Influence of the institutional and socio-economic context for responding to disasters: case study of the 1994 and 2006 eruptions of the Merapi Volcano, Indonesia

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Abstract: This article explores the institutional responses to the volcanic crises and related problems encountered during the 1994 and 2006 eruptions of the Merapi Volcano, Indonesia. It also illustrates traditional responses to the volcanic crisis led by the local community and provides recommendations to encourage a comprehensive institutional volcanic crisis management including community-based response. This study aims to understand and to explain the gap between institutional responses and the community's perception during pre- to post-crisis situations. Interviews, questionnaires and focus group discussions revealed that top-down institutional responses to the volcanic crisis are not fully appropriate in regions with a high cultural perception. Working with the community is an ideal solution to minimize the gap between the government, scientists, non-governmental organizations and the community itself. A community-based methodology combined with natural hazard studies generates comprehensive risk and crisis management.

Disasters are, by definition, extraordinary catastrophic events that can overwhelm normal coping strategies and resources (Reser 2007). Despite the fact that disaster management is complex in all its aspects, the government, the people and stakeholders need it in order to cope with disasters (Bermejo 2006). The number of studies on volcanic risk management has increased considerably in the last decade and deliberately so, because disasters come with the greater potential to affect growing populations. Thus, new theoretical perspectives and policy guides are required (McEntire *et al.* 2002).

Communities should be included in disaster management programmes in order for governments and communities to play complementary roles in coping with volcanic disasters (Paton *et al.* 2008). The role of governments and scientists is to anticipate volcanic eruptions and communicate about them to the population. Lack of knowledge about volcanic hazards can lead to low volcanic risk perception (Carlino *et al.* 2008). Information dissemination and education to the society at risk are key factors in correcting and improving the perception of volcanic threats (Leone & Lesales 2009). However, information dissemination and education implies passive absorption rather than active consultation (Eden 1996). So, the need for community participation and involvement in raising hazard awareness is crucial.

Top-down planning cannot be applied directly, and needs to be modified and adapted to the existing disaster situation and conditions. Differences in perception of disaster management issues by local communities and scientists or emergency planners can provoke a disruption of crisis management plans (Johnston & Ronan 2000). Human responses to disasters do not simply reflect individual patterns of behaviour. People's responses to disasters in the long term are expressed as a cultural adaptation by way of belief or warning messages (Reser 2007), and it is essential to consider the local and cultural factors in risk and crisis management (Lavigne *et al.* 2008). In order to create locally adapted crisis management, both institutional and traditional responses must merge through active participation of the community and institutions.

The study aims to understand and illustrate the gap between institutional responses and the community's way of thinking before, during and after crisis situations in the Indonesian context, using the Merapi Volcano as an example. This study is part of the FP 7 European programme 'Mitigate and Assess Risk from Volcanic Impact on Terrain and Human Activities' (MIAVITA), which seeks to develop tools and to integrate cost-effective methodologies to mitigate risks from various hazards on active volcanoes including Merapi.

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This article focuses on the institutional responses, the problems encountered during the 1994 and 2006 Merapi volcanic crises management, and how the community led traditional responses to volcanic crises. It also suggests recommendations to encourage a comprehensive institutional volcanic crisis response that includes the traditional one. Merapi's 2010 eruption is not included in this article, owing to the incomplete data collection (work in progress). However, several important elements of crisis management of the 2010 Merapi eruption will be discussed and the chronology of the 2010 centennial eruption will be briefly presented.

Merapi volcanic activity

Merapi is one of the most active volcanoes worldwide, with over 70 eruptions since 1548 (Voight *et al.* 2000*a*). During the last two centuries, this volcano has erupted explosively every 8–15 years and violently every 26–54 years, and the repose periods have not exceeded 3.5 years (Thouret *et al.* 2000). It lies approximately 25 km north of Yogyakarta, a city whose population is of over 1 million (BPS 2005). Approximately 1.1 million people live on the flanks of this volcano.

The eruptive activity during 1993–1994 encompassed a major phase of lava extrusion and dome growth that formed the 1994 dome, with a volume of 2.0×10^6–2.6×10^6 m^3. Since February 1994, rock falls have produced a talus and rock-fall deposit build-up against the south run-out channel wall (Voight *et al.* 2000*a*). The dome became unstable upon reaching a critical volume and collapsed on 22 November 1994 (Ratdomopurbo & Poupinet 2000; Young *et al.* 2000). This VEI (Volcanic Explosivity Index) 2 eruption produced 7 km of pyroclastic flows along the Boyong River (Wilson *et al.* 2007). Because of the unpredictable nature of dome collapse and lack of short-term precursors (Voight *et al.* 2000*b*), 69 people were killed by the dome-collapse pyroclastic flows and associated ash-cloud surges.

The last eruption prior to the 2010 major eruption occurred in 2006. This eruption was categorized as typical Merapi-type pyroclastic flows due to dome collapse, similar to the 1994 eruption but over a longer period. The lava-dome growth started in March 2006 and it was rapidly followed by periods of numerous rock falls and dome-collapse pyroclastic flows during May and June 2006. A first eruption occurred on 5 May and was followed by a second eruption phase that was associated with a *M* 6.5 tectonic earthquake on 27 May 2006 in Bantul, approximately 30 km south of Merapi. On 14 June, two dome-collapse pyroclastic flows partly filled the Gendol River valley as far as 7 km. After 14 June, the volcanic activity progressively decreased until the end of the eruption in early July 2006 (Charbonnier & Gertisser 2008). The long period of volcanic unrest caused an extended period of evacuation time, starting in late April and lasting until July (Table 1).

The 2010 eruption of Merapi lasted from late October until November 2010. This eruption was classified as a subplinian eruption with column-collapse pyroclastic flows (St Vincent type). On 20 September, authorities increased the alert level from level I (normally active) to level II (on guard), as recommended by the Centre of Volcanology and Geological Hazard Mitigation (CVGHM). One month later, the Indonesian government raised the alert to level III. On 25 October, the alert was raised to its highest level (IV) and the government warned villagers in threatened areas to move to safer grounds. People living within a 10 km radius were told to evacuate. The first casualties, including Mbah Maridjan, the volcano's gatekeeper, and 16 people in the Kinahrejo village, died on 26 October. The gatekeeper was the spiritual guardian of the volcano; and local people believed he had the power to speak to the spirits of the volcano. He also led annual sacrificial ceremonies called *labuhan* (Lavigne *et al.* 2008). Local people believed in him rather than government officials and volcanologists when it came to determining Merapi's danger level.

