ZONING REGULATION GUIDELINE ON DISASTER-RISK AREA IN SEMERU VOLCANO, LUMAJANG REGENCY

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ABSTRACT: Disasters are a series of events that threatens and disrupts the life and livelihood of a society by both natural and non-natural factors that may cause the loss of life, environmental damages, and psychological impacts. In disaster studies, the main thing to do is to do an assessment on disaster risk, which is the calculation of damage and loss level from a disaster-related phenomenon. Zoning regulation guideline on a disaster-risk area in Semeru Volcano serves a purpose to provide guidance on zoning regulations on land uses that is indicated to be at risk from the presence of Semeru's volcanic disaster. This is done in order to reduce the current disaster risk level. Semeru Volcano is recorded to not be inactive from 1818 to 2016, several activities have shown loss of lives and damages to the environment. The currently active Semeru Volcano, as well as the cultivation land uses around the Semeru Volcano that has a potential to erupt anytime could cause substantial loss to the neighboring villages. This research is using a joint qualitative-quantitative method; qualitative method is used to describe the existing condition in the researched area, while quantitative method is used to carry out a disaster risk assessment. High-risk area requires a guideline that limits residential area developments due to the vulnerability indicator has shown to be on a medium stage, if there is shown to be an increase on residential development, the disaster risk level will also increase.

Keywords: Zoning Regulation, Disaster Risk, Semeru Volcano.

1. Introduction

Disasters are a series of events that threatens and disrupts the life and livelihood of a society by both natural and non-natural factors that may cause the loss of lives, environmental damages, property losses, and psychological impacts (Sartohadi et al., 2014). One example of a natural phenomenon that may result in a disaster is the danger of a volcano. The danger of a volcano is caused by the eruption or volcanic activity, which comprises solid, liquid, and gaseous materials, also the combination of either of them which threatens or has a tendency to destroy, causes loss of lives and properties in the environmental order of human life (Djauhari, 2011). However, the transfer of knowledge technology regarding Semeru Zonin Regulation will assist government to reduce the impact of volcano activity caused disaster, since knowledge and technology transfer could improve the knowledge and the capability of its acceptance (Handoko et al., 2014; 2016)

Indonesia is a country in which its territories are vulnerable towards volcanic eruptions. This is due to the fact that Indonesian archipelago is located in the intersection of three major Earth plate; Indo-Australian Plate, Eurasian Plate, and Pacific Plate. The Pacific Ring of Fire is a line where collisions and abrasions occur among Earth plates. Apart from causing earthquakes, the collision of Earth plates may also result in the formation of ocean trenches, tectonic foldings, ridges, and tectonic faultings in the archipelagic bow. Besides that, these plate collisions can also form dispersions of volcanoes. The geographical position and the geological condition Indonesia has is considered to be very complex. The western part to the southern part of Indonesia is a subproduction zone which is a volcanic path. Indonesia has around 129 active volcanoes that stretch from Sumatra, Java, Sulawesi, Nusa Tenggara, even to Maluku. Java

Island has numerous active volcanoes, among which are; Semeru, Slamet, Sumbing, Arjuno-Welirang, Raung, Merbabu, Ceremai, Merapi, Gede, Papandayan, Dieng, Bromo, Guntur, Salak, Galunggung, Tangkuban Perahu, and Kelud (Supriyono, 2013).

Semeru Volcano is an active volcano in East Java, precisely in the border of Malang Regency and Lumajang Regency of East Java Province. Geographically, it is located on 08°06'30" South Latitude and 112°55'00" East Longitude with its highest peak reaching 3,676 metres above sea level, making it the highest mountain in Java Island. Semeru's volcanic activity can be found on Jonggring Saloko Crater which is located on the southeasten part of Mahameru Peak (Geological Agency, 2016). Around Semeru Volcano, are fertile farm areas, whereas on the eastern and southeastern slope of Semeru, are disaster risk areas filled with farms and residences as their main activities, with a population density of 850 persons/km^2. Aside from that, the sand and rock materials along the riverflows are a natural wealth of its own. The surging inflow of Semeru materials and debris results in the thickening of sand sediments over time. Sand and building stone mining area make up as much as 82.50 hectares with a volume of 5,976,625 m^3. The exploited sand and stone area are only 15 hectares with a volume of 239,065 m^3, or only 4% of the total available capacity (Geological Agency., 2016).

