Damages and Problems to Land Use Plans Caused by the Merapi Eruption in 2010 Case Study in Sleman Regency, Yogyakarta, Indonesia

University of Miyazaki, Graduate School of Civil and Environmental Engineering, Student Member, Abdur RAHMAN
University of Miyazaki, Member, Chikashi DEGUCHI

1. Introduction

Mount Merapi is located in the middle of Java Island and has been the most active volcano over last 100 years[1]. It has 3-7 year eruption cycles and erupted on November 2010. Turi, Pakem, and Cangkringan Sub-districts of Sleman Regency are located in the disaster prone area of Mount Merapi. Merapi eruptions caused 277 deaths, 71,579 refugees, and 2,828 livestock (cows) died. The eruptions during the last 100 years have been one of the largest. This paper aims to discuss the damages and problems of land-use planning from the viewpoint of disaster risk reduction at Sleman Regency.

Figure 1 Location of Mount Merapi, Jawa Island, Indonesia

2. Damage Caused by the Merapi Eruption 2010

Gadjah Mada University issued the distribution map of the pyroclastic flow of the Merapi eruption on November 15th 2010[2]. **Figure 2** shows a flowchart of the damaged areas from a GIS analysis using an overlay technique between a pyroclastic flow distribution map and an existing land use map of Sleman Regency. The results of the GIS analysis are presented in **Table 1**. It shows the land-use affected by the eruption. It can be seen that the forest area is the most widely affected 2,007 (ha); 37.4 %, while the amount of settlement area affected is 281 (ha); 5.2%, and the total area affected is 5,363 (ha). The government of Sleman Regency announced that the number of damaged houses was 2,641 units, based on the field survey, as shown in **Table 2**. It shows that the village with the most severe damage is Kepuharjo Village in the Cangkringan Sub-district, where there were 828 damaged houses; this area was closest to the Merapi crater (5 km) as shown in **Figure 3**. The farthest village from the Merapi crater still affected by Merapi eruption is Sindumartani Village at Ngemplak Sub-district, with a distance of 15 (km), as shown in **Figure 3**.

To accommodate victims, Sleman Regency planned to construct temporary shelters close to the original location of the victims, after which Sleman Regency would like to relocate the settlement at the distance from Merapi crater of 5–7 (km), to safer places. There are two alternative locations for resettlement: 1) Transmigration to other islands and 2) Relocation to other places (owned by the King of Yogyakarta "Sultan Ground" or owned by the village "Tanah Kas Desa").

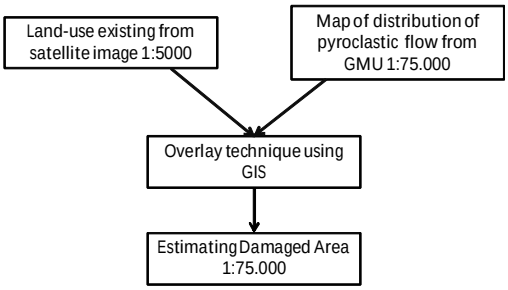

Figure 2 Outlines of GIS

Table 1 Land-use directly affected by the eruption 2010

No	Land-use	Total Area (ha)	%
1	Forest Area	2,007	37.4
2	Agriculture	1,967	36.7
3	Critical Land	417	7.8
4	Field	60	1.1
5	Settlement	281	5.2
6	Plantation	456	8.5
7	Rice Field	96	1.8
8	Bush	20	0.4
9	Moor	59	1.1
	Total	5,363	100

Table 2 Villages affected by Merapi eruption[3]

No	Sub-districts	Villages	House damaged
1.	Cangkringan	Glagaharjo	802
		Argomulyo	261
		Kepuharjo	828
		Wukirsari	381
		Umbulharjo	283
2.	Ngemplak	Sindumartani	25
3.	Pakem	Hargobinangun	55
4.	Turi	Bangunkerto	1
		Girikerto	2
		Wonokerto	2
		Donokerto	1

