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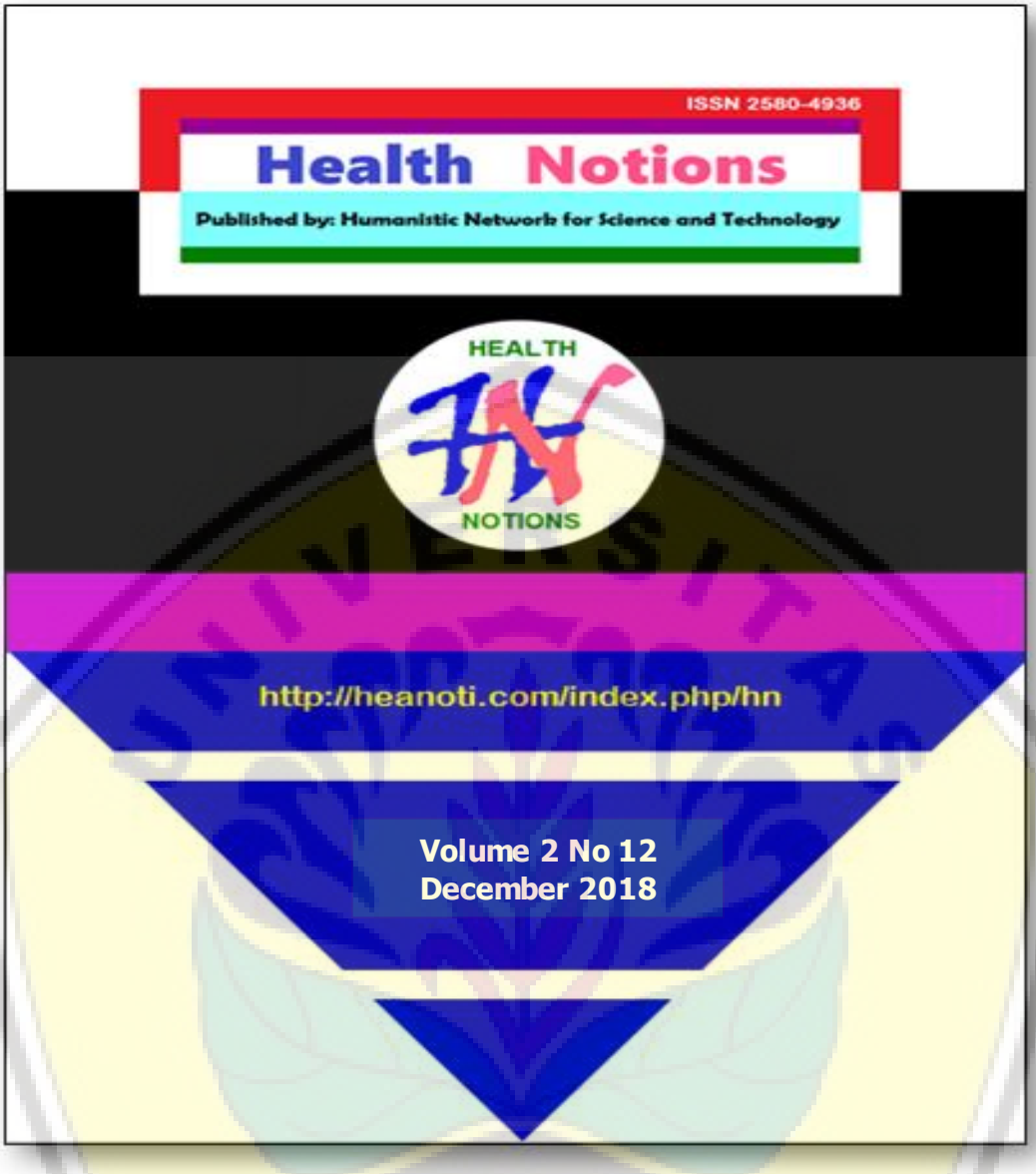

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Risk Analysis of Mount Ijen Eruption Disaster Based on Geographic Information Systems

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ABSTRACT

Mount Ijen is a strato active volcano located in Banyuwangi and Bondowoso Regencies. Mount Ijen has a risk that can cause various problems, both related to social, economic and public health issues. The aim of this study is to analyze the risk of the disaster of the Mount Ijen eruption and develop a map of disaster-prone risks. This type of research was quantitative descriptive research. The results showed that the four sub-districts of Mount Ijen threat level included in the category of KRB II (medium), the capacity level was included in the medium category and the level of vulnerability was different for each sub-category of high vulnerability categories were Wongsorejo and Licin Districts. The conclusion of the risks of the Mount Ijen eruption based on the GIS map of Licin Subdistrict and Wongsorejo Subdistrict are categorized as high risk, Kalipuro Subdistrict is included as the medium risk category and Ijen Subdistrict as the low risk category.