Lumajang Regency is a region which will experience the biggest impact from the danger of Semeru Volcano, which is caused by the location of Lumajang Regency being on the southeastern part of Jonggring Saloko Crater. The condition of Semeru Volcano which can potentially erupt any time, or the presence of cultivation activities on the southeastern slope, or the environmental condition of the Lumajang Regency itself, requires a research study regarding "Zoning Regulation Guidelines on Disaster-risk Areas in Semeru Volcano" to be written, where from the formulation of this research, it can be expected that a land use control emerges as a form of disaster prevention and countermeasures to reduce or even eliminate loss of lives, environmental damages, and property losses.

The purpose of this research is to provide zoning regulation guidelines on areas that have disaster-caused risks from Semeru Volcano in Lumajang Regency, where the zoning regulations meant here are land use zoning regulation that is done as a step towards reducing disaster risk level. In order to obtain the desired goals from this research, the targets that need to be achieved are to analyze the zoning of Semeru Volcano's disaster risk area and to provide zoning guidelines towards Semeru Volcano's disaster risk area.

2. Literature Review

2.1 Disaster

Disasters are a series of events that threatens and disrupts the life and livelihood of a society by both natural and non-natural factors that may cause the loss of lives, environmental damages, property losses, and psychological impacts (Sartohadi et al., 2014). Natural disasters are a phenomenon that impacts negatively to human which is caused by a single event or a series of events. Disasters can happen due to, among others, earthquakes, tsunamis, volcanic eruptions, floods, droughts, tornadoes, and landslides (Supriyono, 2013). Based on the given definition, it can be concluded that volcanic disasters are a natural disaster which is caused by volcanic eruptions, therefore resulting in the loss of lives, environmental damages, property losses, and psychological impacts.

2.2 Disaster Risk

Disaster risk is the level of damage and loss that has been calculated from a natural event or phenomenon. Disaster risks have been determined based on the product of hazard factors and vulnerability factors. The term hazard here means, the probability and quantity of what can be

anticipated from a natural event, while vulnerability is influenced by political, economic, socio-cultural, and geographical factors.

2.3 Volcano Hazard

Volcanoes are mountains that have cavities or fracture holes where liquid magma, gas, or other fluids discharge to Earth's surface (Supriyono, 2013). The danger of a volcano is caused by the eruption or volcanic activity, which comprises solid, liquid, and gaseous materials, also the combination of either of them which threaten or have a tendency to destroy, resulting in the loss of lives and properties in the environmental structure of human life (Djauhari. 2011).

2.4 Disaster Risk Management Activity

The activities of assessing disaster risk consist as follow (Djauhari. 2011):

a. Risk Assessment
b. Disaster Prevention and Mitigation
c. Disaster Preparedness
d. Disaster Risk Management as a part of Rehabilitation and Reconstruction
e. Disaster Risk Management Role in Development Cooperation Sector

2.5 Volcanic Disaster Mitigation

Mitigation is a series of events of reducing disaster risk. The main purpose of volcanic disaster mitigation is to promote various actions that can reduce the risk of death tolls, wounded and injured casualties, damaged environments, property losses, as well as the disruption of the economy. Within mitigation there are structural and non-structutral mitigation; structural mitigation comprises actions to engineer buildings to that they can withstand earthquake trembles, hot clouds, and magma flows, while non-structural mitigation comprises actions involving building dams in river to anticipate flood threats, and also to install early warning instruments as well as volcano monitoring devices.

