

DEBRIS FLOW DISASTER MITIGATION THROUGH COMMUNITY-BASED INTEGRATED SEDIMENT MANAGEMENT (BEST PRACTICE IN MT. MERAPI AREA, INDONESIA)

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ABSTRACT

Mt. Merapi is one of many active volcanoes in Indonesia which erupts frequently. The small eruption occurred nearly every year, whereas the big ones occurred at approximately once every five years. The eruption often produces impacts at both positive and negative view points, such as production of sediment as construction material and damage on infrastructures due to debris flow occurrences respectively. The eruption produces two types of disasters, i.e. primary disaster (such as ash fall, pyroclastic flow, and lava flow), and secondary disaster such as debris flow. This paper presents the long term effort on the development of community participation in the sand mining management as one of strategic disaster mitigation activities. The raising awareness of the community on the necessity of conducting proper sand mining management and its effect on reducing the risk due to debris flow disaster has shown the effectiveness of the approach being introduced. The local government acceptance on the presence of the community participation in the whole system of sediment management may involve further collaboration between the local government authority and community society in the future.

Keywords: sediment management, community-based, debris flow disaster, mitigation.

1 INTRODUCTION

The history of the Mt. Merapi eruption has shown that the impact of the primary disaster due to the eruption may cause relatively higher casualties rather than the secondary disaster. However, the threat of the secondary disaster would be longer and often contributes a huge damage and losses, which often caused severe suffers to the people at surrounding Mt. Merapi area. Eruption frequency in the last twenty years is more than once in five years, resulting 8 times eruption since 1990. Mt. Merapi eruption is generally characterized with 1) pyroclastic flows due to collapse of lava dome or lava tip leaving the volcanic loose deposit on the slope of Mt. Merapi, 2) volcanic ash fall and 3) debris flows in the following rainy seasons after eruption. On the other hand, dense populated cities/towns such as Yogyakarta City (center for education, tradition and culture) extend in the south foot of Mt. Merapi and there are 2.7 million inhabitants around Mt. Merapi.

The scale of the last eruption in October and November 2010 with the spewed pyroclastic material of 130 million m³ exceeds the 1872 eruption (the largest eruption on record), causing 386 fatalities, and

400,000 evacuees and loses of 3,300 houses/buildings. During the rainy season from December 2010 to March 2011, a large amount of erupted sediment flew to downstream as debris flows causing the significant damages on river infrastructures and assets. The above illustration performs the evidence of how the severe the impact of the debris flow occurrence. However, it is obvious that the eruption also produces the huge number of sediment that may contribute economic value where community could take advantages. Since Mt. Merapi is located in densely populated area and important region for economy and administration, it is well equipped with disaster management facilities such as monitoring, forecasting & warning system, evacuation system, emergency relief, structural measures (sabo dams), and research institutions to analyze the nature of hazard, develop & disseminate disaster management, NGOs participation and so on. The Urgent Disaster Reduction Project for Mt. Merapi, Progo River Basin funded by Japan International Cooperation Agency (JICA) has been implemented by the Directorate General of Water Resources (DWGR), Ministry of Public Works, since

July 2006. As a part of the project, the study on institution and community development for disaster management (DGWR, 2010a) was conducted from 2007 to 2010. The study is mainly composed of the following items;

- Social aspect study related to sand mining management and disaster management
- Pilot project to develop the community based organization for sand mining management and disaster management
- Events for improving the community understanding on natural hazards and their countermeasures
- Evacuation drill to improve dealing capacity of community against natural hazards

Among of the above items, the followings discuss only the establishment of pilot project as a part of conducting the community-based integrated sand mining management. The sand mining contributes to the regional economy, while the uncontrolled sand mining has damages on the rural infrastructure, environment and society. Besides, the sand mining can have either positive or negative effect on the disaster management.

2 SAND MINING AND SOCIAL IMPACTS

2.1 Sand Mining Activities in Mt. Merapi Area

Since the sand and gravel provided by the pyroclastic flow have good quality as construction material, the sand mining in river courses is conducted extensively in Mt. Merapi. Annual sand mining volume from 2002 to 2006 was approximately 3 million m³, however, fluctuated in time and space depending upon Mt. Merapi eruption. Market prices of sand in 2007 are IDR 60,000 – 70,000/m³ in Yogyakarta, IDR 80,000 – 90,000/m³ in Solo and IDR 90,000 – 14,000/m³ in Semarang. As a result, the sand mining contributes to the regional economy (DGWR, 2009).

