Risk perception analysis of the population in sustainable disaster management plan: a case study of Mount Merapi eruption in Yogyakarta

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Abstract. The risk concept in the realm of natural disasters in several countries such as earthquakes, fires, floods and volcanoes shows the difference between the perspectives of the population on the risks and the principles of the normative decision theory. This study aims to determine the conception and behaviour of the population on the risk of Mount Merapi as a study to manage a sustainable disaster management system. This research uses an exploratory retrospective view approach, utilizes survey and questionnaire as its research instruments. The questionnaire consisted of four categories based on the literature study, which include the respondent profile, risk definition, risk perception, and risk action. The sampling technique used is a multi-stage stratified convenience sampling (n = 300, response rate = 91%). Its stratification is the disaster-prone areas (DPA) and the population gender. The results showed that most respondents perceived risk as a consequence, in contrast to the normative theory. Respondents in DPA III have a tendency of risk attitude as risk moderate, while respondents in DPA II have a risk-averse tendency. In relation to the respondent behaviour during eruption, it was found that DPA and gender differences showed different respondents’ response in facing Mount Merapi eruption disaster in terms of the evacuation time, the action when hearing the warning sign, the evacuation route being followed, and the willingness to help others.

Keywords: Merapi Eruption, Risk, Risk Perception, Risk Attitude, Risk Action, Sustainable

1. Introduction

Disaster is defined as an event or series of events that threaten and disrupt people's lives and livelihoods caused by natural factors or non-natural factors, human factors, that result in the occurrence of casualties, environmental damage, property loss and psychological impact. Natural disasters are events caused by nature, such as earthquakes, tsunamis, volcanoes, floods, droughts, hurricanes and landslides [1]. The eruption of Mount Merapi in 2010 was the biggest eruption disaster compared to similar incidents in the previous five years (1994, 1997, 1998, 2001 and 2006). The 2010 eruption disaster killed 242 people in Yogyakarta and 97 people in Central Java [10]. Until 2018,
Mount Merapi is an active volcano that often emits eruptions, although still on a small scale. Therefore, several related stakeholders such as the government, BNPB, humanitarian organizations, researchers and volunteers work together in designing preventive and coordination efforts.

Merapi disaster area is divided into three Disaster Prone Areas (DPA). First, DPA III is an area located at a radius of 5 km from the peak of Mount Merapi, near the source of frequent hot clouds hazard, lava flows, falling rocks, incandescent rocks and heavy ash rains, and it has a high level of vulnerability. Second, DPA II is an area located at a radius of 10 km from the peak of Mount Merapi, and if there is an increase in the status of Merapi then the population must evacuate and return again after the state is declared safe by the Center for Volcanology and Geological Hazard Mitigation. Third, DPA I is an area located along the river flow, and the potential danger of this area is in the form of hot lava and cold lava flows.

Previous studies of earthquakes, fires, volcanoes, and floods show that a person’s perceptions of risk will affect his attitude in the face of risky situations. Risk perception will affect the behavior in facing risks. The proper behaviour during a disaster occurrence will reduce the impact of the disaster. The purpose of this research is to know the conception and the response of the population to disaster risk of the eruption of Merapi and to compare it with related theories and studies [2].

People’s perceptions of natural, spiritual, and social phenomena are socially constructed. Social perception is important because it helps people to make sense of the physical and social world and therein interact with it. [3]. Each country has different respondents who take self-protection measures in the occurrence of an earthquake [4]. Populations in some countries have different behaviours in dealing with disasters, and people with the disaster experience will act with negligence, while the behaviour is also influenced by culture and customs [5]. In addition, each country has a different response in performing self-protection measures when an earthquake occurs, which is known as ethnic variation response [6]. People are generally afraid of geological hazards. The female population, the low-income and lowest-educated population have a higher level of fear [6]. In addition, women are generally more easily surprised and frightened [7].

Eight factor influencing the disaster risk perceptions are gender, age, education, annual income, size of households, children, distance from rivers, and disaster experience. Impact analysis of risk perception factors showed that women had higher flood risk perception than men, respondents with more education, lower annual income, children at home and previous flood experience had higher flood risk perception than others, and people who lived near rivers had higher flood risk perception than those who lived away from rivers [8].

