carrying flammable goods, the existence of area regulations, monitoring by officers, comply with the guidelines of the area manager, cooperation and reports from visitors, as well as the presence of fire departments in vulnerable areas. The Mount Bromo land fire case on September 6, 2023 occurred due toelement of negligence, where the WO manager as a suspect is threatened with articles related to forest and land burning. Punishment in the context of forgetfulness, either intentionally or unintentionally, regulated in Islamic criminal law, and its sanctions in the form of diyat and calculated according to the level of loss caused. In conclusion, the perspective of Islamic criminal law provides a basis for assess and determine penalties for acts of forest burning and land, by taking into account the element of negligence and responsibility for impact.

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