By the early morning of Saturday 30 October 2010, the volcano erupted again, for a longer period of time and more violently than the previous events. On Wednesday 3 November, the authorities decided to move the shelters 15 km away from the summit instead of the initial 10 km. By 4 November 4, Merapi had been erupting continuously for 24 h. The following day, owing to the strong persistent activity, the government decided to extend the safety zone to a radius of 20 km. The volcano continued to erupt until 30 November 2010. At least 320 000 people had been evacuated to emergency shelters and the death toll was over 353. On 3 December 2010, the official alert status was reduced to level 3 from level 4, as the eruptive activity had already waned.

Methods

The methods used in this study include statistic data collection regarding the 1994 and 2006 eruptions; interviews with stakeholders; focus group discussions; and questionnaire-based surveys with villagers living in the area prone to pyroclastic flows and surges. Quantitative methods such as statistical analysis of questionnaire responses are known to be highly effective in measuring the 'cause and effect' of individual variables and have been successfully used in the volcanic risk perception domain

Table 1. *Chronology of the 2006 eruption of Merapi (Wilson* et al. *2007)*

Date	Time	Event	Alert level
12 April 2006		First pyroclastic flow (PF)	III
25 April 2006		198 multi-phase (MPT) earthquakes, four shallow volcanic tremors (SVT), one tectonic earthquake (TT)	III
26 April 2006		57 MPTs, one SVT	III
3 May 2006		84 MPTs, one SVT	III
4 May 2006	02.00	Lava erupted from summit	III
7 May 2006		133 MPTs, 88 TTs, one SVT	III
8 May 2006		One SVT, 34 MPTs, 152 rock fall tremors (RFT)	III
9 May 2006		Six SVTs, 142 MPTs, 152 RFTs	III
10 May 2006		One SVT, 123 MPTs, 88 RFTs, four TTs. Evidence of new growing lava dome at summit reported	III
12 May 2006		90 MPTs, 214 RFTs, four TTs, 11 PFs upper Krasak and Boyong rivers	III
13 May 2006		27 MPTs, 24 RFTs, 14 PFs of uncertain distances	IV – evacuation order
14 May 2006	00.00–00.06	23 ash/steam clouds erupted once every 15 min	IV
20 May 2006		Pyroclastic flows	IV
4 June 2006	unknown	Geger Boyo collapses	IV
13 June 2006		Alert level lowered from 4 (caution) to 3 (alert)	IV–III
14 June 2006		Small dome collapse flow causes renewed evacuation of Kaliadem and surrounds	IV
14 June 2006		Dome collapse, block-and-ash flow down the Woro Valley onto Kaliadem village. Two men were killed in a bunker where they tried to escape the flow	IV
22 June–5 July 2006		Small dome collapse, block-and-ash flows continue, but decrease in intensity and frequency	
12 July 2006		Lowering alert level	III – evacuees return home
12 July–25 August 2006		Continued decrease in eruption activity	III
25 August–30 September		Decrease in eruption activity	II
By 1 October 2006		Return to baseline alert level	I

(Johnston *et al.* 1999; Dominey-Howes & Minos-Minopoulos 2004; Gregg *et al.* 2004; Barberi *et al.* 2008; Carlino *et al.* 2008; Bird *et al.* 2010). Qualitative data collection methods were also used in order to understand and explain the community's way of thinking before, during and after crisis situations. Interviews were undertaken with people involved in the management process of volcanic crises; notably representatives from institutional organizations, municipality officials and community members, (Table 2).

The field data collection took place from April to August 2010 in the village of Turgo, which is part of the Purwobinangun and Ngargomulyo municipalities. Turgo is located on the southern side of the Merapi Volcano and Ngargomulyo on the western side (Fig. 1). The sites were chosen because they are located within the most hazard-prone areas. Both villages had experience of dealing with volcanic disasters; Ngargomulyo was damaged by pyroclastic flows and surges in 1930 and 1961, and Turgo in November 1994.

Focus group discussions (FGDs) were conducted in Turgo from 19 to 24 July 2010, and in Ngargomulyo on 28 and 29 July 2010. The aim of these FGDs was to analyse catastrophic events in the past (notably related to volcanic disaster), their impacts, problems and difficulties, vulnerability and capacities. The FGDs were moderated as advised by Krueger (1998) and conducted mostly in the Javanese language. In each village, four FGDs were achieved with 20 participants for each discussion: a group of women, a group of elderly people, a group of youths and a group of men, which also comprised local officials and villagers.

A questionnaire-based survey distributed to 143 respondents was carried out in May–July 2010 among 154 families in Turgo. Its goal was to

Table 2. *Interviewed people*

Institutional organizations	Number	Village's officials and community member	Number
Provincial Disaster Coordinating Council (Yogyakarta Special Province)	1	Head of municipality (Purwobinangun; Ngargomulyo)	2
Municipal Disaster Coordinating Council (Sleman, Magelang, Klaten and Boyolali districts)	4	Village officers (Purwobinangun)	2
Merapi Volcano Observatory (BBPTK)	2	Heads of villages (Turgo village, Purwobinangun municipality)	7
Public Work (Sleman, Magelang and Klaten)	3	Head of cluster (Turgo)	2
		School teacher (Turgo)	1
		Local search and rescue operation volunteer group (Purwobinangun)	2

study in depth the community's knowledge and individual perception of volcanic activity, experience in handling volcanic crisis, and traditional coping strategies to prevent or minimize future volcanic eruptions. Interviews were conducted face to face and in the local Javanese language.

Responses to 1994 and 2006 eruptive crises

Institutional responses

Government responsibility. There are four levels of government administration in Indonesia; that is, province (*propinsi*), district (*kabupaten/kota*), sub-district (*kecamatan*) and municipality (*kelurahan/desa*). A municipality encompasses from five to 10 villages. Most organizations in Indonesia follow the government structure, with larger-size organizations having representatives at the provincial and district levels (Fig. 2). The local officials in municipalities and villages are also local villagers. Local leadership has a significant role in local capacity and their decision-making abilities.