The factors shaping smallholder risk perception vary among hazards within the study population and that characteristics of both hazards and individuals are important. Regression analysis reveals a surprising relationship between risk perception, self-efficacy, and protective action [9]. Hard and soft intervention measures exemplify neighbourhoods developing perceptions according to institutional influences, local organization strategies and marginalization level, highlighting the importance of local participation on risk reduction programs to improve perception, trust and therefore, intervention measures [11].

Studies on the perception and behaviour of the population in facing a disaster in Indonesia require further research. Technological improvements will not be optimal if it is not supported by appropriate perceptions and behaviours in facing high-risk conditions. The contribution of this research can be useful to agencies and disaster organizations to recognize the concept and the public response to the risk of the eruption of Merapi so that an appropriate intervention to reduce the impact of Merapi eruption can be formulated. In addition, the results of this study can be used as an evaluation material by the community.

2. Research Method

The approach of this research is exploratory, which is one of the empirical methods that is able to provide preliminary information for new research areas [6]. The focus of the information studied is the conception and the behaviour of the population with the increase of Merapi status on October 2010.
This research is in the phase of emergency response with retrospective view research method by using information from the past events. The multi-stage stratified convenience sampling is used in some regional stages, and the first disaster-prone areas are DPA III and DPA II covering Cangkringan Sub-district, Pakem Sub-district, and Pakem Sub-district. The stratification used is disaster-prone areas (DPA III and DPA II) and the gender of the population (male and female). The use of convenience sampling method aimed to facilitate researchers in taking data. The convenience sampling is at the stage of determining villages and hamlets.

Survey instruments are developed into three activities. First, the literature review was used to identify the related information to be obtained. Second, the main part was developed into question items. Third, the pilot study was done to test the effectiveness of survey instruments as a communication tool between researchers and respondents. The pilot study was employed on two things: face validity and content validity. The final questionnaires were distributed to respondents directly to each survey area, which included six villages in three sub-districts, namely DPA II (Huntap Q-Tel, Huntap Batur, Ledok Lempong Hamlet and Boyong Hamlet) and DPA III (Kendal Karang Huntal, Turgo Hamlet, and Tunggularum Hamlet).

To increase the response rate, the researcher gave a gift to each respondent. The total number of questionnaires distributed is 300 questionnaires. The number of questionnaires distributed in DPA II is 248 questionnaires, with 228 questionnaires being returned, and the response rate is 92%. As for DPA III, the questionnaires distributed are as many as 52 questionnaires, and the questionnaire returned are as many as 45 questionnaires, which means that the response rate is 87%. The overall response rate is 91%.

The response rate of this study is similar to another study which response rate is 90%2 and 87%3, and the response rate for areas with high disaster impact intensity is 75% - 80%4, while the response rate for areas with low impact intensity is 42% - 57%5. In this study, respondents’ perceptions of the risk of Merapi eruption include questions about what respondents think about the risk of Merapi eruption on October 26th, 2010, based on the respondents’ agreement on the likelihood level of the disaster occurrence, the Merapi eruption threat level against respondents’ life and possessions, the level of fear of the respondents, and the knowledge of the respondents related to disaster occurrence [2].

3. Results and Discussion

a. The Profile of the Respondents

The overall total respondents which the data can process is 266 people. A detailed data on the number of respondents can be seen in Table 1.

| Region   | Number of Respondents | Total | Percentage of Respondents |
|----------|-----------------------|-------|---------------------------|
|          | Male  | Female |     | Male  | Female |     |
| DPA III  | 18    | 27     | 45  | 40%   | 60%    |
| DPA II   | 94    | 127    | 221 | 43%   | 57%    |
| Overall  |       |        | 266 |       |        |     |

Most of the respondents are in the age group of 21-60 years old. The educational level of the respondents in DPA II is higher than the respondents in DPA III. The level of education of DPA III respondents is 44% of male and 33% of female respondents of elementary school graduate, 22% male respondents did not complete primary school, and 26% female respondents graduated from junior high school. There are also 39% of male and 32% of female respondents that have completed junior high school, 27% respondents who have graduated from primary school and 32% of female respondents who have graduated from senior high school.
Most of the respondents are farmers and livestock farmers, and there is no significant difference between respondents in DPA III and DPA II. The income of male respondents is higher than the income of female respondents which ranges from Rp.500,000 to 1 million and larger than 1 million, while the income of female respondents ranges from Rp.500,000 - 1 million and less than Rp.500,000.