There are two types of sand mining, one in river course (in-stream) and another on land (off-stream). Issues related to the sand mining are summarized below.

- In-stream: riverbed degradation, damages on river structures (dyke, sabo dam, weir etc.) and decrease in groundwater level
- Off-stream: reduction of land productivity, damage on forest and vegetation cover, damage on tourism resources and decrease in groundwater level

- Transportation: damage on road and bridge, environmental degradation and damage on tourism resources

2.2 Impact of Sand Mining on the River Environment

The sand mining in river course is directly related to the disaster management. For example, excess volume of sand mining induces the severe river bed degradation resulting in collapse of sabo dams and dykes. Besides, a dyke itself is often a target of sand mining. As long as the sand mining is controlled in terms of volume and location, it can contribute to remove sand and gravel in dam reservoir so that a sabo dam will be ready to regulate the further debris flows (see photo in Figure 1 and sketch in Figure 2). Actually during the last rainy season, the sand mining contributed to dredging pyroclastic material (sand and gravel) in river courses at certain level, resulting contribution to mitigation of debris flow disasters.



Figure 1. Photo of sand mining activity at Boyong River

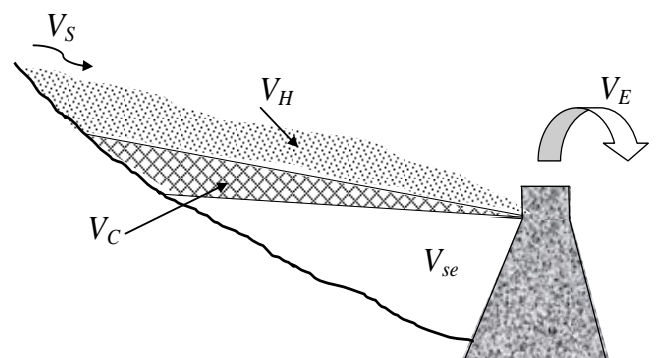


Figure 2. Sketch of sediment control due to sabo structure

As seen in Figure 2, the analysis of sediment balance is usually carried out applying Equation (1), based on Shimoda, 1995 in Sudiarti (2001).

$$V_E = V_S - (V_H + V_C + V_{se}) \quad (1)$$

where:

- V_E : sediment overflowing the structure (m^3)
- V_S : sediment entering upstream of structure (m^3)
- V_H : sediment trapped at upstream of structure (m^3)
- V_C : sediment controlled at upstream of structure (m^3)
- V_{se} : dead storage of structure (m^3)

Depending upon the dynamic storage capacity of a structure which is a function of the dead storage volume (V_{se}), the sediment control volume (V_C), the sediment volume trapped or accumulated at the upstream of structure (V_H), the sediment supply from upstream (V_S), and the intensity of the sand mining activity, the sediment overflowing the structure (V_E)

could be positive or zero. The very intensive sand mining activity is in such that the volume is much larger than the sediment supply. In such a case, the sediment overflow could be relatively small or even zero.

3 PILOT PROJECT ON SEDIMENT MANAGEMENT

Through continuous and long process of communication with the local people in the three piloted villages i.e. village of Kemiren, Kepuharjo, and Sindumartani (see Figure 3), and only one village (Kemiren Village) was considered of having promising future sustainability, particularly in term of pursuing the integrated sediment management. The name of organization established in Kemiren Village through a pilot project under Study on the Institution and Community Development at Mt. Merapi Area Project (2007 – 2009) is Bumi Lestari, which means “Eternal Earth” in Java language.