Keywords: Risk Analysis, GIS, Mount Ijen, Disaster

INTRODUCTION

Background

Indonesia is a country that has enormous potential for geological disasters. One of the most frequent geological disasters is volcanic eruptions. This is because Indonesia has 127 volcanoes that are still active and spread throughout the archipelago (about 13% of the world's volcanoes)[(1)]. The catastrophic eruption incident is becoming the particular concern to Indonesia. This is due to the location of Indonesia which is right on the "The Ring of Fire" line which is the pathway of active volcanoes in the world[(2)]. Volcanic eruptions are events that occur due to deposits of magma in the bowels of the earth that are pushed out by high-pressure gas. Magma is an incandescent liquid that is found in the earth's layers with very high temperatures, which is estimated to be more than 1000 °C. Magma liquid that comes out of the earth is called lava. The temperature of lava released can reach up to 700-1200 °C. Volcanic eruptions carrying rocks and ash can spray up to a radius of 18 km or more, while the lavender can flood as far as radius of 90 kilometers[(1)].

Mount Ijen is one of the series of volcanoes in East Java. Mount Ijen is currently still active, administratively located in Ijen District, Bondowoso Regency and Licin District, Banyuwangi Regency, East Java Province. Ijen volcano is Strato type, one of the generations of volcanic cones after the formation of Ijen cadets. The characteristics are the crater lake measures 960 meters, with a depth of 200 meters, which is bordered by crater cutters with an altitude of 2,145 - 2,386 meters above sea level. The volume of crater water is around 32 - 36 million cubic meters[(3)]. Mount Ijen had experienced a break in 1796 and there have been several phreatic eruptions. Phreatic eruptions as high as approximately one thousand meters have since occurred in 1817, 1917, 1936, 1952, 1962, 1976, 1991, 1993, 1999, 2000, 2001, 2004, and 2005. These phreatic eruptions caused considerable property losses . The last eruption occurred in 2000 and had previously occurred in July 1993. It was known that the longest eruption of Mount Ijen was 100 years and the shortest was 1 year[(3)].

The potential danger of the Mount Ijen eruption is the threat of poison gas flow, hot cloud flow, hot mud, lava flows, heavy ash rain and lava eruptions within a radius of 1.5 km from the center of the eruption. The flow

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of hot clouds, lava eruptions, rain lava, heavy ash rain, the possibility of volcanic debris avalanches and throwing incandescent rocks are within a radius of 6 km from the center of the eruption. Being affected by rain lava flows, the possibility of expansion of hot clouds or lava eruptions, heavy ash rain, may be exposed to incandescent rocks within a radius of 8 km from the eruption center[(1)]. Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, regulate and display all types of geographic data[(4)]. In principle, GIS is used to combine technology and map capabilities along with their geographical attributes. The results of our subsequent research are input into the GIS application by using QuantumGIS 20.18 Version Software so that it will produce a partial study and map. This study can be a basis for disaster mitigation efforts to improve early awareness of the threat of Mount Ijen that will occur, efforts to mitigate post-Ijen eruption disasters and become as a basis for determining evacuation routes and risk levels in five sub-districts around Mount Ijen such as: Licin District, Kalipuro District Wongsorejo District and Ijen District.

Purpose

The purpose of the study is analyzing the disaster risk of the Mount Ijen eruption and preparing a map of disaster risk in four sub-districts around Mount Ijen.

METHODS

The type of research was quantitative descriptive. The total area studied was four areas around Mount Ijen in Banyuwangi and Bondowoso Districts namely Licin, Kalipuro, Wongsorejo and Ijen Districts. The analysis of this research was based on risk analysis from the threat index (hazards), capacity index, and vulnerability index. The results of the analysis were then developed in the form of a disaster risk map with a spatial approach and an overlay technique using the Quantum GIS 2.18.0 version application[(5)].

RESULTS

The Risk Analysis Based on Threat Index (Hazard)

The data distribution and results of the Ijen Eruption Disaster Index analysis in Banyuwangi and Bondowoso Districts could be seen in Table 1.

Table 1. Mount Ijen eruption threat index in four sub-district

Sub-district	KRB Status	Weight (%)	Score	Scoring (weight x value)	Threat Index
Licin	II	100	2	0.67	0.67
Kalipuro	II		2	0.67	0.67
Wongsorejo	II		2	0.67	0.67
Ijen	II		2	0.67	0.67

Source: Mulyana, 2006

Table 1 shows that the threat index in the four regions around Mount Ijen, namely: Licin District, Kalipuro District, Wongsorejo District and Ijen District have the same threat value: 0.67, classified as medium threat.

