The Multi-Risk Analysis of Various Disasters in Karanganyar Regency

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Abstract. Karanganyar Regency is one of the districts in Central Java which prone of the natural disasters. Based on data Posdes 2018, it is known that the types of disasters that often occurred in Karanganyar Regency during the last three years, from 2015 to 2017 were landslides, floods, and drought. Therefore, it is important to know the multi-risk level of the three types of disasters. The method used in this research is scoring and weighting, as well as overlay between constituent parameters. Based on the results of research using the VCA matrix multiplication method, it is known that the high risk level covers 3,589.67 Ha or 4.46% areas that spread in 15 districts (except Jatipuro and Jumapolo); moderate risk level covers 34,624.94 Ha or 43.04% areas that spread in 16 districts (except Tasikmadu); The low risk level covers 42,254.98 Ha or 52.53% areas that spread in 7 districts (Colomadu, Gondangrejo, Tasikmadu, Matesih, Tawangmangu, Jumapolo, Jatiyoso).

Keywords: Landslide, Flood, Drought, Multi-Risk Disaster

1. Introduction

Karanganyar Regency is prone to disasters based on data from BNBP Central Java in 2015, Karanganyar Regency has a high potential for the threat of landslides, drought and technological failures from 12 disaster threats in Central Java Province. This is influenced by geological, geomorphological, climatological and social characteristics. The configuration of relief which varies greatly in wet tropical climate conditions is the reason why Karanganyar Regency prone to various kinds of both endogenous and exogenous disasters. These conditions are supported by the high population size and density, coburnplus low awareness and knowledge of disasters in Karanganyar Regency. This shows that the risk of natural disasters in Karanganyar Regency is quite high.

UNDP (2010) defines risk as the likelihood of dangerous consequences - loss of life, damage to property, loss of livelihoods, disruption of economic activity, and environmental damage - resulting from interactions between natural or human-induced hazards and vulnerable conditions. Risk assessment is the process of determining the nature and level of that risk, by analyzing hazards and evaluating existing conditions of vulnerability that together have the potential to harm people, property, services, livelihoods and the environment on which they depend.

It can be seen that the high risk of disasters that occur in an area, including Karanganyar Regency, is not only influenced by the many types of hazards that threaten, but also due to the increasing number of
people who are vulnerable to the threat of disasters and the low community capacity in dealing with disasters [6], [13].

This condition requires Karanganyar Regency to carry out disaster risk reduction management which is more targeted, integrated, and comprehensive. It can be supported by a disaster risk assessment in Karanganyar Regency, because disasters cannot be avoided, but their impact can be minimized using the right information available at the right time. One source of information can be used is a map of disaster-prone areas and levels of disaster risk. It can be the basic basis for supporting the implementation of disaster management [15].

Disaster management is taking immediate and appropriate actions to deal with disasters and their components, their consequences under pressure and time due to hazards that are not clearly defined and lack of adequate and accurate information and other resources. Therefore, disaster management needs to be well planned. Disaster management and prevention differ according to the type and size of the disaster and its severity. Planning must include strategic planning, determining specific objectives, environmental strategic analysis, using prediction tools related to crisis types and hazard analysis, coordination of efforts and design of effective organizational structures [17].

Through a risk assessment and capacity to deal with disasters, including hazard and vulnerability assessments, disaster management directives can be developed, especially disaster mitigation and preparedness [2], [3], [5]. Disaster mitigation is a term used to refer to all actions to reduce the impact of a disaster that can be taken before it occurs, including long-term preparedness and risk reduction measures. This includes planning and implementing measures to reduce risks associated with known natural and man-made hazards, and planning processes for effective responses to disasters that do occur (Coburn et al, 1994; Mohamed, 2019).