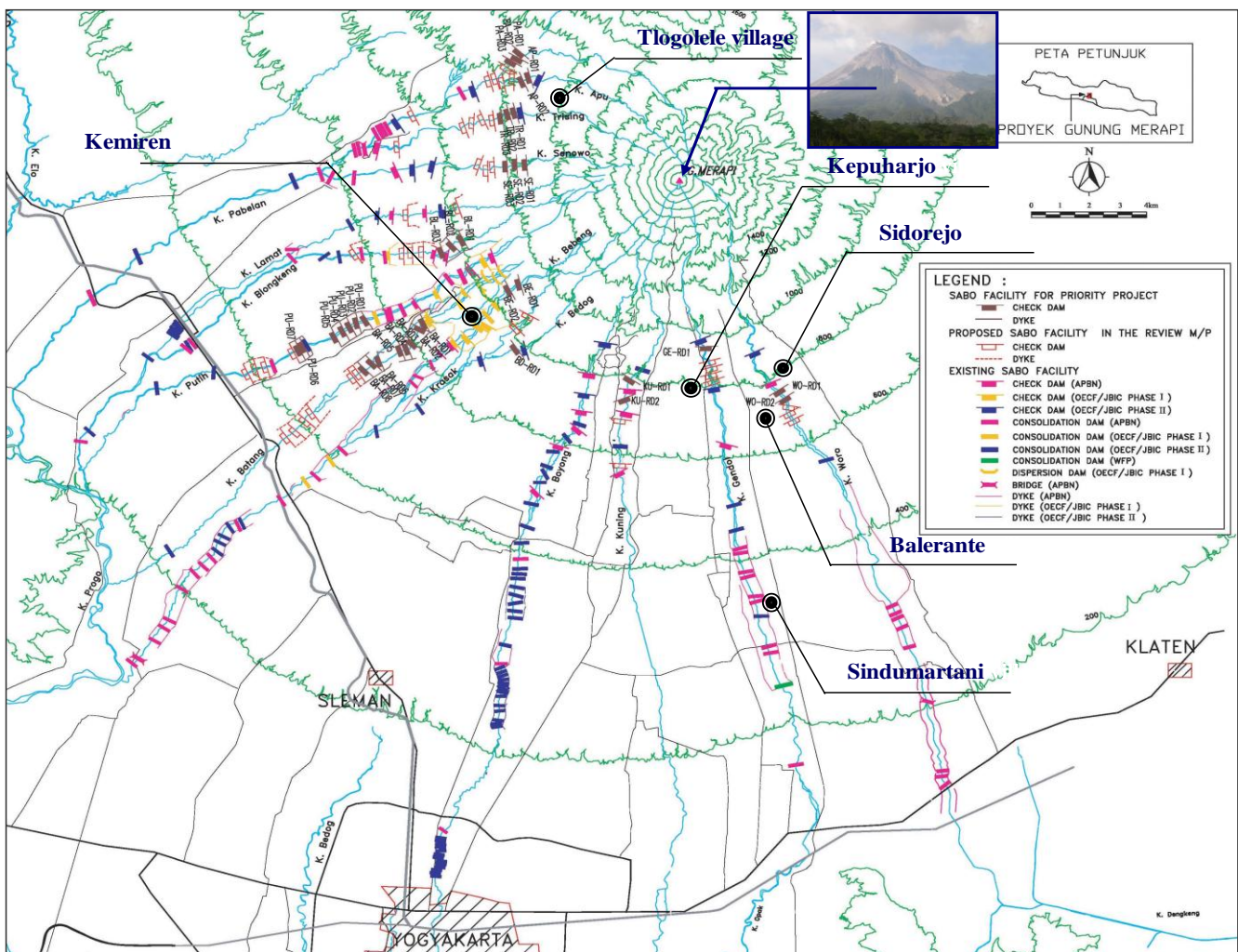


Figure 3. Situation map shows several villages as candidates of pilot project

The type of organization is a community organization and the member works voluntarily. Declared on May 17, 2008, Bumi Lestari organization structure has main board, including the head, the secretary, and the treasurer, and four divisions, namely Disaster Management and Environmental Conservation Division; Mining Division; Agriculture Division; and Tourism Division (see Figure 4). The task of Bumi Lestari is managing village resources and potentials fairly and wisely and in a sustainable way to improve the prosperity of people in Kemiren Village. There are many activities has been conducted since the establishment including those which is related to the sand mining management in Kemiren Village. Among

those is collected necessary information regarding the sand mining activity in Kemiren Village through surveys under Mining Division coordination. Results of the survey are supposed to be important information for the local government. Several surveys has been conducted during September to November 2009, namely truck survey and sand miners survey.

The truck survey was conducted on October 2009 for seven days from 07.30 am until 07.00 pm. In total 3,692 sand trucks from the quarry that passed survey post has been surveyed. The information about sand volume, the source of material, the destination of material and the purpose of the material has been collected during that survey (Figure 5).

