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Analysis of Risk Assessment of Mount Merapi Eruption in Settlement Area of Sleman Regency

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Abstract. Mount Merapi is one of the most active volcanoes in Indonesia. Seeing the status of Mount Merapi which until now is still quite active, disaster mitigation action efforts are needed. One of the disaster mitigation actions is by making the Risk Map. This study aims to provide an assessment of risk assessment of eruption of Mount Merapi in settlement areas so as to minimize losses that can occur. Mapping of eruption risk of Mount Merapi using two parameters, namely hazard and vulnerabilities. Risk assessment is derived from Matrix comparison of Risk Assessment. Making the risk map using processing method and spatial analysis of Geographic Information System (GIS) with scoring method, weighting, and overlay. The addition of settlement information was obtained using the Normalized Difference Built-up Index (NDBI) method to know total settlement areas. This research will produce a risk settlement area map of Mount Merapi eruption and conclusion that there is still a large risk that occurs in Sleman regency. And Remote sensing technology and GIS can answer challenges in providing disaster analysis with a fast response and better accuracy so that the need for other implementations in building disaster maps in other regions with this technology.

Keyword: NDBI, GIS, remote sensing, volcanoes

1. Introduction

One of the major disasters that occurred in 2010 on the island of Java was the eruption of Mount Merapi. The eruption resulted in a loss of lives and property. Based on data from the National Disaster Management Agency (BNPB), the disaster of Mount Merapi eruption claimed a total of 308 deaths, and the total damage and losses reached 3.62 trillion rupiahs in the Yogyakarta and Central Java regions [1]. Volcanic eruptions have a large impact or potential loss. Potential losses can be in the form of damage to infrastructure, housing, productive land, property, livelihoods, even the lives of residents who live in the area around the volcano [2]. Seeing the status of Mount Merapi, which until now is still fairly active, efforts are needed in disaster management, especially volcanic eruptions to reduce the impact of disaster risk.

Mitigation is a series of efforts to reduce disaster risk, both through physical development and awareness and capacity building to face disaster threats [3]. According to Indonesian National Law No. 24 of 2007, mitigation efforts can take the form of pre-disaster, during disasters, and post-disaster. Preparations in the form of preparedness or efforts to provide understanding to residents to anticipate disasters, through providing information, and increasing preparedness in the event of a disaster so that there are steps to minimize disaster risk. Disaster risk can be assessed at a level based on the level of threat and vulnerability in an area. Disaster risk reduction activities need to be ensured effective, efficient and sustainable. One of the act for mitigation can be done by risk mapping. The definition of



disaster risk mapping is an activity to make a map that represents negative effects that may happen, in the form of material and non-material in certain place after the disaster occurred [4].

One parameter of disaster risk assessment is the aspect of vulnerability. Vulnerability is a condition of a community or community that leads to or causes an inability to deal with disaster threats [3]. Whereas the definition of vulnerability Map is a description or representation of a region or location that states the condition of a region that has a certain vulnerability to its livelihood assets and life that can lead to disaster risk [5]. Many aspects affect the level of vulnerability of a region, whether physical, social, economic and environmental. These aspects have been regulated in PERKA BNPB No. 2 of 2012 concerning General Guidelines for Disaster Risk Assessment. One other effort to reduce disaster risk is the conditioning of house buildings. The number of settlements in disaster-prone areas is also a problem in mitigation efforts. When linked to the level of risk to an area, the denser of the settlement, make the higher the risk level of the area.

One of the efforts to prevent and reduce the impact of disasters is the availability of information packaged into digital maps of disaster-prone areas, which can be used for planning control or early prevention. Geographical Information System (GIS) is the right method in risk mapping for a wide area coverage with a relatively short time. This is done as an effort to analyze risk and disaster mapping through the dissemination of hazard information so that the resulting mapping will accelerate the process of delivering information to the public and relevant agencies and can improve preparedness in taking actions to reduce the risk of disaster threats [6]. Then for settlement detection and analysis using remote sensing technology with the Normalized Difference Built-up Index (NDBI) method. NDBI method can facilitate the detection of settlement locations located on volcanic slopes at the radius of danger. One of reason using NDBI method is because NDBI enables built-up areas to be mapped at a higher degree of accuracy and objectivity [7].