2.6 Land Use Planning in Disaster Prone Areas

In order to live safely and comfortably throughout the ongoing changes on the surface of the Earth, we are ought to understand natural environments and the pace of changes that occur on it too, as well to be able to adapt ourselves with the characteristic of those changes. In relation with the reaction humans make towards possible disasters that may occur on the environment that they live, these reactions are: avoidance, stabilization, provision for safety in structure, limitation of land use and occupancy, establishment of early warning system (Supriyono, 2014). Some natural disasters can be predicted, which means several possible emergency measures can be done beforehand. Early warning systems have proven to be effective in preventing and minimizing the impact of a disaster that will occur on a region.

3. Research Method

The type of research that will be carried out is a combination of qualitative and quantitative type research, where there are problems that can explained by descriptions but there are also problems that must be explained mathematically, for example the use of GIS to process map data (Istiwigati et al., 2013). To achieve the desired purpose, based on the targets that are needed to be achieved, several analyses that will be done are: listed in Table 1.

Table 1 Research Analysis Order

Target	Analysis Technique	Result
Analyze disaster risk area in Semeru Volcano, Lumajang Regency.	Overlay hazard map with vulnerability using Raster Calculator on GIS.	Semeru Volcano Disaster Risk Zoning Map
Provide zoning regulation guidelines on area that are prone to the impact of Semeru Volcano disaster.	Overlay Semeru VolcanoDisaster Risk Zoning Map with the existing land uses.	Discover land uses that are in risk and must be dealt with.
	Descriptive method using spatial allotment zoning matrix.	Zoning regulation guideline.

Source: Result from writer, 2016

The border of researched area is based on the area of the district that is within the Semeru Volcano disaster prone area. There are 12 districts of Lumajang Regency that is included in the Semeru Volcano disaster prone area, which are Candipuro district, Gucialit district, Lumajang district, Padang district, Pasirian district, Pasrujambe district, Pronojiwo district, Senduro district, Sukodono district, Sumbersuko district, Tempeh district, and Tempursari district. Inside the 12 districts, there are 85 villages that are included in the disaster-prone area.

The majority of land uses in the researched area are moor areas that cover 23,535.51 hectares or 23.61% of the total area, and second to it, are jungle areas that cover 24,131.66 hectares or 22.31% of the total area of the land uses in the researched area.

Semeru Volcano is one of the most active volcanoes in Indonesia. Geographically, it is located at 08°06'30" South Latitude and 112°55‘00” East Longitude, with its highest peak (Mahameru Peak) reaching up to 3,676 metres above sea level. Its morphology is described as having a well-formed cone shape, but in essence, its peak is actually rather complex. This is due to its repeatedly-shifting crater from Northwest to Southeast. Semeru Volcano has a composite type of eruption, which is a Vulcanian type interspersed with the Strombolian type. The main eruption product from Semeru Volcano are; incandescent material discharges, hot cloud avalanches, and lava flows that go into the river upstream near the Semeru Volcano in the rainy season. Semeru Volcano is located in one continuous path that goes from North to South along the Jambangan Mountain and Tengger Mountain Ranges. Semeru exhibits its perfect cone shape if observed from the South and Southeast, but in fact it doesn’t really have a perfect shape due to the peak’s complex shape. This peak’s complex shape is caused by the displacement of its craters from the Northwest to the Southeast. Mahameru (± 3,676 m) is an old crater body wall on the Northern side, meanwhile its younger part develops to the Southeasten and South side. Semeru Volcano’s complex morphology – Jambangan, is formed by an old Quarter Volcano that is characterized by a morphological shape that experiences denudation. A younger morphology consists of the peak and the body of Semeru Volcano. Parasitic cone, such as Papak Mountain and Leker Mountain, are located on the Eastern slope of Semeru Volcano.