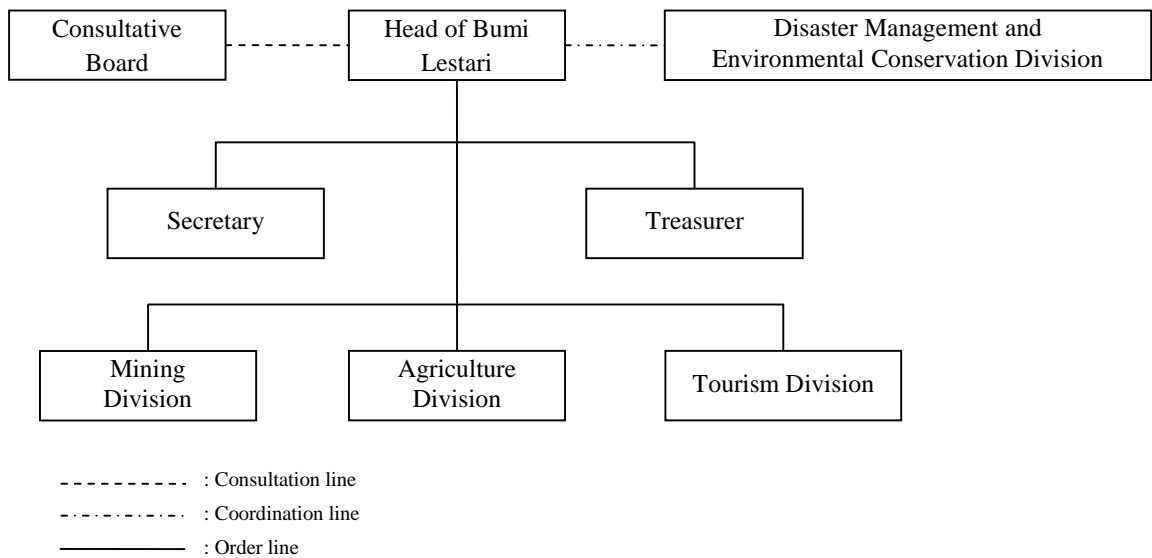


Figure 4. Organization structure of LPSPD Bumi Lestari



Figure 5. Self-community truck survey

4 RESULT AND DISCUSSION

4.1 Evaluation on the Pilot Project Implementation

There are 6 (six) items were utilized as measures of the evaluation on the pilot project implementation, these consisted as follows;

- a) Recognition of the presence of community institution,
- b) Legal status of Bumi Lestari,
- c) Community participation on the community institution,
- d) Benefit of Bumi Lesatri to community,
- e) Necessity of establishment of the action plan, and
- f) Benefit of Hand Book for proper sand mining management.

Post activities of Pilot Project those have been carried out by Bumi Lestari seem to continue; even the resources (i.e. the availability of budget, equipment's, software's, and human resources) are limited. It was found from the evaluation of the questionnaire that majority of the community knows exactly about the presence of the Bumi Lestari organization. Recognition of such community institution is acknowledged by either village government officials, common community, and local leaders (see Figure 6.a). The status of Bumi Lestari as it is currently held is considered sufficient for further development of Bumi Lestari (see Figure 6.b).

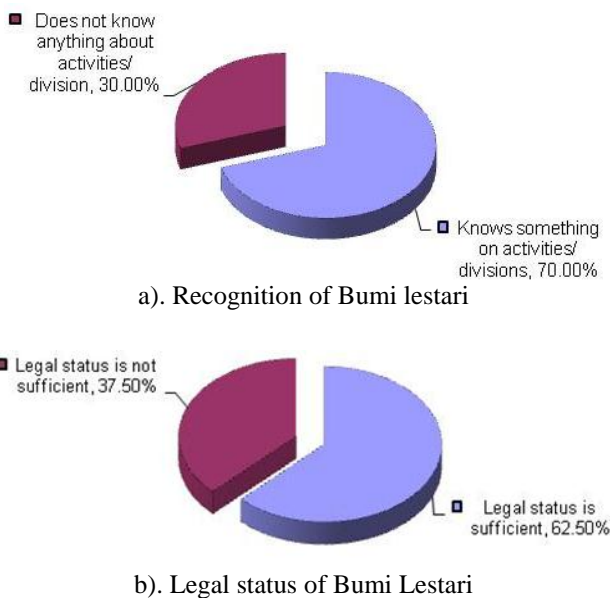


Figure 6. Bumi Lestari recognition and legal status

The community participation in Bumi Lestari is relatively clear and a promising process that all parties, not only the village officials, but also villagers and local leaders feel that the presence of the organization is expected to contribute better community welfare (see Figure 7.a and Figure 7.b).