This research tries to conduct a disaster risk assessment of Mount Merapi eruption using GIS methods and remote sensing in accelerating the development of risk maps as part of disaster mitigation efforts. The urgency of this study is as a reference for the local government in the effort to mitigate disaster risk, especially from the threat of the eruption of Mount Merapi. And provide information about risk assessment in residential areas affected by eruption disasters.

2. Hazard, Vulnerability, and Risk Mapping Assessment

Hazard mapping is assessing and presenting hazard information to display hazard characteristics (nature and type of hazards), intensity (time and duration of impacts) and extent of impact areas as hazard zones useful for disaster mitigation activities [8]. Each type of disaster is assessed using a different model, even one type of disaster can be built using different methods. In general it can be said that in the hazard assessment the data relating to the return period and the intensity of the hazard plays an important role of quality assessment results. GIS technology helps a lot of hazard assessment because it is able to combine various data and accommodate the calculation of the occurrence of occurrence and modelling the probability of hazard into the data processing [4].

Vulnerability is an individual or group characteristic that reflects its capacity to anticipate, overcome, survive and recover from the effects of hazards [9]. Vulnerability is formed and produced by humans. Its dynamic nature is more determined by human factors, including aspects of physical, social, economic, system and institutional vulnerability. Although the types of natural hazards may be the same between regions, but with different levels of vulnerability, they will have different impacts [5]. Vulnerable conditions can also be grouped into several classes depending on data availability and the purpose of vulnerability analysis. Vulnerability parameters are divided into sub-classes as follows: physical vulnerability, social vulnerability (especially related to population), economic vulnerability and environmental vulnerability [3].

The concept of risk relates to the probability that an event, either natural or human induced, affect human presence and activity and indeed it concerns the geographical distribution of human settlements. A distinction is made between risk analysis that deals with the quantification of the probabilities and expected consequences of identified risks, and risk evaluation that deals with the socio-politic and moral-ethical component in which judgments are made about the significance and acceptability of risks [10]. Disaster risk mapping is a mapping process that gives an overview of the negative impacts that

cause losses from the threat of a disaster in a region. Examples of risk maps of any hazards [11] provide some ways in which the territory is zoned into classes of risk levels for different types of risks, e.g., risks to life, to assets, to economy, etc. Clearly, without the spatial expression of the risk levels provided by such risk maps, natural risk management would hardly be feasible. With spatial data models hazard prediction can be empirically validated in order to obtain risk maps to potentially bridge the gap with disaster management. The process of using hazard predictions, vulnerability analyses and risk assessments must be linked to the subsequent stage of disaster preparedness [12].

3. Mapping Settlement areas using NDBI

The normalized difference building index (NDBI) was created with the aim of facilitating the mapping of urban areas through Landsat imagery. NIR channels on Landsat satellites are very sensitive to detect vegetation, while reflectance for open land and land is very low. It uses the near infrared and short wave infrared spectral bands to identify the settlements, roads, bridges and dams. The short wave infrared band (SWIR) indicates high reflection of the moisture from soil, vegetation or rocks [13]. Unfortunately, the similarities between spectral signatures of buildings, some agricultural crops, rocks and gravels do not allow the accurate separation between these land cover classes. The standardized differentiation of using two bands of Landsat imagery (equation 1) will result in close to 0 for woodland and farmland pixels, negative for water bodies, but positive values for built-up pixels, enabling the latter to be separated from the remaining covers. So, the NDBI is able to serve as a worthwhile alternative for quickly and objectively mapping built-up areas or settlement areas [7].

$$\text{NDBI} = (\text{TM5} - \text{TM4}) / (\text{TM5} + \text{TM4}) \dots\dots\dots (1)$$