The number of family members who live in respondents’ house is to at least 1-2 people and a maximum number of 6 people. The respondents have been living in the disaster-prone areas for an average of 39 years for both respondents in DPA III and DPA II. The average male respondent has been living for 31 years and for 28 years for the female respondents in DPA II. 99% of the respondents of this study were residents of Javanese ethnicity.

The limitation of the respondents studied is the presence or the absence of children, the existence of pets, ownership of paddy field/garden, and the type of house being occupied. Respondents who have children will look for their children when they hear the disaster warning. In this study, 72% of male respondents in DPA III, 67% of female respondents in DPA III, 67% of male respondents in DPA II and 74% of female respondents in DPA II have children aged 3-15 years old. The number of children in a family is at least 1 person and a maximum of 3-4 people. When the respondents hear the disaster warnings, they will look for their livestock. In this study, 89% of male respondents, 93% of female respondents in DPA III and 71% of respondents in DPA II own livestock, such as cows and chickens. 72% of male respondents, 67% of female respondents in DPA III and 62% of male respondents and 60% of female respondents in DPA II own paddy field/garden. The status of the fields/gardens is self-owned.

The type of house will affect a person’s reaction to a warning sign. People who are in a single home will react quickly in receiving warning signs compared to the respondents who live in an apartment. In this study, the respondent lives in a single home. Almost 100% of the houses are self-owned [3]. In addition to considering the limitations of the respondents, the ability factor, which is the ability to drive, is also incorporated. Respondents who are able to drive resulted in the respondents that can immediately evacuate and move faster. The percentage of male respondents who are able to drive is higher than its female respondents, with 72% of male respondents in DPA III and 44% of female respondents in DPA II. While for DPA II, there are 87% of male respondents and 68% of female respondents who are able to drive a vehicle. The type of vehicles owned by most respondents is motorcycles, and only a small portion of respondents owns a car. The general tendency of respondents in facing risks can be seen in Table 2.

To see the difference of response between the groups of respondents, a non-parametric statistical method of the Kruskal Wallis test is employed. The categories of the willingness of respondents in taking the risk can be seen in Figure 1.

| Male | Female |
|------|--------|
| General Willingness to Take Risks | Percentage | General Willingness to Take Risks | Percentage |
| **DPA III** | | | |
| Willing to take risks | 44% | Not willing to take risks | 56% |
| Not willing to take risks | 39% | Neutral on risks | 37% |
| Neutral on risks | 17% | Willing to take risks | 7% |
| **DPA II** | | | |
| Not willing to take risks | 48% | Not willing to take risks | 48% |
| Neutral on risks | 28% | Neutral on risks | 35% |
| Willing to take risks | 21% | Willing to take risks | 15% |
| No answer | 3% | No answer | 2% |

Table 2. The general tendency of respondents to take risks
Willing to take risks Neutral on risks Avoid risks

Figure 1. Categories of Respondents’ Willingness in Taking Risks

Hypothesis :
H\(_0\): \(\mu_1 = \mu_2 = \mu_3 = \mu_4\) (sample from the same population)
H\(_1\): \(\mu_i \neq \mu_j\) (sample comes from a different population)

b. Respondents’ Attitude to Risk

Respondent’s attitude to risk in this research is seen from the respondents’ willingness to evacuate. As many as 56% of male respondents and 44% of female respondents in DPA III chose to evacuate depending on the conditions; if the situation is really dangerous, they would start to evacuate. The percentage of respondents in DPA II who chose to evacuate is less than the percentage of respondents in DPA III, as only 21% of male respondents and 17% of female respondents chose to evacuate.

Table 3. Respondents’ Understanding on the Risk of Mount Merapi

|        | Male | Female |
|--------|------|--------|
|        | Definition of Risk | Percentage | Definition of Risk | Percentage |
| DPA III | Consequences       | 67%       | Consequences       | 63%       |
|        | Probability x      | 17%       | No answer          | 22%       |
|        | No answer          | 17%       | Probability x      | 11%       |
|        | Probability        | 0%        | Consequences       | 4%        |
| DPA II  | Consequences       | 62%       | Consequences       | 74%       |
|        | No answer          | 23%       | No answer          | 17%       |
|        | Probability x      | 12%       | Probability x      | 9%        |
|        | Consequences       | 3%        | Consequences       | 1%        |
|        | Probability        |           | Probability        |           |

To see the difference of response between the groups of respondents using non-parametric statistical methods of the Kruskal Wallis Test, the category of respondents’ willingness to evacuate is shown in Figure 2.