The Risk Analysis Based on Capacity Index

The data distribution and results of the Total Capacity Index of the Mount Ijen Eruption Disaster in Banyuwangi and Bondowoso Regency could be seen in Table 2.

Table 2. The total capacity index of Mount Ijen eruption

Capacity Parameters	Weight (%)	Category	Score	Scoring	Index
Health Facility	60	Medium	2	0.40	0.35
Health workers	40	Medium	2	0.27	

Source: Dinkes Banyuwangi, 2018; Dinkes Bondowoso, 2018; BPS, 2018

Table 2 shows that the total capacity of the Mount Ijen eruption disaster in Banyuwangi Regency and Bondowoso from the parameters of the Health Facilities and Health Workers has a vulnerability index value of 0.35 or includes a medium category.

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The Risk Analysis Based on Vulnerability Index

The data distribution and results of the Ijen Eruption Disaster Vulnerability Index in four areas in Banyuwangi and Bondowoso Regencies could be seen in Table 3.

Table 3. The vulnerability index in Licin, Kalipuro, Wongsorejo, and Ijen Sub-District

Vulnerability	Parameter	Weight (%)	Category	Scoire	Scoring	Index
Licin Sub-District						
Physical	House	40	Medium	2	0.66	
	Public Facility	30	Medium	2	0.66	0.66
	Critical Facilities	30	Medium	2	0.66	
Economy	Productive land	60	Medium	2	0.66	0.80
	PDRB	40	Low	1	1.00	
Social	Population density	60	Medium	2	0.66	0.53
	Ratio of Vulnerable Groups	40	Low	1	0.33	
Environment	Protected forest	40	Low	2	0.66	
	Forest and Nature Reserve	40	High	3	1.00	0.86
	Production forest	10	High	3	1.00	
	Conservation Forest	10	High	3	1.00	
Kalipuro Sub-District						
Physical	House	40	High	3	1.00	0.9
	Public Facility	30	Medium	2	0.66	
	Critical Facilities	30	High	3	1.00	
Economy	Productive land	60	Low	1	0.33	0.46
	PDRB	40	Medium	2	0.66	
Social	Population density	60	High	3	1.00	1.00
	Ratio of Vulnerable Groups	40	High	3	1.00	
Environment	Protected forest	40	Low	1	0.33	0.33
	Forest and Nature Reserve	40	Low	1	0.33	
	Production forest	10	Low	1	0.33	
	Conservation Forest	10	Low	1	0.33	
Wongsorejo Sub-District						
Physical	House	40	High	3	1.00	1.00
	Public Facility	30	High	3	1.00	
	Critical Facilities	30	High	3	1.00	
Economy	Productive land	60	High	3	1.00	1.00
	PDRB	40	High	3	1.00	
Social	Population density	60	Low	1	0.33	0.60
	Ratio of Vulnerable Groups	40	High	3	1.00	
Environment	Protected forest	40	High	3	1.00	0.60
	Forest and Nature Reserve	40	Low	1	0.33	
	Production forest	10	Low	1	0.33	
	Conservation Forest	10	Low	1	0.33	
Ijen Sub-District						
Physical	House	40	Low	1	0.33	0.33
	Public Facility	30	Low	1	0.33	
	Critical Facilities	30	Low	1	0.33	
Economy	Productive land	60	Low	1	0.33	0.33
	PDRB	40	Low	1	0.33	
Social	Population density	60	Low	1	0.33	0.33
	Ratio of Vulnerable Groups	40	Low	1	0.33	
Environment	Protected forest	40	Medium	2	0.66	0.60
	Forest and Nature Reserve	40	Low	1	0.33	
	Production forest	10	High	3	1.00	
	Conservation Forest	10	High	3	1.00	

Source: Dinkes Banyuwangi, 2018; Dinkes Bondowoso, 2018; BPS, 2018

Table 3 shows that the vulnerability of the total risk of the Mount Ijen eruption disaster in four Subdistricts from Physical, Economic, Social and Environmental parameters had different index values between Sub-Districts. The vulnerability index value in Licin was 0.71 including the High category. Kalipuro Sub-District vulnerability index value was 0.67 including the medium category. Wongsorejo Sub-District had a vulnerability index value of 0.80 including the High category, Ijen District with a vulnerability index value of 0.40 including the Low category.

