Systems Analysis of Social Resilience against Volcanic Risks:

Case Studies of Mt. Merapi, Indonesia and Mt. Sakurajima, Japan

by

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Chapter 1. Introduction

This chapter explores the introduction to this thesis, the research problem, research objectives and the research design.

1.1. Why is Social Resilience important?

Ronan and Johnston (2005) highlighted the importance of resilience which covers how people prepare for, respond to, and cope with man-made or natural disasters. They further pointed out that “resilience is linked to how well a community can bounce back after a major disaster”. Therefore, resilience is seen as one of the factors that significantly need to be included in the disaster preparedness at community level. The importance of social resilience issue was shown by recent research studies in several ways, such as proposing a framework to assess resilience (Bruneau et al., 2003), looking resilience as part of socio-ecological approach (Adger, 2000; Adger et al., 2005; Holing, 1973), defining the resilience (Klein et al., 2003) and researching factors that affect the social resilience (Paton, 2003; Paton et al., 2008).

The studies on resilience above indicate how a social system, including society and infrastructure, should have and develop it’s own mechanisms to deal with the external disturbances. This may be well addressed by knowing the source of the threats (hazard assessment) as well the internal capacities the social system. However many research studies yet emphasize more on the hazard assessment aspects (physical aspects).. Instead, we need to form how societies particularly respond to the hazards.

Many catastrophic disasters provided us with the examples of the necessities to increase communities’ resilience. For example, in the Tsunami Indian Ocean, it was found out if the communities living on the coastal areas of the affected countries had proper understanding of how the possible threats that might occur to their area, the number of victims might have been much lower (Kelman, 2006) . Similarly, it is important for a community to develop it’s own disaster preparedness at their home and communities before a disaster strikes, i.e. nailing furniture, earthquake proof structure, preparing water for emergencies, etc. However, it is even more difficult to take such proactive measures as many studies have found how communities are reluctant to enhance preparedness for a disaster.

A common assumption in public hazard education is that providing the public with information (i.e: flyers, yellow pages) on hazards and how to mitigate their consequences will motivate people to carry out disaster preparedness (Lindell and Perry, 2004; Quarantelli, 1997; Smith and Petley, 2009). Thus, community organizations and governments often carry out hazard education by providing information to the public in order to increase resilience. However, the above assumption is not supported by many research studies (Ballantyne et al., 2000; Duval and Mulilis, 1999; Lindell and Whitney, 2000; McLure et al., 1999; Mulilis and Duval, 1995; Paton, 2000). This has led to recognition that it is how people interpret their circumstances and the information available to them that underpins whether or not they decide to prepare for disaster (Lindell and Prater, 2002; Lindell and Whitney, 2000; Okada and Matsuda, 2006; Paton, 2003; Whitney et al., 2004).

Building on the previous work on how people's beliefs about hazards influenced behavior (Lindell and Whitney, 2000; McLure et al., 1999; Paton et al., 2005), Paton et al. (2008) developed a social resilience model that argued that people's interpretation of infrequent and complex hazard events involve personal beliefs, the social context in which beliefs about risk and how to mitigate it, and people's beliefs about expert and civic sources of hazard information, all interact to influence whether or not people prepare. It is the inclusion of the social context, and evidence for a significant role in western (individualistic) cultures that provided the basis for its selection as an appropriate model for exploring cross cultural similarities in how people decide whether or not to prepare for disaster.

1.2. Volcanic Hazards and Human Adjustments

Tilling (2005) estimates that about 10% of the world's population live within proximity of active and potentially active volcanoes. As the population increases, this number might become larger and indicate how more people will be at risk from the volcano hazards (Marti and Ernst, 2005). Besides the dangerous that a volcano could pose to the people, many inhabitants of areas affected by volcanoes are still less aware of the threat by the volcano. Gregg et al (2004) on their studies in Hawaii reported only a small number of the communities were aware of the threat from volcanic risks. Similarly, Lavigne et al (2008) reported a low level of awareness by the residents of Merapi on the potential hazards that might occur. To increase people's awareness of the volcanic risks, many researchers suggest the promotion of disaster education for people who are at risk.

Chester (1993) in his book "Volcano and Society" noted that "in any hazardous situation, realistic assessments of danger are required so that individual citizen may choose appropriate adjustments and responses". In addition, Keller and Blodgett (2008) mentioned that apart from the psychological adjustment to losses, the primary human adjustment to volcanic activity is evacuation as in an extreme eruption there is nothing one could do but to evacuate. Inline with this, Smith and Petley (2009) suggest it is essential that the population at risk is advised well in advance about the evacuation routes and the location of evacuation shelter prior to a volcanic eruption.

Nevertheless, community preparedness for a volcanic disaster is equally important. Paton et al (2008) argued a resilient community may know what actions to do when a volcanic disaster occurs. These include preparing some tools prior to an eruption, such as: a mask to prevent ash hazard from inhaling, a tool to clean up the ash and an evacuation map, etc.

The case study we discuss in this thesis examines the communities living on the slopes of volcano as the main attention. Mt. Merapi, one of the most active volcanoes in the world, is the home for many residents who live and earn their living from the volcano. Mt. Merapi is located at Java Island and in Yogyakarta province as shown by the arrow (Figure 1-2). The frequent eruption of this volcano is also expected to increase people' adaption of the volcano. Thus, the social resilience may also increase as the communities learn from their observation from the environment.

In addition to that, to give a broader perspective, an additional field study was also carried out at Mt. Sakurajima, Kagoshima Prefecture, Japan (Figure 1-3). Mt. Sakurajima is one of the most active volcano in Japan and therefore the residents are assumed to be more alert in term of their awareness towards the hazards from this volcano. The comparison between the two cases allow to find some common and un-common factors related to social resilience.

1.3. Research Objectives

As mentioned earlier, communities living on the slopes of Mt. Merapi have been frequently exposed to the volcano hazards. The history of the volcano occurrence in Mt. Merapi witnesses how dangerous the volcano is (see Table 3-3 on historical eruption of Mt. Merapi). Yet still many people live and have their sources of livelihood in this area. The way people survive and how resilience the people to the volcano hazards need to be examined thoroughly. The basic question may start from the following: Are the communities really prepared in the case of an eruption? Do they really know what to do when there is an eruption? Are they socially resilient to the disaster? What sort of factors affecting their decisions and intention to prepare for the volcano hazards?

Understanding the factors that affect the social resilience of a community will help us to better address the real problem. Social resilience governs the way the communities deal with their intention to prepare for the disaster. This is seen as a causal relationship model that is determined by factors that exist at individual, community and institutional level (Paton et al., 2008). Nevertheless, in an extreme situation evacuation might be the only way to survive (Perry and Godchaux, 2005). Therefore, apart from the examination on social resilience this research also examines the factors that correspond to the evacuation decisions (Figure 1-1). Figure 1-1 means social resilience covers the preparation activities prior to a disaster (preparedness and mitigation), during a disaster (warning and evacuation) and after a disaster (reconstruction). However, Keller and Blodgett (2008) and Smith and Petley (2009) argued that evacuation is critically needed when a volcanic eruption occurs. Thus, our study also examines the factors that are related or correspond to the evacuation decisions at household level.

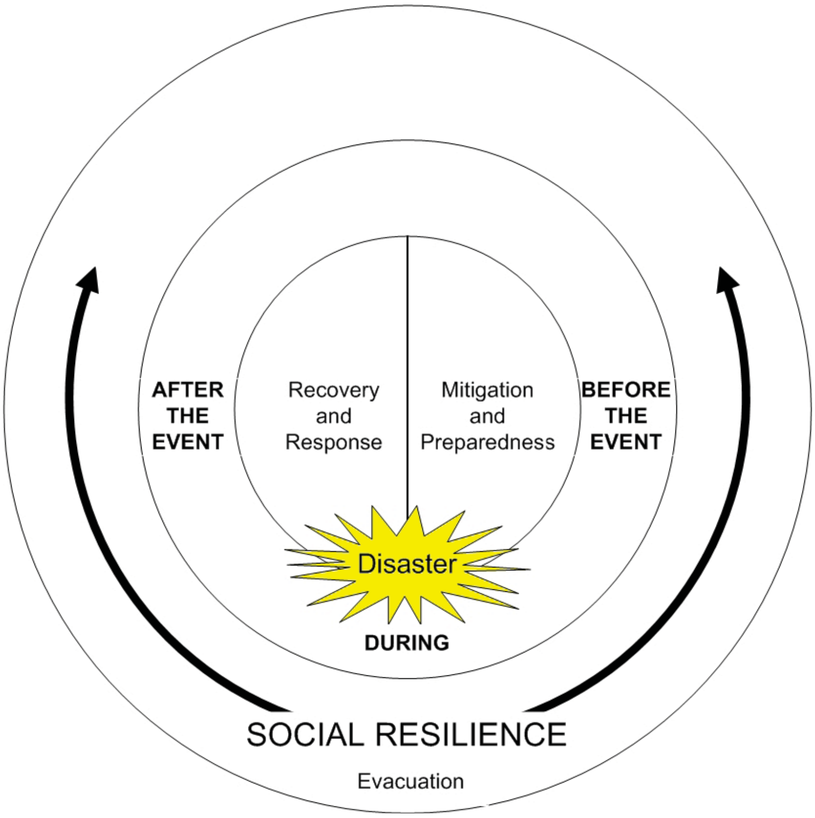

Figure 1-1 Disaster Clock: Positions of Social Resilience and Evacuation

Okada (2008) proposed a disaster clock to depict the disaster management cycle. A disaster management cycle normally includes the activities before a disaster occurs (includes the mitigation and preparedness), during the disaster and after the disaster (recovery and response). Using a similar concept, we could also see social resilience within the disaster management cycle. Additionally, evacuation is added into the concept of social resilience as in the context of volcanic eruption, evacuation is one of the major issues.

Evacuation decisions in this research are examined based on some factors proposed by several authors, such as hazard related factors (Lindell and Perry, 2004) and traditional cultural belief factors (Dove, 2008; Schlehe, 1996; Schlehe, 2007). The knowledge on how an evacuation decision is related to the above factors will help an emergency manager or government officials during an evacuation process. On the eruption in 2006, evacuation was the crucial issue that the government dealt with. This included the rejection of a number of residents to evacuate their houses as they are afraid of losing their belongings and the lack of quality of the evacuation shelters. Additionally, printed and online media reported the reason was due to the traditional beliefs that people hold towards the spirits in the volcano. However, after waiting for more than two months (April-June 2006), the eruption occurred yet no casualties to the residents except two volunteers from the other area who were burned by the heat from the pyroclastic flow.

In term of the time span, social resilience covers a wider area as it occurs at people daily live and in their relationships among the peers and the relationships with the authorities. On the other hand, the evacuation decisions were limited to a point where there is a possibility of extreme situation. The knowledge of both social resilience of communities and household evacuation decisions will help the local authority to make disaster risk reduction planning.

With the background above, the main aims of this thesis is to identify the main factors that affect the social resilience of the communities and the evacuation decisions of the household living in the slopes of this volcano. To deal with these issues, the approach in this thesis is mainly carried out with social resilience approach (chapter 4 and chapter 6) but complemented with evacuation decision analysis (chapter 5). The social resilience approach refers to a model developed by Paton (2003), while the evacuation decision refers to the literature related to evacuation decisions at household level (Lindell et al., 2005; Riad et al., 1999; Tobin and Whiteford, 2002; Zhang et al., 2004).

1.4. Selection of the case study areas

Communities living in Mt. Merapi are interesting areas to research about as they frequently experience the volcanic hazards from Merapi Volcano. Within the last decade, the eruptions in 1994 and 2006 are among the extreme events that occurred in this area. Subsequently, the communities must have learned from the eruption events and developed mechanisms to deal with volcano problems.

It is also interesting to test the application of "social resilience model" which has been previously applied in developed countries (New Zealand and Australia) to the case of a developing country like Indonesia. This interest has encouraged the author to carry out research under a developing country setting, applying models originally in developed countries and try to see what improvements or adjustments could be made to suite with the requirements in a developing country context. More importantly, testing the model at different environments will enable further cross-cultural comparative studies which will help increase common applicability and generality of the model.

Merapi, in fact, is interesting since in term of hazard studies has been accumulated in enormous literature studies (Newhall et al., 2000; Voight et al., 2000), yet the social aspects of Mt. Merapi are still lacking. Among those of few literature, one can refer to the following (Schlehe 1996, 2007 and Dove 2008). In a similar way, recent studies in disaster risk reduction argue that one can not see disaster from a physical science only but also from social or community perspective.

Figure 1-2 Location of Yogyakarta in Indonesia

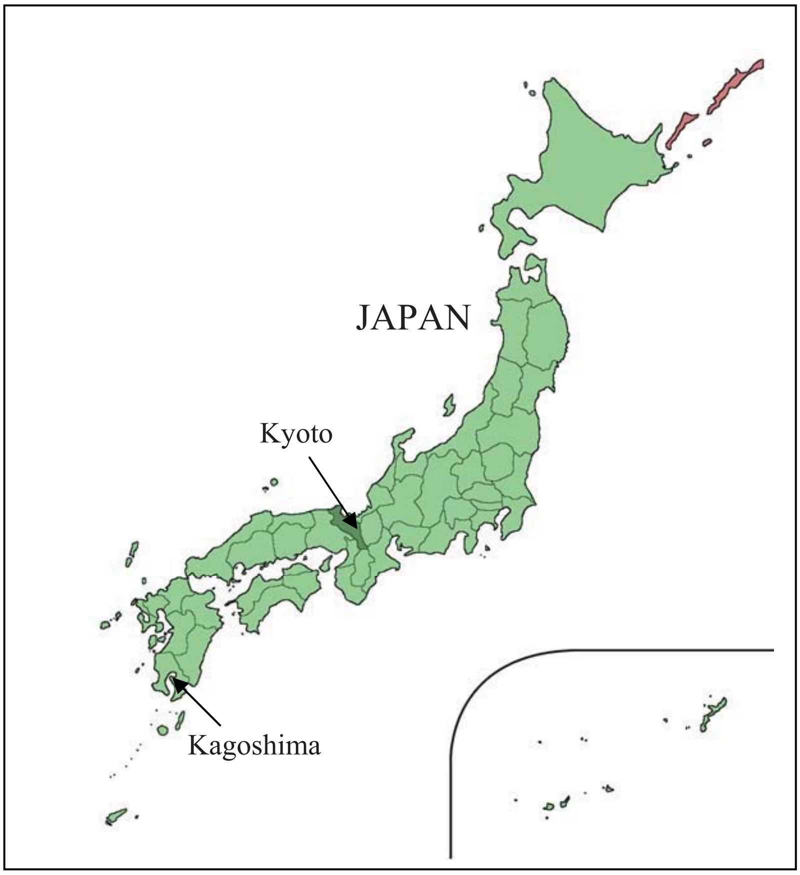

Figure 1-3 Location of Kagoshima and Kyoto in Japan
Source: Wikimedia

1.5. Research Framework

Based on the above discussions, structure of this thesis is designed as follows (Figure 1-4):

This thesis consists of seven chapters as described in Figure 1-4. The first chapter introduces the existing problem in the field of social resilience in Mt. Merapi and the outline of the study.

Chapter 2 describes the literature review of some significant studies related to volcanic hazards used in this study, some of the earlier studies carried out on social resilience and evacuation decision of households. Additionally, the theoretical background of the methods used (structural equation model) for this study is also discussed.

Chapter 3 discusses the process of the data collection, the issues of the case study areas.

Chapter 4 examines the social resilience of the communities living in Mt. Merapi. Factors involved in determining the social resilience are discussed also in this chapter.

Chapter 5 examines the factors that correspond to the household evacuation decisions.

Chapter 6 revisit the discussion on social resilience with the data of Kagoshima City which is affected by Mt. Sakurajima.

Chapter 7 concludes the thesis and provides policy implication and recommendation derived from the findings and discussions.

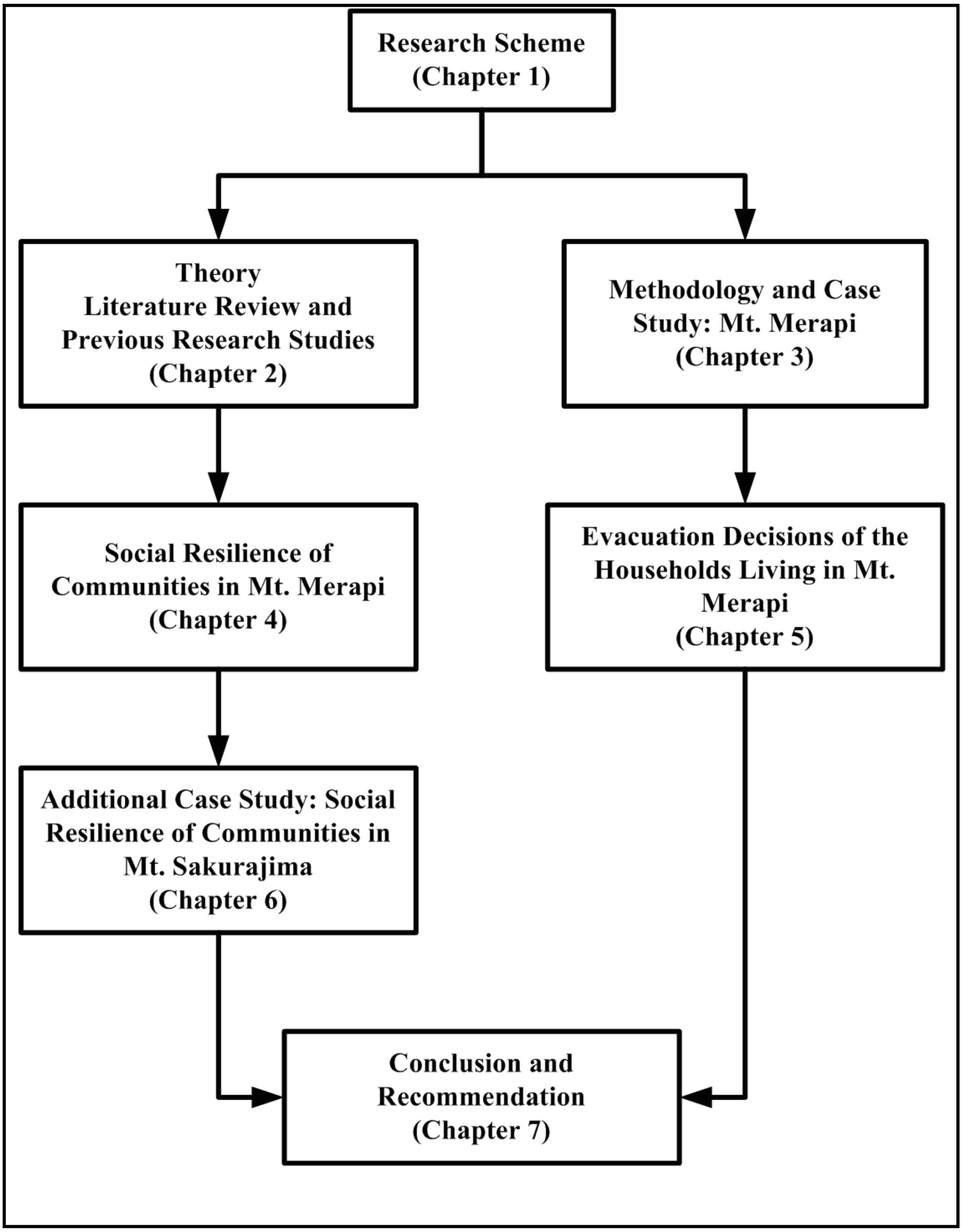

Figure 1-4 Research Framework

References

Adger, W., 2000. Social and ecological resilience: are they related? Progress in Human Geography, 24(3): 347-364.

Adger, W., Hughes, T., Folke, C., Carpenter, S. and Rockstrom, J., 2005. Social-Ecological Resilience to Coastal Disasters Science. Science Magazine, Accessed from www.sciencemag.org, December 3, 2006, 309.

Ballantyne, M., Paton, D., Johnston, D., Kozuch, M. and Daly, M., 2000. Information on Volcanic and Earthquake Hazards: The Impact on Awareness and Preparation, Institute of Geological and Nuclear Sciences Report, No. 2.

Bruneau, M., Chang, S., Eguchi, R., Lee, G., O'Rourke, T., Reinhorn, A., Shinozuka, M., Tierney, K., Wallace, W. and von Winterfeldt, D., 2003. A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. Earthquake Spectra, 19(4): 733-752.

Chester, D., 1993. Volcanoes and Society. Edward Arnold.

Dove, M., 2008. Perception of volcanic eruption as agent of change on Merapi Volcano, Central Java. Journal of Volcanology and Geothermal Research, 172: 329-337.

Duval, T. and Mulilis, J., 1999. A person-relative-to-event (PrE) approach to negative threat appeals and earthquake preparedness: a field study. Journal of Applied Social Psychology, 29: 495-516.

Gregg, C., Houghton, B., Paton, D., Swanson, D. and Johnston, D., 2004. Community preparedness for lava flows from Mauna Loa and Hualalai volcanoes, Kona, Hawaii. Bulletin of Volcanology, 66: 531-540.

Holing, C., 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4: 1-23.

