Evaluation of lahar flood hazard management policy using participatory planning in Putih watershed, Magelang regency, central java, Indonesia

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Abstract. The occurrence of Lahar floods after Merapi Volcano eruption in 2010 still continue to be a concern for the government and the community. Kali Putih is one of the rivers that originates in Merapi Volcano and is one of the Lahar flood hazard area. Non-structural mitigation efforts have been carried out by the government. Until now, there are still community activities in the forbidden hazard area. Regulations regarding to spatial planning regulation in the hazard area need to be evaluated. The aim of the study is to evaluate the Lahar flood hazard mitigation based on participatory mapping and Focus Group Discussions (FGD). The research area is Jumoyo Village, which is the highest Lahar hazard flood area. The results indicate that there are still residential areas and community activities in the Lahar flood hazard area. The community does not want to lose their livelihood or relocation of their homes. The community expect that the government is able to revive the economic activities of the community through the establishment of new economic centres without relocation of their homes. The community also expect that the government able to creating new employment.

1. Introduction
Merapi Volcano is one of the most active volcanoes in the world with more than 70 eruptions since 1548 [1] that had varied eruption periods from two to eight years [2]. The eruption in 1994 and 2006 caused 6,000 and 20,080 residents respectively to evacuate to safe areas or shelters [3, 4]. The last period of Merapi eruption was occurred from 26 October until 5 November 2010. It was the biggest eruption in the last 10 years evidenced by 130 million m³ of tephra volume, and nine kilometres of cloud column height [5]. Until 2010, there were more than 1.3 million people living on the hazard area of Merapi volcano within 20 km radius from the summit [6]. Moreover, the last eruption occurred in 2010, left approximately 400,000 people evacuated from the disaster area [6, 7]. The pyroclastic flow that occurred during the Merapi eruption in 2010 also resulted in more than 2,200 houses being damaged [8].

One of the rivers located on a type I hazard area of the Merapi Volcano and originated at the peak of Merapi Volcano is Kali Putih river. Kali Putih river has high potential of Lahar flood. Lahar flood is triggered by the large amount of material in the Upper White River and potential for rain in the rainy months (November - April). Lahar flood has destructive power which also impacted the river flow morphology. Lahar flood events in Kali Putih were recorded 30 times and resulted in 678 houses damaged. With 215 were totally damaged and 463 partially damaged [9].
Lahar flood mitigation efforts can be carried out through structural and non-structural mitigation efforts. The structural mitigation effort which carried out by the Ministry of Public Works and Housing was by rehabilitation and reconstruction of sediment control buildings (sabo dam) as well as rejuvenating the streamline of Kali Putih river. Rejuvenation and straightening of Kali Putih putih has been carried out with a width of 70 meters and a height of embankment of 5 meters. In addition, sabo dam, 23 groundsile and river dikes were built for 2 kilometers on the right and left sides of the river. The function of this sabodam is to 'brake' the flow of Lahar, stabilize river flow and maintain river morphology. The groundsile also prevent erosion and strengthen the sabo dam building. In addition to Kali Putih river, there have also been built a number of Lahar ducts to prevent flooding or overslag [10]. The design of Kali Putih river straightening can be seen in Figure 1.

![Figure 1. Design of Kali Putih River Straightening.](image)

Meanwhile the non-structural mitigation efforts can be done by giving a role to the community, which can be in the form of participatory planning to implement sustainable development planning of hazard prone areas. Community participation can be recognized as an additional element in disaster management. Community participation will build culture, safety and ensure the implementation of sustainable development for all [11].

The reality in the field is that many residential buildings are located in the flood hazard area in Kali Putih, not all after there is an river alignment/ straightening, there are still settlements and activities of the surrounding residents The research objectives are to evaluate the Lahar flood hazard area and planning for mitigation [11].

2. Methods
The research methodology is using qualitative research method. Qualitative research is carried out by examining participant’s perspectives (respondents or informants) with strategies that are interactive and flexible. Research with qualitative methods is shown to understand environmental phenomena according to the research objectives. Events that occur in a social situation are the main studies in qualitative research [12]. This qualitative research is concerned with evaluating the determination of Lahar flood hazard areas in Kali Putih, especially after river straightening using participatory mapping and Focus Group Discussions (FGD).
2.1 Research Location
This research conducted in Jumoyo Village, which divided into 13 Hamlets along the Kali Putih (Putih Watershed) straightening line. The Kali Putih watershed has experienced 62 lahars, which represent 22% of all lahars triggered on 17 rivers at Merapi between 2010 and 2012 [13]. Jumoyo village is a village that is located in a high Lahar flood hazard area. Figure 2 shows the research area map.

![Figure 2. Research Area Map](image)

2.2 Data Collection Technic
Focus Group Discussion (FGD) is an activity of collecting data with the community and local village officials. The Jumoyo Village as the research areas located at a high level of Lahar flood hazard and are located around the river basin of kali Putih River. By using FGD and participatory mapping techniques, information can be obtained about the condition of the community at the Lahar flood hazard zone and information on evaluating community-based hazard area planning and mitigation.

2.3 Data Analysis
Analysis of disaster risk mitigation and evaluation in spatial planning, including determining disaster-prone, prohibiting or limiting development and activities in disaster-prone areas through zoning regulations and mitigation planning. The result from participatory mapping then analysed by integrating existing conditions in the field, regulation and community opinion.
Results and Discussion

3.1. Community Perception on Disaster Hazard Area in Jumoyo Village

Jumoyo village was the most affected by Lahar flood after the eruption of Merapi volcano in 2010. Total of 33% of its area are affected by Lahar flood. Overall, the total area affected is 178.5 hectares. Based on the results of measurements of existing Lahar flood that have occurred in Kali Putih river, Lahar flows begin to overflow in Jumoyo Village [7]. Figure 3 shows the Lahar flood hazard area of Jumoyo Village.