4. Case Study and Research Location

Mount Merapi has an altitude of 2,980 meters above sea level, the Strato type and the most active in Indonesia even in the world, with an average eruption intensity with a short cycle reaching 2-5 years and a long cycle reaching 5-7 years. This condition makes the intensity of the area at risk causes the level of disaster risk in the surrounding area to be high. One of the areas affected by the eruption of Mount Merapi is Sleman Regency. Sleman Regency is one of the regency in Central Java Province which was affected by the Merapi eruption in addition to Boyolali regency, Magelang regency, and Yogyakarta Province. In that incident, many people in Sleman regency became victims. There were 123 deaths, hospitalization 147 people, and as many as 56,414 people were displaced [1]. Merapi eruption in 2010 almost made the economy of Sleman district paralyzed in five sub-districts so that there was almost no economic activity. The five sub-districts are Cangkringan Subdistrict, Pakem Subdistrict, Turi Subdistrict, Subdistrict, and Ngemplak Subdistrict. One of the losses or impacts that are felt in Klaten district is damage to agricultural land and residential areas. Damage to agricultural land in Klaten District occurred in Kemalang Subdistrict with an area of 501 ha of damaged land, especially Balerante Village with volcanic ash cover ranging from 4-13 cm. In addition, there are also many residential areas that have been severely damaged by the eruption of Merapi, covering an area of 496 ha [1]. This level of risk will be even higher because there are still many people who continue to choose or deliberately live in the area around mount Merapi, pushing for higher disaster risk including Sleman regency [2]. The emergence of problems in residential areas in disaster-prone areas is inseparable from the fertile land conditions in the area, which attracts residents in the Sleman regency to cultivate the land into agricultural land. The increasing number of resident settlements in the disaster-prone areas adds to the risk of being affected by the active and unknown volcanoes when it will erupt [14]. Based on the situation, these study tried to provide literacy how to mapping risk of eruption of Mount Merapi in the settlement area quickly and accurately using GIS and remote sensing methods in Sleman Regency.

5. Methods

This research was conducted in the sequence of activities with details as follows:

In this study produced 5 mappings. First, mapping the threat of volcanic eruption resulting from studies of areas that have been hit by the eruption of mount Merapi and its lava flows. Then, based on BNPB 2011 [1], the hazard zone category is divided into three zones of Disaster Prone Area (KRB) or

Hazard Zone. The second is vulnerability mapping. The mapping is done by calculating the weights and scores of the four vulnerability parameters. Furthermore, each parameter of the vulnerability is done weighting and scoring that refers to the regulations in Indonesia, namely PERKA BNPB No. 2 of 2012 on General Guidelines for Disaster Risk Assessment. The mapping produced a vulnerability assessment map. The third result is a risk map for the eruption of mount Merapi. The map is generated from the comparison matrix between hazard classes and vulnerability classes. Then, the mapping of the settlement area was carried out by processing Landsat 8-OLI satellite imagery using the Normalized Difference Build-Up Index (NDBI) method. The results of processing satellite imagery produce a map of settlements. Finally, an overlay between the risk map and the settlement map resulted in a risk map of the settlement against the eruption of Mount Merapi.

From the output produced by this study, can be used as a reference in forming a risk map of Mount Merapi eruption and can be used as a material in mitigation measures in the affected area of Mount Merapi eruption, especially in the Sleman regency.

5.1. *Hazard of Merapi Eruption Mapping*

According to figure of Sleman District 2016, Sleman regency consists of 17 subdistricts and 86 village. A total of 4 districts are prone to Mount Merapi Eruption, such as Pakem, Cangkringan, Turi, and Tempel [15], while disaster prone areas of flood due to lahar are Pakem, Cangkringan, Turi, Tempel, Ngalik, Sleman, Ngempal, and Kalasan. so, the area of the threat of Mount Merapi eruption in Sleman Regency is 8 sub-districts and 43 villages. Furthermore, from the threatened area based on BNPB 2011 [1], a classification based on the Disaster Prone Area (KRB) or Hazard Zone is divided into 3 zones. KRB III with a radius of 5 km from the peak of Mount Merapi is classified as a high hazard class, KRB II with a radius of 15 km is classified as a moderate hazard class, and KRB I with a radius of 30 km is classified as low hazard class.

5.2. *Vulnerability of Mount Merapi Erption Mapping*

According to regulations in Indonesia, namely PERKA BNPB No. 2 of 2012 concerning General Guidelines for Disaster Risk Assessment, an area vulnerability assessment is carried out by calculating and analyzing the 4 main vulnerability parameters, namely social vulnerability, physical vulnerability, economic vulnerability and environmental vulnerability. Each parameter of vulnerability has compiler indicators. These data are secondary and primary data. The data must be collected per vulnerability parameters, as follows:

- 1) Social parameters: population density, sex ratio, age ratio, poverty ratio, and the ratio of disabled people.
- 2) Physical parameters: number of houses and public facilities.
- 3) Economic parameters: Gross Regional Domestic Product (PDRB) and productive land.
- 4) Environmental parameters: forest, land sand, gardens and shrubs.