Hypothesis :
H\(_0\): \(\mu_1 = \mu_2 = \mu_3 = \mu_4\) (sample from the same population)
H\(_1\): \(\mu_i \neq \mu_j\) (sample comes from a different population)

The statistical test results obtained that the p-value 0.001 < critic value 0.05. Therefore, H\(_0\) is rejected, as there is sufficient evidence to suggest that there are differences between the four groups. The significance test of the differences between groups is followed with the Mann-Whitney test. The result of the test only found that the comparison between male respondents in DPA III with female respondent in DPA II have a sign. 2 tailed value of 0.0003 < critical value 0.05, which means that there is a significant difference between the two groups of respondents.
The reasons why the respondents choose to evacuate are to save themselves and their families, because they are told to evacuate by the officers, and because of the fear of the eruption disaster. The reason why the respondents choose to evacuate depends on whether the condition is dangerous or not and because their cattle must still be taken care of and be fed, and they are waiting for the government’s order for evacuation.

In relation to the willingness to evacuate, the respondents were also asked to determine their risk attitude, whether they are included in risk taker, risk moderate or risk-averse. The results showed that the respondents in DPA III are mostly risk-moderate, while the respondents in DPA II are mostly risk-averse. As many as 56% of male respondents and 52% of female respondents in DPA III tend to take and not take risks, respectively; 17% of male respondents of DPA III tend to take risks and 28% of male respondents and 48% of female respondents avoid risks. As for the respondents in DPA II, 68% of male respondents and 72% of female respondents tend to avoid risks, 24% of male respondents and 21% of female respondents tend to take and not take risks, respectively, and 2% of women choose to take risks.

Questions related to respondents’ willingness to evacuate and the respondents’ tendency to take risks are calculated in terms of the correlation between both questions. The correlation value is calculated by using SPSS and the Spearman method. The test results showed that only male respondents in DPA III had the significance value > 0.01. This shows that there is no correlation between the willingness to evacuate and the tendency to take the risk on male respondents in DPA III. The significance value can be seen in Table 4.

| Region | Male       | Female       |
|--------|------------|--------------|
| DPA III| 0.63502    | 0.000005826 |
| DPA II | 0.00500    | 0.00024      |

c. Respondents’ Perceptions of Risk

The results showed that the respondents’ concern on the risk of Mount Merapi eruption is mostly related to their behaviour and actions at the moment of the eruption, in terms of escape route and displacement, panic, confusion, sadness, and trauma reactions, and the impact caused by eruption. During the eruption of Merapi disaster, the respondents’ main concern was also associated with their behaviour and actions at the time of eruption. Besides, most respondents stated that they did not expect that the impact of the eruption would be that enormous.

d. The Likelihood of Disaster Occurrence

The results showed that 72% of male respondents and 70% of female respondents in DPA III stated that within five years there are frequent disaster occurrences, whereas for respondents in DPA II, 54% of male respondents and 47% of female respondents stated that they agreed that disaster often occurs in the last five years.

e. The Level of Threat of Mount Merapi Eruption to the Respondents

The results showed that 61% and 37% of male and female respondents in DPA III agreed, and 22% and 44% of male and female respondents in DPA III strongly agreed that the eruption of Merapi was very threatening to them. The results were different from those in DPA II, as 47% and 29% of male respondents agreed and disagreed, respectively, and 46% of female respondents agreed and the rest 28% disagreed.

f. The Level of Fear of Respondents to the Merapi Eruption Disaster

The results showed that for respondents in DPA III, as much as 83% of male respondents agreed, 56% of female respondents strongly agreed, and 33% of female respondents agreed that they are afraid of the Merapi eruption disaster. As for the respondents in DPA II, 43% and 23% of male
respondents agreed and strongly agreed, respectively, while 50% of the female respondents agreed and the rest 32% strongly agreed.