Considering the importance of this in reducing the impact of disasters, carrying out disaster risk analysis is an important part in disaster management activities. Disaster risk analysis is a research activity and a study of activities that allow disasters to occur [14]. As for the Regulation of the Minister of Energy and Mineral Resources No. 15 of 2011 concerning Guidelines for Volcanic Disaster Mitigation, Land Movement, Earthquakes and Tsunamis, states that one of the considerations in disaster risk assessment is the result of an analysis of disaster-prone areas [11].

However, disaster risk assessment has only covered one type of risk from one disaster. There have not been many studies that combine the various risks from many disaster threats or what can be called the term multicaster risk, namely the combination of various types of disaster risks generated by various types of hazards (multihazard). The assessment of various disaster risks in an integrated manner is known as a multirisk assessment [7].

Based on the potential for several types of disasters that have occurred in Karanganyar Regency, research on the multiple risks of various disasters in Karanganyar Regency is important considering that Karanganyar Regency really needs this information as one of the important steps in disaster risk reduction to be applied in district development planning. The information on multi-risks can be useful for reducing risks not only from one type of disaster, but also for another increasing risk of other hazards. Therefore, this research was conducted by focusing on several problems, the characteristics and levels of vulnerability to various disasters in Karanganyar Regency, the capacity of the people of Karangnyar Regency in facing disaster-prone, and the multi-risk distribution pattern of various disasters in Karanganyar Regency.

2. Method
This research are using descriptive quantitative. Data analysis technique used to measure the level of disaster risk by scoring to determine the high, medium and low risk of a disaster and calculated using the equation:

\[ R = H \cdot V / C \]

with the equation identity:

\[ R = \text{Risk} \]
H = Hazard
V = Vulnerability
C = Capacity

Hazard Mapping (H)
The disaster threat map is created based on data and records of events that have occurred in Karangnyar Regency during the last three years, It is 2015, 2016 and 2016, and were obtained from the Village Potential data of Central Java Province in 2018.

Vulnerability Mapping (V)
There are three disaster vulnerability analyzed in this study:
Landslide Vulnerability. The parameters to determine the level of landslide vulnerability can be seen in Table 1.

| No | Parameter     | Weight |
|----|---------------|--------|
| 1  | Slope         | 0.30   |
| 2  | Rainfall      | 0.20   |
| 3  | Geology       | 0.30   |
| 4  | Land Use      | 0.20   |

Source: Paripurno et al, 2006 in [4]

Flood Vulnerability. The parameters to determine the level of flood vulnerability can be seen in Table 2.

| No | Parameter         | Weight |
|----|-------------------|--------|
| 1  | General Flood Area | 0.25   |
| 2  | Rainfall          | 0.25   |
| 3  | Elevation         | 0.25   |
| 4  | Land Use          | 0.25   |

Source: Paripurno et al, 2006 in [4]

Drought Vulnerability. The parameters to determine the level of drought vulnerability can be seen in Table 3.

| No | Parameter        | Weight |
|----|------------------|--------|
| 1  | Rainfall         | 0.33   |
| 2  | Land Use         | 0.27   |
| 3  | Water Sources    | 0.20   |
| 4  | Types of Soil    | 0.13   |
| 5  | Elevation/Slope  | 0.7    |

Source: [9]
Capacity Mapping (C)
The parameters used to determine disaster capacity which based on PERKA BNPB No. 2 of 2012 which consists of several parameters as listed in Table 4 [1], the data of which are obtained from data Posdes (the Village Potential) of Central Java Province in 2018.

Table 4. Disaster capacity parameters

| Capacity Parameters | Weight (%) | Capacity Class |
|---------------------|------------|----------------|
|                     | Low Value  | Medium Value   | High Value |
| Number of Health    | <10 person | 10-20 person   | >20 person |
| Workers             |            |                |            |
| Number of Health    | <10 unit   | 10-20 unit     | >20 unit   |
| Facilities          |            |                |            |
| Disaster Socialization | None      | 0              | Exist      |
|                     |            |                |            |
| Disaster Anticipation Effort | None | 0 | Exist | 3 |

Source: [1]

Disaster Risk Mapping
The calculation of the score and classification of disaster risk from the parameters of hazard, vulnerability and capacity using the VCA matrix multiplication method is carried out according to Table 5.