Governments are mainly responsible for dealing with disasters and considering the roles played by stakeholders. Crisis management in

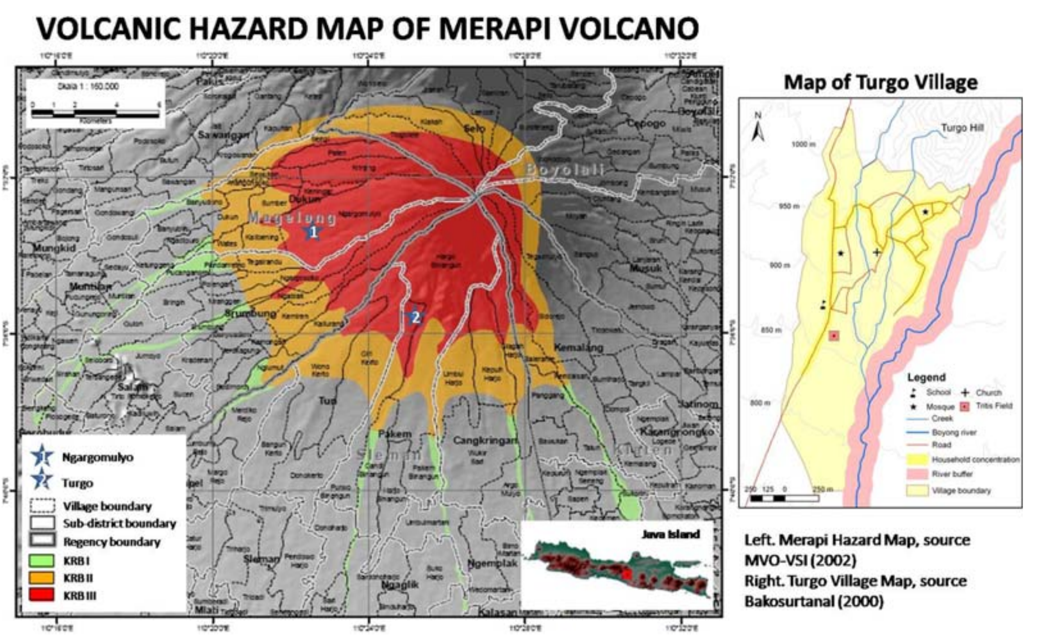

Fig. 1. Volcanic danger zone map of Merapi Ngargomulyo municipality, Turgo village and Tritis field.

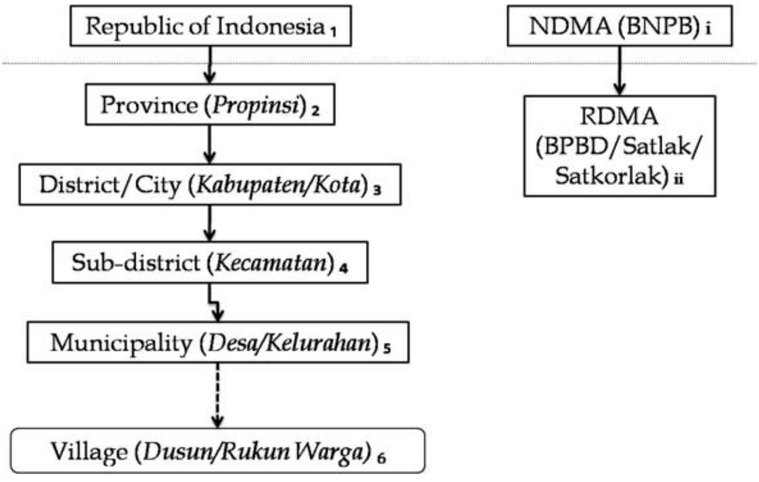

Fig. 2. Administrative divisions (1–6) and disaster management agency in Indonesia (i–ii).

Indonesia is based on a top-down hierarchical organization (President of the Republic of Indonesia 1990, 2008). The National Disaster Management Agency (NDMA: or, in Indonesian, BAKORNAS/BNPB (*Badan Koordinasi Nasional Penanggulangan Bencana/Badan Nasional Penanggulangan Bencana* – Indonesian National Coordinating Agency for Disaster Management/Indonesian National Board for Disaster Management)) initiated in 1966, is a non-departmental body; its membership comprises up to 10 ministers and related governors. This agency's functions are to formulate, stipulate, and co-ordinate disaster management and its activities, pre-disaster, emergency response and post-disaster activities. To implement disaster management duties in Province and District/City regions, Regional Disaster Management Agencies (Satkorlak-Satlak/BPBD in Indonesian) have been established (Fig. 2).

A clear definition of a national disaster management policy is essential if a country is to establish and maintain adequate arrangements to deal with every aspect of its disaster threat, in all levels of the national structure and organization (from the national government through to local government or community level) (Carter 1991). If there is no policy to deal with disaster, arrangements to cope with it will be inadequate, and loss of material and human resources will occur.

The Centre of Volcanology and Geological Hazard Mitigation (CVGHM) is responsible for assessing and monitoring volcanic hazards (Fig. 3). Day-to-day conditions of the volcanic activity (*aktif normal, siaga, waspada, awas* – normally active; on guard; prepared; and beware conditions) are broadcast on the local radio. These four warning levels inform the community to get ready in case of an evacuation order (prepared and beware condition levels) (Fig. 4). CVGHM also provides maps that delineate three danger zones ranking from 3 to 1 (KRB 3, KRB 2 and KRB 1) judged unsafe for settlement. These maps are intended to support volcanologists in describing the pattern of past eruptions and to estimate the areas likely to be affected by various hazards (Suryo & Clarke 1985). The first danger zone map of Merapi at a 1:100 000 scale was published in 1978 by the VSI (Pardyanto *et al.* 1978). It is based on the lateral extent of the pyroclastic and lahar deposits from the 1930 and 1969 eruptions (Thouret *et al.* 2000). The most recent version of the hazard map, published in 2002, is based on volcanic deposits of the last 100 years, which is clearly limited with regard to Merapi's long eruption history (Hadisantono *et al.* 2002). Therefore, further volcanic hazard studies on Merapi should be undertaken in order to improve the official hazard map. A second problem for risk management is that this volcanic hazard map is not yet used for regional planning activities. Based on the volcano hazard map, the settlements situated within the hazard zone III should theoretically be permanently abandoned, whereas around 40 000 people inhabit this area on the whole volcano. For example, Turgo and Ngargomulyo municipalities encompass 922 houses for 3085 habitants. Another limitation of the official CVGHM map relates to the lack of data on potential damage and disaster prevention activities. In brief, a volcanic risk map would be very helpful in risk management, as well as in regional planning. Such a map is under construction in the frame of the MIAVITA FP 7 European project.