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The Risk of The Mount Ijen

The data distribution and the results of the risk analysis of the Mount Ijen eruption in Banyuwangi Regency and Bondowoso in four districts could be seen in the following Tables 4 and Figures 1.

Table 4. The risk of the Mount Ijen eruption disaster in Banyuwangi and Bondowoso Regencies

Threat district	Threat (H)	Vulnerability (V)	Capacity (C)	Risk (R)	Category
Licin	0.67	0.71	0.35	1.36	High
Kalipuro	0.67	0.67	0.35	1.28	Medium
Wongsorejo	0.67	0.80	0.35	1.53	High
Ijen	0.67	0.40	0.35	0.77	Low

Source: Dinkes Banyuwangi, 2018; Dinkes Bondowoso, 2018; BPS, 2018 (Data were processed)

The results of data analysis from Table 4 shows that the disaster risk of the Mount Ijen eruption in four sub-districts from the calculation of threats, vulnerabilities and capacities revealed that Licin District's risk value of 1.36 included in the High risk category, Kalipuro District at 1.28 included in the medium risk category, Wongsorejo District at 1.53 included in the High risk category, and Ijen sub-district of 0.77 included in the Low risk category. The partial risk map in each sub-district based on geographic information system is shown in the following figure:

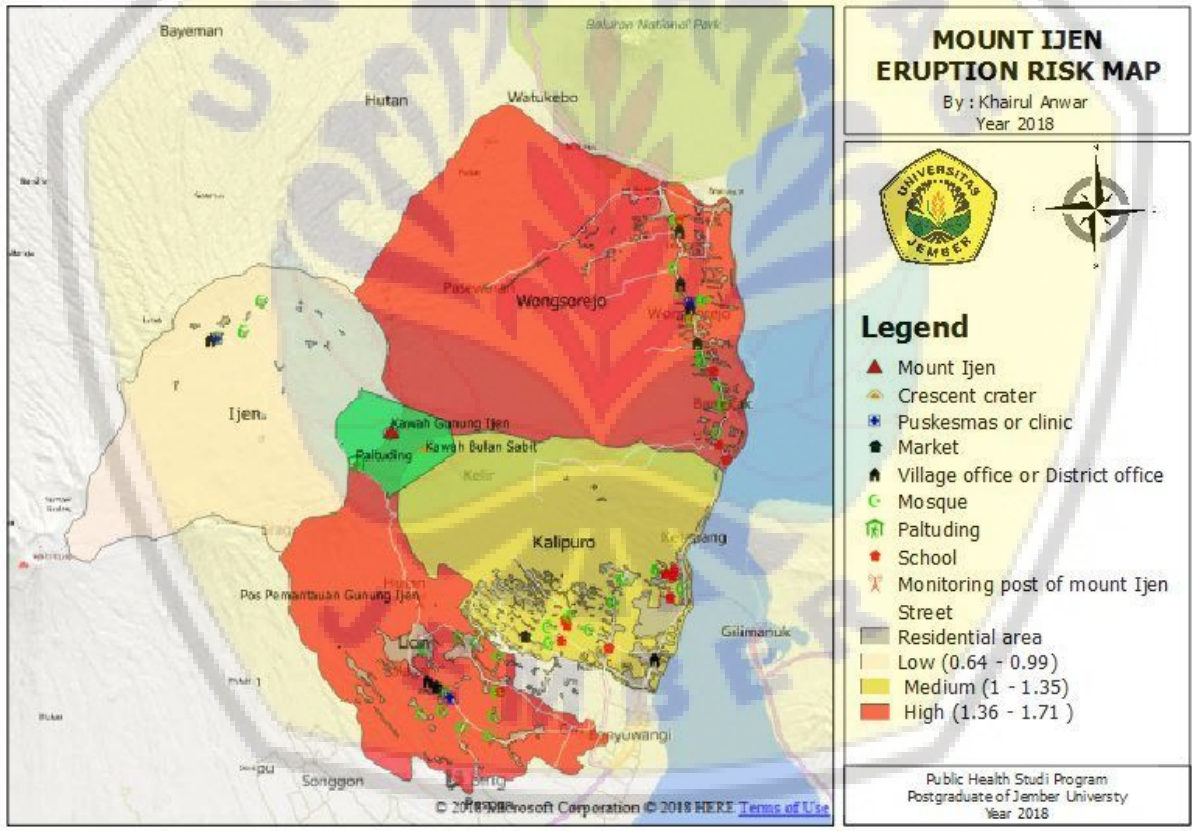

Figure 1. Mount Ijen Eruption risk map in four districts in Banyuwangi and Bondowoso Districts