3. Problems in Land-use Plans and Disaster Risk Reduction at Sleman Regency

Spatial planning in Indonesia is classified into national, provincial, local (regency and municipality), and sub-districts. Spatial planning at the local level can be divided into two categories:

1) General Municipal Spatial Plan (RTRW): The plan addresses the pattern and structure of spatial usage on residential, transportation, and utility properties. Sleman Regency has made a general land-use plan map 2009 on the scale 1: 75,000.
2) Land-use plan (RDTRK) called sub-district or municipal technical spatial plan: The plan contains information on zoning, density, ratios of buildings and open space. Sleman Regency has made eight RDTRKs for eight sub-districts from 17 sub-districts. RDTRK is usually represented on maps on a scale of 1:5,000.

Land use is part of the spatial planning at Sleman Regency and should be changed, as a result of the impact of the Merapi eruption of 2010, especially at Cangkringan, Pakem, Turi and Ngemplak Sub-district, as the most affected areas (**Table 2**). Consequently, the RTRW and RDTRK should be revised. According to four possible roles of spatial planning for disaster risk reduction proposed by Fleischhauer[4], the following aspects should be considered in land-use planning:

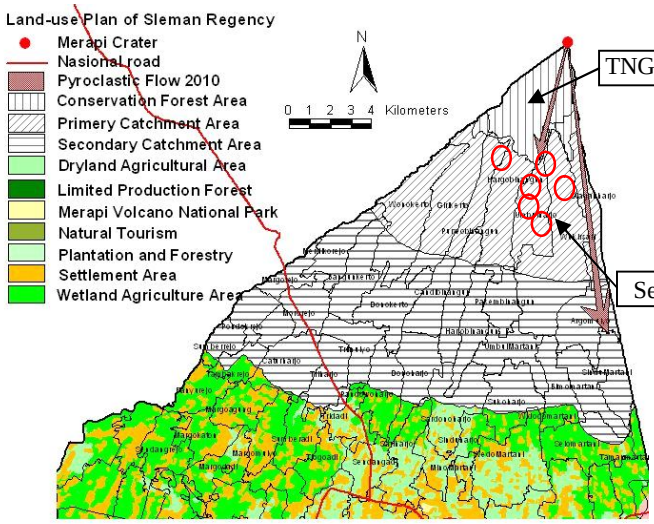

Figure 3 Land-use of Sleman Regency

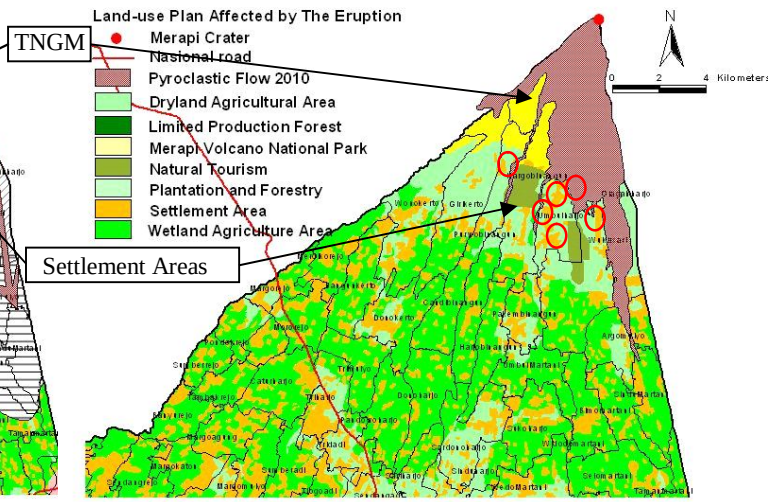

Figure 4 Affected area of Merapi Eruption 2010

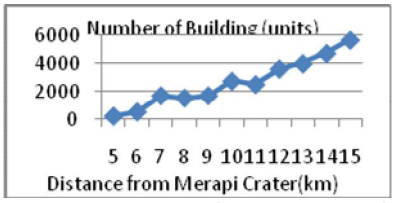

Figure 5 Distance of total number of building from Merapi crater in Sleman Regency.