Lahar flood events in Kali Putih in 2010 - 2011, made Jumoyo Village a prone area for Lahar floods. However, until now there are still many people living and doing activities in the hazard prone area. According to Mr. Sungkono, the village leader of Jumoyo, stated that there are 50% of the people of Jumoyo village who still live in the hazard area and 50% of the residents live in permanent housing.

Based on data from the Jumoyo Village authority and results from Focus Group Discussions (FGD), there are total 13 Hamlets under the village of Jumoyo which can be analysed based on their hazard condition and the areas that should be used for residential area. There are Hamlets of Jumoyo Kidul, Pulosari and Remame which are safe to use for residential areas. This is because the area has a far enough (± 700 m - 1 km) from the banks of Kali Putih River, approximately 700 m until 1 km. Hamlets of Dowakan, Kemiren, Babadan, Jumoyo Lor, Tegalsari, Kemburan, Wironayan and Babadan are also areas that can be used as residential areas. Especially in the Remame Hamlet. The most prone area to Lahar flood are Gempol Hamlet. The Gempol area is the most severe area affected by Lahar flood in 2011. But to residents of Gempol Hamlet are decided to stay at their hamlet because it is the land of their ancestors and neglected the condition of their hamlet that is prone to Lahar flood. Figure 4 shows the safe residential area in Jumoyo Village.
Overall, residents of Jumoyo Village chose areas along the main road (Magelang – Yogyakarta highway) as a center of economic activity. But residents of Remame Hamlet have the opinion to move the center of economic activity. Because if there is a flood in a long period of time, it does not paralyze the economic activities of the community. Several location points were chosen by residents as the center of economic activity, and almost all residents’ representatives chose locations on the side of local roads and provincial roads. Nevertheless, representatives of the Seloiring Hamlet residents chose sand mining locations for the center of economic activity. This is because some people in Jumoyo Village earn their living as miners of sand and stone around Kali Putih River. Figure 5 shows the center of economics plan for Jumoyo Village.

According to representatives of Pulosari Hamlet residents, evacuation routes are hamlet roads and highways leading to the gathering point at the NU MWC Building in Pulosari. In addition, most residents chose the location of the Evacuation Gathering in the Jumoyo Village Field. Because of its wide location and easy road access. Remame and Pulosari Hamlets are safe areas as evacuation gathering points. Besides Tegalsari Hamlet is also an evacuation route, because there are hills of the Chinese Cemetery that can be used as evacuation gathering points. Figure 6 shows the evacuation plan for Jumoyo Village.
3.2 Community Perception on Lahar Flood Disaster Management and Spatial Planning

The community is one of the elements involved in managing disasters. The role of the community can be used as input in managing disaster areas. Related to community activities in Lahar flood hazard areas. There are pro and contra results with the activities of community in the Kali Putih’s Lahar flood hazard area. Representatives from Jumoyo, Remame, Karanggawang, Pendem and Seloiring Hamlets argue that citizens must be given understanding, solutions and other alternative locations that can be used as settlements and economic activities. If there are still people who still insist on staying there, they must be forced to move. According to the results of discussions between Kemiren and Babadan residents, they are supporting the activities of citizens in the Lahar flood hazard areas. As long as it does not damage the environment and the sabo dam building. Residents of Gempol, Pulosari and Dowakan Hamlets still want to remain active and live in their area. Because it is a birthplace, a place to live from generation to generation.

The results of the FGD from community representatives provided advice and input for the government to pay more attention to the Hamlets located on the banks of Kali Putih River, especially in the economic and employment opportunity. The government must be more careful in mapping the Lahar flood hazard area. In addition, according to representatives of the residents of the village of Pendem, the government must curb the sand miners and stones, to not to damage the environment. Based on the experience of Jumoyo villagers in dealing with Lahar flooding in 2010 - 2011, residents proposed disaster education tours to further increase the knowledge on disaster mitigation and to live in harmony with natural disasters. Representatives of the Babadan Hamlet proposed a Village Regulation regarding flood observation posts in several locations along Kali Putih River, to monitor river conditions during the rainy season. In addition, an early warning system is needed using siren media, so it can be heard widely by the community as an early warning sign of Lahar floods.
4. Conclusion

Result from Focus Group Discussions (FGD) and participatory mapping conclude that areas for residential of Jumoyo Village include the Hamlets of Jumoyo Kidul, Remame, and Pulosari. Especially in the Remame area. The center of economic activity, residents of Jumoyo Village chose areas along the main road (Magelang – Jogja Highway) as a center of economic activity. There are three points of evacuation gathering points, namely the MWC NU Building in Pulosari, the Evacuation Gathering Point at Jumoyo Village Field and Chinese Grave Mountain.

The results of the policy analysis of the determination of *La* *ha*r flood hazard areas in community-based spatial planning indicates that there are pro and contra results with the activities of community members in the Kali Putih *La* *ha*r flood hazard area. Some residents argue that the community must be given understanding, solutions and other alternative locations that can be used as settlements and economic activities. Whereas the residents of Gempol, Pulosari and Dowakan Hamlets still want to continue their activities and live in their area. Because it is a land of birth, a place to live from generation to generation.

The community needs to be provided with knowledge so that they do not lose their livelihoods. Residents provide advice and input for the government to pay more attention to the Hamlets located on the banks of Kali Putih River, especially in the economy and new jobs opportunity. Residents also proposed to make flood observation posts in several locations along Kali Putih River. An early warning system is needed using media sirens, as a sign of early warning of *La* *ha*r floods.
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