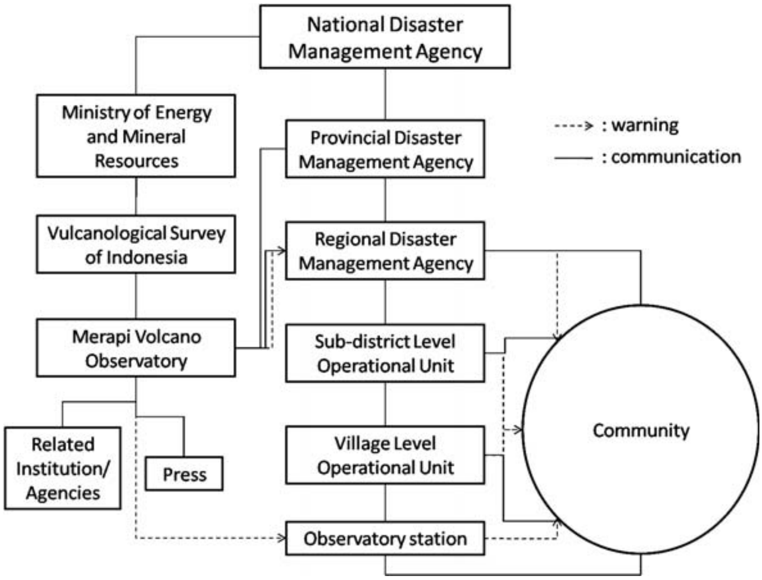

Fig. 3. Early warning system diagram in Indonesia.

Relying on a short eruption history. An ideal disaster management system needs to support the activities related to prevention, mitigation, preparedness, response, rehabilitation, reconstruction and development (Carter 1991). During the 1994 Merapi eruption, the lava dome collapsed, generating pyroclastic flows. On 22 November 1994, the *Kaliurang Post* reported flaming lava with hot clouds moving westward on Merapi's slope. The report reached Merapi Volcano Observatory (MVO) in Yogyakarta at 7:30 a.m. and was forwarded to the Sleman District, which relayed the information to the Pakem Subdistrict. By 10:00 a.m. the alert was given at the Hargobinangun municipality, upon advice of the Pakem Subdistrict, but it was too late. Two hours before, dozens of houses were destroyed or heavily damaged by an ash-cloud pyroclastic surge, killing half of the 69 victims at a wedding party in Turgo. The other victims were buried by pyroclastic flows within the Boyong Valley at the same time.

Disaster preparedness encompasses actions undertaken before the event of a disaster to minimize its impacts. Local authorities and communities are highly vulnerable when the institution responsible for disaster lacks preparedness. Lacking

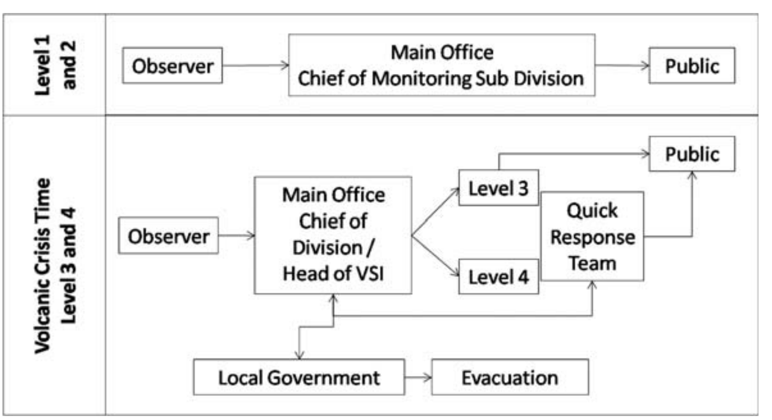

Fig. 4. Schematic diagram of volcanic activity and dissemination of information.

prevention, mitigation and preparedness response may explain the 1994 eruption. Prevention such as institutional support from the government in social protection was limited at that time. During the mitigation phase, land-use regulations prohibiting people from settling in the prone area were not well implemented. During the preparedness stage, the provision of warning systems, emergency communications, public education and awareness, as well as training programmes to reduce the volcanic risks, were also limited, if not inadequate. Before the 1994 eruption, there was no preparation or educational information on volcanic hazard, neither from government nor from non-governmental organizations. Without any preparation, local authorities were overwhelmed with the sudden eruptive crisis.

One aspect, which is not always given adequate priority, is individual and family preparedness. In many circumstances when government resources and emergency services are limited, such individual and family preparedness may be vital for survival (Carter 1991). Lack of first-aid knowledge and how to help the injured-burns victims became a challenge for local authorities, as well as for the community. As a result, many victims died on their way to the hospitals located in Pakem (12 km south of Turgo) and Yogyakarta City (20 km from Turgo). 'Most of the villagers who helped the burns victims did not have any knowledge of first aid. It was the first time we dealt with a volcanic crisis situation' (Suwaji, 52 years old, former head of Turgo village, interviewed on 30 June 2010).

Local authorities were not able to support rescue organization and emergency response, to organize effective evacuation, provide enough shelters and to facilitate the displacement of people. 'The conditions of shelters were very unpleasant, but at the time, what was most important for us was our safety. We brought nothing except the clothes on our backs. We were lucky to be able to run away from danger' (Sutirejo, a 78 year-old woman from Turgo, interviewed on 26 June 2010). Thousands of people evacuated through their own initiative, without their belongings (clothes, food, documents) settling in local shelters with limited facilities near the village office.

Aids for displaced people in local economic sectors were considerably low and not well organized. Since the majority of Turgo's inhabitants had at least one cow used for their income, the government offered a livestock shelter in Kaliurang. However, this solution was not helpful because there was no governmental support to feed the livestock. Villagers returned to their villages to collect grass for their cattle as they had no income to buy grass from the market. In many instances, villagers were forced to sell their livestock for a low price. It shows that a disaster makes people more vulnerable.

During the 2006 eruption, after learning from past disasters, the local government tried to improve the disaster management system. In the prevention phase, information dissemination about volcano-related hazards was conducted. Vital infrastructure development was undertaken, upgrading the quality of evacuation routes by asphalting the roads before the 2006 eruption. An effort to conduct an effective evacuation was shown by the first evacuation on 13 May. Pregnant women and elderly people were the first to be moved, followed by children. Men chose to stay behind in their villages in order to look after their houses and farms. Trucks and vehicles provided by the authorities and local people were used to evacuate. By 19 May 2006, the Indonesian Red Cross reported a total of 20 080 people housed in emergency shelters. According to UNOCHA (2006*a*), 907 were sheltered in the Boyolali District, 6163 in the Sleman District, 8866 in the Magelang District and 4144 in the Klaten District. From 12 April until 13 June 2006, volcanic activity was still taking place but without the expected occurrence of pyroclastic flows. Merapi's behaviour induced villagers to think that staying in refugee camps was no longer necessary. The government and scientists failed to anticipate a long-onset eruption and then failed to communicate this fact to the local people. It resulted in a lack of trust between the local people, scientists and government. Despite daily warnings from the VSI of the continuing danger, people gradually trekked back to their villages. Some returned home daily from morning until afternoon, whereas others returned home discreetly and permanently regardless of the official order to evacuate. By 28 May 2006, up to 1800 people were believed to have returned to their villages (UNOCHA 2006*a*). Evacuees went home during the day and returned to evacuation camps at night. For example, in Turgo, 68% of the questionnaires' respondents declared having returned home every day in order to feed their cattle and clean their houses during the daytime (5 a.m. until 4 p.m.). 'Ever since I was young, every time there is a volcanic crisis, we go home almost every day during the evacuation period to feed the cattle and look after the farm land. We often come home very early in the morning, around 2 or 3 a.m. to avoid the police or guards' (Warno, a 62 year-old man from Ngargomulyo confirms during FGD on 28 July 2010).