Kelman, I. (2006), Warning for the 26 December 2004 tsunamis, Disaster Prevention and Management 15(1): 178-189

Keller, E. and Blodgett, R., 2008. Natural Hazards: Earth's Processess as Hazards, Disasters, and Catastrophes. Pearson Prentice Hall.

Klein, R., Nicholls, R. and Thomalla, F., 2003. Resilience to natural hazards: How useful is this concept? Environmental Hazards, 5: 35-45.

Lavigne, F., De Coster, B., Juvin, N., Flohic, F., Gaillard, J., Texier, P., Morin, J. and Sartohadi, J., 2008. People's behaviour in the face of volcanic hazards: Perspectives from Javanese communities, Indonesia. Journal of Volcanology and Geothermal Research, 172: 273-287.

Lindell, M., Lu, J. and Prater, C., 2005. Household decision making and evacuation in response to Hurricane Lili. Natural Hazards Review, 6(4): 171-179.

Lindell, M. and Perry, R., 2004. Communicating Environmental Risk in Multiethnic Communities. Sage Publication.

Lindell, M. and Prater, C., 2002. Risk area resident' perceptions and adoption of seismic hazard adjustments. Journal of Applied Social Psychology, 32(11): 2377-2392.

Lindell, M. and Whitney, D., 2000. Correlates of Household Seismic Hazard Adjustment Adoption. Risk Analysis, 20(1): 13-25.

Marti, J. and Ernst, G., 2005. Volcanoes and the Environment. Cambridge University Press.

McLure, J., Walkey, F. and Allen, M., 1999. When an earthquake damage is seen as preventable: attributions, locus of control and attitudes to risk. Applied Psychology: An International Review, 48: 239-256.

Mulilis, J. and Duval, T., 1995. Negative threat and earthquake preparedness: a person relative-to-event (PrE) model of coping with threat. Journal of Applied Social Psychology, 25: 1319-1339.

Newhall, C., Bronto, S., Alloway, B., Banks, N., Bahar, I., del Marmol, M., Hadisantono, R., Holcomb, C., McGeehin, J., Miksic, J., Rubin, M., Sayudi, S., Sukhyar, R., Andreastuti, S., Tilling, R., Torley, R., Trimble, D. and Wirakusumah, A., 2000. 10,000 Years of explosive eruptions of Merapi Volcano, Central Java: archaeological and modern implications. Journal of Volcanology and Geothermal Research, 100(1-4): 9-50.

Okada, N. and Matsuda, Y., 2006. Community Diagnosis for Sustainable Disaster Preparedness. Journal Of Natural Disaster Science, 28(1): 25-33.

Okada, N., 2008. Case Station-Field Campus (CASiFiCA)-DRH: Illustrations of Process Technology, IDRiM Forum, 1 Sept 2008, Varese, Italy.

Paton, D., 2000. Emergency Planning: Integrating Community Development, Community Resilience, and Hazard Mitigation. Journal of the American Society of Professional Emergency Planners,, VII.

Paton, D., 2003. Disaster preparedness: a social-cognitive perspective. Disaster Prevention and Management, 12(3): 210-216.

Paton, D., Smith, L., Daly, D. and Johnston, D., 2008. Risk perception and volcanic hazard mitigation: Individual and social perspectives. Journal of Volcanology and Geothermal Research.

Paton, D., Smith, L. and Johnston, D., 2005. When good intentions turn bad: Promoting disaster preparedness. The Australian Journal of Emergency Management, 20(1).

Perry, R. and Godchaux, J., 2005. Volcano Hazard Management Strategies, Fitting Policy to Patterened Human Responses. Disaster Prevention and Management, 14(2): 183--195.

Quarantelli, E., 1997. Problematical Aspects of the Information/ Communication Revolution for Disaster Planning and Research: Ten Non-technical Issues and Questions. Disaster Prevention and Management, 6(2): 94-106.

Riad, J., Norris, F. and Ruback, R., 1999. Predicting evacuation in two major disasters: Risk perception, social influence, and access to resources. Journal of Applied Social Psychology, 29(5): 918-934.

Schlehe, J., 1996. Reinterpretation of Mystical Traditions: Explanation of a Volcanic Eruption in Java. Anthropos, 91: 391-409.

Schlehe, J., 2007. Cultural politics of natural disasters: Discourses on volcanic eruptions in Indonesia. In: M. Casimir (Editor), Culture and The Changing Environment:

Uncertainty, cognition and risk management in cross-cultural perspective, Berghahn, Oxford/ New York.
Smith, K. and Petley, D., 2009. Environmental Hazards: Assessing risk and reducing disaster. Routledge.
Tilling, R., 2005. Volcano Hazards. In: J. Marti and G. Ernst (Editors), Volcanoes and the Environment, pp. 121-151.
Tobin, G. and Whiteford, L., 2002. Community Resilience and Volcano Hazard: The Eruption of Tungurahua and Evacuation of the Faldas in Ecuador. Disasters, 26(1): 28-48.
Voight, B., Sukhyar, R. and Wirakusumah, A., 2000. Introduction to the special issue on Merapi Volcano. Journal of Volcanology and Geothermal Research, 100(1-4): 1-8.
Whitney, D., Lindell, M. and Nguyen, H., 2004. Earthquake Beliefs and Adoption of Seismic Hazard Adjustments. Risk Analysis, 24(1): 2004.
Zhang, Y., Prater, C. and Lindell, M., 2004. Risk Area Accuracy and Evacuation from Hurricane Bret. Natural Hazards Review, 5(3): 115-120.

Chapter 2. Literature Review

This chapter describes the theoretical background applied in this study. First, to make things clear, some definitions of volcano hazards which are relevant for this study are explained. This aims to give a basic understanding of what hazards the communities have to cope with. Next, we discuss the literature on social resilience of communities and household evacuation decisions in the context of disaster preparedness. Finally, the theoretical background of the methods used in this study is also discussed.

2.1. Some definition of volcanic hazards

To provide a clear meaning of hazards that are discussed in this study, the following section covers brief characteristics of volcanic hazards. The explanation of the volcanic hazards below refer to those mentioned in literature of physical characteristics of volcano, such as those of Smith and Petley (2009), Tilling (2005) and Keller and Blodgett (2008) as illustrated by Figure 2-1. The relative measure of the explosiveness of volcanic eruptions was measured through the Volcanic Explosivity Index (VEI). The VEI was devised by Chris Newhall of the U.S. Geological Survey and Steve Self at the University of Hawai'i in 1982 (Newhall and Self, 1982).

Volcanic hazards may be divided into primary and secondary hazards (Smith and Petley, 2009) (see Figure 2-1).

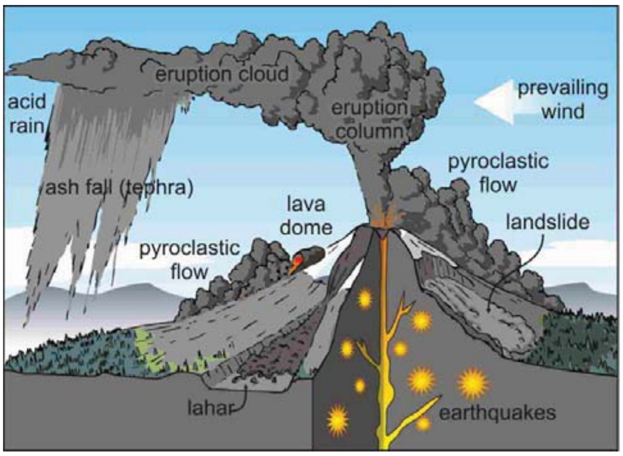

Figure 2-1 Types of volcano hazards

In the following picture, we can find the illustration of volcanic hazards and where they normally occur. In the case of Mt. Merapi, the most common phenomenon includes the occurrence of pyroclastic flows, lava and lahars. Image courtesy of Geological survey of Canada (2009) .
Source: http://gsc.nrcan.gc.ca/volcanoes/images/fig32_e.jpg

2.1.1. Primary Volcanic Hazards

Primary volcanic hazards are associated with the products ejected by the volcanic eruption. They include lava flows, air-fall tephra and pyroclastic activity (see Figure 2-1). Lava flows occur when magma reaches the surface and overflows the central crater or erupts from a volcanic vent along the flank of a volcano. Lava flows can be quite fluid and move rapidly or be relatively viscous and move slowly. With the exception of some flows on steep slopes, most lava flows are slow enough for people to easily move out of the way as they approach. The speed of volcanic materials during the eruption is presented in Figure 2-2.

Tephra comprises all the fragmented material ejected by the volcano that subsequently falls to the ground. Most eruptions produce less than 1 km^3 volume of material but the largest explosions eject several times this amount. *Pyroclastic* activity refers to explosive volcanism in which tephra is physically blown from a volcanic vent into the atmosphere. *Pyroclastic flows* are also known as ash flows, hot avalanches, *nuee ardentes* (French) or *awan panas* (Indonesian). Eruption in Mt. Merapi normally includes the occurrence of awan panas or pyroclastic flows. The fast moving pyroclastic flow in November 1994 surged down to Turgo hamlet at Merapi Volcano which killed at least 60 people, injured a dozen of the residents and caused major physical damages.

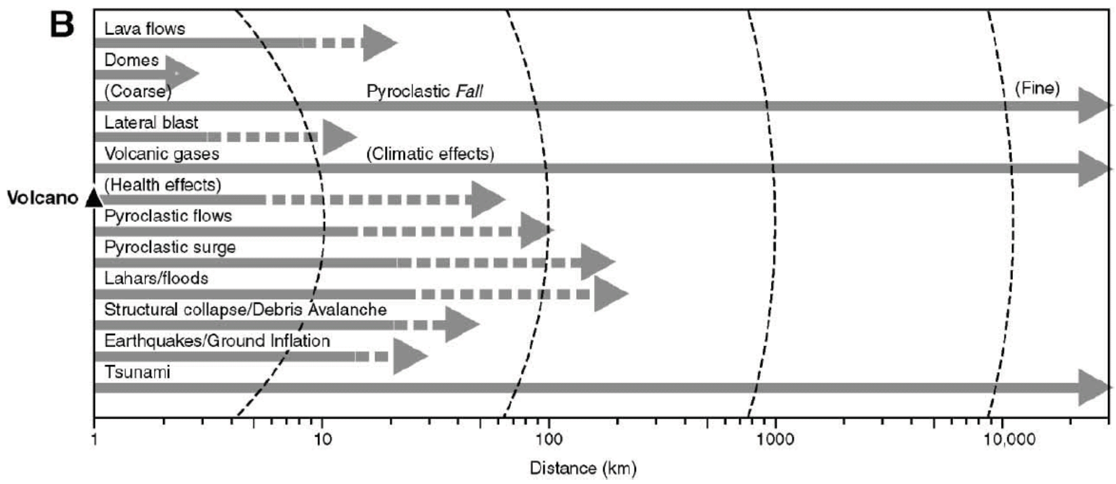

Figure 2-2 Distance of the impact of destructive phenomena of volcanic eruptions

From this figure, we can see that pyroclastic flows may occur for more than 10 km away from the volcano. Lahars, as induced by rainwater, may reach even further distance.

Image courtesy of Chester et al. (2001)

Figure 2-3 Pyroclastic Flow in Mt. Merapi
Image of the very hot pyroclastic flows in Mt. Merapi that may occur at more than 100 km / hour. The temperature of the pyroclastic may reach up to 200 Celcius. Image is the courtesy of Klaten Government (www.klaten.go.id)

2.1.2. Secondary volcanic hazards

Secondary volcanic hazards are those that are not directly associated with an eruption, but rather result from the environment created by the volcano. They include landslides, debris flows, mudflows, groundwater contamination, and surface water contamination. All these hazards may persist at a volcano for decades after an eruption and even long after the volcano is considered extinct. The secondary volcano hazards include the occurrence of lahars after the remnant or debris of lava and pyroclastic flows were flown by rainwater.

Lahar is an Indonesian word that describes a slurry of water and rock particles produced directly or indirectly by volcanic activity (for example lahars in Mt. Merapi, see Figure 2-4). Lahars typically have the consistency of wet concrete and consist of particles of many different sizes, ranging from flour-sized particles to blocks as large as houses. Although extremely destructive, they are topographically controlled, and usually follow river valleys where they are confined to valley bottoms. They are most common and voluminous as a result of explosive eruptions on snow-clad volcanoes, because pyroclastic flows can instantaneously melt ice and slow, creating large-volume lahars.

Figure 2-4 Lahars in Mt. Merapi

Lahars in Mt. Merapi brought a large amount of sands and rocks along the river channels. After the occurrence of lahars, the local people collect sands and rocks for construction materials. This figure shows many trucks and workers down the Gendol River to transport the sands and rocks and sell them to the city. Image is courtesy of Bozhart (2007)

Source: http://media.photobucket.com/image/lahar%20merapi/bozhart/e85d4dd9.jpg

2.2. Concept of Social Resilience

There are many definitions of social resilience. Among the first and famous definition of resilience is back to year 1973 when Holling introduces this concept on his paper titled "resilience and stability of ecological systems". According to Holling (1973), resilience includes two aspects: i) the ability of the system to "bounce back" to the previous equilibrium state after the disturbance and ii) the degree to which the system can absorb the disturbance and still remaining in the equilibrium state. So, this definition deal with the internal of the systems and the systems adapt to the external shocks.

However, this system can be seen as a community or a group, as Adger (2000) attaches the word "social" to resilience and defines (social) resilience as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change. This definition highlights social resilience in relation to the concept of ecological resilience which is a characteristic of ecosystems to maintain themselves in the face of disturbance. Social resilience has economic, spatial and social dimensions and hence its observation and appraisal require interdisciplinary understanding and analysis at various scales.

In further clarification, Adger et al (2002) delineates social resilience as the ability of a community to withstand external shocks and stresses without significant upheaval. Although the notion of community long has been problematic, resilience at this level can be conceived as made up of, or shaped by, the dynamic structures of livelihoods, access to resources, and social institutions. External shocks and stresses, including changes in government policy, civil strife, or environmental hazards, exert pressures on social structures, livelihoods, and resources. When communities are resilient – with a resilient and accessible resource base and a dynamic range of viable livelihoods and responsive institutions – they may be able to absorb these shocks, and even respond positively to them. However, when communities are less resilient – perhaps because their resource base is fragile or inaccessible, their set of livelihoods are insecure, or their community institutions are rigid – or when external changes are rapid and far reaching, significant upheaval may occur.

Walker et al (2002) argue that the terms “resilience” and “adaptive capacity” are sometimes used interchangeably. The amount of change a system can undergo (and, therefore, the amount of stress it can sustain) and still retain the same controls on function and structure (still be in the same configuration—within the same domain of attraction). The degree to which the system is capable of self-organization.

In term of socio-psychology, the term “resilience” (Dunning, 1999) encompasses a paradigm shift that accommodates the analysis and facilitation of growth. Resilience describes an active process of self-righting, learned resourcefulness and growth – the ability to function psychologically at a level far greater than expected given the individual’s capabilities and previous experiences. Dunning (1999) further described that resilience comprises of three components: dispositional, cognitive, and environmental. Dispositional resilience defines how personal characteristics affect adjustment or personal preparedness. The cognitive component is related with the individual’s sense of coherence and meaning. Environment is seen as management strategies that create practices, procedures and a culture which mitigate adverse consequences and maximise potential for recovery and post-traumatic growth.

2.2.1. Measuring resilience

Paton and Johnston (2001) argue that to be valuable for emergency planning, resilience variables must have predictive capability and validity independent of the community or hazard under investigation. They further pointed out the importance of identifying the generic principles that underpin resilience and can facilitate the development of models capable of use with diverse communities and hazards, and provide emergency managers with a framework within which they can develop strategies tailored to the specific context (e.g., mix of hazard and community characteristics) within which they will be used.

The quantification of social resilience using a socio-psychological approach was first proposed by Paton (2003) (see Figure 2-5) and further supported by findings by the other research studies (Paton et al., 2008; Paton et al., 2005).

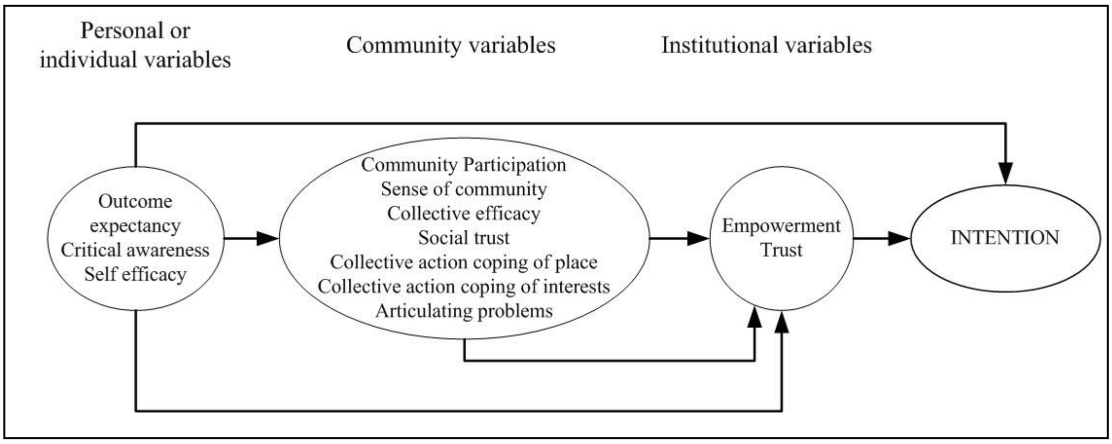

Figure 2-5 Conceptual factors that affect social resilience
Adapted from Paton (2003)

In the concept of social resilience, it is assumed that an individual adjustment or preparedness will be influenced by the interplay of three groups of variables at individual, community and institutional level. Figure 2-5 illustrates the proposed model of how these factors are inter-related each other. It is based on the assumption that relationship between people, communities and civic agencies influence the decisions whether or not to act to reduce risk (Kee and Knox 1970; Mayer et al 1995). The model starts from the individual accounts or perception of disasters and continues to get connected with the community and institutional factors, The factors in this model are described in the following sections.

2.2.2. Personal Variables

Personal variables include all factors at personal or individual level that affects the intention (to carry out preparedness) and affect other factors that contribute to intention. In the social resilience approach, the personal factors include critical awareness, outcome expectancy and self-efficacy variables.

Critical awareness

Critical awareness describes the extent to which people think and talk about a specific source of adversity or hazard within their environment. Lindell and Whitney (2000) proposed the inclusion of a similar variable. However, their recommendation was based on a measure of traumatic stress symptomatology, intrusiveness that is symptomatic of the subconscious processing of discordant information following a traumatic experience. In contrast, Dalton et al. (2001) describe a process that prevails under normal, and pre-disaster, circumstances, which describes conscious reasoning about issues people perceive as personally important. A role for critical awareness may be particularly important given the rarity of natural hazard activity, and the fact that, in contemporary society, people face adversity from several sources: natural hazards, unemployment, crime and so on.

Self efficacy

Self-efficacy has been implicated as a precursor of adjustment adoption and resilience in natural hazards contexts (Bishop et al., 2000; Duval and Mulilis, 1999; Hurnan and McLure, 1997; Lindell and Whitney, 2000; Paton and Johnston, 2001; Paton et al., 2001). For example, the number and quality of action plans, and the amount of effort and perseverance invested in risk reduction behaviours is strongly dependent on self-efficacy (Abraham et al., 1998; Bennet and Murphy, 1997). Third, natural hazard effects are often perceived as uncontrollable. Self-efficacy has been identified as a significant influence on behaviour when dealing with issues perceived as less controllable (Godin and Kok, 1996).

Outcome expectancy

Consistent with the predictions of the social cognitive approaches outlined above, it is proposed that outcome expectancy will precede efficacy judgements. The model postulates that once motivated to think about hazards, people then make judgements regarding whether their actions will mitigate hazard effects. If a person forms a favourable Outcome Expectancy, whether or not they progress towards the formation of preparedness intentions is a function of the level of their self-efficacy beliefs (Paton, 2003). Ballantyne et al's. (2000) finding that this outcome resulted from people transferring responsibility for safety from the self to others illustrates how people's reasoning can support decisions not to prepare. Health research has identified outcome expectancy (perceptions of whether personal actions will effectively mitigate or reduce a problem) and self-efficacy (beliefs regarding personal capacity to act effectively) as predictors of intention formation (Abraham et al., 1998; Bagozzi and Edwards, 1998; Bandura, 1992; Bennet and Murphy, 1997).

Negative outcome expectancy reflects beliefs that hazard consequences are too catastrophic for personal action to make any difference to peoples' safety. If people hold this belief (outcome expectancy), no further action is likely to take place. In contrast, positive outcome expectancy (the belief that preparation can increase personal safety) can motivate people to prepare. However, a distinction can be drawn between the belief that preparing can be effective and knowing how to prepare. Consequently, if people hold positive outcome beliefs and possess the necessary knowledge and resources to prepare, they will act. If however, they need guidance to understand their circumstances and what they should do, people look first to other community members and subsequently to emergency management agencies.

2.2.3. Community Variables

The community factors include the community participation, collective efficacy and sense of community.