Semeru Volcano disaster-prone area can be categorized into three areas, which are Disaster-Prone Area III, Disaster-Prone Area II, and Disaster-Prone Area I. The following are an explanation for each disaster-prone area (Geological Agency, 2016):

a. Disaster-Prone Area III
   Disaster-Prone Area III is an area that is potentially struck by hot clouds, lava flows, lava falls, incandescent stone discharges, and/or toxic fumes. This area comprises peak region and its surroundings.

b. Disaster-Prone Area II
   Disaster-Prone Area II is an area that is potentially struck by hot clouds, lava flows, incandescent stone discharges and/or lava falls, heavy ash rains, hot mud rains, lahar flows, and toxic fumes. This area is further categorized into two types, which are:
   - Areas prone to hot clouds, lava flows, lava falls, lahar flows, and toxic fumes especially upstream of Kali Manjing, Kali Glidik, Kali Sumbersari, Besuk Sarat, Besuk Kembar, Besuk Kobokan, Kali Pancing, Besuk Semut, Besk Tunggeng, Besuk Sat, Kali Mujur, Kali Liprak, Kali Regoyo, and Kali Rejali.
   - Areas prone to heavy ash rains, incandescent stone discharges and/or hot mud rains.

c. Disaster-Prone Area I
   Disaster-Prone Area I is an area that is potentially struck by lahar, material falls such as ash rain, and/or highly-acidic water. If the eruption increases, this area can potentially experience the expansion of hot clouds and material falls such as heavy ash rains as well as incandescent stone discharges. This area is further categorized into two types, which are:
   - Areas prone to lahar. This area is located along the valleys and riversides, especially those having upstreams near the peak, which are: Kali Manjing, Kali Glidik, Besuk Sarat, Besuk Kembar, Besuk Kobokan, Kali Pancing, Besuk Semut, Besuk Tunggeng, Besuk Sat, Kali Mujur, and Kali Rejali.
   - Areas prone to ash clouds without considering wind direction.

4. Analysis and Discussions

In the course of providing zoning regulation guidelines in Semeru Volcano disaster risk areas, the first thing that needs to be done is to do an assessment on disaster risk levels in the researched areas and is continued by providing zoning regulations on land uses that is at risk of the impacts from Semeru volcanic disaster. Additional explanations from each factor are as follows.

4.1 Semeru Volcano Disaster Risk Zoning Analysis

Disaster risk is the level of damage and loss that has been calculated from a natural event or phenomenon. Disaster risks have been determined based on the product of hazard factors and vulnerability factors. The term hazard here means, the probability and quantity of what can be anticipated from a natural event, while vulnerability is influenced by political, economic, socio-cultural, and geographical factors.

To formulate Semeru Volcanic disaster risk zonation, this research performs an overlay of hazards map and vulnerability map that have been made on the previous analysis. As for the analysis itself, this research uses ArcGIS 10.1 software through algebraic map analysis method. Based on the result of Semeru Volcanic disaster risk zoning analysis, it is found that there is an area of 3,342.7 hectares categorized as “High risk” which comprises of Candipuro District, Parujampe District, and Pronojiwo District; an area of 35,536.63 hectares categorized as “Medium risk” which comprises of Candipuro District, Pasirian District, Pasrujambe District, Pronojiwo District, Senduro District, and Tempursari District; and an area of 65,197.82 hectares categorized as “Low risk” which is spread all across the researched region.

4.2 Zoning Regulation Guidelines for Semeru Volcano Disaster Risk Areas

In the course of providing zoning regulation guidelines for Semeru Volcano disaster risk areas, descriptive analysis is used. Descriptive analysis is carried out to describe the existing conditions on the researched areas, which is used as a basis to provide zoning regulations on Semeru Volcano disaster risk areas. The followings are descriptions regarding the zoning regulation guidelines.

4.2.1 Land Use Conditions Based on Risk Levels

Land use condition analysis based on risk levels is performed to find out the type of land uses that are according to their risk levels, where the result of it will be used as a basis for providing zoning guidelines on each type of land uses. Based on the overlay of disaster risk map with land use map, it can be found that there are several land use conditions found on the researched area that falls into the category of "High risk" to the "Low risk". Zoning guideline provision for each zone is different from each other, where within the zoning guideline provision is based on the zoning function guideline conditions.