To facilitate the analysis process, these data are carried out with the preparation of the geodatabase for each indicator combined with the Sleman district administration map so the vulnerability indicator map layers were built.

The results of each data collection of vulnerability indicators are calculated and weighted for each indicator of vulnerability (see Table 1 to 4). The classification of the level of vulnerability is adjusted to the Regulation of the BNPB No. 2 of 2012. Then the final score is calculated from each parameter, where the final score is obtained from the results of the score multiplication and weight.

Furthermore, a total vulnerability map is made. Making a total vulnerability map of mount Merapi eruption disaster using spatial analysis in GIS that are overlay and union method. Creation of this disaster vulnerability map by combining the four vulnerability parameters, namely social vulnerability, economic vulnerability, physical vulnerability, and environmental vulnerability. Making a vulnerability map of mount Merapi eruption disaster is carried out by calculating the accumulation of the final score score for each parameter in accordance with Regulation No. BNPB. 2 of 2012.

Table 1. Social vulnerability parameters

Parameter	Weight (%)	Class			Score
		Low	Moderate	High	
population density	60	<500 life/km ²	500-100 life/km ²	>1000 life/km ²	Score Max Class
sex ratio (10%)	40	<20%	20-40%	>40%	
poverty ratio (10%)					
ratio of disabled people (10%)					
Age ratio (10%)					

Table 2. Physical vulnerability parameters

Parameter	Weight (%)	Class			Score
		Low	Moderate	High	
Number of House	60	< 500 item	500-1000 item	>1000 item	Score Max Class
Public facilities	40	< 10 item	10-30 item	>30 item	

Table 3. Economic vulnerability parameters

Parameter	Weight (%)	Class			Score
		Low	Moderate	High	
Productive land	60	<100 ha	100-200 ha	>200 ha	Score Max Class
PDRB	40	<100 million	100-300 million	>300 million	

Table 4. Environment vulnerability parameters

Parameter	Weight (%)	Class			Score
		Low	Moderate	High	
Forest	10	<25 ha	25-75 ha	>75 ha	Score Max Class
Land sand	50	<10 ha	10-30 ha	>30 ha	
gardens	10	<10 ha	10-30 ha	>30 ha	
shrubs	20	<10 ha	10-30 ha	>30 ha	

5.3. Risk of mount Merapi Eruption

Disaster risk is defined as the possibility of an adverse impact or loss as a result of interactions between disaster threats (natural or non-natural) and vulnerable conditions [16]. All natural disaster risk reduction processes can only begin if there is preliminary data available on the distribution and level of risk of damage and losses faced by the community when natural disasters come. Distribution and level of risk are representations of potential and frequency (based on incident data) of disaster threats, vulnerability of the community and environment and the capacity of communities to face disasters. In this study, the development of the risk of mount Merapi eruption was carried out by matrix comparisons between the threat class and the total vulnerability class, with the rules as in Table 5.

Table 5. Matrix comparison of Risk Assessment

Vulnerability	Hazard			
	X	Low	Moderate	High
	Low	Low	Low	Moderate
	Moderate	Low	Moderate	High
	High	Moderate	High	High

5.4. Settlement Mapping using NDBI

To get the residential area which is the object of the risk of mount Merapi eruption is done by processing the transformation of Normalized Difference Build-Up Index (NDBI) on Landsat 8-OLI imagery in 2016. The results in NDBI processing are then classified into 3 classes of land namely vegetation, water, and settlements [17]. The steps in NDBI processing are as follows:

- 1) Radiometric Correction. Radiometric Correction is done to change the change / convert value of downloaded original image data from DN (Digital Number) to reflect of Top of Atmospheric. In Landsat satellite imagery 8. Channels used in this processing are channels 5 and 6.
- 2) Geometric Correction. Geometric correction is done to justify the position of the image, to fit the field situation. This geometric correction process uses the Image to Image method.
- 3) Cropping Imagery. The corrected landsat image must be cut according to the study area, namely the area that enters into the Disaster Prone Area (KRB) I, II, and III Sleman regency.
- 4) Classification of the built-up index (NDBI) normalized difference. Classification of normalized difference built-up index (NDBI) in Landsat 8 processing is done using remote sensing software (ENVI). The image that has been cut, then entered the NDBI algorithm using Band Math tools.
- 5) Accuracy Test. Accuracy calculation can be done with various methods, one method is confusion matrix. The field validation point used in this accuracy test is based on High Resolution Satellite Imagery (CSRT) in 2015 with 61 points used.