Community Participation

Faced with complex and uncertain events, when lacking all the information they need themselves, peoples' perception of risk and how to manage it is influenced by information from others who share their interests and values. Because participating in community activities provides access to information from people that share one's interests, values and expectations, a measure of "community participation" (Eng and Parker, 1994) was included in the model.

Collective Efficacy

However, the infrequent nature of volcanic activity means that people may first have to work out what consequences they could have to deal with to identify the information they need to prepare. Because it provides a means of assessing community members' ability to identify the information, resource and planning needs required to advance their tsunami preparedness, a measure of 'collective efficacy' (Zaccaro et al., 1995) was incorporated in the model. Paton and Johnson (2001) discussed how collective efficacy is a good indicator of co-operation and assistance available within a community and thus it represents a measure of the likelihood of the success of mitigation strategies that require collective and co-ordinated action.

Sense of Community

Sense of community (feelings of attachment for people and places) can influence adjustment decisions (Bishop et al., 2000; Paton et al., 2000). People with strong feelings of belonging to a place may be more likely to convert intentions into actual preparedness. The degree to which people accept personal responsibility for their safety may act in a similar capacity (Ballantyne et al., 2000; Duval and Mulilis, 1999; Lindell and Whitney, 2000; Mulilis and Duval, 1995; Paton, 2000; Paton et al., 2000). If people perceive others (e.g. local councils, emergency management agencies) as being responsible for their safety, they are less likely to convert intentions to actions (Ballantyne et al., 2000). The unpredictable and infrequent nature of natural hazard activity means that beliefs regarding the anticipated timing of the next damaging hazard event could moderate the relationship between intentions and adjustment adoption (Mulilis and Duval, 1995). The longer this time interval is perceived to be, the less likely people are to perceive any urgency to act on their intentions.

Social Trust

With respect to whether trust influences people's decision making, two aspects of the situation have been identified as being important (Mayer et al., 1995; Siegrist and Cvetkovich, 2000). The first concerns familiarity with a situation. The second involves the availability of information. The importance of social trust, according to this view, is inversely related to familiarity with the hazard, and the availability of information about the hazard. As frequency and experience increase, the more information will be directly available to the person or accessible from within their community, negating the need to acquire and evaluate information from other sources. Consequently, it is only in unfamiliar situations, in which reliance upon external expert sources is greater, that trust in the source of information becomes a component in decision making about mitigation. While this relationship has been found for several technological hazards (Siegrist and Cvetkovich, 2000), its applicability to infrequently-occurring natural hazards has not been examined. The communities differ with regard to their relative familiarity (based on frequency of exposure) with each hazard.

The model (Kee and Knox, 1970; Mayer et al., 1995) predicts that levels of social trust will be predicted by community characteristics that reflect the capacity of community members to acquire and use information to confront the uncertainty they face. This prediction was tested using data from the low familiarity/low information volcanic scenario.

Articulating Problems

Community groups must be able to articulate their needs into a set of meaningful questions, the answers to which will reduce their uncertainty and provide direction for their actions. Eng and Parker's (1994) measure of ‘articulating problems’ was used to assess this aspect of community functioning. Eng and Parker also argued that the utility of the information provided is a function of the quality of the inter-relationships people enjoy with its sources: in this case local councils in general and their emergency management functions in particular. Participation, per se, will not necessarily allow people to assess the utility of the information they receive. That is, community members need some means of evaluating information in a way that reduces their uncertainty and facilitates their ability to act in ways consistent with their needs and expectations (Earle, 2004; Lion et al., 2002; Paton et al., 2006a). One way in which this can be achieved is by defining the problem for which they seek information. It is the consistency between the expectations formed through problem definition and the information received that helps people reduce uncertainty (Earle, 2004; Paton et al., 2006a) and influences trust.

Diversity

A further consideration is whether sections of the community can be differentiated with regard to the source(s) they find most influential (Latimer and Martin-Ginis, 2005). If groups can be differentiated in this regard, strategies will need to be developed to accommodate this aspect of diversity (Paton, 2005). It will also be pertinent to examine whether referents can be influential vicariously, or whether contact is a requirement.

The rarity of hazard phenomena suggests that the process should focus on integrating hazard education with community development and problem solving to deal with existing or contemporary problems, with a focus on opportunities for growth. These scenarios can be used to elicit their hazard perceptions, and the information and resource requirements necessary for their formulation and adoption of mitigation strategies, consistent with their beliefs, needs and goals, to capitalise on, contain or minimise demands. This approach makes it easier to accommodate the diversity and distribution of groups within a community by facilitating their access to appropriate information and through mobilising natural coping strategies rather than attempting to develop communication strategies to meet the needs of all possible groups (Paton and Johnston, 2001)

Collective action coping of place and interests

To meet requirements of Japanese social organization two additional scales were developed to fit in the Paton's model (Bajek, 2007): "Collective Action Coping with regard to communities of place and Collective Action Coping with regard to communities of interest, thus named as "collective action coping of place (CACP)" and "collective action coping of interests (CACI)", respectively. Collective action coping of place reflects the belief in confronting problems in life collectively with the members of residential community (community of place). Meanwhile, collective action coping of interest reflects the belief in confronting problems in life collectively with the members of outside community (community of interest) that can be school, work, friends, sports club etc. This distinction was made to capture the potential predictor of social resilience which may originate from outside of residential community. This differentiation makes this research original and distinctive from the others.

2.2.4. Institutional Variables

The institutional variables involve empowerment and trust in the model.

Empowerment

Given that this process may identify new information and resource needs that cannot be met within existing community contexts, the degree to which these needs are met by expert sources has a salient role in the model. People's willingness to take responsibility for their own safety is increased, and decisions to prepare more likely, if they believe that their relationship with formal agencies is fair and empowering (e.g., agencies are perceived as trustworthy, as acting in the interest of community members). If this relationship is not perceived as fair and empowering , people lose a sense of trust in the agency (i.e., the source of information), reducing the likelihood that they will use the information and prepare. Empowerment means citizens' capacity to gain mastery over their affairs while being supported in this regard by external sources . "Empowerment" was assessed using a measure developed by Speer and Peterson (2000) and "trust" with a measure used in an earlier study of hazard preparedness (Paton et al., 2005).

Trust

According to this view, the concepts of participation and empowerment (Dalton et al., 2001; Paton, 2000) deserve inclusion. Recent work on the importance of trust in the authorities as a determinant of community action (Dillon and Phillips, 2001 in Paton, 2003) warrants its inclusion here. Trust and participation/empowerment are thus included here as moderators.

The greater the uncertainty they face, the more people attribute weight to their trust beliefs about a source of information (Johnson-George and Swap, 1982; Sjoberg, 1999). Trust influences perception of other's motives, their competence and the credibility of the information they provide (Earle, 2004; Kee and Knox, 1970). As such, it would be expected to play a prominent role in mediating relationships concerned with acquiring information about, understanding, and taking action to mitigate infrequently-occurring natural hazard consequences. While considerable attention has been directed to the content of risk communication, the role of people's perceptions of agencies that provide the information has been less extensively researched. This paper examines how trust in the civic agencies that provide risk communication influences hazard preparedness.

When dealing with natural hazard issues, people rely on sources (e.g. emergency planners) with whom they have a general relationship (e.g. their being officers of local councils or other civic agencies) that extends beyond natural hazard issues. Hence, the quality of trust developed in general contexts (e.g. in relation to people's experience of council/civic services, their dealings with council officers) may influence trusting in the context of risk communication about infrequent natural hazard events. The specific relationship between trust in civic emergency planners and the quality of risk communication has not been systematically examined. The relationship between trust and hazard mitigation is examined using a model developed by Kee and Knox (1970) and Mayer et al. (1995) that views trust as a process influenced by situational (familiarity, information availability) and structural (e.g. community competence) factors.

2.2.5. Intentions

Building on previous work (Paton et al., 2005), the extent to which critical awareness, outcome expectancy, action coping and trust predicted intention to prepare was examined. The inclusion of intention as the dependent variable is consistent with a model that argues that intentions precede actions (Mayer et al., 1995).

This model examines preparing as a process that involves people making judgements regarding the relationship between themselves, the hazards present in their environment, and the action available to mitigate the attendant risk (Paton, 2003). It is argued that an important component of this process is the mediating role that intentions play in deciding how to deal with hazard consequences. In a study of intentions to prepare for earthquake hazards, Paton et al. (2006b) demonstrated that intention comprised two factors; “intention to prepare” and “intention to seek information”. Importantly, while “intention to prepare” did predict the adoption of protective measures, “intention to seek information” did not. The latter represented an end-point in itself and held no relationship with actual preparedness activity.

Intentions provide valuable insights into how people are reasoning about their relationship with hazards. While those who form “intentions to prepare” are likely to convert them into actions, the formation of “intentions to seek information” appears to preclude the adoption of protective measures. The finding that this differential relationship is apparent for earthquake and bushfire hazards adds support for the contention that it represents a consistent characteristic of how people evaluate their relationship with hazards.

There are at least two ways to measure the intention. The first way is to use an “aggregate” variable which represent the intention. This means all variables contribute to the resilience. On the other hand, second approach is to “disaggregate” the intention into “intention to seek for information” and “intention to prepare”. The use of this approach is valid and is applied in papers by Paton et al. (2006b) and Paton et al. (2005) which differentiated these two (see Figure 2-6).

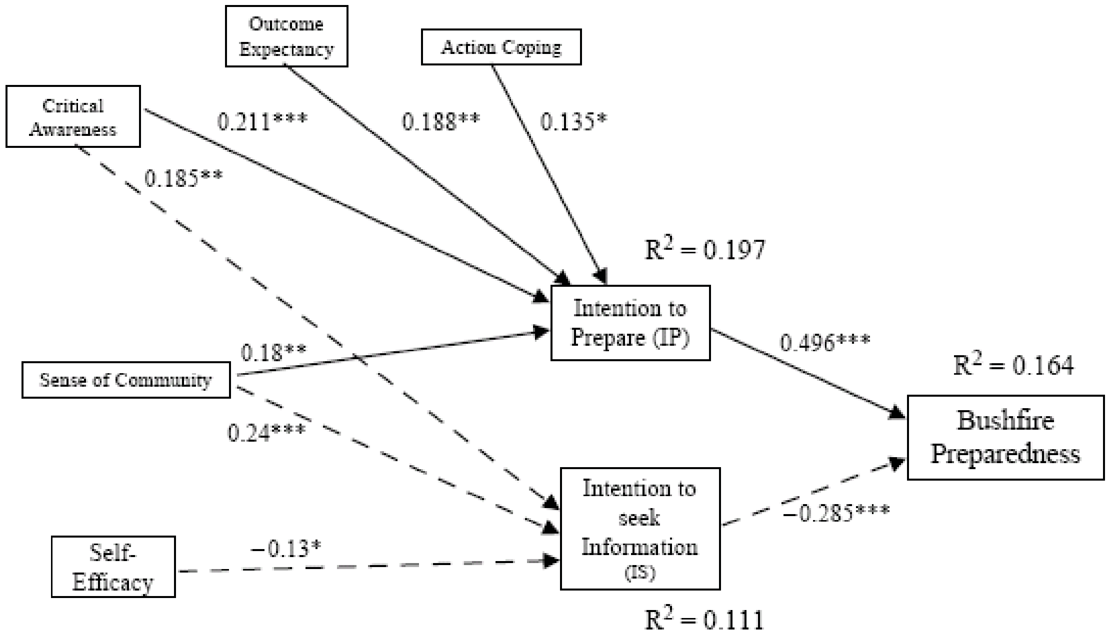

Figure 2-6 Predictors of Intention to Prepare and Intention to Seek for Information
Source: (Paton et al., 2006b)

2.3. Previous studies in Auckland and Kyoto

The previous factors discussed in section 2.2 were applied in the communities in Auckland and Kyoto. In Auckland, New Zealand, it was applied to the people who were threatened by the volcano while in Kyoto it was applied to people under earthquake disasters.

2.3.1. Case Study of Auckland, New Zealand

Building on work that identified how people's beliefs about hazards influenced behavior (Lindell and Whitney, 2000; McLure et al., 1999; Paton et al., 2005), Paton et al. (2008) developed a model that argued that people's interpretation of infrequent and complex hazard events involved personal beliefs, the social context in which beliefs about risk and how to mitigate it, and people's beliefs about expert and civic sources of hazard information interact to influence whether or not people prepare. It is the inclusion of the social context, and evidence for it playing a significant role in western (individualistic) cultures that provided the basis for its selection as an appropriate model for exploring cross cultural similarities in how people decide whether or not to prepare for disaster.

Figure 2-7 Map of New Zealand and Location of the Case Study

Source: Lonely Planet

The model was applied using data from communities living in Auckland, a city that was built on a volcanic field that last erupted about 600 or so years ago. The data collection was conducted in the form of telephone survey to 297 Auckland residents (Paton et al., 2008).

The main measures of the model in Auckland were based on two personal variables (negative and positive outcome expectancy), two community variables (community participation and articulating problems) and two institutional variables (empowerment and trust). All these previous variables were then linked with dependent variable intention to adopt protective measures using structural equation model (SEM) (see Figure 2-8).

The estimated model (Figure 2-8) described how each variables above contributed to other variables and the intention which is shown in the value of relationship varies from 0 (no relationship) to 1. Positive and negative outcome expectancy indicated the highest strength of relationship with intention (0.43 and 0.23), while other variables such community participation and trust contributed 0.14 and 0.16 respectively (see Figure 2-8). The high values of personal variables, as compared to community and institutional variables, indicated that one will likely to carry out intention if they have strong belief in the capacity of personal action to mitigate the risks. The small, but significant, relationship between community participation and intention illustrated the role of community participation that people sharing similar beliefs and values would likely forge their risk perception and risk management choices.

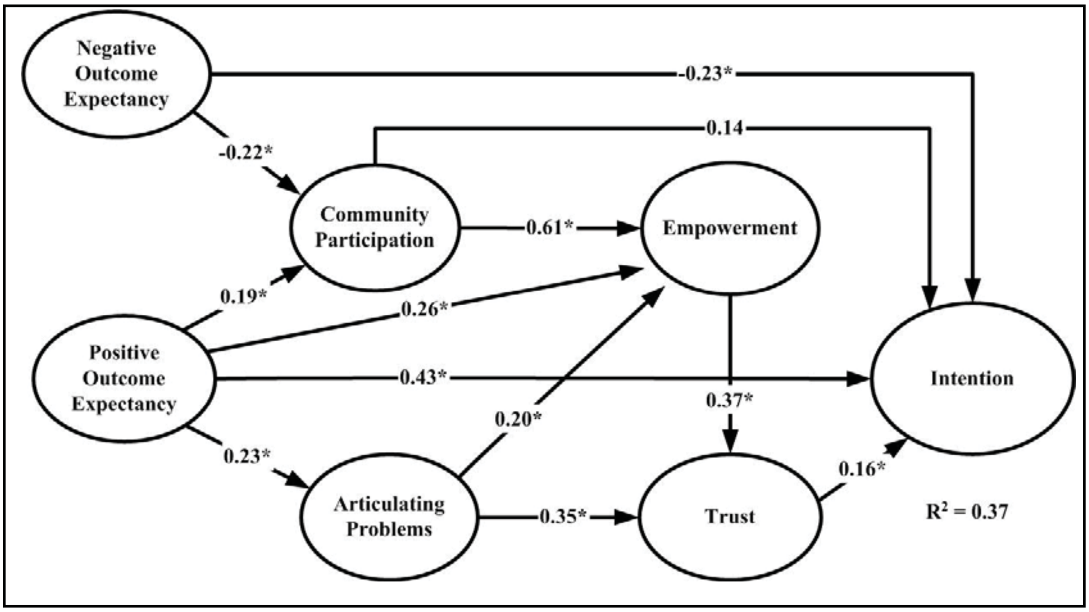

Figure 2-8 Social Resilience of the Communities in New Zealand

Summarized structural equation model of social predictors of intention to prepare for volcanic hazards (Auckland, 2005) ($\chi 2$ = 9.02. df = 11, p -0.62) RMSEA = 0.052, GFI = 0.99, NFI = 0.98. This model shows a direct contribution to intention from personal variables (negative outcome expectancy and positive outcome expectancy), community variables (community participation and articulating problems) and institutional variables (empowerment and trust). Source: Paton et al 2008

2.3.2. Case Study of Kyoto

Shuhachi, Nakagyoku Ward, Kyoto City, Japan has an active community-based disaster prevention organization "Jishubosai-soshiki". Annually, they carry out a disaster drill that aims to remind the people to get prepared in case a disaster occurs (Figure 2-9).

A similar study as the case study in Auckland was also carried out in this Shuhachi community by Bajek (2007). Sagala et al. (2008) also followed up this and checked the level of intention of people in this area and found the following information found that only a few people had intentions to carry out preparedness against earthquake risks.Kyoto indicates a typical Japanese society where collective and organized actions are often carried out. Data collection processes were carried out through mailing the questionnaires and the respondents were provided with stamps to return the filled-up questionnaire. The sources of hazard are earthquakes and fires as the Kyoto city is located along several fault lines prone to cause earthquakes. Thus, the model was developed with reference to people' view on threats from earthquake hazards.

The results of the model indicated high value of the relationships between intention with community variables, such as community participation and collective efficacy were 0.20 and 0.27 respectively. Variables at personal level (positive and negative outcome expectancy), however, indicated lower values, as compared to community variables (Figures 2-10, 2-11 and 2-12).

Figure 2-9 Disaster Drills in Shuhachi, Kyoto, Japan

This figure describes an annual disaster drill carried out by Shuhachi Jishu-Bo, a disaster prevention community organization. Image courtesy of Saut Sagala (2008).

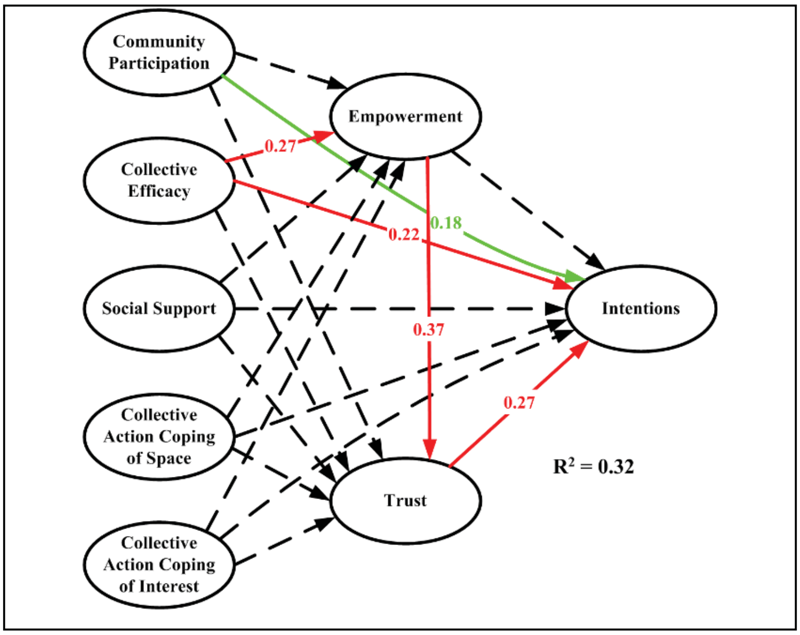

Figure 2-10 Social Resilience of Earthquake in Shuhachi, Kyoto

This model shows the direct contribution of community variables (collective efficacy and community participation) to intention variable. Besides the community variables, the institutional variables (empowerment and trust) also show a significant contribution to intention. Source: Bajek 2007

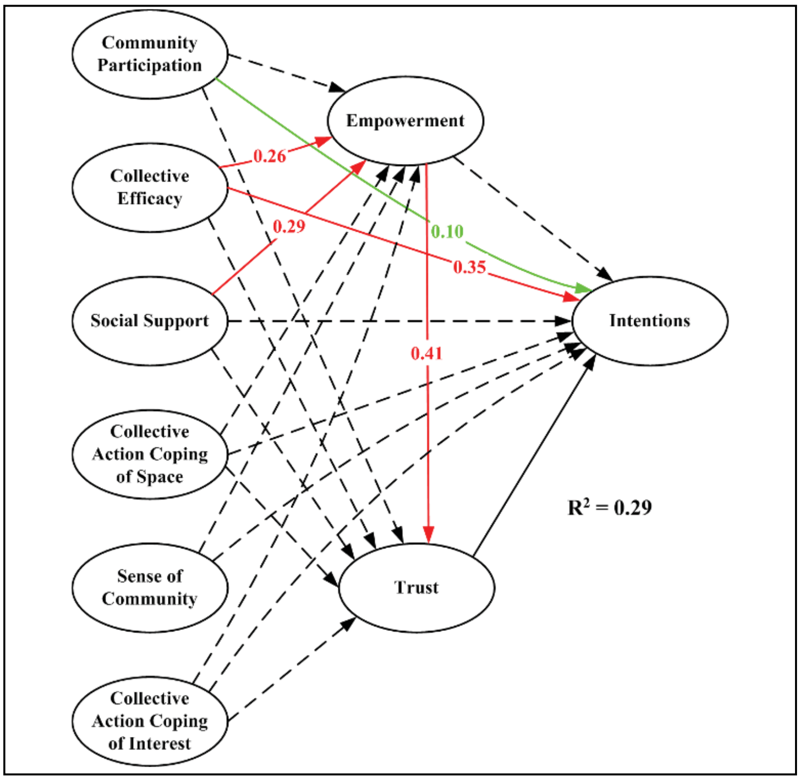

Figure 2-11 Social Resilience of Earthquake in Jouson, Kyoto

This model shows the direct contribution of community variables (collective efficacy and community participation) to intention variable. However, the institutional variables (empowerment and trust) do not show any significant contribution to intention. Source: Bajek 2007