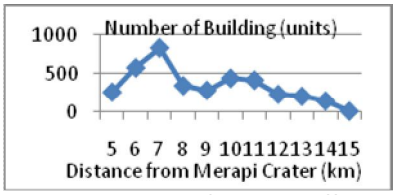

Figure 6 Number of building affected by pyroclastic flow based on distance from Merapi crater in Sleman Regency.

1. *Prohibiting future development in certain areas.* The RTRW of Sleman Regency has guides on types of land use. From the RTRW, the southern area of Mount Merapi, which is included on Sleman Regency administration designated as conservation and buffer areas, is shown in **Figure 3**. Conservation areas are steep slopes around the Merapi crater and prohibited for human activities, as well as conservation forest areas, which are part of the "Merapi Volcano National Park (TNGM)". In eruption 2010, this area was the most widely damaged, as shown in **Figure 4**. In addition, this conservation forest area is also determined as buffer zone areas which serve as water catchment areas. Consequently, Sleman Regency has to control the development of the settlement areas of this region.
2. *Classify different land-use settings for disaster prone areas.* Based on land use in the RTRW of Sleman Regency, the areas of the Merapi slope are given priority for conservation forest areas, agriculture areas, tourism areas and limited sand mining areas. These areas are not designated as residential development areas; nevertheless, rural settlements have long existed in this region. **Figure 5** illustrates the relationship between the distance from the Merapi crater and the number of buildings in each 1 km-area. It shows that thousands of buildings are located in disaster prone areas. Pyroclastic flow from eruption 2010 spreads to 15 (km) from the Merapi crater. **Figure 6** shows the relationship between the distance from the Merapi crater and the number of buildings in each 1 km-area of the pyroclastic flow area. It can be seen that within the 7 km area is where there is the most damage. As a result, the RTRW of Sleman Regency has classified land-use setting on disaster prone areas to reduce the causalities of a Merapi eruption.
3. *Regulating land-use or zoning plans with legally binding status.* Sleman Regency does not have a spatial planning regulation; it is still in draft to discuss with the local parliament (DPRD). As such, only effort to control land-use change exists with local regulation No.19/2001 about land-use control.
4. *Hazard modification.* Hazard modification can be customized by building early warning system (EWS) and Sabo Dam. In Sleman Regency, there are EWS in the peak of Mount Merapi and a lot of the Sabo Dam distribute in the river stream around Mount Merapi.

4. Summary

(1)The Merapi eruption of 2010 affected a forested area that included the "Merapi Volcano National Park" that functioned as a conservation area. In addition, based on the RTRW map of 2009, there are many settlement areas within 5–7 (km) of the Merapi crater. Consequently, the last eruption damaged 281 (ha) of settlement areas. It caused many victims in Sleman Regency to relocate to their current settlement areas.

(2)Problems on land-use planning in disaster prone areas of Mount Merapi are follows;

1. RTRW and RDTRK should be revised, especially for resettlement and disaster prone area planning related to high causalities and the damage impacts of the last eruption in 2010. Improvements in these planning processes should accommodate forbidden areas for settlement and prioritize land-use which can serve as buffer zones to prevent causalities.
2. A buffer zone area, especially for 5-7 (km) from the Merapi crater area, is prohibited for settlement area, however, it still allows for limited activities, i.e., agriculture, tourism and limited sand mining activities.

References

1) Siswowidjoyo, Suryo and Yokoyama: Magma Eruption Rates of Merapi Volcano, Indonesia during one century (1890-1992). Bull Volcano, 1995.
2) The Faculty of Geography, Gadjah Mada University: klinik lingkungan dan mitigasi bencana, http://cybergisforum.blogspot.com/ 2010.
3) Sleman Regency, Indonesia: www.slemankab.go.id, 2010.
4) Fleischhauer, M., S. Greiving, et.al.: Spatial Planning in the Focus of Hazard and Risk Assessment/Management in Europe, Wroclaw,2005.