6. Result and Analysis

6.1. Result and analysis of hazard of mount Merapi eruption

From the eruption of Mount Merapi in 2010, the hazard zone (KRB) was divided into three zones. The hazard zone is divided based on the radius of the peak of Mount Merapi, namely the high hazard zone (KRB III) with a radius of 5 km, moderate hazard zone (KRB II) with a radius of 15 km, and a low hazard zone (KRB I) with a radius of more than 15 km.

The results obtained from the mapping of the mount Merapi eruption disaster and lava flows regarding sleman regency, there are eight affected sub-districts with a total area of 31,298.450 hectares (see Table 6 and Figure 1). While the most affected area is in the village of Hargobinangun with an area of 1330,134 hectares or 75.31% of the area of high hazard zones.

Table 6. Hazard zone of mount Merapi eruption

Hazard zone	Area (ha)	Percentage (%)	Prone areas (sub-district)
HIGH	1,766.137	5.65	Pakem, Turi, Cangkringan
MODERATE	10,893.283	34.80	Pakem, Turi, Cangkringan, Ngemplak, Tempel
LOW	18,639.029	59.55	Pakem, Turi, Cangkringan, Ngemplak, Tempel, Sleman, Ngaglik, Kalasan
Sum	31,298.450	100	

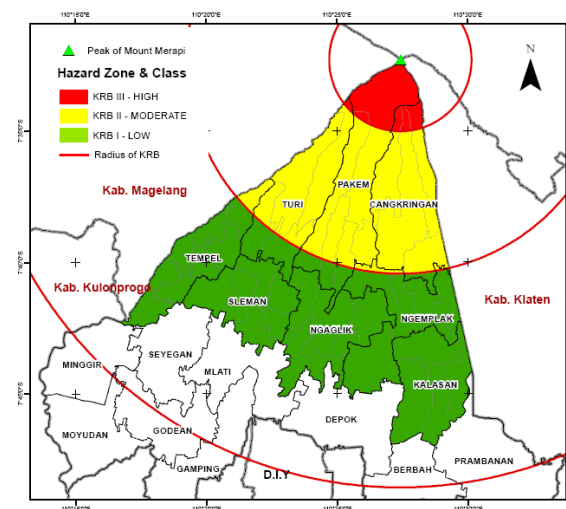
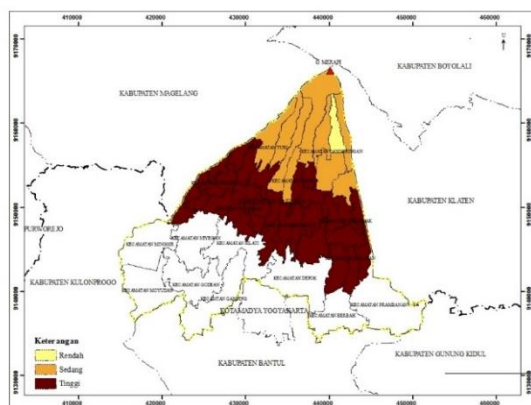


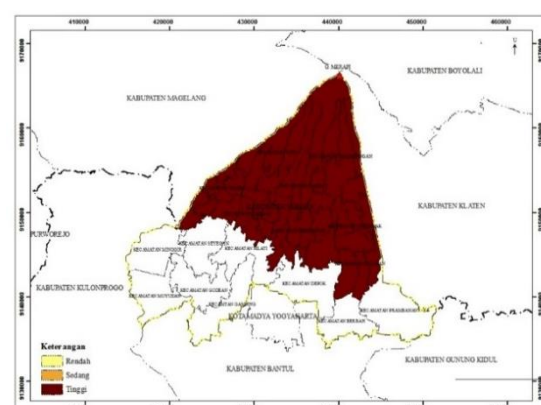
Figure 1. Hazard zone of mount Merapi eruption map