Early in the morning of 27 May 2006, an earthquake with a magnitude of 6.2 on the Richter scale hit Bantul, 30 km south of Merapi (UNOCHA 2006*b*). This tectonic quake killed over 5800 people, injured more than 20 000 and demolished over 150 000 houses in Yogyakarta and central

Java provinces (UNOCHA 2006*b*). The earthquake swiftly increased the scale of emergency, and the volcanic eruption crisis and evacuation were overwhelmed by earthquake response. This tectonic earthquake did, indeed, correlate with an increase in pyroclastic flows in Merapi (Walter *et al.* 2007). The earthquake itself did not cause extensive damage to villages on Merapi. However, some problems arose when the evacuation camps on Merapi faced a shortage of relief supplies as efforts were directed to the earthquake-damaged areas in the south of Yogyakarta and Klaten, in the 10 day period following the earthquake (UNOCHA 2006*b*).

The statements above show that local authorities were not able to cope with two concomitant disasters occurring in the same area. Response to disaster is usually extensive and its success depends vitally on efficient preparedness (Carter 1991). The response operations usually have to be carried out under disruptive and traumatic conditions. Heavy demands of personnel, equipment and other resources are usually the main obstacles in disaster response. Without a basis of planning, organization and training, response operations are unlikely to achieve optimum success (Carter 1991).

The lack of anticipation during a long eruptive crisis by scientists and the government created a lack of trust and worsened the risks. On 13 June 2006, VSI lowered the alert level from level 4 (beware) to level 3 (prepared) a week after the partial collapse of the dome, which relieved pressure in Merapi's plumbing system (ESA 2006). Following the lowered alert level, refugees came back to their villages in trucks. However, they had to remain on guard and the trucks remained on standby in the villages. On 14 June, at around 12 p.m. a sudden increase in eruptive activity prompted sirens to be activated along the Gendol River (Fig. 5). Immediate evacuation was carried out and most people were able to evacuate on time. The same day, the largest block-and-ash pyroclastic flows reached a distance of 7 km from the summit, causing two fatalities and the total destruction of the Kaliadem village.

After this event, evacuation areas were redefined: including areas within an 8 km radius from the crater, as well as extending the forbidden zone within a 300 m on buffer of the valley rims of the Gendol, Boyong, Bedog, Krasak and Bebeng rivers (Fig. 6). The last evacuees began to return on 22 June in Magelang. The alert level was lowered to level I on 10 July, and by late July most evacuees had returned home (HA 2006*b*). The short period between the lowering and raising of the alert level on 13 and 14 June caused the villagers' uncertainty and distrust of both the government and scientists. Indeed, conditions to obtain a successful response to volcanic disaster include solid and well-coordinated efforts of local authorities, scientists and NGOs, and the use of an efficient early warning system.

Multi-agency cooperation. At Merapi, at least seven formal institutions and several non-governmental organizations (e.g. Kappala) work together on volcanic crisis management at each district level, namely the Regional/District Disaster Management Agency (RDMA), the Merapi Volcano Observatory (MVO), the army, the police, the Health Agency, the Public Works Agency and the Social Agency. The RDMA is in charge of stipulating and coordinating crisis-related activities with all institutions involved (e.g. evacuating the community, constructing evacuation shelters and providing food, logistics and health facilities). The functions of several institutions during a volcanic crisis were defined by a contingency planning, which the RDMA, MVO and UNICEF collectively created in 2009.

The multi-agency cooperation is not only needed during the crisis, but also before and after it. For example, the maintenance of evacuation roads becomes a major issue for post-crisis management. Following the 2006 eruption, the local government tried to enhance the quality of the roads by paving them with asphalt. However, after several years, the condition of the roads became worse due to trucks hauling volcanic material (De Belizal *et al.* 2011). The effort to maintain evacuation routes is

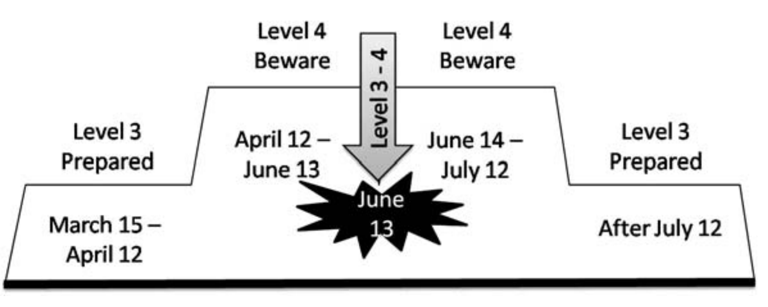

Fig. 5. Alert level of 2006 eruption.