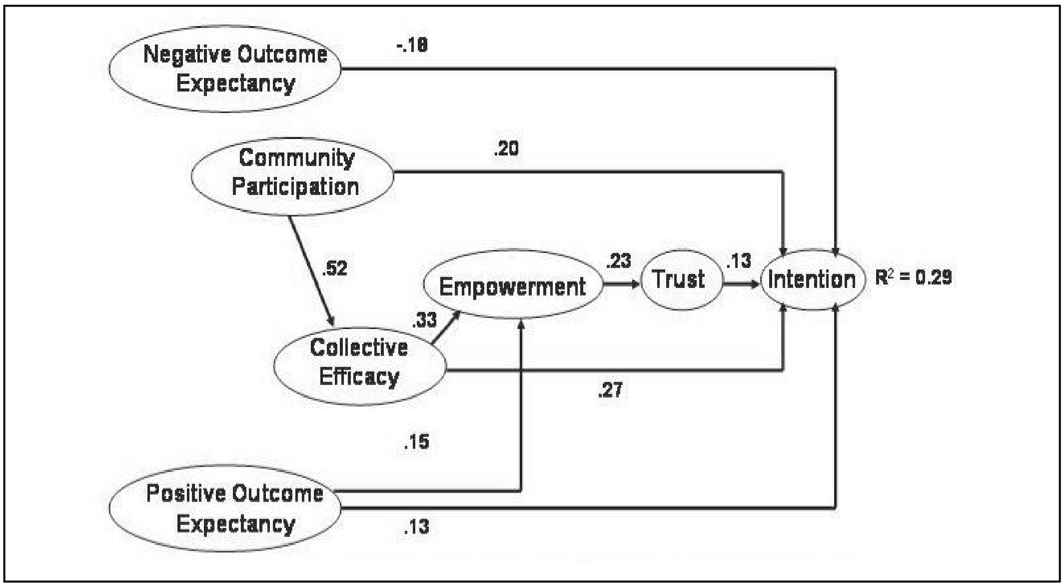

Figure 2-12 Social Resilience in Kyoto

This model shows a direct contribution to intention from personal variables (negative outcome expectancy and positive outcome expectancy), community variables (community participation and articulating problems) and institutional variables (empowerment and trust). Source: Paton (2008)

2.4. Evacuation Decisions Factors

People's decision to evacuate under disaster risks could be guided by many factors. The first is the factor related to hazards as observed in many research studies about Hurricane in United States (Aguirre, 1991; Baker, 1991; Gladwin et al., 2001; Peacock et al., 2004; Riad et al., 1999). The second one is related to economic factors as found in the study of evacuation in Mt. Tungarahua (Lane et al., 2003; Tobin and Whiteford, 2002) and studies related to vulnerability (Wisner et al., 2004). Poor people are assumed to be reluctant to evacuate because they are afraid of looters and lost of their belongings during the evacuation. The last factor, which is specifically observable in the case study of Mt. Merapi, is the influence of people's traditional cultural beliefs (Lavigne et al., 2008; Schlehe, 1996; Schlehe, 2007).

2.4.1. Hazard Related Factors

Hazard-related factors can not be omitted as one of the main factors. Knowing how these affect people's evacuation decision is important since the emergency agencies can examine whether the communities observe the disasters and the threats in their environment and whether the communities take their observation into account when making decisions in reducing risk to their lives and properties. Thus, the civic agencies can estimate how people react in the future disaster and provide appropriate the right guidance before carrying out disaster preparedness measures and risk communication.

A number of research studies emphasize the roles of hazard related factors which include: disaster experience, hazard proximity and natural signals (Lindell and Hwang, 2008; Lindell and Perry, 2004; McAdoo et al., 2006). The hazard experience is defined as exposure to the past occurrence of hazards which lead to casualties and damage experienced by the respondent himself/herself and by members of the extended family (Lindell and Perry, 2004). It does not include the process of listening to the news related to disasters or seeing the remaining hazard occurrence. Hazard experience can be related to the function of annual probability of the occurrence of major events and the number of years since the past exposure at the certain location. Hazard experience relates to people's decision on hazard's preparedness. Hazard experience is related to whether the people or their relatives have suffered from injuries themselves and whether their houses have become damaged due to the volcanic disasters.

Hazard proximity is defined by the geographical distance from the hazard source to the people's residence (Lindell and Hwang, 2008). Hazard source can be in the form of a volcano and or the rivers nearby that channels lava from the volcano. In the southern part of Mt. Merapi there are at least four big rivers where lavas could flow during volcanic activities.

Natural signals include physical cues which serve to remind that a real threat exists (Lindell and Perry, 2004). Lindell and Perry (2004) used a term of “environmental cues” which share a similar meaning. In 2004, natural signals served to remind the population of Simeulue Island, Indonesia to head towards highland to escape from tsunamis (McAdoo et al., 2006). Similarly, volcanic eruptions might show some signals during increasing activities or alert condition. If people understand this phenomenon correctly, they can be motivated to evacuate from a danger area.

2.4.2. Traditional Cultural Beliefs

Culture, as observed and hypothesized in several studies (Chester, 2005; Chester et al., 2008; Schlehe, 1996; Schlehe, 2007), determines the way people view the hazards and subsequently affect their decisions towards the hazards. In more traditional societies, the role of culture is more visible in shaping their decisions (Gaillard and Le Mason, 2007).

The volcanoes and the Javanese communities have long been very closely related (Dove, 2008; Lavigne et al., 2008; Schlehe, 1996; Schlehe, 2007). Not only is the volcano a place for livelihood, but it is also related to cultural backgrounds, the history of Yogyakarta and the Sultanate which has lasted for several centuries. Nature, volcano and the ocean, have been seen as the integral part of the Sultanate of Yogyakarta and there are spirits living in the volcano and the ocean who always get connected with the Sultan (Triyoga, 1991). As a result, the residents of Yogyakarta believe that there is a connection between the Sultan (the King) and the Spirits at Mt. Merapi and the ocean. The spirit in Merapi is known by the name of Kyai Sapujagat, while the spirit in the Ocean is known by the existence of Nyai Roro Kidul. It is believed that those spirits maintain the balance in the Yogyakarta Region, including threats from natural hazards, such as volcanic eruptions from the north and possibly sea waves from the south. In maintaining relationship with the spirit(s) in Mt. Merapi, a person who lives on the slope of the volcano was appointed by the Sultan to communicate and do offerings annually for the spirits. Later he was popular called as the Merapi key-holder (juru kunci). The key holder resides at Pelemsari hamlet, one of the closest hamlets to the volcano. The key-holder was appointed from generation to generation, also by the previous Sultan(s). The current key-holder of Merapi is Marijan. The local people call him Mbah Marijan. Mbah means grandfather in Javanese language.

2.5. Statistical Tools

Statistical tools are applied to measure the hypothesis developed in this thesis. The following section will discuss the statistical tools that are use to analyze the data in this research.

2.5.1. Structural Equation Model

Structural equation model is a statistical tool that enables the user to calculate causal-relationship between factors. It is more powerful than multiple regression, since it takes into account the modeling of interactions, nonlinearities, correlated independents, measurement errors, correlated error terms, multiple latent independents each measured by multiple indicators , and one or more latent dependents also each with multiple indicators (Garson, 2008). Since SEM is considered a causal modeling tool, it can be carried out with either longitudinal or cross-sectional data and is not typically used to analyse data produce from an experimental design.

SEM is used for the analysis in determining the social resilience. This is used for the analyses in chapter 4 and chapter 6 which deal with the factors that predict personal intention to prepare for natural hazards.

The main task of SEM is "to determine the goodness of fit between the hypothesized model and the sample data" (Byrne, 2001). Latent variables are the unobserved variables or constructs or factors which are measured by their respective indicators (Garson, 2008). Indicators are observed variables that we can measure from the field. These include the questions that we ask directly to the respondents. For example, in our study, one of the latent variable is "intention". The observable variables include a question of "in a month or so, will you check your level of preparedness" and the answer options "no", "probably" and "definitely".

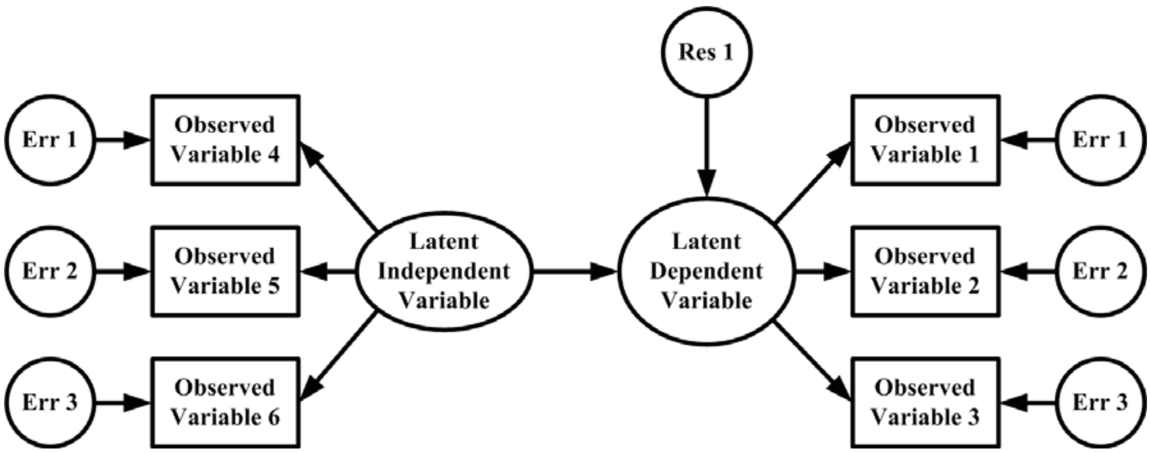

Figure 2-13 General Structural Equation Model

This structural equation model explains that the latent variables is predicted by the latent independent variable (see the arrow from latent independent variable to latent dependent variable). Since the latent (independent and dependent) variables can not be measured directly, they are connected with several observed variables. Assumably, the latent variables can explain several observed variables. Source: Byrne, 2001.

Goodness of fit

Goodness of fit tests determine if the model being tested should be accepted or rejected (Garson, 2008). The first is model chi-square. Model chi-square or also called as discrepancy, is the most common fit test. In contrast with the normal statistical chi square, the chi-square of the model should be not significant. Therefore, chi-square in SEM is also called as the "badness of fit" instead of goodness of fit as it normally serves for. This means the model chi-square should be larger than 0.05 to have the model accepted. Other measures include GFI, NFI, and RMSEA as explained in Table 2-1.

Table 2-1 Summary of the goodness of fit used for the structural equation model

Measure	Meaning	Standard
NFI	Normed-Fit- Index or Bentler-Bonett normed fit index. NFI = (χ^2 for the null model - χ^2 for the default model)/χ^2 for the null model.	NFI close to 0.90 is an acceptable / good value
GFI	Goodness of fit index, also called gamma-hat or Joreskog-Sorbom GFI. GFI = 1 – (χ^2 for the default model/χ^2 for the null model)	GFI larger than 0.90 is a cut-off for a good model fit.
RMSEA	Root mean square error of approximation, RMSEA	RMSEA <= 0.06 is a cut-off for a good model fit.

2.5.2. Statistical Tests

The following statistical tools are employed in the thesis. These tools include Pearson Correlation Tests and Chi-Square Tests.

Table 2-2 Statistical Tests Applied in the model

Statistical tools	Purpose	Location
Pearson	To check the correlation / relationship among variables that	Chapter 5

Correlation Tests	are related to hazards that could be related with the evacuation decisions	
Chi-square tests	To check the correlation and tabulation between variables related to hazards and evacuation decisions	Chapter 5

Pearson Correlation Tests

In statistics, the Pearson product-moment correlation coefficient (sometimes referred to as the PMCC, and typically denoted by r) is a measure of the correlation (linear dependence) between two variables X and Y, giving a value between +1 and −1 inclusive. It is widely used in the sciences as a measure of the strength of linear dependence between two variables. It was first introduced by Francis Galton in the 1880s, and is named after Karl Pearson. The correlation coefficient is sometimes called "Pearson's r."

The statistic is defined as the sum of the products of the standard scores of the two measures divided by the degrees of freedom. The result obtained is equivalent to dividing the sample covariance between the two variables by the product of their sample standard deviations:

2.6. Summary of literature review

This chapter outlines the literature studies used for this thesis. The discussion on literature review on the volcano explains what kinds of hazards faced by the mountain communities. The discussion on social resilient explains how factors related to personal, community and institutional may influence the way people deal with the hazards. A discussions on evacuation decisions add the aspects which are not covered by the social resilience model but useful for volcano risk management. Last, the statistical tests were also discussed which will be used to complement our approach based on the social resilience model.

References

Abraham, C., Sheeran, P. and Johnston, M., 1998. From health beliefs to self-regulation: theoretical advances in the psychology of action control. Psychology and Health, 13: 569-591.

Adger, W., 2000. Social and ecological resilience: are they related? Progress in Human Geography, 24(3): 347-364.

Adger, W., Kelly, P., Winkels, A., Huy, L. and Locke, C., 2002. Migration, remittances, livelihood trajectories, and social resilience. Ambio (Royal Academy of Sciences), 31(4): 358-366.

Bagozzi, R. and Edwards, E., 1998. Goal setting and goal pursuit in the regulation of body weight. Psychology and Health, 13: 593-621.

Bajek, R., 2007. Development of Evaluation for Community - based Participatory Risk Management - with a focus on Social Earthquake Resilience, Kyoto University, Kyoto.

Ballantyne, M., Paton, D., Johnston, D., Kozuch, M. and Daly, M., 2000. Information on Volcanic and Earthquake Hazards: The Impact on Awareness and Preparation, Institute of Geological and Nuclear Sciences Report, No. 2.

Bandura, A., 1992. Exercise of personal agency through the self-efficacy mechanism. In: R. Schwarzer (Editor), Self Efficacy: Thought Control of Action. Hemisphere Publishing Company, Washington, DC.

Bennet, P. and Murphy, S., 1997. Psychology and Health Promotion. Open University Press, Buckingham.

Bishop, P., Paton, D., Syrne, G. and Nancarrow, N., 2000. Coping with environmental degradation: salination as a community stressor. Network, 12: 1-15.

Byrne, B., 2001. Structural Equation Modelling with AMOS: Basic Concepts, Applications and Programming. Lawrence Erlbaum Associates Publishers, New Jersey.

Chester, D., 2005. Volcanoes, Society, and Culture. In: J. Marti and G. Ernst (Editors), Volcanoes and the Environment. Cambridge University Press, Cambridge, pp. 404-439.

Chester, D., Degg, M., Duncan, A. and Guest, J., 2001. The increasing exposure of cities to the effects of volcanic eruptions: a global survey. Environmental Hazards, 2: 89-103.

Chester, D., Duncan, A. and Dibben, C., 2008. The importance of religion on shaping volcanic risk perception in Italy with special reference to Vesuvius and Etna. Journal of Volcanology and Geothermal Research, 172: 216-228.

Dalton, J., Elias, M. and Wandersman, A., 2001. Community Psychology, Wadsworth, Belmont, CA.

Dash, N. and Morrow, B., 2001. Return delays and evacuation order compliance: the case of Hurricane Georges and the Florida keys. Environmental Hazards, 2: 119-128.

Dove, M., 2008. Perception of volcanic eruption as agent of change on Merapi Volcano, Central Java. Journal of Volcanology and Geothermal Research, 172: 329-337.

Dunning, C., 1999. Post-intervention strategies to reduce police trauma: a paradigm shift. In: J. Violanti and D. Paton (Editors), Police Trauma: Psychological Aftermath of Civilian Combat. Charles C. Thomas, Springfield, IL.

Duval, T. and Mulilis, J., 1999. A person-relative-to-event (PrE) approach to negative threat appeals and earthquake preparedness: a field study. Journal of Applied Social Psychology, 29: 495-516.

Earle, T., 2004. Thinking aloud about trust: a protocol analysis of trust in risk management. Risk Analysis, 24: 169-183.

Eng, E. and Parker, E., 1994. Measuring community competence in the Mississippi Delta: the interface between program evaluation and empowerment. Health Education Quarterly, 21: 199-220.

Gaillard, J. and Le Mason, V., 2007. Traditional Societies' Response to Volcanic Hazards in Philippines. Mountain Research and Development, 27(4): 313-317.

Garson, 2008. Structural Equation Modeling, accessed from http://faculty.chass.ncsu.edu/garson/PA765/structur.htm on October 15, 2008.

Godin, G. and Kok, G., 1996. The theory of planned behaviours: a review of its applications to health related behaviors. American Journal of Health and Promotion, 11: 87-97.

GSC, 2009. Volcanoes of Canada, Geological Survey of Canada.

Holing, C., 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4: 1-23.

Hurnan, F. and McLure, J., 1997. The effect of increased earthquake knowledge on perceived preventability of earthquake damage. Australasian Journal of Disaster and Trauma Studies, 1.

Johnson-George, C. and Swap, W., 1982. Measurement of specific interpersonal trust: construction and validation of a scale to assess trust in a specific other. Journal of Personality and Social Psychology, 43: 1306-1317.

Kee, H. and Knox, R., 1970. Conceptual and methodological considerations in the study of trust and suspicion. Journal of Conflict Resolution, 14: 357-365.

Keller, E. and Blodgett, R., 2008. Natural Hazards: Earth's Processess as Hazards, Disasters, and Catastrophes. Pearson Prentice Hall.

Latimer, A. and Martin-Ginis, K., 2005. The importance of subjective norms for people who care what others think of them. Psychology and Health, 20: 53-62.

Lavigne, F., De Coster, B., Juvin, N., Flohic, F., Gaillard, J., Texier, P., Morin, J. and Sartohadi, J., 2008. People's behaviour in the face of volcanic hazards:

Perspectives from Javanese communities, Indonesia. Journal of Volcanology and Geothermal Research, 172: 273-287.
Lindell, M. and Hwang, S., 2008. Household perceived personal risk and responses in a multihazard environment. Risk Analysis, 28(2): 539-556.
Lindell, M., Lu, J. and Prater, C., 2005. Household decision making and evacuation in response to Hurricane Lili. Natural Hazards Review, 6(4): 171-179.
Lindell, M. and Perry, R., 2004. Communicating Environmental Risk in Multiethnic Communities. Sage.
Lindell, M. and Whitney, D., 2000. Correlates of Household Seismic Hazard Adjustment Adoption. Risk Analysis, 20(1): 13-25.
Lion, R., Meertens, R. and Bot, I., 2002. Priorities in information desire about unknown risks. Risk Analysis, 20: 13-25.
Mayer, R., Davis, J. and Schoorman, F., 1995. An integrative model of organizational trust. Academy of Management Review, 20: 709-734.
McAdoo, B., Dengler, L., Prasetya, G. and Titov, V., 2006. Smong: How an Oral History Saved Thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 Tsunamis. Earthquake Spectra, 22(S3): s661-s669.
McLure, J., Walkey, F. and Allen, M., 1999. When an earthquake damage is seen as preventable: attributions, locus of control and attitudes to risk. Applied Psychology: An International Review, 48: 239-256.
Mulilis, J. and Duval, T., 1995. Negative threat and earthquake preparedness: a person relative-to-event (PrE) model of coping with threat. Journal of Applied Social Psychology, 25: 1319-1339.
Newhall, C. and Self, S., 1982. The volcanic explosivity index (VEI): An estimate of explosive magnitude for historical volcanism. Journal of Geophysical Research, 87(C2): 1231-1238.
Paton, D., 2000. Emergency Planning: Integrating Community Development, Community Resilience, and Hazard Mitigation. Journal of the American Society of Professional Emergency Planners,, VII.
Paton, D., 2003. Disaster preparedness: a social-cognitive perspective. Disaster Prevention and Management, 12(3): 210-216.
Paton, D., 2005. Community Resilience: Integrating Hazard Management and Community Engagement, Proceedings of the International Conference on Engaging Communities, Brisbane, Queensland Government/UNESCO.
Paton, D., Gregg, C., Houghton, B., Lachman, R., Lachman, J., Johnston, D. and Wongbusarakum, S., 2006a. The Impact of December 26th 2004 Tsunami on Coastal Thai Communities: Assessing Adaptive Capacity.
Paton, D. and Johnston, D., 2001. Disaster and communities: vulnerability, resilience and preparedness. Disaster Prevention and Management, 10(4): 270-277.
Paton, D., Kelly, G., Burgelt, P. and Doherty, M., 2006b. Preparing for bushfires: understanding intentions. Disaster Prevention and Management, 15(4): 566-575.