6.2. Result and analysis of vulnerability of mount Merapi eruption

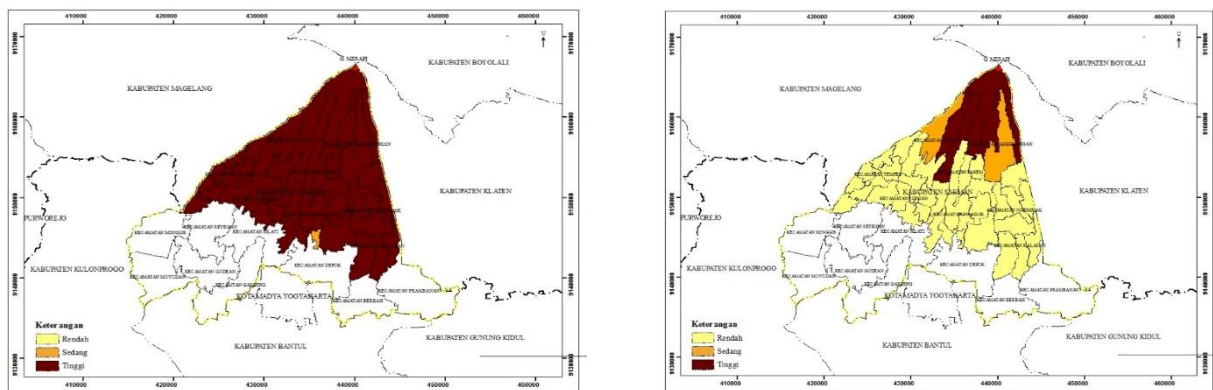
Based on the results of the processing of social vulnerability, areas with high vulnerability levels were as many as 32 villages, while areas with moderate vulnerability were 9 villages and low vulnerability levels were 1 village. Based on the results of physical vulnerability processing, as many as 42 villages are in a high level of vulnerability or 100% of the research area is very vulnerable from the danger of eruption of mount Merapi. This can prove that the large number of houses in Sleman Regency and the development of Sleman Regency are quite good in terms of infrastructure so that there are many public facilities as a means of supporting people's daily lives. Then based on the results of processing economic vulnerabilities, there is 1 village in the moderate vulnerability class and 41 villages in the high vulnerability class. Vulnerability classes are found in the KRB I area so that it is far from the danger points of lava and lava, but it is possible to be exposed to rock throws and cold lava floods if there are around the river flow. High vulnerability classes are in KRB I, KRB II, as well as KRB III. Furthermore, based on the results of environmental vulnerabilities, there were 34 villages in the low vulnerability class, 3 villages in the moderate vulnerability class, and 5 villages in the high vulnerability class. Low vulnerability classes dominate the results of vulnerability based on economic parameters. High vulnerability classes must be considered more closely in relation to the location of vulnerability classes in the vicinity of KRB II and KRB III, where both are very vulnerable positions directly affected by volcanic eruptions both lava flows, lava, as well as rock throws/falls. The existence of a high vulnerability class at the peak of mount Merapi is due to the large amount of sand or rocks in the area.



(a) Social Vulnerability Map



(b) Physical Vulnerability Map



(c) Economic Vulnerability Map

(d) Environment Vulnerability Map

Figure 2. Parameter of Vulnerability of mount Merapi eruption map

The total vulnerability map of the mount Merapi eruption disaster is the result of combining vulnerability based on social, economic, physical and environmental parameters. Making a total vulnerability map for the mount Merapi eruption disaster is done by calculating the accumulated value of the final score of each parameter in accordance with Regulation BNPB No. 2 of 2012. The establishment of vulnerability is also influenced by the hazard aspect, where this aspect is used to determine which locations need to be identified before being grouped into the level of vulnerability, which is then performed data overlay. The results and distribution of total vulnerabilities can be seen in Table 7 and Figure 3. From the total vulnerability of the eruption of Mount Merapi, the overall results from the Sleman district area have a high vulnerability class, and only one village in Cangkringan Subdistrict has a moderate vulnerability class. The village is Kepuharjo Village with an area of 771,154 hectares. This is because the area of Mount Merapi, especially in Sleman Regency has a high level of social, economic and physical vulnerability.