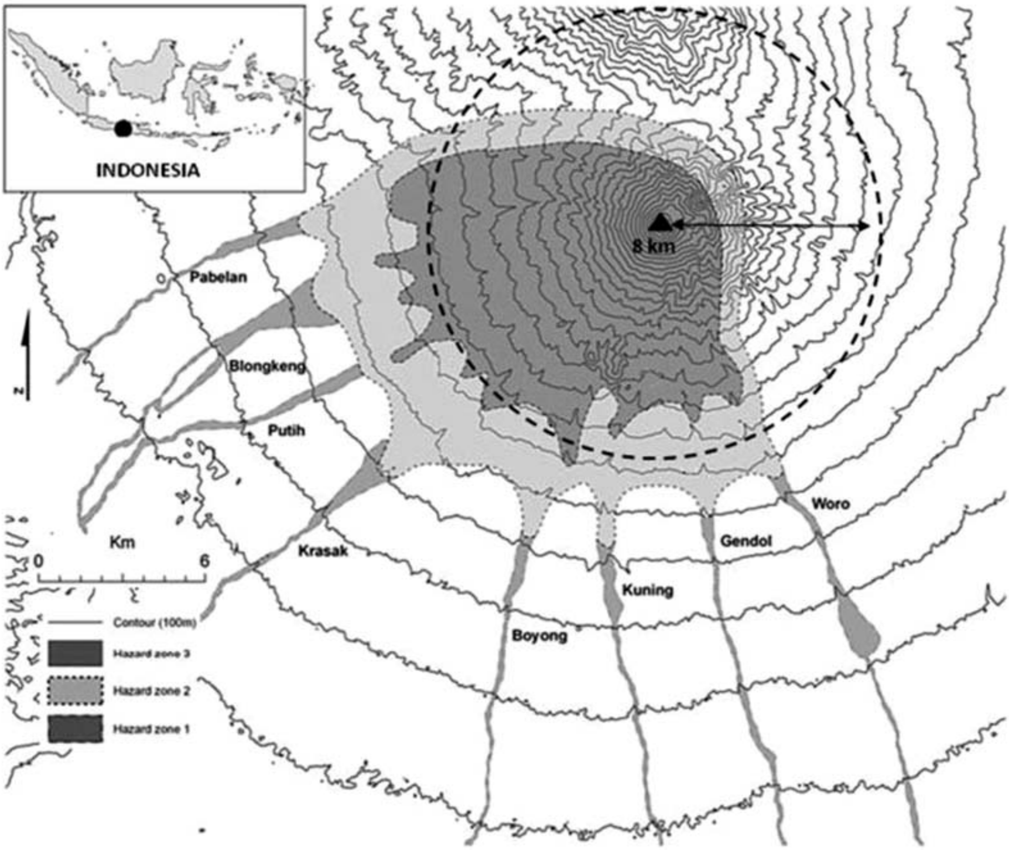

Fig. 6. Areas within a radius of 8 km from the crater, with several rivers on Merapi Volcano. *Source*: Hadisantono *et al.* (2002) and courtesy of BAKOSURTANAL, the National Agency for Survey and Mapping (Indonesia).

not uniform in each district; related institutions and society play an important role in this issue. For example, on the west flank of the Merapi Volcano, the chief of the Kemiren, Ngablak and Ngargomulyo municipalities refused to allow volcanic sand mining activity in their territory because they feared that the evacuation routes would be damaged by the trucks (De Belizal *et al.* 2011). In contrast, people and even the government of the Klaten District do not pay much attention to the condition of evacuation routes because sand mining is seen as a key sector of their economy. These examples illustrate how people's awareness and government support is essential in order to maintain infrastructure as a risk mitigation tool.

As mentioned by the BNPB (2010), the need for comprehensive disaster management planning is obvious, because during a disaster it is not clear who does what; every institution wants to help, but does not know what to do. In some cases, the same activities performed by different institutions results in overlapping planning. Therefore, a disaster management plan involving various stakeholders is needed.

Responses of communities at risk

The community is the primary stakeholder and also the recipient of the direct impact of disasters. However, the role of communities in crisis management is often not taken into account. Volcanic crisis management should be carried within the framework of the socio-cultural background, involving national and local governments and non-governmental organizations.

The influence of livelihood on local actions. The community's volcanic risk perception plays a main role in crisis management; the perception of risk and success of response in minimizing volcanic risk are correlated (De la Cruz-Reyna & Tilling 2008). Socio-traditional responses towards disasters are common in Java (Oliver-Smith & Hoffman 1999). In the case of Merapi, the volcano is materially or spiritually significant to the local community; Javanese people consider the Merapi Volcano to be one of the sacred places, inhabited by spirits. It is the source of life, providing fertile soil for agriculture, and is the home of forests, fresh water and resources (Lavigne *et al.* 2008).

Social relationships between communities in Java are quite strong. It is reflected in their communal efforts ('*gotong royong*') in building mosques, churches, gates and portals, and during the planting season. During the 1994 volcanic disaster, this tradition of helping one another was exemplified during the evacuation of victims in Turgo. The evacuation process was initiated by the villagers after the first dome collapse, villagers fled by foot to the evacuation meeting point located at Tritis field in the southern part of Turgo (Fig. 1). During a second phase, the evacuation of victims was carried out using local resources such as motorcycles and cars owned by villagers. The poor condition of the roads and the lack of vehicles became major obstacles to evacuation. In the first days following the dome collapse, local people provided food and constructed temporary tents before the arrival of relief supplies from the government.

The influence of livelihood on local actions was also displayed during the 2006 eruption: apart from institutional responses, some villagers developed their own surveillance and warning system with their own observation teams. Similar attitudes have also been observed during post-eruptive lahars following the 2010 eruption of Merapi (Lavigne *et al.* 2011). Others prepared available local vehicles that could be used during evacuation. After the 26 May 26 2006 earthquake in Bantul, people from the still-erupting Merapi also helped earthquake victims, providing food and first aid, and even helping the reconstruction process. Societal interdependence in handling resources is quite important among the communities to reduce their vulnerability (Cashman & Cronin 2008). At the immediate aftermath of the earthquake, local people from the southern part of Yogyakarta fled toward Merapi because they feared a potential tsunami even though the status of the volcano was still at alert level IV. Such local response underlines the high level of traumatism due to the 2004 tsunami, which killed 170 000 people in Banda Aceh (Sumatra).

Traditional responses. Many legends and stories about the Merapi Volcano and its hazards are connected to the Javanese people's cultural and moral beliefs. As an example, according to a Pelemsari resident, the deaths of people in Turgo were due to a wedding ceremony that should not have been held during sacred days (Donovan 2010). Residents of Turgo disobeyed the rules and therefore suffered the consequences. Another example relates to the construction of a bridge connecting Turgo and Kaliurang in 1993. According to traditional belief, the bridge was not supposed to be built; hence, it was destroyed by post-eruptive lahars (Fig. 7). 'Oral history underlines that we are not allowed to cross the lahars road. Several workers who had built the bridge were killed by the eruption. It was a sign from unseen creatures and God that the bridge would impede the lahars flow and create higher risk to the community in Turgo'(Ninik, a 50 year-old woman from Turgo, interviewed on 26 July 2010). In Javanese nature, these religious–cultural worldviews and society are intrinsically interlinked (Schlehe 2010).

Traditional responses can become a source of difficulty for local authorities. When the Merapi Volcano's gatekeeper refused to evacuate during the 2006 eruption, some of the villagers, particularly in the Kinahrejo village, chose not to escape (Tempo Interaktif 2006). Based on their traditional belief and knowledge, they trusted Marijan, although they were highly exposed to the imminent danger. At the time, Marijan undertook a 3 day meditation with the intention of asking Merapi to limit the level of destruction. Marijan and hundreds of villagers believed that the 2006 eruption would not trigger a disaster. During the 2010 eruption, Marijan refused, as usual, to move out of his house prior to the eruption; he believed that his time to die in his village had come. The eruption on 26 October 2010 devastated the villages of Kaliadem and Kinahrejo; Marijan and 16 other people were found dead in his burnt house about 4 km from the Merapi summit.