Paton, D., Millar, M. and Johnston, D., 2001. Community Resilience to Volcanic Hazard Consequences. Natural Hazards, 24: 157-169.
Paton, D., Smith, L., Daly, D. and Johnston, D., 2008. Risk perception and volcanic hazard mitigation: Individual and social perspectives. Journal of Volcanology and Geothermal Research, 172: 179-188.
Paton, D., Smith, L. and Johnston, D., 2005. When good intentions turn bad: Promoting disaster preparedness. The Australian Journal of Emergency Management, 20(1).
Paton, D., Smith, L. and Violanti, J., 2000. Disaster response: risk, vulnerability and resilience. Disaster Prevention and Management, 9(3): 173-179.
Riad, J., Norris, F. and Ruback, R., 1999. Predicting evacuation in two major disasters: Risk perception, social influence, and access to resources. Journal of Applied Social Psychology, 29(5): 918-934.
Sagala, S., Dwiyani, R., Bajek, R., Takeuchi, Y. and Okada, N., 2008. Examining the Relationship between Earthquake Preparedness Factors at Household Level, Case Study: Nakagyouku Communities, Kyoto City, Annual Conference, Disaster Prevention Research Institute, Kyoto University, Japan.
Schlehe, J., 1996. Reinterpretation of Mystical Traditions: Explanation of a Volcanic Eruption in Java. Anthropos, 91: 391-409.
Schlehe, J., 2007. Cultural politics of natural disasters: Discourses on volcanic eruptions in Indonesia. In: M. Casimir (Editor), Culture and The Changing Environment: Uncertainty, cognition and risk management in cross-cultural perspective, Berghahn, Oxford/ New York.
Siegrist, M. and Cvetkovich, G., 2000. Perception of hazards: the role of social trust and knowledge. Risk Analysis, 20: 713-719.
SIVSC, 2009. Volcanic Sabo in Japan, Sakurajima International Volcanic Sabo Center, accessed July 9, 2009.
Sjoberg, L., 1999. Consequences of perceived risk: demand for risk mitigation. Journal of Risk Research, 2: 129-149.
Smith, K. and Petley, D., 2009. Environmental Hazards: Assessing risk and reducing disaster. Routledge.
Speer, P. and Peterson, N., 2000. Psychometric properties of an empowerment scale: Testing cognitive, emotional and behavioral domains. Social Work Research, 24: 109-118.
Tilling, R., 2005. Volcano Hazards. In: J. Marti and G. Ernst (Editors), Volcanoes and the Environment, pp. 121-151.
Tobin, G. and Whiteford, L., 2002. Community Resilience and Volcano Hazard: The Eruption of Tungurahua and Evacuation of the Faldas in Ecuador. Disasters, 26(1): 28-48.
Triyoga, L., 1991. Manusia Jawa dan Gunung Merapi: Persepsi dan Sistem Kepercayaan (The Javanese People and Merapi Volcano: Perceptions and System of Belief). Gadjah Mada University Press, Yogyakarta.

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Jannsen, M., Lebel, L., Norberg, J., Peterson, G. and Pritchard, R., 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conservation ecology, 6(1).

Wisner, B., Blaikie, P., Cannon, T. and Davis, I., 2004. At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge, London.

Zaccaro, S., Blair, V., Peterson, C. and Zazanis, M., 1995. Collective Efficacy. In: J. Maddux (Editor), Self-efficacy, adaptation and adjustment. Plenum Press, New York, pp. 305-328.

Zhang, Y., Prater, C. and Lindell, M., 2004. Risk Area Accuracy and Evacuation from Hurricane Bret. Natural Hazards Review, 5(3): 115-120.

Chapter 3. Study Areas and Survey Methods

This chapter explains the study areas in Mt. Merapi and Mt. Sakurajima and the survey methods to be employed. The chapter starts the discussion by introducing brief information on volcanoes in Indonesia and Japan and why studies on volcano disaster preparedness in both countries are necessary. Next, the chapter discusses the study areas and issues related to volcanic risks, the communities living nearby, the problems they face and the countermeasures introduced. Subsequently, the chapter discusses the field survey methods employed for data collection and general characteristics of the respondents in this study.

3.1. Volcanoes and communities in Indonesia and in Japan

Indonesia and Japan are countries that are located in the pacific rim of fire and therefore many seismic and volcanic activities take place in these two countries (SI-USGS, 2009). Both countries are inhabited by a large number of population and many of them live near the volcanoes or at seismic faults making them at risk to the consequences of natural disasters such as volcano eruption and earthquakes. Nonetheless, living in such prone condition has made the communities adapt to their environment and it is expected that they have developed their mechanisms in dealing with volcanic disasters. In the following section, first we briefly review the volcanoes in Indonesia and Japan and later we will discuss the countermeasures developed by the local government and also the communities.

Indonesia is a home to many active volcanoes. Among the largest volcanoes that have ever erupted in the world, three volcanoes are located in Indonesia, namely: Toba volcano, Tambora Volcano and Krakatoa Volcano. Though the first one, Toba Volcano, has not been active for a long time, scientists have regarded this volcano as a sleeping giant (de Boer and Sanders, 2002; Savino and Jones, 2007). The most recent eruptions in the past decades in Indonesia have made reference to the eruptions of the active Merapi Volcano.

Figure 3-1 Map of Volcano Distribution in Indonesia

This picture illustrates all the active volcanoes in Indonesia. In total, currently there are around 100 active volcanoes in this country. Image courtesy of Wikimedia (2009).

Table 3-1 describes the major eruptions of volcanoes in Indonesia before 1990s. It describes that Mt. Merapi (our study area) is very active among the volcanoes in Indonesia. Considering frequent volcanic eruptions in Indonesia, it is important to increase the anticipation and to prepare for future volcanic risks. Preparedness is important not only for the municipal governments but also for the population at risks. Additionally, since population increases, the exposures (human and economic vulnerability) to the volcano hazards also increase. To reduce the risk, it is important for the municipal government(s) and the residents to understand preparation before an eruption occurs. While in most cases, high attention is given to physical countermeasures, this study attempts to assess from the social perspectives so that the application of disaster preparedness will take place properly.

Similar to Indonesia, Japan also is a home to many active volcanoes. In 1991, the eruption of famous Mt. Unzen in Nagasaki Prefecture, killed 43 people including volcanologist (Wikipedia, 2009) and a large amount of volcanic materials (picture earlier provided in Chapter 2).

Eruption Date	Volcano	Cessation Data	VEI	Characteristics	Tsunami	Tephra Volume	Fatality
10-Feb-1990	Kelut	Mar-90	4	cv,cl,pf,ph,ld,lm	no	0.13 km³	35
18-Jul-1983	Colo	Dec-83	4	cv,pf,ph	no	N/A	0
5-Apr-1982	Galunggung	8-Jan-83	4	cv,pf,lf,lm	no	> 0.37 km³	68
6-Oct-1972	Merapi	Mar-85	2	cv,pf,lf,ld,lm	no	0.021 km³	29
26-Apr-1966	Kelut	27-Apr-66	4	cv,cl,pf,lm	no	0.089 km³	212
17-Mar-1963	Agung	27-Jan-64	5	cv,pf,lf,lm	no	1 km³	1,148

31-Aug-1951	Kelut	31-Aug-51	4	cv,cl,pf,lm	no	0.2 km³	7
25-Nov-1930	Merapi	Sep-31	3	cv,rf,pf,lf,ld,lm	no	0.0017 km³	1,369
19-May-1919	Kelut	20-May-19	4	cv,cl,pf,lm	no	0.19 km³	5,110
7 Jun 1892	Awu	12 Jun 1892	3	cv,pf,lm	yes	N/A	1,532
26 Aug 1883	Krakatau	Feb 1884	6	cv,se,pf,fa,lm,cc	15–42 m	5–8.5 km³	36,600
15 Apr 1872	Merapi	21 Apr 1872	4	cv,pf	no	0.33 km³	200
2 Mar 1856	Awu	17 Mar 1856	3	cv,pf,lm	yes	0.51±0.50 km³	2,806
8 Oct 1822	Galunggung	Dec 1822	5	cv,pf,ld,lm	no	> 1 km³	4,011
10 Apr 1815	Tambora	15 Jul 1815	7	cv,pf,cc	1–2 m	160 km³	> 71,000
6 Aug 1812	Awu	8 Aug 1812	4	cv,pf,lm	no	0.55±0.50 km³	963
12 Aug 1772	Papandayan	12 Aug 1772	3	cv,ph	no	N/A	2,957
4 Aug 1672	Merapi	unknown	3	cv,pf,lm	no	N/A	3,000
1586	Kelut	unknown	5	cf,cl,lm	no	> 1 km³	10,000
≈ 74,000 BP	Toba	unknown	8	pf,lf,cc	likely	2,800 km³	near extinction of human population

Table 3-1 Major eruptions of Volcanoes in Indonesia

Notes: cv=central vent eruption, pf=pyroclastic flows, lf=lava flows, lm=lahar mudflows, cl=crater lake eruption, ph=phreatic eruption, ld=lava dome extrusion, cc=caldera collapse, se=submarine eruption, fa=fumarole activity, rf=radial fissure eruption.

Source: Wikipedia. http://en.wikipedia.org/wiki/List_of_volcanoes_in_Indonesia

Many active volcanoes in Japan have erupted in the past decades. Table 3-2 lists the detailed records of volcanic eruptions in Japan since 1996. While recently, not so many people killed in Japan as those in Mt. Unzen, the intensities of the active volcanoes need to be carefully examined. In particular, if the volcano is located near the inhabited places like those of Mt. Sakurajima, Mt. Unzen and Mt. Bandai, it is necessary to enhance awareness among the residents.

Table 3-2 Recent Eruptions in Japan

Last update, June 10, 2006. Data courtesy of (VRC, 2006)

Volcano	Activities
Sakurajima	Erupted since 4 June 2006; new eruption started in the middle slope of the Minamidake (06/10/2006)
Anatahan (Northern Marianas)	Inspections in July 2003 and August 2005
Asama	Erupted on 1 September and intermittent eruptions continued (10/05/04)
Aso	Mud eruptions within the summit crater (01/17/04)
Kirishima	New fumarolic activity in middle December (01/17/04)
Aso	Continuous volcanic tremor following very small phreatic eruptions (07/28/03)
Asama	Puff of small amount of ash (06/02/03)
Suwanose-jima Volcano	Frequent explosions (09/12/02)
Hachijojima	Declined seismic activity but LF events (9/04/02).
Izu-Torishima Volcano	Small eruptions waned (08/21/02)
Asama	High seismic activity (06/27/02)
Satsuma-Iwojima Volcano	Ash eruptions (06/07/02)
Iojima	Small phreatic eruption (10/19/01)
Hakone	High seismic activity and swelling (8/08/01)
Fuji	High seismicity in the end of April and early May, but no other anomalous signs (5/11/01)
Miyakejima	Extremely high SO2 and small low-frequency eathquakes (5/11/01)
Sakurajima	An explosions in October (10/16/00)

Volcano	Activities
Bandaisan	Earthquake crisis (8/16/00)
Usu	Phreatomagmatic eruption started on March 31; decreasing the activity by mid-May, but still continued. About 60-m uplifting of the crater area (6/01/00)
Iwate	Increasing activity, though still no surface manifestation (11/16/99)
Kirishima	Elevated volcanic earthquake events (11/16/99)
Kuchinoerabujima	Quake swarm, since July (9/17/99)
Me-Akan	Small phreatomagmatic eruption on 9 November 1998 (11/12/98)
Hokkaido-Komagatake	Small phreatic eruption on 25 October 1998 (11/12/98)
Izu-Tobu Volcano Group	Swarm of earthquakes during the late April-early May. (5/16/98)
Adatara	Volcanic gas fatality at Adatara Volcano, four hikers killed. (9/30/97).
Akita-Yakeyama	A small eruption on 16 August 1997 (8/25/97)
Hakkoda	Three soldiers inhaling CO2-rich gas died. (7/17/97)
Fukutoku-okanoba submarine volcano	Discolored-sea surface found in February-May. (6/16/97)
Kuju	Seismologically low in level, keeping powerful emission of steam and deflation of the crater area during June- September 1996.
Unzen	No magma supply for more than 1 year, but block-and-ash flows on 10-13 February 1996; keeping slow deformation of dome.

Figure 3-2 Volcano Hazards of Mt. Unzen, Japan

Mt. Unzen is among the most active volcano in Japan. The large eruption in 1991 generated a pyroclastic flow that killed 43 people, including three volcanologists. Image Courtesy of Sakurajima International Volcanic Sabo Center (SIVSC, 2009)
http://www.qsr.mlit.go.jp/osumi/sivsc/home/english/j035.html

3.2. Mt. Merapi and Mt. Sakurajima

The study areas for this study are located at two volcanoes: Merapi Volcano and Sakurajima Volcano. The following section will provide the brief explanation of Mt. Merapi and Mt. Sakurajima.

3.2.1. Merapi Volcano

Mt. Merapi (Figure 3-2) is a conical volcano located on the border between Central Java and Yogyakarta, Indonesia. It is the most active volcano in Indonesia and has erupted regularly since 1548. Its name means Mountain of Fire. The height of Mt. Merapi changes over time due to the active materials produced and the current height is 2,968 metres (9,738 ft). It is very close to the city of Yogyakarta, and thousands of people live on the flanks of the volcano, with villages as high as 1700 m above sea level. Merapi has been very active within the last two decades. The records noted that the volcano previously erupted in 1994, 1997, 2001 and 2006 (Ratdomopurbo et al., 2006). In term of numbers of people killed and size of eruption, the eruptions in 1994 and 2006 are among the most dangerous eruptions. In 1994 Turgo hamlet has been severely affected by the eruption that at least 63 people died after the pyroclastic flow climbed down to the hamlet (Paripurno et al., 1999). Despite the negative impacts, the eruptions also bring positive impacts to the people. For example, the most recent eruption in 2006 has brought excessive sands and rock materials. In the 2006 eruption, the Sleman District Government prepared the evacuation shelter located far further down on the southern parts of the volcano. The distances from the evacuation shelters to the volcano vary from 10 – 14 km.

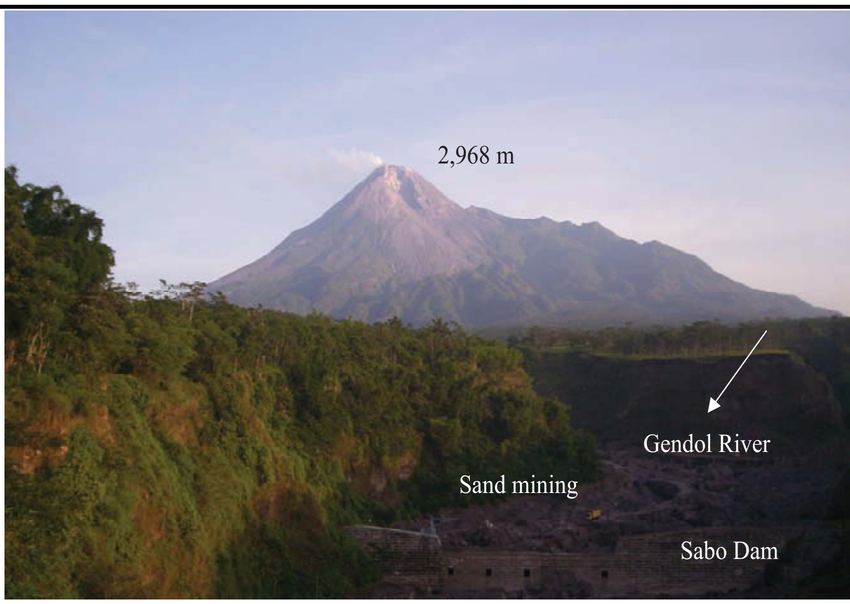

Figure 3-3 Mt. Merapi from Gendol River
Mt. Merapi in the morning, a view from near Gendol River. Sand mining activities and Sabo Dam construction are visible. Image courtesy of Saut Sagala (2008)

Recent Disasters

After 1990s, Mt. Merapi has erupted for several times, including the eruption with human fatalities in 1994 (see Table 3-2). The records in table 3-2 noted that the volcano previously erupted in 1994, 1997, 2001 and 2006. In term of numbers of people killed and eruption size since 1990s, the eruptions in 1994 and 2006 have been among the most dangerous eruptions. For example, in 1994 Turgo hamlet was severely affected by the eruption and at least 63 people died after the pyroclastic flow inundated the hamlet. Despite such negative impacts, the eruptions also bring positive impacts to the people. For example, the most recent eruption in 2006 has brought excessive sands and construction materials that can be exploited by the local people and sold to nearby cities for construction development. The experience of the volcanic eruptions could thus have direct and indirect influence on the resilience and adaptive capacity of the communities.

Table 3-3 Records of Volcano Hazards and Reported Damages of Mt. Merapi
Data are courtesy of Thouret et al. (2000)

Eruptive events	**Type of eruption**	**Life Loss PF / DF**	**Affected Villages**
1672	Ex, PF, DF	3000	
1822-1823	Ex, PF, DF, D	100	
1832-1835	Ex, PF, LF, D	32	
1849	Ex, PF, LF	Hundreds	
1871-1872	Ex, Tf, PF, LF	200	
1902-1904	Ex, D, LF, PF	16 (PF)	3
1920-1921	Ex, PF, D, DF	35 (PF)	1
1930-1931	Ex, PF, LF, D, ps, DF	1369 (PF + DF)	42
February 1932	Ex, sec. DF	DF	1
1953-1954	Ex, PF, Ph, LF, D	64 (PF)	6
1961	Ex, PF, D, ps, sec. DF	6 (PF + DF)	10
January 1969	Ex, PF, LF, ps, sec. DF	3 (PF + DF)	26
1972-1975	Ex, PF, LF, D, sec. DF	9 (DF)	Several tens
Nov-Dec 1976	LF, PF, sec. DF	29 DF	Several tens
22 Nov – 7 Dec 1994	Ex, PF, ps, DF	66 (PF, ps)	Several
14-18 Jan 1997	Ex, PF, D	6 missing, several injured	
April – June 2006	Ex, PF	2 volunteers died	

Apart from the eruptions, secondary hazards includes landslides and lahars after rainfalls. Some cases reported the casualties to physical infrastructures and vehicles which were hit by the rocks and debris. Thouret et al (2000) summarized the historical record of hazards and damages in Mt. Merapi from many sources as noted in Table 3-2. They also summarized the eruption direction (Figure 3-3) that the most recent eruptions have shifted from south-west towards the south of Merapi volcano. The last deadly eruption occurred in 1994 where most of the victims were those who lived at Turgo Hamlet. The most recent eruption went to the direction of Boyong (1994) and Gendol river (2006). When the eruptions go to this direction more people will be at risk since many residents live in the southern part of this volcano. Additionally, Yogyakarta City, the capital of the province is also located at the southern of this active volcano . Based on this condition, we selected the southern flanks of the volcano as our study area.

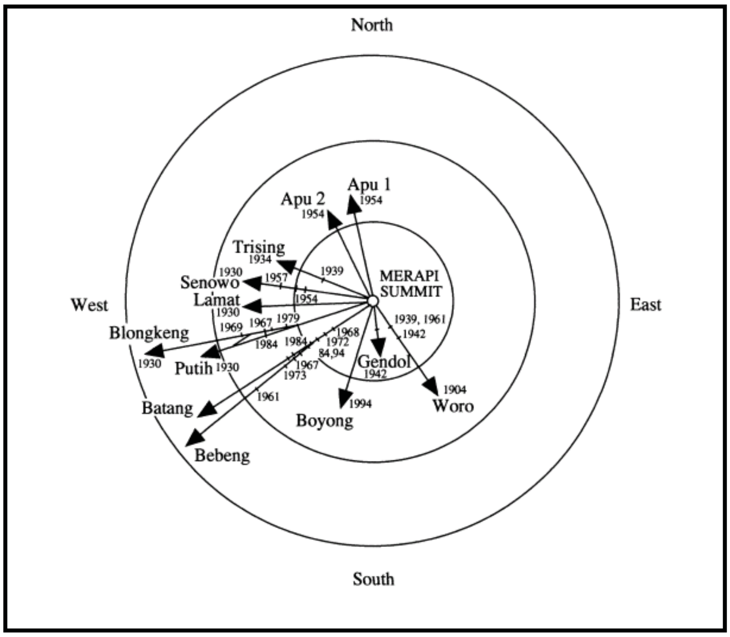

Figure 3-4 Azimuths and travel distance for pyroclastic flows released at Merapi
The picture above shows that most of the pyroclastic flow occurred at the west and south-west of Mt. Merapi. Picture is courtesy of Thouret et al. (2000)

Eruption in 2006

In 2006, the volcano erupted for two months (Sagala, 2007). Therefore, the population on the southern slopes of Mt. Merapi had to evacuate from April – June, 2006. The eruption left two volunteers died while no casualties to the local people. Since the volcano produced huge amount of volcanic materials, the residents could benefit from and get many materials (sands and rocks) for their building construction and for selling these construction materials to the cities. No casualties to the local people happened, except two volunteers that were died since they escaped to a bunker provided by the government which was poorly able to withstand the heat from the pyroclastic flow.

