Chapter 10

The importance of communication in hazard zone areas: case study during and after 2010 Merapi eruption, Indonesia

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Merapi is one of the most active volcanoes in Indonesia (2,948 m summit elevation). Eruptions during the twentieth and twenty-first centuries resulted in: 1,369 casualties (1930-1931), 66 casualties (1994) (Thouret et al., 2000), and 386 casualties (2010). The 2010 eruption had impacts that were similar to the unusually large 1872 eruption, which had widespread impacts and resulted in approximately 200 casualties (Hartmann, 1934). These casualties are considered to be a large number given the relatively sparse population in the late nineteenth century by comparison with the population density today.

The 5 November 2010 Merapi eruption affected two provinces and four regencies, including Magelang (west-southwest flank), Sleman (south flank), Klaten (southeast-east flank, and Boyolali (northern flank). The eruption led to the evacuation of 399,000 people and resulted in a total loss of US$ 3.12 billion (National Planning Agency: National Disaster Management Agency, 2011-2013).

The large number of evacuees of Merapi in 2010 was due to warnings of an unusually large eruption – a warning that was based on precursors during the months to days preceding the eruption. These precursors included large increases in seismicity and deformation of the volcano's summit, high rates of dome extrusion, increased temperature of crater fumaroles (reaching 460^{o}C by 20 October), and an abrupt increase in CO_2 at a summit fumaroles. During the time of crisis, there was rapid escalation in rates of seismicity, deformation and rates of initial lava extrusion. All the monitoring parameters exceeded levels and rates of change observed during previous eruptions of the late twentieth century. Consequently, a Level IV warning was issued and evacuations were carried out and then extended progressively to greater distances as the activity escalated. The exclusion zone was extended from 10 to 15 and then to 20 km from Merapi's summit.

Indonesia applies four levels of warnings for volcano activity. From the lowest to highest: at Level I (Normal), the volcano shows a normal (background) state of activity; at Level II (Advisory) visual and seismic data show significant activity that is above normal levels; at Level III (Watch) the volcano shows a trend of increasing activity that is likely to lead to eruption; and at Level IV (Warning) there are obvious changes that indicate an imminent and hazardous eruption, or a small eruption has already started and may lead to a larger and more hazardous

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eruption. At Level III people must be prepared for evacuation and at Level IV evacuations are required. Figure 10.1 presents the chronology of warnings and radius of evacuations during the 2010 Merapi eruption (time increases from the bottom of the diagram upwards).

	ALERT LEVEL	DATES	RADIUS	ERUPTION
DECREASING	NORMAL	15-9-2011		
	ADVISORY	30-12–2010		
	WATCH	3-12-2010		
		4-11-2010	20 KM (11:00 UTC)	4 Nov. 17:05 UTC (16,5 km)
INCREASING		3-11-2010	15 KM (08:05 UTC)	3Nov. 08:30 UTC (9 km)
	WARNING	25-10-2010	10 KM (11:00 UTC)	26-10-2010 (10:02 UTC)
	WATCH	21-10-2010		
	ADVISORY	20-9-2010		
	NORMAL	17 -9-2010		

Figure 10.1 Chronology of warnings and radius of evacuations during the 2010 Merapi eruption (time increases from the bottom of the diagram upwards). Distances given in the eruption column show extent of pyroclastic flows.

Following the first explosive eruption on 26 October 2010 and before the climactic eruption on 5 November, a lava dome was extruded rapidly (at rates of ≥25 m^3/s, Pallister et al. (2013)). Explosive eruptions took also took place and were accompanied by pyroclastic flows. The lengths of pyroclastic flows increased from 8 km (26 October 2010) to 12 km (3 November) and then to 16.5 km during the climactic eruption on 5 November.

The 2010 Merapi eruption offers an excellent lesson in dealing with eruption uncertainties, crisis management and public communication. Good decision making depends not only on good leadership, but also on the capabilities of scientists, good communication and coordination amongst stakeholders, public communication and on the capacity of the community to respond. All of these factors were in place before the 2010 eruption and contributed to the saving of many thousands of lives.