g. **The Knowledge Level of Respondents to Disaster Prior to the Eruption**
   The results showed that 83% of male respondents and 70% of female respondents in DPA III already had disaster-related knowledge. The knowledge of respondents in DPA II is lower than the knowledge of the respondents in DPA III, with as many as 50% of male respondents and 44% of female respondents already had disaster-related knowledge.

h. **The Respondents’ Experience in Facing Eruption Prior to Mount Merapi Eruption**
   In relation to the eruption disaster experience before the eruption of Merapi, it was found that 83% of male respondents and 77% of female respondents in DPA III already have a lot of experience related to the eruption of Merapi. As for the area of DPA II, 54% of male respondents and 45% of female respondents have been affected by Mount Merapi eruption.

i. **The Participation of Respondents in Disaster Training or Simulation before the Mount Merapi Eruption and Their Understanding of the Evacuation Route**
   The results showed that only 56% of male respondents in DPA III, 52% of female respondents in DPA III, 47% of male respondents in DPA II and 32% of female respondents in DPA II had attended training or simulation before the 2010 eruption. All male respondents and 85% of female respondents in DPA III understand the evacuation route. On the contrary, for the respondents in DPA II, only 64% of male respondents and 52% of female respondents are aware of the evacuation route.

   In this study, most respondents (50%) started to evacuate after getting an order from the officers to evacuate immediately. As many as 11% - 15% of new respondents started to evacuate after they were exposed to volcanic ash. The actions of the respondents initiating evacuation after they were exposed to volcanic ash could lead to the death toll.

   The type of warning that was first received by the respondent was a warning from the head of hamlet/ the village officers, and the sound of siren and warning from HT radio. After hearing the warning sign, 55% of male respondents and 70% of female respondents in DPA III immediately evacuated, 65% of male respondents and 76% of female respondents in DPA II immediately decided to evacuate. The rest of the respondents waited for the others to flee or waited to be picked up by the officers and there are still 1% - 4% of respondents who think that they will not be affected by the eruption, and they are waiting for the situation to be really critical before evacuating.

j. **The Action of the Respondents after Hearing the Warning Sign**
   The action of the respondent after hearing the warning sign was to gather their family to immediately evacuate. As many as 83% of male respondents in DPA III evacuated through existing evacuation routes, and 6% of the respondents evacuated through shortcuts. For the female respondents in DPA III, as many as 33% followed the existing evacuation routes, and 26% were waiting for the evacuation officers. 50% of male and female respondents in DPA II followed the existing evacuation routes. As many as 67% of male respondents and 52% of female respondents in DPA III, and 51% of male respondents and 48% of female respondents in DPA II followed the evacuation routes due to the instructions of the officers to follow the route that has an evacuation signpost. The rest of the respondents joined the group because they were following their family.

   At the time of evacuation, all male respondents in DPA III, 78% of female respondents in DPA III, 76% of male respondents in DPA II and 70% of female respondents in DPA II have been able to see the evacuation signpost clearly. This indicates that the evacuation sign has been effective. The final evacuation destination of the respondents is mostly to the evacuation barracks. In relation to the willingness of the respondents in helping others, it was found that male respondents have a higher percentage of helping other people compared to their female counterpart.

4. **Conclusions**
This research was conducted to investigate the perception and the understanding of the people in the disaster-prone areas of Mount Merapi on the general risks, the risks in facing the eruption of Merapi, the risk attitude, and the behaviour of the population during the Mount Merapi eruption disaster. The results showed that the respondents still perceive the risks as the consequences of the eruption of Merapi, and these results are different from the normative theory and the utility theory. The respondents in DPA III have the tendency of risk attitude of risk moderate, while respondents in DPA II have a risk-averse tendency. In relation to respondents’ behaviour during the eruption, it was found that different DPA and gender resulted in different responses from the respondents in facing the Mount Merapi eruption disaster, in terms of the evacuation time, the actions when hearing a warning sign, the evacuation route being followed, and the willingness to help others.

The contribution of this study can be useful to agencies and disaster organizations to recognize the humanitarian relief concept, evacuation stages and the public response to the risk of the eruption of Merapi so that an appropriate intervention to reduce the impact of Merapi eruption can be formulated. In addition, the results of this study can be used as an evaluation material by the community, government and relate stakeholders.

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