However, a tourist spot on the slope of Merapi Volcano suffered from pyroclastic flows that many shop buildings were destroyed and some were buried with the pyroclastic flows in 2006 (Figure 3-10). Gendol River, one of the main rivers in Mt. Merapi was full of pyroclastic flows in the 2006 eruption (Figure 3-7). After the eruption and the temperature became normal, the local residents started to collect the materials and sell them to the cities for constructions.

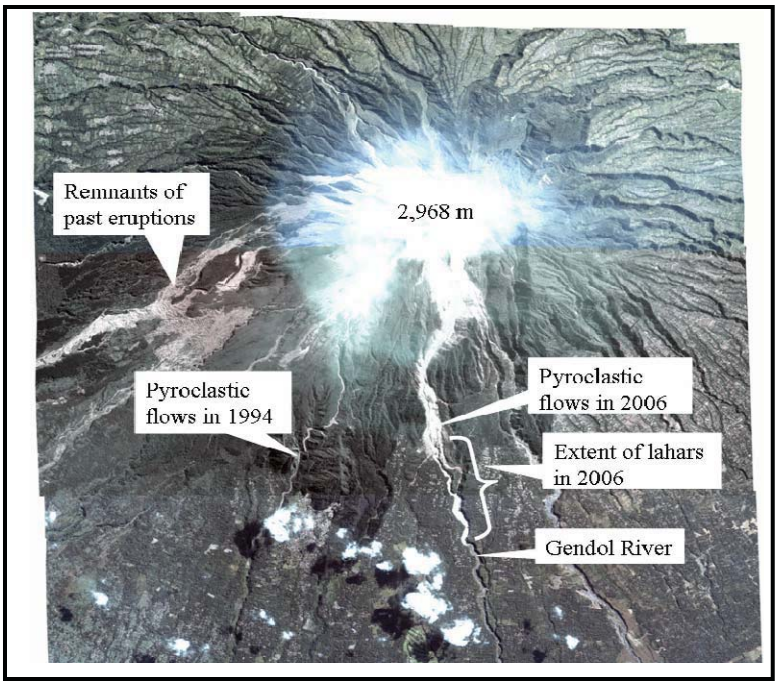

Figure 3-5 Ikonos Merapi

This figure of Ikonos Satellite Imagery shows the extent of the eruption in 2006. The white reflection is the top of Merapi Volcano showing the remnant of sand and debris. Down to the flank of Gendol River shows the extent of the pyroclastic flow to that area. Image courtesy of Wahid Doddy (2007)

Figure 3-6 Kaliadem tourist spots after eruption Merapi eruption

Picture left: Kaliadem tourist spots were buried by the pyroclastic flow of Mt. Merapi eruption in 2006. Image courtesy of Oxfam (2006). Right: The scenery of the tourist spot two years after eruption. Image courtesy of Saut Sagala (2008)

Figure 3-7 Gendol River After Eruption in 2006 and 2 years after eruption in 2008
Picture above: Gendol River when it was half full of pyroclastic flows during the eruption in 2006. Image courtesy of Oxfam (2006). Below: Gendol River two years after eruption. Courtesy of Saut Sagala (2008)

Hazard Zone

To reduce the impacts of volcanic risks, the government of Indonesia attempts to divide the areas close to volcano into several hazard zones (Figure 3-8). Hazard zone 3 bears the maximum potential volcanic risks therefore the government recommends no permanent settlements in this zone. Despite this recommendation, several inhabited villages and hamlets locate in this zone. Hazard zone is also one of the considerations when preparing for a field survey in Mt. Merapi. To have a balanced geographical distribution among the respondents, nearly half of the respondents are from hazard zone 2 and half of the respondents are from hazard zone 3.

Current community initiatives

After the occurrence of the Merapi Volcano disaster in 1994 that claimed many fatalities, the communities set their own early warning systems. The early warning systems include by making networks among the people living from different slopes of the volcano and from different hamlets and villages. People from different slopes of the volcano share information each other about the situation during an intense activity of the volcano through radio communication. Some local voluntary groups have also been set-up to monitor the volcanic activity. According to our respondents, during the eruption in 2006, the local community based activity warning system turned to work effectively. The role of the local warning alo help to supplement government's existing warning or network. The summary of the information flow in Mt. Merapi are found in the following Figure 3-9.

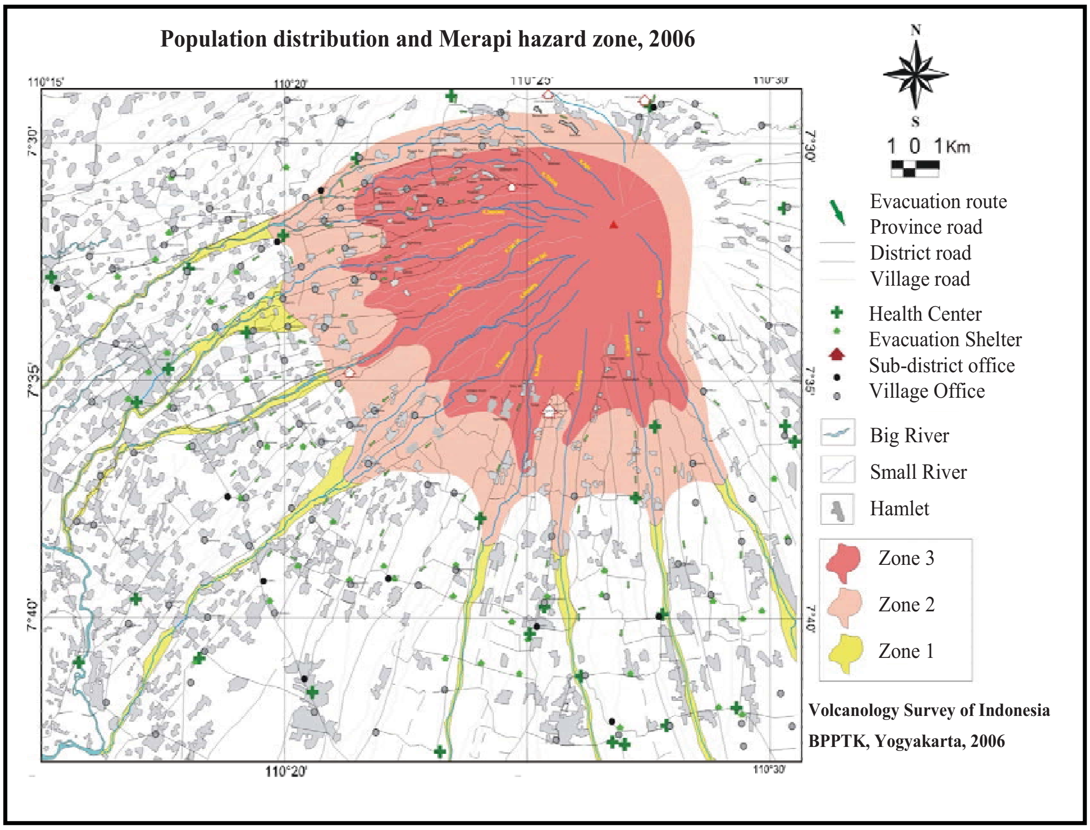

Figure 3-8 Hazard Zone Map of Merapi Volcano

The dark red colour is the most dangerous zone or hazard zone 3, no permanent settlement is allowed. The pink colour is the hazard zone 2, settlements are allowed but the residents must evacuate during the high intensity of the volcano. Image courtesy of Volcanology Survey of Indonesia (2006)

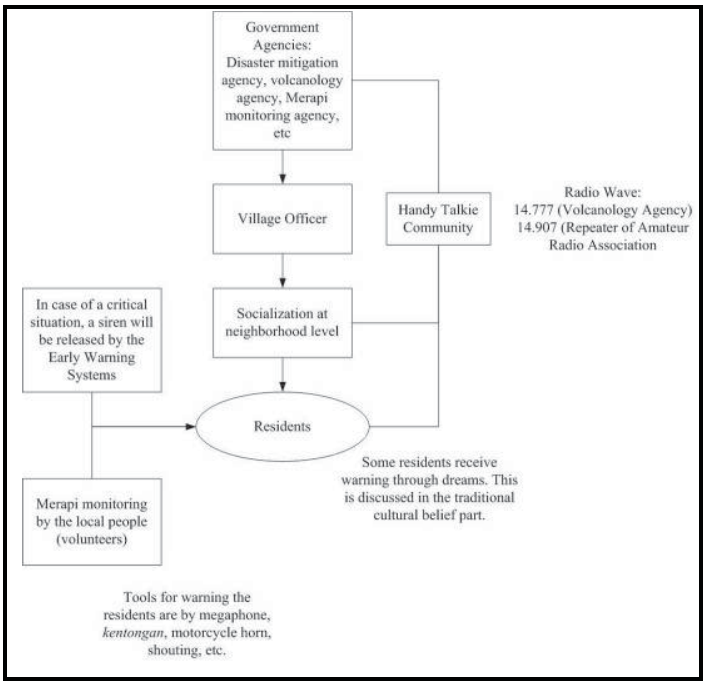

Figure 3-9 Information Flow of Warning Systems in Mt. Merapi

Source: interviews with the local people

Physical countermeasures

The Indonesian Government prepares some measures to reduce the risk of volcanic hazards. These are mainly implemented in the form of physical counter measures, such as the development of Sabo Dams and bunkers against lahars and pyroclastic flows. Just recently, the government install warning equipments through sirens (Figure 3-10) that are installed in some areas close to the slope of volcano. Unfortunately, during the eruption in 2006 some sirens were destroyed by the pyroclastic flows and did not work as what was expected.

Some physical countermeasures carried out to reduce the volcanic risks are by building the sabo-dam system. See the picture of Sabo-Dam here (Figure 3-9). Additionally, the government also constructed some temporary places to evacuate when pyroclastic flows occurs. However, the temporary places do not seem working properly since two volunteers who tried to escape from the pyroclastic flows in 2006 still suffered burning from the hot temperatures of the pyroclastic flows. Some residents who lived close to the volcano argued they understood that the temperature was so high that they agreed the only way to escape is by running away when the pyroclastic flows occur.

Figure 3-10 Sabo Dam in Mt. Merapi
Left: The construction of new Sabo Dam in Kuning River, Cangkringan Sub-District and is expected also to serve as a bridge as well as a dam. Right: The sabo dam in the picture below is located in Kali Boyong. A river that channelled the lahars in 1994. Images courtesy of Saut Sagala (2008).

There are many Sabo Dams constructed along the rivers in Mt. Merapi. The constructions of these Sabo Dams helped to slower the speed of the volcanic materials flowing out through the river. Yet, the problem that people are still afraid from is the pyroclastic flows that may occur at high speeds and high temperature.

Figure 3-11 Bunker as an escape place in Mt. Merapi?
Left: Bunker in Kaliurang, is a place designated to evacuate temporarily when a pyroclastic flow occurs very quickly and one does not have enough time to run away. Image courtesy of Saut Sagala (2008). Right: In 2006, two volunteers who ran away from the pyroclastic flows and entered the bunker got burned and died due to very high temperature. Image courtesy of Oxfam (2006)

The local government provides some physical countermeasures to reduce the disaster risks. To deal with pyroclastic flow, the government provides some bunkers, intended for places to escape or temporarily evacuate when a pyroclastic flow occurs (Figure 3-16). However, it turns out that these bunkers were not effective to deal with pyroclastic flows as two volunteers were found dead after escaping from pyroclastic flows and entering a bunker in Bebeng tourist spot at the slope of Merapi Volcano.

Unfortunately, it was only recently that the soft-countermeasures, such as: educating people, are being applied in the study area. Lavigne et al (2008) noted that the government emphasized much on the physical counter measures rather than provided the sufficient knowledge to the residents at risk. Therefore, the unwillingness of the residents to evacuate in many eruptions could be due to lack of knowledge of the real problems that they really face.

Figure 3-12 A siren to remind the people at risk of volcanic eruption
A siren is expected to remind people during an alert situation. However, an interview to the residents reported that the siren was destroyed by the pyroclastic flow. Image courtesy of Saut Sagala (2008)

3.2.2. Mt. Sakurajima

Sakurajima, an elevation of 1,117m, is an andesitic active volcano, located almost at the center of Kagoshima Bay (SIVSC, 2009). It was born about 13 thousand years ago, and is still continuing a remarkable volcanic activity. Especially, its eruptions in the Bunmei, An'ei, Taisho, and Showa periods were of a large scale, respectively. In the eruption in the Taisho period, the eruption was so large and the mountain ejected so vast an amount of pumice and lava from the mid-slope that Sakurajima was connected to the Osumi Peninsula with those ejected matter.

Figure 3-13 Location of Field Survey in Kagoshima Prefecture
Image is courtesy of Google Map (2009)

Kagoshima is the capital city of Kagoshima Prefecture at the south-western tip of the Kyūshū island of Japan, and the largest city in the prefecture by some margin. As of 1 January 2005, the city had an estimated population of 605,650 and a density of 1,107.81 persons per km². The total area is 546.71 km².

The 1914 Sakurajima eruption was the most powerful in twentieth-century Japan. Lava flows filled the narrow strait between the island and the mainland, turning it into a peninsula. The volcano had been dormant for over a century until 1914. The 1914 eruption began on 11 January. Almost all residents had left the island in the previous days, in response to several large earthquakes that warned them that an eruption was imminent. Initially, the eruption was very explosive, generating eruption columns and pyroclastic flows, but after a very large earthquake on 13 January 1914 which killed 35 people, it became effusive, generating a large lava flow. Lava flows are rare in Japan—the high silica content of the magmas there mean that explosive eruptions are far more common—but the lava flows at Sakurajima continued for months.

The island grew, engulfing several smaller islands nearby, and eventually becoming connected to the mainland by a narrow isthmus. Parts of Kagoshima bay became significantly shallower, and tides were affected, becoming higher as a result. During the final stages of the eruption, the centre of the Aira Caldera sank by about 60 centimetres (24 in), due to subsidence caused by the emptying out of the underlying magma chamber. The fact that the subsidence occurred at the centre of the caldera rather than directly underneath Sakurajima showed that the volcano draws its magma from the same reservoir that fed the ancient caldera-forming eruption.

Figure 3-14 Kagoshima City covered by ash from Mt. Sakurajima eruptions in 1914
Image courtesy of Wikimedia

Figure 3-15 Mt. Sakurajima View from a tourist spot
Image courtesy of Travelwebshot (2002)

Furthermore, this active volcano has attracted many tourists coming to explore the mountain and enjoy the surroundings of the island. Previous places where lava and ash falls buried the built environment (such as Tori / gate) become famous spots for tourists (Figure 3-16).

Figure 3-16 A Shrine Gate buried by ash falls as a tourist attraction.
Image Courtesy of Saut Sagala (2009)

Hazard Zone

Based on the previous eruptions and the potential eruptions, hazard zone map has been developed in Mt. Sakurajima (Figure 3-17).

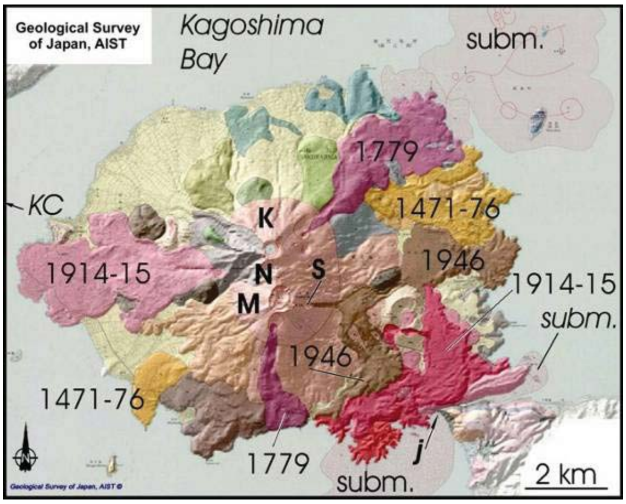

Figure 3-17 Hazard map in Mt. Sakurajima
Image courtesy of Smithsonian (2009)

Recent Disasters

Record of volcanic disasters in Mt. Sakurajima are presented in Table 6-1. Mt. Sakurajima is considered active along the year since it produces a lot of volcanic activities noticed by the smokes and some tremors from the volcano. However, the the last major eruption occurred in 1946 as noticed by the produce of lava flows that damaged the crops of agricultural areas.

Table 3-4 Record of volcanic disasters and activities in Mt. Sakurajima
Source: SIVSC (2009)

Year	Eruption Activities
708 -	Eruption.
764 - 766	A submarine eruption occurred, and three islands were formed.
1471 – 1476	Big eruption: Lava flowed out of a spot near Kurokami in the northeastern part or Sakurajima, and today's Omoezaki was formed; in 1473, lava flowed out of a spot near Nojiri and in the next year a big explosion occurred accompanied with the ejection of a lot of cinders and ash; this eruption gave rise to a new island, which was connected to the main island to form today's Moezaki.
1779 – 1781	A big eruption occurred on the southern mid-slope of Minamidake; another big eruption occurred also on the northeastern mid-slope; much lava ran down on the northeast side and on the south side. This eruption gave rise to nine islands to the northeast of Sakurajima through submarine eruptions and upheaval. Later these islands sank in the sea or united with each other and left five islands (Inokojima, Nakanoshima, lojima, Niijima, and Dorojima). In this big eruption, the dead 153, and houses and agricultural fields much damaged.
1914	On January 18, it began with a big eruption on the west side of Nakadake at 8:00 a.m. and then big explosions occurred on the eastern and western midslopes, ejecting a large amount of lava and ash. At 10:15 an explosion occurred with a big sound near Nabeyama on the eastern part of the island and the island was connected to the Osumi Peninsula. This eruption buried Akamizu village and Torishima, and buried also Arimura and Kurokami villages on the eastern slop. The dead 58, the injured 112, and houses damaged 2268.
1935 - 1946	It began with a small explosion at the Minamidake crater. In 1939 a new crater was formed on the eastern mid-slope of Minamidake. In March, 1946, a big eruption occurred accompanied with a lava flow, but the damage was limited only to agricultural products.
- today	The crater at the top of the mountain is erupting or ejecting cinders, ash, volcanic gas, etc. The number of eruption since 1965 reached 4800. In 1983 and 1985 the frequency of explosion exceeded 1 per day on the average. In recent years, the frequency recorded the peak in 1991, and after that, the situation has become relatively composed.

Soft-countermeasures

The city conducts regular evacuation drills to ensure the safety of the populous. This drill is conducted every year on the 12th of January, which is the memorial day for the devastating eruption of 1914. They use ferryboats, helicopters, and aircrafts to make sure everyone could get out of the city safely if there was ever and unexpected explosion. Kagoshima also built refuge shelters where people could hide in safely if ever an extreme eruption were to suddenly occur. An array of mitigation measures is in place in the city, including a 220-million-Yen-per-year operation to keep the city streets clear of ash. Residents are expected to collect ash from their properties in yellow supermarket type bags and put it out at one of 5504 collection sites twice a week. Hand sweepers are used to sweep pavements and around houses. Public workers in this occupation wear eye protection, basic facemasks and helmets (to prevent ash from getting into the worker's hair).

The most pertinent problem for the city is that ash falls on the roads and obscures the road markings, causing traffic problems. It is also slippery when wet. The city has a target to sweep up the ash within three days. Ash is deposited in harbour reclamation or compacted ash landfill sites. School children have to wear yellow crash helmets to school to protect their heads from the debris. There are many eruption shelters for people to hide in too. Additionally, each year, Sakurajima is fully evacuated so that residents are fully prepared for the day when volcanic activity may require them to leave quickly. People live in ash-proof houses which have no spouting but have special tiles to withstand the acidic nature of ash. The island is also covered by debris flow channelling devices which are immense and extremely wide in places.

Besides, sophisticated seismic, ground deformation and strain monitoring systems on the volcano provide effective warning of eruptions. Various organizations had comprehensive manuals covering all aspects of their operations. Both the Prefecture and the City Government had manuals covering their responses to volcanic and earthquake events. There are many elaborate monitoring systems in place to record daily events and pick up abnormal activity such as a swarm of "B" type earthquakes, which will give early warning to a major event. Moreover, there is serious agronomic damage caused by the ash, particularly when ash falls at critical points in the growing season. Pumice ash can also kill fish in fish farms. The discharge of volcanic gases such as sulphur dioxide is a significant issue as the gas can travel hundreds of kilometers and not only produce acid rain, but also can cause death in extreme situations.