After the 2010 Merapi eruption with its large impact, revision of the hazard map was carried out to take into account the greater extent of eruption deposits and impacts compared to previous events in the twentieth century. This map is the basis for the implementation of land-use planning and it is represented by the "Map of Impacted Area by Eruption and Lahar" (Peta Terdampak Erupsi dan Lahar), shown in Figure 10.2. The map delineates three hazard zones: Hazard Zone III (directly affected area (ATL)), which includes Forest Conservation/National

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Park Development areas with 'closed society settlement' (living in harmony with disaster/zero growth) and National Park and Protected Forest; Hazard Zone III indirectly affected area (ATTL), which includes National Park and Protected Forest; Hazard Zone II (not affected and intended for settlement but according to the land-use plan, highly controlled); and Hazard Zone I (area impacted by lahar). The width of restricted development in river overbank areas is decided by the Governor, and integrated into the Regency/City land-use plan.

Figure 10.2 Map of Impacted Area by Eruption and Lahar (Peta Terdampak Erupsi dan Lahar) (Source: Map by Center for Volcanology and Geological Hazard Mitigation, CVGHM, Aster Landsat, courtesy Franck Lavigne).

The hazard map was approved by the Ministry of Energy and Mineral Resources, Ministry of Public Work, Ministry of Forestry, National Plan Agency, Head of National Disaster Agency, Governor of Yogyakarta and the Governor of Central Java. The map of impacted area by eruption and lahar is the basis for Merapi land-use plan and the rehabilitation and reconstruction plan. The process has been supported by Ministry Decree of the Republic Indonesia No 16, 2011 (Ministry Decree of Republic Indonesia No 16, 2011, on Team of Coordination on Rehabilitation and Reconstruction of area post disaster of Merapi Eruption, in Yogyakarta Special Province and Central Java Province).

An action plan policy for rehabilitation and reconstruction includes the land-use plan as the basis for determination of secure locations for settlementas well as the design for relocated houses, which are constructed with a risk reduction approach. The map in Figure 10.3 shows the location of temporary and permanent settlement in Sleman, Yogyakarta and the photos (Figure 10.4) show examples of permanent and temporary housing.

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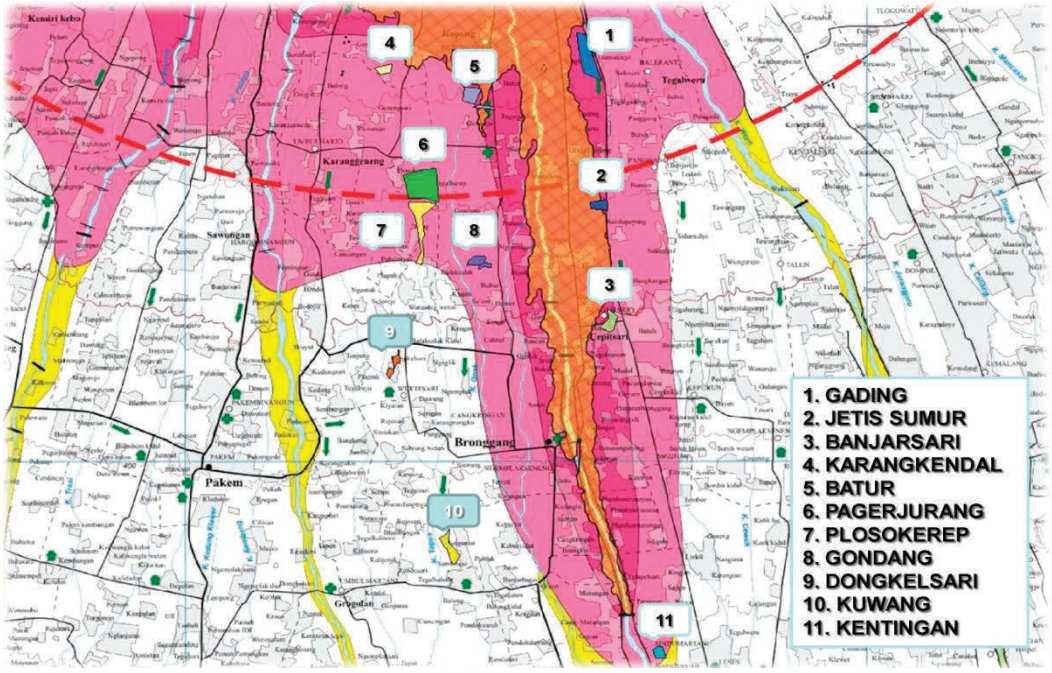