Table 5. VCA Multiplication Matrix

| V/C             | Capacity (C) |
|-----------------|--------------|
|                 | High | Medium | Low  |
| Low             | Low   | Medium | High |
| Vulnerability (V)| Medium | Low   | Medium | High |
|                 | High  | Medium | High  |
| Risk            | V/C   |        |      |
| H*(V/C)         | Low   | Medium | High  |

Source: [4]

Multi-Risk Disaster Mapping
After generating the risk map for disasters, landslide, floods, and drought, the merging process is carried out by multiplying the matrix according to Tables 6 and 7.
### Table 6. Multi-Risk Floods and Landslide VCA Matrix

| Multi-Risk Disaster | Landslide Risk |
|---------------------|----------------|
|                     | Low  | Medium | High |
| Flood Risk          | Low  | Low    | Low  |
|                     | Medium | Low   | Medium |
|                     | High  | Medium | High  |

Source: [4]

### Table 7. Multi-Risk Flood, Landslide and Drought VCA Matrix

| Multi-Risk Disaster | Drought Risk |
|---------------------|--------------|
|                     | Low  | Medium | High |
| Flood and Landslide Risk | Medium | Low   | Medium |
|                     | High  | Medium | High  |

Source: Researcher analysis, 2020

3. Result and Discussion
Karanganyar Regency is one of the districts in Central Java that astronomically located at coordinates 110°04′38″-111°12′04″ East Longitude and 7°06′17″-7°46′07″ South Latitude, while geographically, Karanganyar Regency located at the west of Mount Lawu slope.

The risk level of landslide, floods, and drought, and also the multi-risks of the three disasters in Karanganyar Regency can be explained as follows:

**Hazard Map**
The disaster threat map is created by using data and records of disaster events that have occurred in Karanganyar Regency during the last three years, It is 2015, 2016 and 2016. Based on the disaster event data, it is known that the type of disaster that most often occurs in Karanganyar Regency is landslides, hemorrhoid, and drought.

**Landslide Hazard Map.** During the last three years the intensity of landslide hazards that occurred in most areas of Karangnyar Regency was classified as low, with a percentage covering 94.91% of the area, while those classified as moderate were 3.39% of the area and those classified as high were 1.69% of the area, as shown at Figure 1.
During the last three years, the intensity of the flood hazard that occurred in most areas of Karangnyar Regency was classified as low, with a percentage covering 93.22% of the area, while those classified as moderate were 5.65% of the area and those classified as high were 2.25% of the area, as shown at Figure 2.

**Figure 1. Landslide Hazard Map**

**Figure 2. Flood Hazard Map**
**Flood Hazard Map.** During the last three years, the intensity of drought in most areas of Karangnyar Regency is low, with a percentage covering 97.74% of the area and 2.26% of the area being classified as high, as shown at Figure 3.

![Flood Hazard Map](image)

**Figure 3. Drought Hazard Map**

**Vulnerability Map**

The vulnerability of landslides, floods, and drought disaster in Karanganyar Regency are as follows:

3.2.1 **Landslide Vulnerability Map.** Results of weighting and overlapping landslide parameters consisting of slope, rainfall, geology, and land use shows that 8.04% of Karangnyar Regency is in the high hazard category, 71.84% is included in the hazard category moderate, and 19.11% is included in the low hazard category, as seen in Figure 4. The factor that mostly influenced this condition is slope, which 47.00% of the area in Karangnyar Regency has a slope of 8-15% (gentle) and conditions. geology, most of which are included in the Lahar Lawu (Qlla) formation, with andesite, basalt and a few pumice components of various sizes mixed with volcanic sand. This formation is indeed scattered, especially filling the plain area at the foot of the volcano or forming several low hills (Samodra, 1997 in [8]).
3.2.2 Flood Vulnerability Map. Based on the weighting and overlaying results of flood parameters consisting of general flood zones, rainfall, altitude, and land use, it can be seen that 27.15% of Karanganyar Regency is in the high hazard category, 64.16% is included in the category moderate vulnerability, and 7.67% are included in the low hazard category, as seen in Figure 5. This condition is most influenced by the high rainfall in Karanganyar Regency (2000-2500 mm / year), as well as 37.92% land use. Its territory is in the form of irrigated rice fields.