4.2.2 Land Use Conditions Based on Risk Levels and Disaster-Prone Areas

In the process of formulating zoning guidelines, another overlay with Semeru Volcano disaster risk area is needed as well. This overlay is done because, based on the result of disaster risk analysis, there is still areas of "Medium Risk" to areas of "Low Risk" that are included in high disaster-prone areas. Judging from the problem, prior to providing zoning guidelines, it is mandatory to observe again the delineation of the Semeru Volcano disaster-prone areas. The result of this analysis will be used as a more detailed version of zoning regulation guideline related to what needs to be done.

4.2.3 Zoning Regulation Guidelines

Based on the result of the overlay of land use map, disaster risk map, and disaster-prone area map that are observed from the researched area, there are three zoning classifications, which are; Cultivation Zones, Limited Cultivation Zones, and Protected Zones. Therefore, zoning regulations will be performed on Protected Zones and Limited Cultivation Zone. The reason is that these zones require specific concerns for an implementation of disaster-mitigation-based spatial planning, so that there will no longer be any death tolls and substantial losses. In order for the provision of zoning regulation that serves to actualize a safe and comfortable life that is harmonious with the constant changes on the face of the Earth, it is necessary for us to understand the natural environment and the pace of changes that occur on it, as well as to be able to adapt ourselves with the characteristics of those changes.

Regarding with the provision of zoning regulation guidelines, the things that need to be carried out are the description the conditions of land uses, disaster risk levels, disaster-prone area delineations, as well as the provision of suitable treatments according to the present conditions that is based on the aforementioned zoning regulation guidelines.

5. Conclusion

Disasters are a series of events that threaten and disrupt the lives and livelihoods of society that are caused by, both natural factors and/or non-natural factors which results in the loss of lives, environmental damages, property losses, and psychological impacts. Volcanic hazards are hazards that are inflicted by volcanic eruptions or activities, including solid, liquid, and gaseous materials as well as the combination of either of them. In disaster studies, the first thing that needs to be done is to assess the disaster risk level.

Based on the result of Semeru Volcanic disaster risk zoning analysis, it is found that there is an area of 3,342.7 hectares categorized as having "High Risk"; an area of 35,536.63 hectares categorized as having "Medium Risk"; and an area of 65,197.82 hectares categorized as having "Low Risk". Due to the existence of these disaster risks, one of the efforts to reduce the level of disaster risks is to carry out a zoning regulation on disaster risk areas at Semeru Volcano by providing a form of guideline on land use conditions, such as to limit building density, implement building structure regulation, etc. Thus, by giving a zoning guideline, the observed factors are not only from the result of disaster risk analysis. The reason for this is that this

research shows the presence of areas with low risk level that are included in the Disaster-Prone Area III. Therefore, in order to create a zoning regulation that is in accordance with the existing condition as well as for the future condition, it is necessary to adhere to disaster risk zonings and disaster-prone areas. The zoning guidelines provided are as follows:

1. On residences existing on DPA III at Semeru Volcano with "Medium Risk" to "High Risk" level, the zoning regulation provided by this research is the limitations of residential developments, where the allowed developments are those related with disaster-wise infrastructures (mitigation path, early warnings, etc.). The residential relocation guidelines are only carried out to the residential areas in Pronojiwo Village – Pronojiwo District, because these residential areas are located right in the middle of Semeru volcanic lahar passageway.
2. On the non-residential cultivation areas which are located on Semeru Volcano DPA II with "Medium Risk" to "High Risk" level, the zoning regulations provided by this research is that there is a prohibition of land use change towards residential uses.
3. On the residences which are located on DPA II with "Medium Risk" to "Low Risk" level, the zoning regulations provided by this research is the construction of these residence using volcanic ash and earthquake resistant building structures. Also, there is a limitation towards building density.
4. On non-agricultural cultivation areas which are located on DPA II with "Medium Risk" to "Low Risk" level, the zoning regulation provided by this research is the approval of land use change towards residential uses with several conditions such as being made of volcanic-ash resistant building structure with low building density. This guideline is based on disaster factors, but also in respect to the regulations beyond disaster factors.
5. On land uses with protected functions, on either DPA I, II, or III, no change in land use is allowed and they will remain as protected function with no form of cultivation activity at all.

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