Table 7. Vulnerability zone of mount Merapi eruption

<i>Vulnerability Zone</i>	<i>Area (ha)</i>	<i>Percentage (%)</i>	<i>Prone areas (sub-district)</i>
HIGH	30,527.296	97.54	Pakem, Turi, Cangkringan, Ngemplak, Tempel, Sleman, Ngaglik, Kalasan
MODERATE	771.154	2.46	Cangkringan
LOW	0.000	0.00	-
Sum	31,298.450	100	

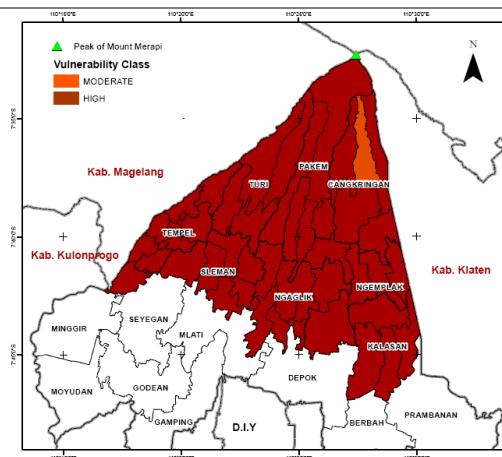


Figure 3. Vulnerability of mount Merapi eruption map

6.3. Result and analysis of risk of mount Merapi eruption

Disaster risk assessment is needed to reduce the impact of a disaster. One way to reduce risk is by conducting a risk assessment. Risk assessment does not only involve one factor but is caused by several interrelated factors, namely hazard and vulnerability factors. From the results of the hazard mapping and total vulnerability mapping, a risk assessment was carried out which resulted in mapping the risk of mount Merapi eruptions with distribution and maps as in Table 8 and Figure 4.

Table 8. Risk zone of mount Merapi eruption

<i>Risk Zone</i>	<i>Area (ha)</i>	<i>Percentage (%)</i>	<i>Prone areas (sub-district)</i>
HIGH	1674.505	5.35	Pakem, Turi, Cangkringan
MODERATE	29623.945	94.65	Pakem, Turi, Cangkringan, Ngemplak, Tempel, Sleman, Ngaglik, Kalasan
LOW	0.000	0.00	-
Sum	31298.450	100	

6.4. Result and analysis of settlement area of mount Merapi eruption

Accuracy test based on the identification of NDBI transformations using visual reference data from High Resolution Satellite Imagery in 2015 resulted in commission error values of 27.70%, omission errors of 36.51%, and overall accuracy of 88.5246% with acquisition kappa coefficient value of 0.8153. The results of the accuracy test using the confusion matrix in this study meet the requirements that the overall accuracy value is greater than 80%. The results and distribution of settlement areas can be seen in Table 8 and Figure 4.

Settlement area per village as a result of processing NDBI transformations. The most densely populated settlements are in Hargobinangun Village at Pakem Subdistrict with an area of 822,005 hectares and the least common settlement is in Merdikorejo Village at Tempel subdistrict with an area of 11,459 hectares.

6.5. Result and analysis of risk settlement area of mount Merapi eruption

Physically, settlement area is the land with the highest risk level when affected by disaster. Then the risk assessment on the settlement zone becomes very necessary in the context of disaster mitigation. This underlies the results of the risk assessment of the settlement areas affected by Mount Merapi by combining risk maps and settlement maps with results that can be seen in Table 9 and Figure 4. The results of the risk assessment of the settlement area of Mount Merapi eruption found that most of the area has medium class and a small portion of which has high class, especially in Hargobinangun Village at Pakem Subdistrict with a total area of affected settlement area is 427,331 hectares.

Table 9. Settlement risk zone of mount Merapi eruption

<i>Settlement Risk Zone</i>	<i>Area (ha)</i>	<i>Percentage (%)</i>	<i>Prone areas (sub-district)</i>
HIGH	500.827	4.50	Pakem, Turi, Cangkringan
MODERATE	10637.110	95.50	Pakem, Turi, Cangkringan, Ngemplak, Tempel, Sleman, Ngaglik, Kalasan
LOW	0.000	0.00	-
Sum	11137.937	100	