3.2.3 Drought Vulnerability Map. Based on the weighting and overlaying results of drought parameters which consist of rainfall, land use, water sources, soil type, and slope, it can be
seen that 20.99% of Karanganyar Regency is in the high vulnerability category, 52.37% is included in moderate hazard category, and 26.59% included in the low hazard category, as seen in Figure 6. This condition is most influenced by the high rainfall in Karanganyar Regency (2000-2500 mm/year), the land use is 37.92%. Its territory is in the form of irrigated rice fields, and is also influenced by the existence of water sources. Karanganyar Regency is included in Lahar Lawu formation, one of which is characterized by the discovery of many water sources (Samodra, 1997 in [8]).

Figure 6. Drought Vulnerability Map

Disaster Capacity Map

Based on the weighting and overlaying results of disaster capacity parameters consisting of the number of health workers, the number of health facilities, socialization and disaster anticipation efforts, it is known that 75.71% of the area covering 134 villages is in the low capacity category, 19.21% of areas covering 34 villages are in the medium capacity category, and 5.09% areas covering 9 villages are included in the high capacity category, as seen in Figure 7. The factor that most influences village areas with high disaster capacity is the number of health facilities (> 20 people) and health workers (> 20 people) who are also classified as high. Meanwhile, there are no factors for socialization of disasters and efforts to anticipate disasters in most areas.
Figure 7. Community Capacity Map of Karanganyar Regency in Facing Disaster

Disaster Risk Map

Landslide Risk Map. Karanganyar Regency Landslide risk map which was generated from the analysis of hazard, vulnerability and capacity mapping using the VCA matrix multiplication method and the results were as listed in Table 8.

Table 8. Results of Landslide Risk Map Area

| Risk | Matrix VCA | Large (ha) | Percentage (%) |
|------|------------|------------|----------------|
| High | 6.456,47   | 8.03%      |
| Medium | 51.649,55 | 64.21%    |
| Low  | 22,363,56  | 27.80%     |

Source: Researcher analysis, 2020

Based on the percentages listed in Table 8, and visualized in Figure 8, it shows that 64.21% of the area in Karanganyar Regency is at moderate risk of landslides. Areas with a high risk of landslides with a percentage of 8.03% are spread over four sub-districts, Jatiyoso and a small part of Tawangmangu, Matesih, and Ngargoyoso. This is because the threat of landslides in most areas of Jatiyoso Subdistrict is classified as moderate and high, with moderate and high levels of vulnerability, but the capacities are classified as medium and low. It means that theoretically it proves the equation $R = \frac{H \times V}{C}$, that with high danger and vulnerability, while the capacity is low, the disaster risk of an area is high.
Figure 8. Landslide Risk Map

Flood Risk Map. The flood disaster risk map in Karanganyar Regency is generated from the analysis of the hazard, vulnerability and capacity mapping using the VCA matrix multiplication method and the results are as listed in Table 9.

Table 9. Result of Flood Risk Map Area

| Risk  | Matrix VCA Large (ha) | Large (ha) |
|-------|-----------------------|------------|
| High  | 3.130,86              | 3,89%      |
| Medium| 5.4237,70             | 67,43%     |
| Low   | 2.3101,02             | 28,72%     |

Source: Researcher analysis, 2020

Based on the percentages listed in Table 9, it can be visualized in Figure 9, which shows that 67.43% of the area in Karanganyar Regency has a moderate flood risk. Areas with high flood risk with a percentage of 3.89% are spread over a small area of the five sub-districts, namely Gondangrejo, Colomadu, Jaten, Karanganyar, and Tasikmadu. Of the five sub-districts, most Vast are scattered in the northern part of Gondangrejo District with the threat of flooding that is classified as Medium and High, with the level of vulnerability classified as Medium and High as well, but the capacity level is classified as Low, resulting in a High flood level.
Figure 9. Flood Risk Map

*Drought Risk Map.* The drought disaster risk map in Karanganyar Regency is generated from the analysis of hazard, vulnerability and capacity mapping using the VCA matrix multiplication method and the results are as listed in Table 10.