As a result of the combined volcanic eruption and earthquake crisis in Java in 2006, several public rituals or ceremonies were conducted as a traditional response to the disasters. At that time, the Sultan of Yogyakarta, who is also the governor of the Yogyakarta Province, invited government representatives, religious leaders and also traditional spiritual leaders to a public meeting. Thousands of villagers attending this ceremony were included in the prayer. In 2006, the annual *labuhan* (auspicious ceremony or ritual) was held on the 30 day of Rejeb (Javanese lunar calendar) or on 26 August 2006 in the Gregorian calendar. Beside *labuhan*, communities in the NW part of Merapi's flank also have another form of ritual that they apply in their house; they offer food, perfume, clothes and other gifts to the unseen creatures each month. These *labuhan* and rituals seek to protect the people from disasters through their belief in God and unseen spirits on the Merapi Volcano (Lavigne *et al.* 2008).

Fig. 7. The bridge over the Boyong Valley between Turgo and Kaliurang. (Above) In December 1994. (Below) In February 1995 (photographs: F. Lavigne).

In some extreme circumstances, where there is great loss or change, human beings are confronted with difficult fundamental questions. In religious or traditional societies, the responses of disaster victims are varied and usually deal with morality, ethics, justice, sin and retribution, causality, liaison between the secular and the sacred, and the divine things (Bode 1977, 1989; Oliver-Smith 1979, 1996; Maida 1993; Cashman & Cronin 2008). This kind of reasoning behaviour exists almost everywhere, as explored by Bode (1977) after the 1970 Peruvian earthquake where myths and legends as well as the religious symbols and rituals sustained individual and cultural identity.

Public ceremonies were conducted as the communities' traditional response during and after the Merapi volcanic crisis in 2006. Traditional responses are not always local, as explained by Schlehe (2010). In Indonesia, a traditional ritual was held at the national level on 9 January 2008, attended by representatives of all religions, government officials, kings, sultans and royal families from 104 kingdoms across the Indonesian Archipelago. The purpose of the ritual was to protect the country against future disasters. These traditional responses can be viewed as an expression towards disaster, which includes social and cosmic justice. The fact that the government was involved in the ritual shows that traditional and institutional responses towards disasters are closely linked.

Linking the community and institutional responses

Unofficial warning. Official statements regarding Merapi's activity should be made by the MVO or municipal disaster coordinating council in each district or province (Fig. 8). Volcanologists have the responsibility to deliver a timely and accurate assessment of the volcanic hazard. However, the challenge is to make sure that the information is not distorted. Rapid release of uncertain or inaccurate information can cause panic in communities. Here is one example of such an occurrence: a local community radio in Klaten interviewed someone who had little expertise in volcanology but who expressed his opinion and even predicted future activity during the 2006 eruptive period of Merapi. This created confusion amongst the residents and would have better been avoided. Better communication between the authorities, the media and also the population should be enhanced to improve crisis management.

Raising public awareness. The limitation of institutional response is when efforts to minimize risk do not involve the community. Information on volcano-related hazards is disseminated through the members of hazard mitigation offices at regional or subdistrict levels. A major lesson was learned from the 1994 eruption: the national government stressed the immediate necessity to promote people's alertness to volcanic hazards and encouraged precautionary measures to be taken by local authorities to reduce vulnerability (UNDHA 1994).

'Shortly before the 2006 eruption and thereafter, there were many programmes related to disaster risk reduction committed by government or non-governmental organizations. The community plays an important role in disaster risk reduction. If they have better knowledge of volcanic hazards and their consequences on society, then in the future the expected risk could be reduced' (Yatin, 37 years old, Head of Ngargomulyo village, interviewed on 29 July 2010). After the 1994 eruption, the local hazard mitigation officers disseminated information about volcanic hazards and risks. However, this effort was not considered efficient because of the lack of community participation. Even though there were several participative programmes on disaster risk reduction, they were conducted in a fragmentary manner by non-governmental organizations. Then, on 26 May 2006, a cooperative network named Forum Merapi was initiated; it gathered local authorities from Sleman, Klaten, Magelang and Boyolali, the MVO, several local and international NGOs, academic institutions, and representatives of local communities. The forum's goal was to create a more comprehensive and participative disaster risk

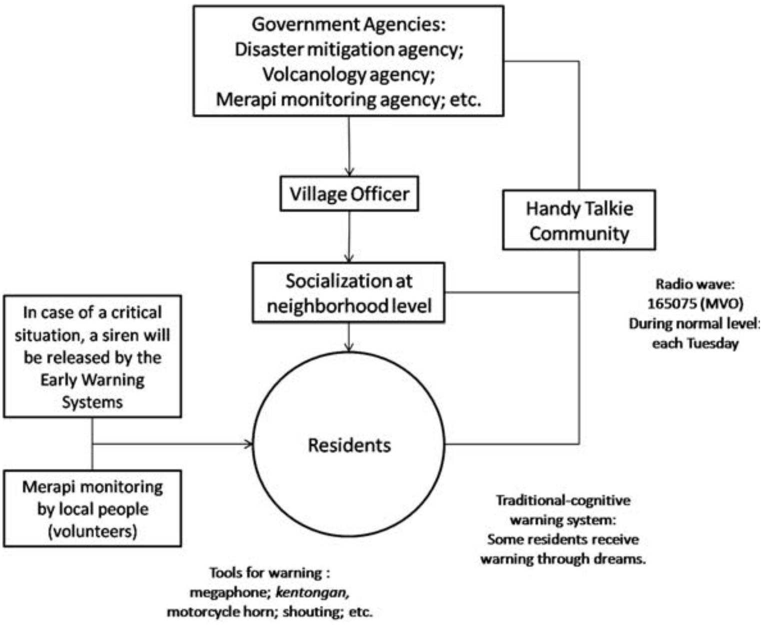

Fig. 8. Information flow during a volcanic crisis at Merapi Volcano (Sagala & Okada 2009).

reduction programme on the Merapi Volcano. Since 2006, several programmes on volcano-related disaster management were conducted under the forum's umbrella. For example, participative volcanic hazard mapping was conducted. Furthermore, local capacities to cope with disasters (Fig. 9) and community evacuation simulations were also integrated into disaster mitigation activities. Compulsory training programmes for hazard mitigation were applied in communities around Mount Merapi. Currently, the local authority of the Yogyakarta Province, in cooperation with the French Red Cross, is coordinating the disaster risk management and warning dissemination.