Figure 10.3 Map of Temporary and Permanent Settlement in Sleman, Yogyakarta (Source: Center for Volcanology and Geological Hazard Mitigation, CVGHM, 2011)

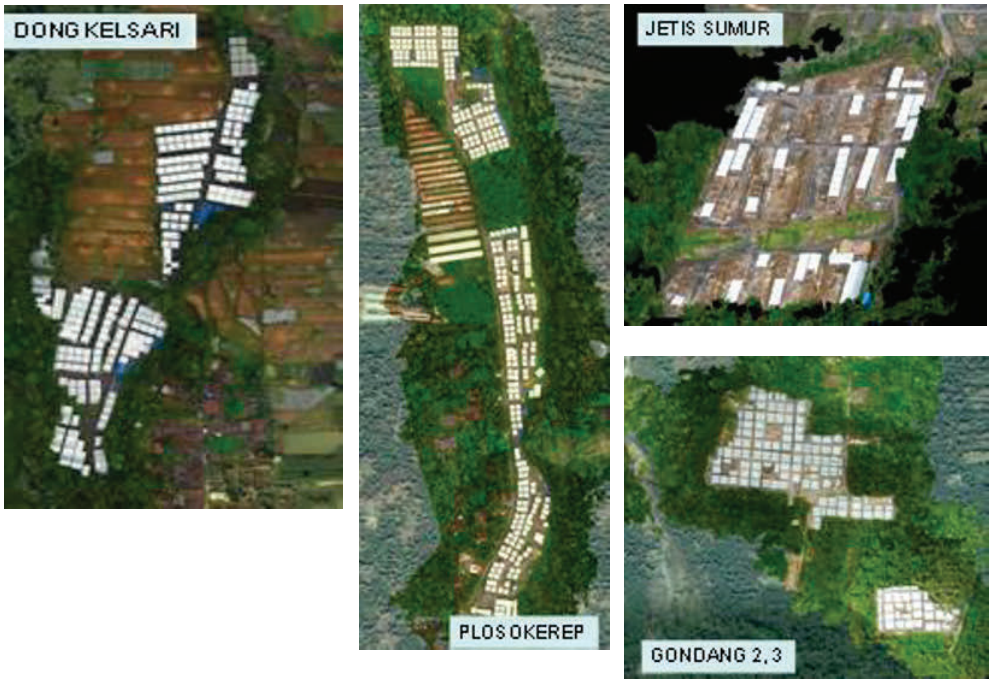

Figure 10.4 Air photo of temporary and permanent settlements of Dongkelsari, Plosokerep,Jetis-sumur, Gondang 2-3 (see map in Figure) (Source: Center for Volcanology and Geological Hazard Mitigation, CVGHM, 2012).

Impacts of Merapi eruptions on the human and cultural environment, livelihood and properties provide a lesson that in densely-populated areas around a volcano there is a need for regular review of hazard mitigation strategies, including spatial planning, mandatory disaster training,

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contingency planning and for regular evacuation drills. Merapi is well known for a capacity building programme named 'wajib latih' (mandatory training) required for people living near the volcano. The aim of this activity is to improve hazard knowledge, awareness and skills to protect self, family and community. In addition to the wajib latih, people also learn from direct experience with volcano hazards, which at Merapi occur frequently. However, the 2010 Merapi eruption showed that well trained and experienced people must also be supported by good management, and that training and mitigation programmes must consider not only "normal" but also unusually large eruptions (Mei et al., 2013).

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