**Table 10. Results of Drought Risk Map Area**

| Risk     | Large (ha) | Matrix VCA | Large (ha) |
|----------|------------|------------|------------|
| High     | 1,554,77   |            | 1,93%      |
| Medium   | 50,232,88  |            | 62,45%     |
| Low      | 28,681,92  |            | 35,66%     |

Source: Researcher analysis, 2020

Based on the percentages listed in Table 10, it can be visualized in Figure 10, which shows that 62.45% of the area in Karanganyar Regency has a moderate risk of drought. Region with a high risk of dryness with a percentage of 1.93% is spread across two districts, Gondangrejo and Jumapolo. Gondangrejo, with threats classified as Low and High, and the level of vulnerability that is classified as Medium and High as well, but the capacity level is classified as Low, resulting in a High flood level.
Figure 10. Drought Risk Map

Disaster Multi-Risk Map
The results of making a risk map of landslides, floods and drought were then overlaid again using the multiplication matrix method listed in table 7, it is known that the areas in Karanganyar Regency with a High Risk level are multi risk of landslides, floods, and drought. 3,589.67 Ha, or 4.46% spread over 15 districts (except Jatipuro and Jumapolo) with the distribution in 9 villages. Areas in Karanganyar Regency with a Risk Medium level of risk of landslides, floods, and drought 34,624.94 Ha, or 43.04% spread over 16 sub-districts (except Tasikmadu) with a distribution to 78 villages. As for the rest, the areas in Karanganyar Regency with a Low Risk level for multiple risks of landslides, floods, and drought at 42,254.98 Ha, or 52.53% spread over 7 districts (Colomadu, Gondangrejo, Tasikmadu, Matesih, Tawangmangu, Jumapolo, Jatiyoso) with distribution in 90 villages. A multi risk map of landslides, floods and drought in Karanganyar Regency can be seen in Figure 11.
Figure 11. Multi-Risk Map of Landslides, Floods, and Drought Disasters in Karanganyar Regency

4. Conclusion
The conclusion of this research are:
1. The hazards of landslides, floods, and drought in most areas of Karanganyar Regency are classified as low with 94.91% each; 93.22%; and 97.74%
2. The vulnerability of landslides, floods, and drought in most areas of Karanganyar Regency is classified as moderate with 71.84% each; 64.16%; 52.37%.
3. Community capacity of Karanganyar Regency in facing disasters in most areas is classified as low with a percentage of 75.71% covering 134 villages.
4. Disaster risk mapping in Karanganyar Regency obtained from overlaying hazard maps, hazard maps, and capacity maps shows that the risk of landslides, floods and drought in most areas of Karanganyar Regency is moderate with a percentage of 64.21%; 67.43%; 62.45%.
5. The Multi-risk disaster map obtained from overlaying risk maps of landslides, floods and drought, it is known that:
   a. The high risk level covers an area of 3,589.67 hectares or 4.46%, which is spread over 15 sub-districts (except Jatipuro and Jumapolo) with a distribution in 9 villages.
   b. The moderate risk level covers an area of 34,624.94 Ha or 43.04%, spread over 16 sub-districts (except Tasikmadu) with the distribution to 78 villages.
   c. The low risk level covers an area of 42,254.98 Ha, or 52.53% spread over 7 districts (Colomadu, Gondangrejo, Tasikmadu, Matesih, Tawangmangu, Jumapolo, Jatiyoso) with distribution in 90 villages.

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