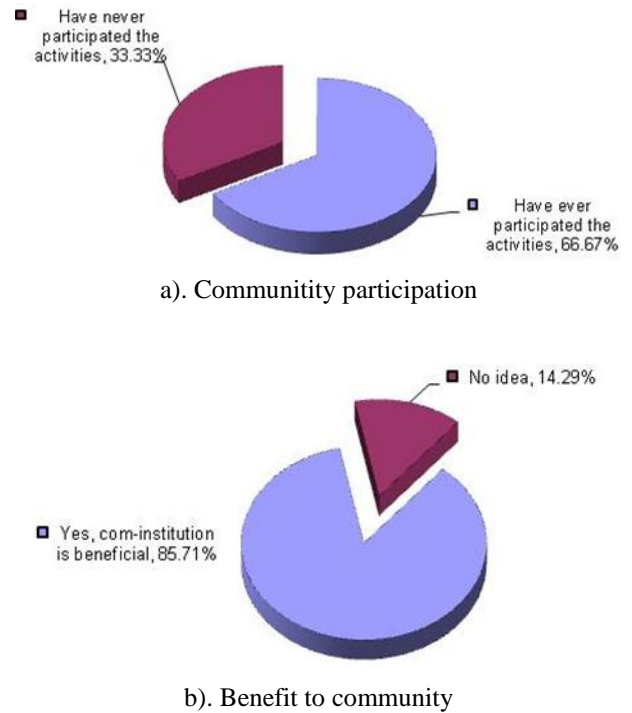


Figure 7. Community participation and benefit of Bumi Lestari

The necessity to conduct action plan in Bumi Lestari seems to be highly appreciated by the community since this may help much in guiding the activity of the organization. The presence of the hand book is also considered contribute beneficial for conducting the proper sand mining management in Kemiren Village (see Figure 7.a and Figure 7.b).

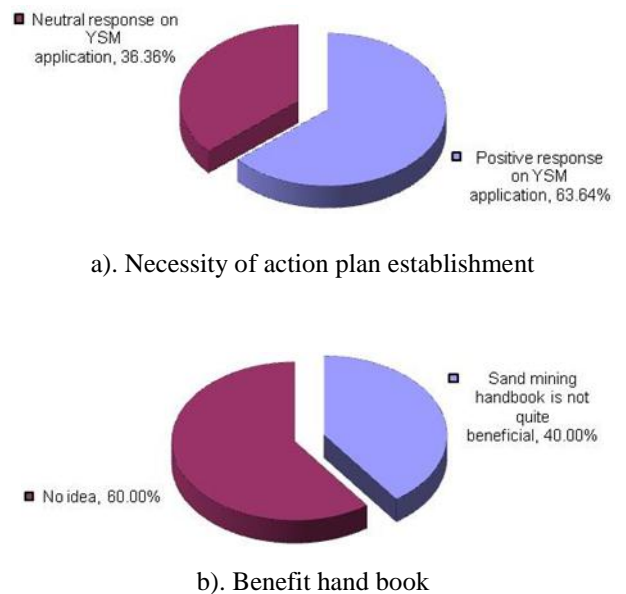


Figure 8. Necessity of action plan and benefit of hand book on sand mining management

5 CONCLUSION

The followings describe several conclusions and recommendations regarding the sand mining activities, i.e.;

- a) High awareness and aspiration of the local community of the three villages to participate on the environment prevention as well as maintaining of sand mining activity is very high. In addition, active participation and high intensity involving of the community during the process of community institutions establishment is a key of success of the community institution development.
- b) Type of the community institutions established is different from one and another which depending on the potential resources and needs of each village community. The institution activity should be supported by local community as well as local government. The principle differences and vision concerning the activities between the local community as well as Village Government and the Board of Institution causing the existence of the institution is not powerful.
- c) Community institution plays the important role in facilitating the local community to gain better quality of life and welfare by maintaining sand mining activity properly and developing the local potency as well as maintaining the sustainability of the environment.
- d) In the long run the networking among local institution at surrounding Mt. Merapi promising to be powerful organization as an agent of environment management.
- e) Most of the Bumi Lestari members and the Kemiren Village Government officials recognize the presence of the Bumi Lestari very well. However, they majority do not know about what the divisions should do and what kind of authorities they have. The contrary conditions were

found in Argo Rahayu where the recognition of the presence of the Argo Rahayu is very low in Kepuharjo.

- f) The presence of the hand book of sand mining contributed significant beneficial in Argo Rahayu, but not so in Bumi Lestari. Such information on the sanctions those have been applied to those who carry out improper sand mining should have been informed in the hand book.

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