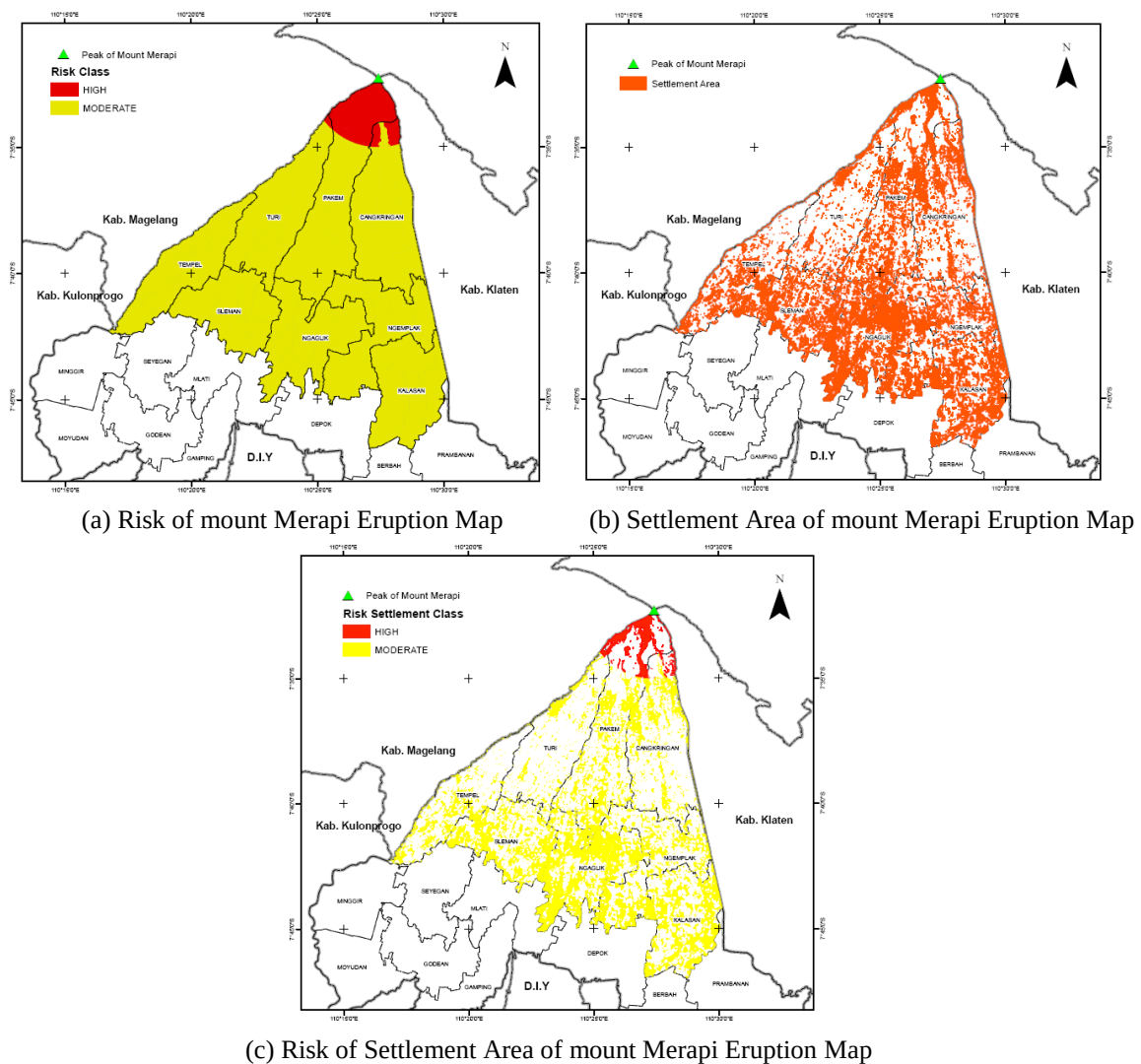


Figure 4. The results of the settlement risk assessment map due to the eruption of Mount Merapi

7. Conclusion

There are settlement areas that have a high risk of eruption of Mount Merapi amounting to 500,827 hectares, and a moderate level of 10637,110 hectares, and there is no low level risk. The distribution of the area affected is very high in the village of Hargobinangun at Pakem District with a total area of 427,331 hectares. These results can be used as an indication that there is still a large risk that occurs in Sleman Regency. And the need for an appropriate strategy in mitigation planning so that if there is an eruption again can prevent the increase in material and non-material losses for the future.

Remote sensing technology applications and GIS can answer challenges in providing disaster analysis with a fast response and better accuracy so that the need for other implementations in building disaster maps in other regions with this technology.

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