Physical Countermeasures

There are several physical countermeasures applied by the local government in Mt. Sakurajima. The physical countermeasures include building up building sabo (Figure) dam and fences along the volcano to protect the physical hazards

Figure 3-18 Physical Countermeasures in Mt. Sakurajima
Left: In many parts of Sakurajima volcano, there are fences to protect the road from big rocks and debris. Right: This temporary shelter aims to protect if someone is near this areas but under the risk of moving large rocks. Courtesy of Saut Sagala (2009)

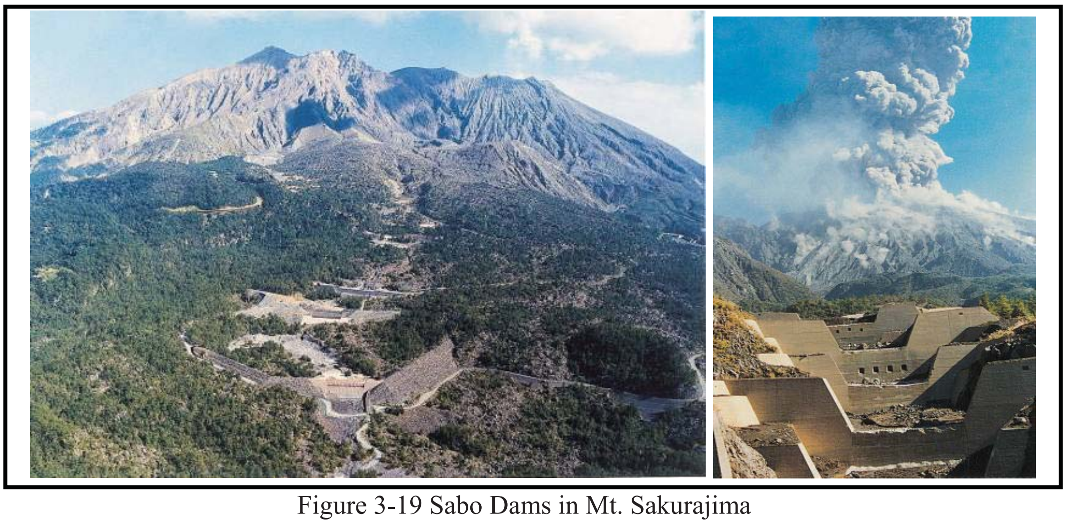

Figure 3-19 Sabo Dams in Mt. Sakurajima
Sabo dams are common in Mt. Sakurajima as shown in above pictures. Image courtesy of SIVSC (2009)

Figure 3-20 A channel to direct the Lava flow in Mt. Sakurajima

Lava flow is the common phenomenon in Mt. Sakurajima. This image shows a channel built by the government to direct the lava flow. Image courtesy of Saut Sagala (2009)

3.3. Research Methodology

This section will discuss the field data methodology and analytical methodology used in this research.

3.3.1. Field Research Methodology

The main data for this study originated from a set of questions in a questionnaire. The questionnaire survey in Mt. Merapi was carried out from January – February 2008. To collect people' responses of the questions, we carried out fieldwork. The respondents are from the communities living at the southern slopes of Mt. Merapi, Yogyakarta (see figure 3.1). The number of respondents is 322. These hamlets were mostly affected by the recent eruption in 2006. Respondents from fourteen hamlets were selected for this study, which cover two sub-districts: Pakem and Cangkringan sub-districts (Figure 3-15).

Questionnaire survey and in-depth Interviews

Two data collection methods from the field include questionnaire survey and in-depth interviews (Figure 3-21). The authors and some facilitators visited the houses of some residents and some key-informants to carry out in-depth interviews. During this in-depth interview process, we collected detailed information on how they perceive the volcanic eruption, some preparedness that they carry out and their experience to the previous evacuation.

Secondary data collection

Apart from direct observation, questionnaire surveys and in-depth interviews, the author also collected secondary data from the offices of sub-districts and villages. This information covers detailed information of the evacuation in 2006.

Figure 3-21 In depth interview and Questionnaire survey
Left: In depth interview to the local residents of Mt. Merapi, to acquire detailed information on their perceptions to volcanic eruptions, their preparedness and experience of evacuation in the past. Right: The residents filled-up the questionnaires, guided by facilitators. Image courtesy of Saut Sagala (2008)

3.3.2. Analytical Methodology

All the data were from the questionnaire inputted to SPSS Statistical Software 15.0. Furthermore, for data related to social resilience model, we used AMOS 7.0 software to examines the causal-relationship between the hypothesized factors. To carry out the statistical tests, we used SPSS software 15.0.

3.4. Field Data Collection

3.4.1. Study Area in Mt. Merapi

The study area is located at the southern flanks of the Merapi Volcano, the areas which were affected by the recent 2006 volcanic eruptions. It belongs to the Sleman district and two sub-districts: Pakem and Cangkringan. In total we surveyed 322 respondents from fourteen hamlets. In the study area, the smallest local administrative unit is the village and each village consists of several hamlets. A hamlet, called dusun in Indonesian, was selected instead of village as the unit of analysis here because the hamlet represents the place where a community lives and in many cases it was found that in each community people take action together with other people from the same hamlet.

The economic bases in both sub-districts are dominated by agriculture, raising cattle, sand and rock mining activities and the other is from tourism activity. Normally, the sand and rock mining activities are available along the river valleys which channelled the lahars from Mt. Merapi eruptions in the past time. The agriculture and farm activities get benefit from the mild climate on the slopes of the mountain. The tourism activities include renting the rooms in the weekend, providing sightseeing of the mountain. Thus, the economic bases of these sub-districts are mainly influenced by the existence of Mt. Merapi.

Figure 3-22 Livelihood Sources in Mt. Merapi

Both pictures above: The residents work as sand-miners and collect the sand and rocks to the trucks. Picture below: an old woman with came back from collecting grass to feed cattle. Images courtesy of Saut Sagala (2008)

Surveys

We conducted a field survey from early January to mid February 2008. The survey included both structured and semi-structured interview. The survey was conducted in fourteen hamlets, resulting in 322 respondents. The structured interview collected data on observable variables used for the analysis. Semi-structured interviews were used to gather information on additional social issues. The questionnaire used in this thesis refers to a study that was earlier applied in New Zealand by Paton et al. (2008) for study of social resilience and a set of questionnaire developed by the author that aims to obtained information on evacuation decisions.

The questionnaire used in this thesis consists of three parts. The first part is the general information of the respondents. This information is shown in table 3-5 on the general characteristics of the respondents (demographical data etc). The second part is the questions on social resilience while the last part is the questions related with the evacuation and warning systems in the study area.

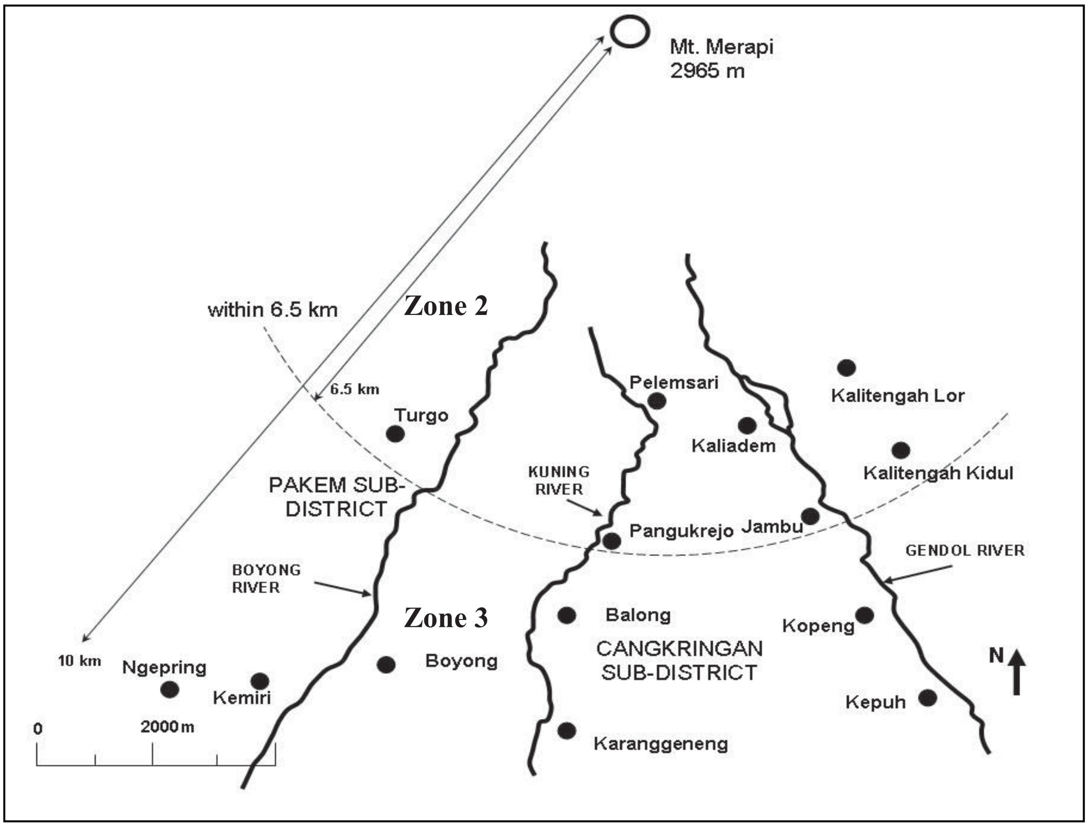

Figure 3-23 Location of surveyed hamlets with reference to Mt. Merapi

Respondents

In Mt. Merapi, our data originate from 322 respondents who filled out the questionnaires. The participants were mainly the head of the households. Our assumption was that if the head of the households have the intention to carry out disaster preparedness, we assumed the whole family would be motivated to follow. Similarly, in the case of evacuation, if the head of the family decided the family to evacuate then the family would evacuate. In the case when the head of the households were absents, the representative (elder or younger) of the family would come to the meeting.

Our aim was to get the respondents to be randomly distributed. For this, we select fourteen hamlets which represented the two hazard zones in the study area (see Figure 3-23). Zone 2 is represented by this eight hamlets while zone 3 is represented by six hamlets.

Hamlets in surveyed in zone 2 in the study consist of Ngepring, Kemiri, Boyong, Karanggeneng, Balong, Kopeng, Jambu and Kepuh. Meanwhile, hamlets surveyed in zone 3 consist of Turgo, Pangukrejo, Pelemsari, Kaliadem, Kalitengah Lor and Kalitengah Kidul. The unit of analysis in our study is not carried out on the basis of zone, since the delineation based on hazard zone seems to be artificial and is not understand properly by the respondents (source: interviews to the respondents). However, the unit of analysis is either based on a hamlet or an aggregate data of the respondents.

The characteristics of the respondents are obtained and can be seen from Table 3-5 and Table 3-6. In term of age, the number of respondents are distributed normally with the average is 30s years old. However, most of the respondents surveyed were male since the questions were aimed to depict the evacuation decision and social resilience at the household level. With this aim, we argue that the heads of the households were better to represent a household.

Table 3-5 General Characteristics of the Respondents in Mt. Merapi
N = 322, Source: (Sagala and Okada, in review)

Characteristics	**Variables**	**%**		**Characteristics**	**Variables**	**%**
Age	20s and 30s	54.8		Household Size	1	0.9
	40s	20.6			2	9.6
	50s	15.3			3	25.5
	60s and > 60s	6.5			4	29.2
					5 or more	19.6
Gender	Male	96.4				
	Female	4.0		Exp of Eruption. 1994	Yes	8.7
					No	91.3
Income / month	< USD 110	67.1				
	110 – 220 USD	23.9		Type of House	Concrete	79
	220 – 550 USD	3.4			Wood	21
	550 – 1100 USD	1.9				
				House Ownership	Own	97
Evacuation 2006	Yes	63.1			Rental	3
	No	36.9				

In term of income, most of the respondents (67%) said monthly they earn around 110 USD and while about few of them (24%) earn between 110 - 220 USD. Housing type of the respondents are mostly constructed by concrete which the most of housing materials they obtained from the volcanic materials (see Figure 3-22). As mentioned earlier, the abundance of these construction materials are the benefit of living near the volcano. In line with this, almost all respondents (97%) reported that they occupy their own house.

In term of occupation, most of the respondents in Mt. Merapi work as sand miner, dairyman and farmer (see Figure 3-25). These types of occupation infer that the respondents depend a lot on the existence of Mt. Merapi.

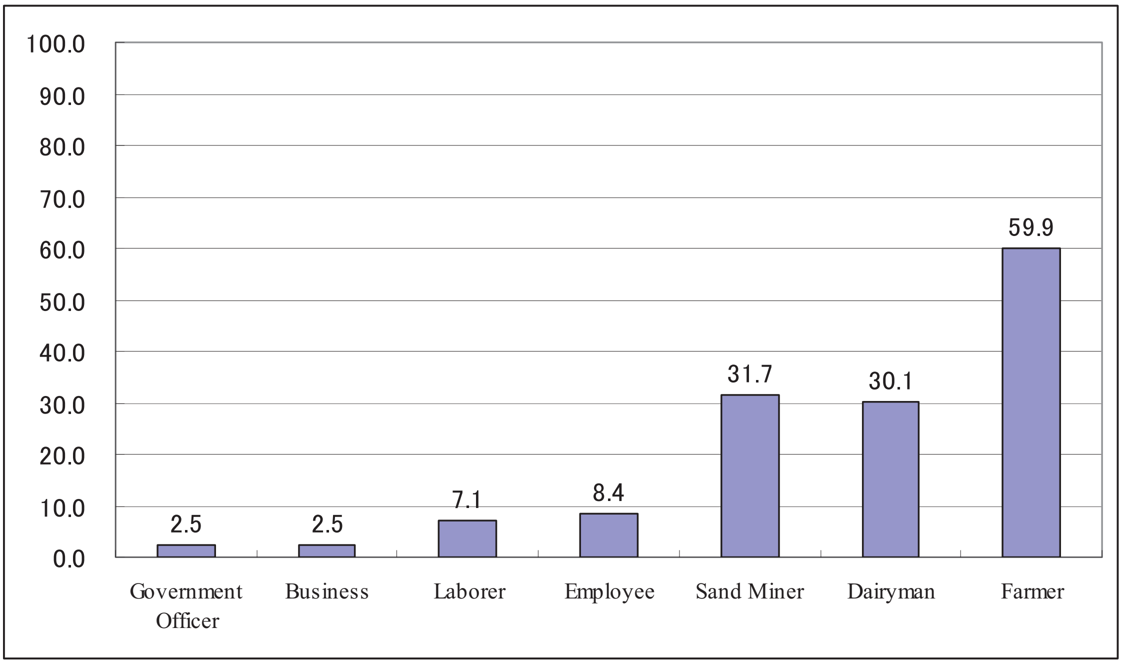

Figure 3-24 Occupation of respondents in Mt. Merapi

Note a respondent may have more than 1 type of occupation and therefore the total number respondents who have occupation are more than 100 percent. Source: field survey (2008)

Table 3-25 Mean, median, mode and standard deviation of the respondents in Mt. Merapi

N = 322 (Sagala and Okada, in review)

	Mean	**Median**	**Mode**	**Std. Deviation**
Family Member	3.81	4.00	4.00	1.26
Did you evacuate in 2006?	0.63	1.00	1.00	0.48
Experience of evacuation in 1994 (0= No, 1= yes)	0.09	0.00	0.00	0.28
Age	40.28	38.00	32.00	12.04

Most of the respondents (63%) reported that they evacuated during the eruption in 2006. This figure does not describe clearly where the respondents live and what factors affect them. In chapter 4, the relationships between the evacuation decisions and the factors that could affect the evacuation are analyzed in details.

3.4.2. Study area in Mt. Sakurajima

This section consists of discussion on study area, survey and the respondents in Mt. Sakurajima.

Study area

The study area in Mt. Sakurajima covers three cities, namely: Kagoshima City, Sakurajima City and Tarumizu City. These three cities were selected since they are among the closest cities to Mt. Sakurajima and therefore they bear the potential risks posed by the volcano (see Figure 3-13) in the earlier section 3.2.2. The respondents living in Kagoshima and Tarumizu cities are mostly living in urbanized areas. The respondents in Sakurajima live in more typical rural area, yet the close distance to Kagoshima City means that they have good accessibilities.

Survey

The questionnaires were distributed through schools and the school headmasters / teachers passed the questionnaires to the pupil which subsequently passed to the pupils parents to fill the questionnaire. The filled questionnaires were then sent back to Research Center for Disaster Reduction Systems, Kyoto University to Uji Campus with a registered stamp provided earlier.

For each city, the approach is a little bit different. In Kagoshima City, we made phone calls to the headmasters and after reaching to an agreement to distribute the questionnaires, we sent the questionnaires through mails to each school. Then, teachers passed the questionnaires to the pupil which subsequently passed to the pupils parents to fill the questionnaire. In Sakurajima City, we approached the schools through our contact a local NGO (Sakurajima Museum), which helped us to visit each school and distributed our questionnaires. In Tarumizu City, we visited the local municipalities and the municipalities sent the questionnaires to each school.

Up to 14th June, we received 400 questionnaires. Some questionnaires that came later, after 20th June were not counted for this thesis due to time limitation. We received 175, 59 and 161 questionnaires from Kagoshima City, Sakurajima City and Tarumizu City respectively.

Respondents

The following section discusses the general characteristics of the respondents from the Mt. Sakurajima field survey. In term of age, most of the respondents are among those whose ages are between 30-50 years old, totalling around 86.9%. Most of the respondents who filled out the questionnaire were female. Household size or "number of people in the household" is mainly dominated by 3-5 persons per household. The questionnaire also asked the vulnerable people, which indicates those who are handicapped and age more than 65 year old. The respondents reported about 28 % of the household has at least one vulnerable person in case of a disaster occurs.

Table 3-6 General characteristics of the respondents in Mt. Sakurajima

Characteristics	Variables	%		Characteristics	Variables	%
Age	below 30	3.8			1 storey house	24.3
	30-40	37.4			2 storey house	65.5
	40-50	49.5		Number of storey	3 storey house	4.9
	50-60	7.8			1-4 storey apartment house	1.5
	60-64	1.0			5-10 storey apartment house	4.0
	65-70	0.5				
Sex	male	27				
	female	73		Ownership	owned	65.5
					rented	34.5
number of people in the household	0	0.5				
	1	4.1		House structure	wooden	63.4
	2	5.4			concrete made	36.1
	3	15.6				
	4	38.3			company employee	24.6
	5	26.8			government official, teaching staff	21.2
	6	6.1		Occupation	businessman	8.1
	7	2.8			farmer	0.8
	8	0.5			housewife	22.0
					part-time job	19.6
Number of vulnerable people in the household	0	71.8			unemployed	1.6
	1	18.9			a pensioner	0.3
	2	7.1			student	0.3
	3	1.5			other	1.6
	4	0.3				
	5	0.5		type of household	Single House	94.5
					Apartment	5.5

In term of housing, 66% of the respondents owned their houses while the rest reported that they rented their house. Most of the respondents stayed in house rather than apartment. When it comes to house structure, most of the respondents reported they stayed at wooden house. In term of occupation most of the respondents were either company employee, government staffs, part time job or a house-wife.

3.5. Summary

This chapter has provided the introductory description of the volcanoes in Indonesia and Japan, further detailed information of Mt. Merapi, Indonesia and Mt. Sakurajima, Japan. It has also described the selection of the study area and general characteristics of the respondents.

In term of the volcanic activities, both volcanoes are considered active and have posed regular hazards to it's environment. Therefore, the hazard exposures given by Mt. Merapi and Mt. Sakurajima are high. However, in term of people living near the environment, lesser people live close to Mt. Sakurajima as compared to those of living in Mt. Merapi. In addition to that, more types of countermeasures provided by the local governments in Mt. Sakurajima as compared to those in Mt. Merapi.

As described earlier, the respondents in Mt. Merapi are characterized by people mainly living in typical rural areas which are also noted by the types of work dominated by farmer, sandminer and dairyman. On the other hand, the respondents in Mt. Sakurajima are mainly characterized by people living in urbanized areas which are noted by the types of work that they hold, namely: company employee, government employee and some part time job.

References

de Boer, J. and Sanders, D., 2002. Volcanoes in Human History: The Far Reaching Effects of Major Eruptions. Princeton University Press.

Lavigne, F. and Thouret, J. Lahars and Micro zonation

Paripurno, E., H. Setiabudi, Sofyan, D. Raharyono, A. Susanto and F. Nawitaningrum (1999). *Merapi Bertutur: Tentang Musibah Awan Panas 22 Nopember 1994 (Merapi describes: About the Pyroclastic Flow, November 22nd 1994)*. Kappala Indonesia and Pusat Studi Manajemen Bencana, UPN Veteran Yogyakarta, Yogyakarta.

Ratdomopurbo, A., Subandriyo, Sulistiyo, Y. and Suharna, 2006. Prekursor Erupsi Gunung Merapi (in Indonesian).

Sagala, S. (2007) Risk Communication for Disaster Preparedness of Earthquake and Volcanic Eruption, case study: Yogyakarta, Indonesia, paper for PhD Summer Academy, Munchen, United Nations University - Institute for Environment and Human Security and MunichRe Foundation, Jul 22-28, 2007, Munich, Germany

Sagala, S. and Okada, N., *in review*. How do hazard-related factors and traditional cultural beliefs affect evacuation? A case study: Communities in Mt. Merapi, Indonesia. Disasters.

Savino, J. and Jones, M., 2007. Supervolcano: the catastropic event that changed the course of human history. The Career Press, Inc.

SI-USGS, 2009. Global Volcanism Program, accessed from: http://www.volcano.si.edu/reports/usgs/ on July 4, 2009.

Thouret, J., Lavigne, F., Kelfoun, K. and Bronto, S., 2000. Toward A Revised Hazard Assessment at Merapi Volcano, Central Java. Journal of Volcanology and Geothermal Research, 100: 479-502.