DISCUSSION

The threat of volcanoes comes from endogenous mountain processes in the form of solid, liquid, gas and mixtures of which can threaten or tend to damage and cause casualties and losses. The status of the threat of a volcanic eruption disaster area is based on the types of threats in the form of toxic gases, hot clouds, lava, incandescent rocks and lava. The distribution of threats is based on the Mount Ijen KRB Map[10] and the assessment of Mount Ijen experts /observers. Based on the Mount Ijen KRB map, there are 4 (four) Subdistricts in Banyuwangi Regency and Bondowoso Regency which are on the slopes or directly adjacent to Mount Ijen

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and have a history of past eruptions, including Licin District, Kalipuro District, Wongsorejo District and Ijen District located in Bondowoso Regency.

Based on the conclusions from the four districts KRB status which is assumed to be directly affected by Mount Ijen eruption, namely Licin district, Kalipuro District, Wongsorejo District, Ijen District, KRB II (medium level) status. Withdrawal of the KRB II distribution limit is based on the morphological and topographic conditions of Mount Ijen (especially around the peak and slope areas) and the history of the Mount Ijen eruption. Disaster-Prone Areas-II is an area that has the potential to be hit by hot clouds, lava flows, stone throws (incandescent), heavy ash rain, rain of mud (heat), heat flow, and toxic gases [(9)].

Determination of threat areas in volcanic risk research was also carried out previously by Firmansyah (2011) and Yogatama (2012). In his research the threat or danger area was sourced from the map of the Disaster Prone Areas issued by the Center for Volcanology and Geological Disaster Mitigas[(1)]. The establishment of a threat area by PVMBG in Yogatama (2012) states that a region is classified as an area threatened by a volcanic eruption with several conditions, including the source of the eruption originating from the source of the central crater, vertical eruption, no caldera formation, and no morphological changes drastically[(10)]. Mulyana's research (2006) states that the expansion of hot clouds is likely to occur if the eruption in the future is greater than the previous eruption and there is a magma mixing process, so that severe eruptions can change the state of Mount Ijen morphology drastically[(6)].

There are four future threat areas of Mount Ijen eruption, namely Licin Sub-District, Kalipuro Sub-District, Wongsorejo Sub-District, Ijen Sub-District. Vulnerability of each threat area is determined through four indicators, namely physical vulnerability, economic vulnerability, social vulnerability, and environmental vulnerability. Based on the results of the study, the physical vulnerability was known to be the largest number of houses, namely Kalipuro Subdistrict as many as 16,160 houses. the most public facilities in Wongsorejo District are 401 units. The most critical facilities in Wongsorejo Subdistrict have a number of critical facilities 2 puskesmas, 6 Pustu and 7 Polindes[(7)]. Economic vulnerability is known that Wongsorejo Subdistrict has a level of Gross Regional Domestic Product (GRDP) which is affected by Rp. 484,823,787, the highest productive land in Wongsorejo Sub-District about the amount of rice produced was 10,900 tons with an area of 1,748 ha. Social vulnerability is known that the highest population density is in Kalipuro Sub-District which is equal to 873 people/km2[(8)], and the percentage of vulnerable groups in Wongsorejo Sub-District is 39.5%. According to environmental vulnerabilities, Wongsorejo Subdistrict has a large forest area consisting of 44,510 ha of protected forest, 1,748 ha of production forest and 96 ha of natural forest[(8)].

Based on the results of the study, it can be concluded that the management of health workers in the handling of Mount Ijen eruptions is still incomplete. This is indicated by the presence of an empty number in several types of health workers that must be prepared including DVI personnel, epidemiologists, surveillance staff, plastic surgeons, forensic specialists, and dental forensic specialists[(11)]. This indicates that until now there has been no clear agreement regarding the management of health workers in the Mount Ijen disaster management. The results of the risk analysis show that the Subdistricts which have the highest risk compared to other Sub-Districts are Licin and Wongsorejo Sub-District, whereas Kalipuro Sub-District is included in the medium risk category and Ijen Sub-District of Bondowoso Regency belongs to the lowest risk category. The results of the risk analysis are in accordance with the description of the geographical information system map. From the results of this research, it is expected to become a policy reference by the government in the effort to mitigate Mount Ijen eruptions.

CONCLUSION

The conclusions obtained in this study are the risk of the Mount Ijen eruption disaster based on a risk analysis with geographic information systems in four sub-districts in Banyuwangi and Bondowoso which are determined by the threat index, vulnerability index and capacity index. The high risk category occurs in Licin and Wongsorejo Sub-District. Moreover, the medium risk category is Kalipuro Sub-District and the Low category is Ijen Sub-District.

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