In 2006, before the eruption occurred, both the community and the government were well prepared in the four districts. In early April 2006, the government used four eruption scenarios prepared by volcanologists as part of their mitigation plans. The government and scientists used the third-case scenario (one level below the worst-case scenario, anticipating over 80 000 people to be displaced: UNOCHA 2006*a*). Logistics were prepared as early as April by local governments. An early warning system was also in place, which included a set of sirens and three CCTVs (close circuit televisions) to warn against incoming pyroclastic flows and lahars. An excellent example of pre-crisis management was carried out in the Sleman District, called the 'Sleman Disaster Information Network'. The scheme connects the regional disaster management agency, village offices, shelters, health centre and several schools within the high volcanic risk zone.

Forced migration. After the 1994 eruption, local authorities decided that 2700 evacuees from the five villages within the dangerous zone should be resettled in the *Sudimoro* (a Javanese word that means 'willing to come') village, located 8 km south of Turgo. Unfortunately, the plan to relocate was not accepted by the residents of Turgo, creating tension between local authorities and villagers who still wanted to live in their village. Several attempts were undertaken by the government to implement the resettlement plan. For example, the village of Turgo was erased from the government map and villagers were not recognized. 'It was difficult to relocate people from Turgo. The government even issued a statement that Turgo would be removed from official maps and its villagers would not be recognized. But this effort failed,

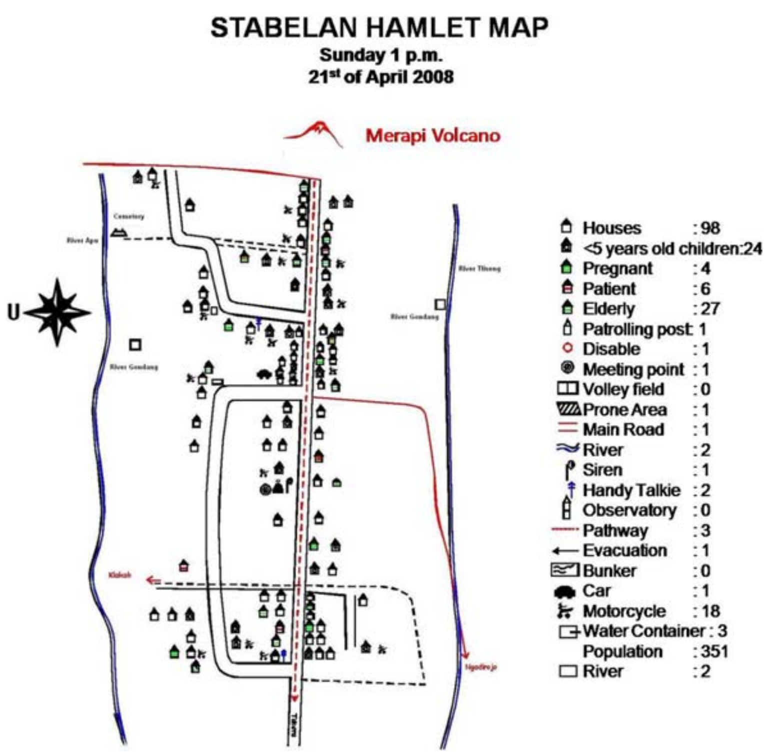

Fig. 9. Stabelan Hamlet map.

because many people finally returned to Turgo and remained there as before' (Misran, 44 years old, Head of Turgo village, interviewed on 28 April 2010).

New housing was built in the Sudimoro village. Although some villagers initially decided to move to the relocation area, most of them returned to Turgo (Dove 2008), even though the new houses were well constructed. Today, there are 111 households in the Sudimoro relocation site against 154 in Turgo, that is 40% of Turgo villagers are living in the resettlement. Attachment to their native village and easy access to resources from their land were the main reasons for wanting to return to live in Turgo after the 1994 eruption. 'Here (in Turgo), it is easier to make money. The access to the city is better in Sudimoro than here, but it is difficult for us to find a job in the city. Farming and cattle raising is our life. In Sudimoro, we do not have any land. If we live there, we have to go to Turgo every day, because our land is here' (Tukirah, 35 year-old woman from Turgo, interviewed on 10 May 2010).

The top-down structural mitigation effort to create resettlement was not well appreciated by the local community. Major issues were the lack of farming land and the difficulty to get food for their livestock. A sustainable post-disaster plan is one where victims participate in resettlement planning, which is an essential requirement (Oliver-Smith 1991). Similar resettlement problems also occurred in Mt Pinatubo's resettlement centre after the 1991 eruption (Gaillard 2008) or after the Skopje Earthquake in Macedonia (Davis 1977). Mitigation efforts should take into account the expectations, culture and socio-professional specificities of the affected people most concerned (Anderson 1993).

Without excluding the institutional modern mitigation measures, local knowledge and beliefs play an important role in disaster management, particularly in traditional societies. Communal perceptions of an event may be altered into myth-like stories and explanations (Cashman & Cronin 2008). In volcanic regions, local traditions and belief systems play an important role in motivating local reactions before, during and after a crisis (Swanson 2008). Thus, it is important to examine both hazards and culture in order to develop more-resilient communities.

Considering the fact that there are at least 5 million people living on the volcano slopes in Indonesia (BNPB 2010), the development of local capacity associated with volcanic disaster is absolutely necessary. Several approaches can be taken in order to gain more traditional knowledge of and responses to volcanic disaster, in the framework of a bottom-up disaster risk reduction programme. For example, participatory rural appraisal (PRA) or focused group discussion (FGD) allows scientists to understand the main local perspective concerns (Cronin *et al.* 2004). The participatory three-dimensional mapping is scheduled to be carried out in the summer of 2011 in order to combine the spatial and time elements, as well as community knowledge and responses to volcanic hazards and risks.

Conclusion

The gap between institutional responses and the community's way of thinking before, during and after crisis situations is the focus of this study. Institutional response to minimize risk is not as effective as when the community is involved. The fact that both people's awareness and the government are involved in ritual traditions shows that traditional and institutional responses towards disasters are closely linked.

Traditional responses towards disasters can provide an acknowledgement of the complexity of human response and a better understanding of the community's point of view on the disaster management process. Using top-down institutional responses to volcanic crisis is not sufficient in regions with a high cultural perception. Working with the community is an ideal solution to minimize the gap between the government, scientists, non-governmental organizations and the community itself. A community-based methodology combined with studies of physical hazards will generate a comprehensive risk and crisis management.

The following step that we propose in this study is to use participatory three-dimensional mapping for disaster risk reduction, where communities can express their knowledge and responses by combining spatial and time elements (Gaillard & Maceda 2009). However, it should be noted that these participative actions would be successful only if supported by at least four important stakeholders: society, government, scientific or academic institutions, and non-governmental organizations.

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