Thouret and Lavigne (2002) in Gupta, The Physical Geography of Southeast Asia

VRC, 2006. Current eruptions in Japan, Volcano Research Center, Earthquake Research Institute, University of Tokyo, accessed from http://hakone.eri.u-tokyo.ac.jp/vrc/erup/erup.html on July 9, 2009.

VSI, 2006. Hazard Zone Map of Merapi Volcano, Bandung. (Pusat Vulkanologi dan Mitigasi Bencana Geologi), Online: www.vsi.esdm.go.id

Wikimedia, 2009. Volcano Distribution in Indonesia, http://upload.wikimedia.org/wikipedia/commons/f/f5/Map_indonesia_volcanoes.gif accessed on July 4, 2009.

Wikipedia, 2009. Mount Unzen, accessed from http://en.wikipedia.org/wiki/Mount_Unzen on July 4th, 2009.

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Chapter 4. Social Resilience of Communities in Mt. Merapi

This chapter[1] discusses the modelling of causal-relationship variables related to social resilience. This study proposed and tested predictors of “intention to prepare”, as a social resilience indicator for volcanic risks in community members living near Mt. Merapi volcano, Indonesia. The model, which extends one developed by Paton et al (2008) in New Zealand to members of a collectivistic culture, proposes that personal-, community- and institutional (e.g., civil defense)- level variables interact to predict the intention to prepare for volcanic hazards. Using the data from communities situated around Mt. Merapi (n = 322), analysis revealed that community-level variables (e.g. collective efficacy and community participation) played invaluable roles, followed by institutional variables. Individual-level variables were less influential compared with studies applying the model in individualistic countries. Some policy implications related to the findings are presented in this chapter.

4.1. Introduction

This chapter analyzes the causal-relationship factors that contribute to development of social resilience in a mountainous community. Social resilience has become important issues since it leads to a better understanding how a system or a community can cope with and recover after the occurrence of an external shock, such as, a disaster, a conflict or an environmental change (Adger, 2000; Adger et al., 2005; Klein et al., 2003). Identifying how the social resilience of a community works at an earlier stage will help the community and a local government to make an emergency plan on what to prepare and what to do to increase the resilience.

In this thesis, the definition of social resilience refers to “the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change” (Klein et al., 2003). This implies that social resilience includes how the societies adapt themselves from the obstacles they face and increase their

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[1] This chapter has been written based on the following articles: (1). Sagala, S., Okada, N. and Paton, D. Predictors of Intention to Prepare for Volcanic Risks in Mt. Merapi, Indonesia, Journal of Pacific Rim Psychology (*in press*) and (2). Sagala, S., Okada, N. and Paton, D. (2009), Modeling Social Resilience of Mountain Communities Under Volcanic Risks. A case study of Mt. Merapi. IEEE International Conference on Systems, Man, and Cybernetics, October 11-14, 2009, San Antonio, Texas, USA. (accepted).

capacities in dealing for the future ones. Arguably, different literature uses different terms which somewhat have similar meaning or share characteristics to social resilience, such as: ‘disaster preparedness’ (Paton et al., 2005) or ‘household adjustment’ (Lindell and Perry, 2004; Lindell and Whitney, 2000). In this thesis, however, we maintain to use the term social resilience as it gives broader meaning in dealing with such an issue.

To date, only a little study has been carried out to understand the social resilience issues in developing countries (Adger et al., 2005). In the case of a disaster or a conflict, many examples indicate delayed responses given by local governments in developing countries. One reason is due to the lack of provisions of capacities and infrastructures before a disaster occurs. One way to deal with this problem is by promoting and increasing community resilience to deal with the disturbance. This study attempts to address this issue by identifying the main variables that affect and encourage people to be resilience. The study focuses the analysis on the concept of social resilience as other studies in the context of economic issues have been well examined by researchers in vulnerability issues (Wisner et al., 2004). Taking the communities living in Mt. Merapi as a case study, this chapter applies the socio-psychological variables that might govern the social resilience of the community. Arguably, the communities living in Mt. Merapi have developed capacities and adopted some ways in in dealing with the eruptions since they have sustained from many occurrences of volcanic eruptions in the past (Paripurno et al., 1999; Ratdomopurbo et al., 2006). Nevertheless, how their social resilience and what variables affect them remains unidentified.

4.2. Theoretical Framework

As discussed earlier on the theory of social resilience model in section 2.2, Paton et al. (2008) identified how interaction between two person-level variables (negative and positive outcome expectancy), two community-level variables (community participation and articulating problems) and two institutional variables (empowerment and trust) could account for differences in levels of people’s hazard preparedness. Paton et al. (2008) found that, as might be expected when using data derived from members of a individualistic culture, that person-level variables played a more significant role in predicting preparedness. However, the fact that community-level variables, such as community participation with people sharing similar beliefs and values made an additional contribution to people’s risk perception and risk management choices opens up the potential to use this model in cultures where collective processes play a more prominent role in community life.

4.3. Data

The data are gathered from the field survey that was carried out by the author in January – February 2008 (see section 3-4 on field data collection). In the context of social resilience, we measure the following variables: negative and positive outcome expectancy, community participation, sense of communities, collective efficacy, trust, empowerment, intention to seek for information and intention to prepare. Detailed explanations of these indicators are mentioned earlier in chapter 2 section.

Structural equation model (SEM), as the analytical tool, needs several rounds of simulation before coming to the final model. After such heuristic trials, it has been decided not to include the self efficacy, action coping, and sense of community variables. Other remaining variables are enough to represent the individual, community and institutional variables.

Characteristics of the respondents are discussed earlier in section 3.4.1

4.4. Measures

The variables selected for this study were those used in the study by Paton et al. (2008) study. Full details of the rationale for the model and the variables it comprises can be found in Paton et al (2008). Key issues are summarized in the following section. The model first examines peoples' beliefs about the efficacy of protective actions. This was assessed by using the construct of outcome expectancy (Paton, 2008). Negative outcome expectancy reflects beliefs that hazard consequences are too catastrophic for personal action to make any difference to peoples' safety. If people hold this belief, no further action is likely to take place. In contrast, positive outcome expectancy (the belief that preparation can increase personal safety) can motivate people to prepare. However, a distinction can be drawn between the belief that preparing can be effective and knowing how to prepare. Consequently, if people hold positive outcome beliefs and possess the necessary knowledge and resources to prepare, they will act. If however, they need guidance to understand their circumstances and what they should do, people look first to other community members and subsequently to emergency management agencies.

Faced with complex and uncertain events, when lacking all the information they need themselves, peoples' perception of risk and how to manage it is influenced by information from others who share their interests and values. Because participating in community activities provides access to information from people that share one's interests, values and expectations, a measure of "community participation" (Eng and Parker, 1994) was included in the model. However, the infrequent nature of volcanic activity means that people may first have to work out what consequences they could have to deal with to identify the information they need to prepare. Because it provides a means of assessing community members' ability to identify the information, resource and planning needs required to advance their tsunami preparedness, a measure of 'collective efficacy' (Zaccaro et al., 1995) was incorporated in the model. Paton and Johnson (2001) discussed how collective efficacy is a good indicator of co-operation and assistance available within a community and thus it represents a measure of the likelihood of the success of mitigation strategies that require collective and co-ordinated action.

Given that this process may identify new information and resource needs that cannot be met within existing community contexts, the degree to which these needs are met by expert sources has a salient role in the model. People's willingness to take responsibility for their own safety is increased, and decisions to prepare more likely, if they believe that their relationship with formal agencies is fair and empowering (e.g., agencies are perceived as trustworthy, as acting in the interest of community members). If this relationship is not perceived as fair and empowering , people lose a sense of trust in the agency (i.e., the source of information), reducing the likelihood that they will use the information and prepare. Empowerment means citizens' capacity to gain mastery over their affairs while being supported in this regard by external sources . "Empowerment" was assessed using a measure developed by Speer & Peterson (2000) and "trust" with a measure used in an earlier study of hazard preparedness (Paton et al., 2005).

Finally, the model argues that the relationship between trust and action is mediated by intentions. Lindell & Perry (2004) suggest that people who seek for information will be more likely to be motivated to prepare. Based on this assumption, this chapter develops the relation between 'intention to seek for information' and 'intention to prepare'. The dependent variable in the model was the intention to prepare (Paton et al., 2008).

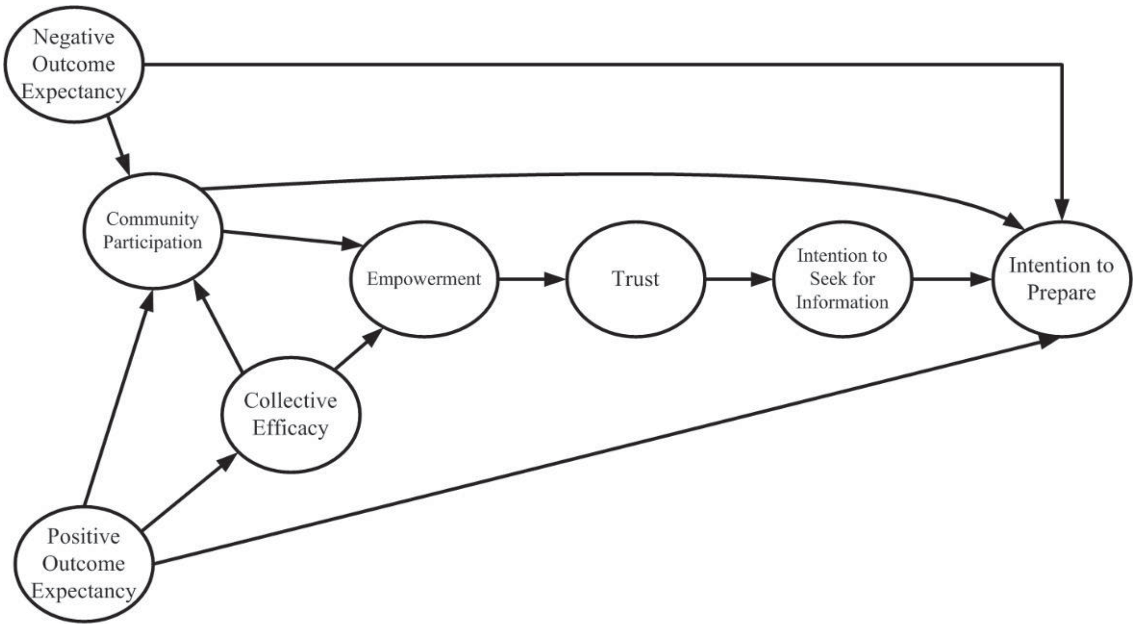

Figure 4-1 Simplified proposed structural equation model for Mt. Merapi

The analysis was conducted using Structural Equation Model (SEM). The model proposes that several independent variables interact to predict the dependent variable. SEM was selected for the analysis because it can calculate multiple and inter-related dependence relationships simultaneously (Cheng, 2001; Kline, 1998). Thus, SEM can test the model as a whole and to show how well the data fit the hypothesized model (Goodness-of-Fit).

All the independent and dependent variables above are set into a structural equation model (Figure 4-1). The model suggests that people's decision to prepare reflect the outcome of a sequence of activities. It is hypothesized that negative outcome expectancy beliefs will reduce the likelihood that people will form intentions to prepare. In contrast, it is hypothesized that positive outcome beliefs will motivate people to form intentions to prepare or stimulate their engagement in collective activities (first with others in their community and then with formal sources) that culminate in their forming intentions to prepare. That is, it is hypothesized that the community (community participation, collective efficacy) and formal (e.g., civic emergency planners and also NGOs in disaster management) institutional (empowerment, trust) variables will mediate the relationship between positive outcome expectancy and intention to prepare.

The whole model is expected to work as a sequential decision process from personal, community and institutional variables that interplay to affect people decision in preparing at personal level. In summary, the assumed model is shown in Figure 4-2. Each path shows the hypothesized relationship between variables. The estimated (final) model will illustrate only significant paths.

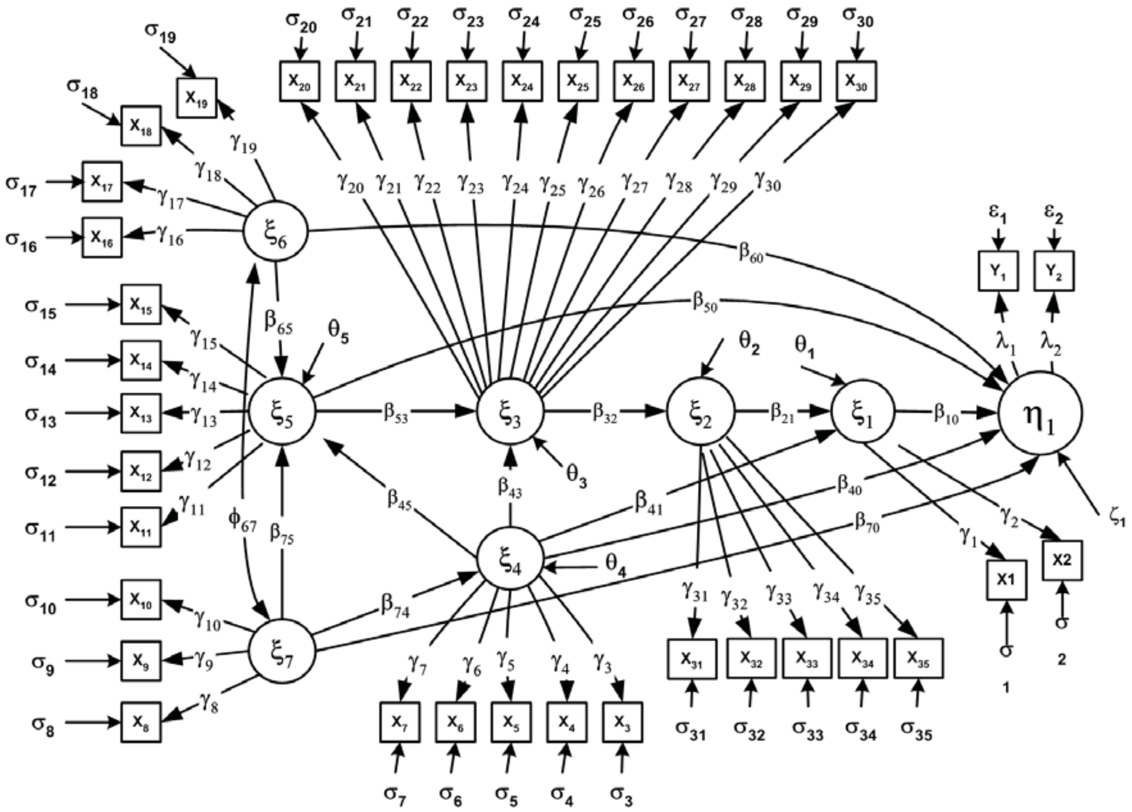

Figure 4-2 A proposed structural equation model of social resilience in Mt. Merapi

Source: Sagala et al., 2009

4.5. Modeling of Social Resilience in Mt. Merapi

The model attempts to demonstrate how socio-psychological variables affect the social resilience of mountainous communities. It is based on the assumption that the quality of relationships between individuals, community and institutional mainly determine the state of resilience. This relationship is being proposed as causal-relationship variables, presented in a structural equation model (SEM) and tested using a data set from Mt. Merapi case.

As in any structural equation model, the aim is to develop a model that illustrates causal-relationship variables which include path diagram that illustrates how much a variable influence others in a structured model. Therefore, the model includes the definition of latent variables, observable variables, errors, residuals and the path diagrams (see Figure 4-1). Our study deals with the socio-psychological variables and thus the variables in the model are latent variables. The latent variables are then connected with the observable variable.

The main analysis for this study is conducted using an SEM. In our model, the SEM is composed of three large components of variables at individual (ξ_6, ξ_7), community (ξ_4, ξ_5) and institutional levels (ξ_2, ξ_3) (see figure 4-1). The meaning of symbols used for the hypothetical model used in Figure 4-1 is presented in Table 4-1.

In this study we performed two sets of models. The first model used the data from all communities (322 respondents) while the second model used the data from all communities minus one hamlet (Pelemsari Hamlet).

The arrows illustrate the direction (originating from outcome expectancy) of the causal relationships between variables identified by the analysis. All paths show positive relationships between variables. The numbers next to each arrow indicate the power of the relationship (from 0 to 1). In this model, only the significant paths are shown and presented ($p < 0.05$). The goal of structural equation model is to find non-significant differences between the estimated model and the actual data (Byrne, 2001; Kline, 1998). This difference is measured by the Chi-Square (χ^2) value.

Table 4-1 Symbols used in the proposed model of social resilience

Symbol	Meaning
η	Endogenous latent variables
ξ	Independent endogenous variables
ζ	Residual
θ	Measurement errors
x	Observed endogenous variables
y	Observed exogenous variables
λ	Path from endogenous latent variables to observed variables
γ	Path from exogenous latent variables to observed variables
σ	error

The model proposes that several independent variables (ξ_{1-7}) and their observable variables interact each other to predict the dependent variable (η_1). The complete interactions of the dependent variable, independent variables, and observable variables used in this chapter are depicted in figure 1. Latent variables are not observable directly and therefore is not measureable directly. As such, the unobserved variable is linked to one that is observable, thereby making its measurement possible. For example, in Figure 1 it is shown that ξ_7 is linked with three observable variables x_{8-10}. Each interaction is similar to an equation in a linear or multiple regression. Therefore in each interaction, there will be a dependent variable, independent variable(s) an error or residual. For example, the observable variable x_8 can be defined as follows:

$$x_8 = \gamma_8\xi_7 + \sigma_8 \quad (1)$$

The dependent variable $\eta 1$ can be described as follows:

$$\eta_1 = \beta_{10}\xi_1 + \beta_{40}\xi_4 + \beta_{60}\xi_6 + \beta_{70}\xi_7 + \xi \qquad (2)$$

or (2) can be re-written as

$$IP = \beta_{10}ISI + \beta_{40}CE + \beta_{60}POE + \beta_{70}NOE + \text{residual} \quad (3)$$

SEM was selected for the analysis because it can calculate multiple and inter-related dependence relationships simultaneously (Arbuckle, 2006; Byrne, 2001; Kline, 1998). These include calculation of total errors, the statistical significance (correlation and covariance) of all relationships. Thus, SEM can test the model as a whole and to show how well the data fit the hypothesized model (Goodness-of-Fit). The measurement of the model is represented by the value of goodness of fit index (GFI), normed fit index (NFI), root mean square of approximation.

Social resilience in this model is measured by using 'intention to prepare' variable. This measure is selected from an assumption that 'intention to prepare' will ultimately increase resilience of a society. If one has motivation to prepare then he will be more likely to increase his/her resilience. The overall model works as causal relation variables that follow the sequences in figure 1. Symbols used in figure 1 and the relation with the model are defined in Table 2. Therefore, the model can be drawn simply as shown in Figure 2. The details of the questions used to measure the latent variables are presented in appendix 1.

Table 4-2 Symbol and Meaning used in the Model

Symbol	Meaning	Abbreviation
η_1	Intention to prepare	IP
ξ_1	Intention to seek for information	ISI
ξ_2	Trust	T
ξ_3	Empowerment	E
ξ_4	Collective efficacy	CE
ξ_5	Community participation	CP
ξ_6	Negative outcome expectancy	NOE
ξ_7	Positive outcome expectancy	POE

Modeling starts by examining peoples' beliefs about the efficacy of protective actions. This belief was assessed by using the measure of outcome expectancy (see figure 2). Outcome expectancy can be in the form of 'negative outcome expectancy' (NOE) or 'positive outcome expectancy' (POE). NOE illustrate beliefs that hazard consequences are too catastrophic for personal action to make any difference to peoples' protection. Those who hold this belief will be unlikely to take action. On the contrary, POE (the belief that preparation can increase personal safety) can motivate people to prepare. However, a distinction can be drawn between the belief that preparing can be effective and knowing how to prepare. Accordingly, for people who hold positive outcome beliefs and possess the necessary knowledge and resources to prepare, they will act.

Finally, the model examines if the relationship between trust and action is mediated by intentions. People who seek for information will be more likely to be motivated to prepare (Lindell and Perry, 2004). Based on this assumption, this chapter develops the relation between 'intention to seek for information' and 'intention to prepare'. The dependent variable in the model was the intention to prepare (Paton et al., 2008).

All the independent and dependent variables above are set into a structural equation model (Figure 4-2). The model suggests that people's decision to prepare reflect the outcome of a sequence of activities. It is hypothesized that negative outcome expectancy beliefs will reduce the likelihood that people will form intentions to prepare. In contrast, it is hypothesized that positive outcome beliefs will motivate people to form intentions to prepare or stimulate their engagement in collective activities (first with others in their community and then with formal sources) that culminate in their forming intentions to prepare. That is, it is hypothesized that the community (community participation, collective efficacy) and formal (e.g., civic emergency planners and also NGOs in disaster management) institutional (empowerment, trust) variables will mediate the relationship between positive outcome expectancy and intention to prepare.

The hypothesized model is expected to work as a sequential decision process from personal, community and institutional variables that interplay to affect people decision in preparing at personal level. In summary, the assumed model is shown in Figure 4-2. Each path shows the hypothesized relationship between variables. The estimated (final) model will illustrate only significant paths. The model was analyzed using data collected from a survey on people living in the southern flanks of Mt. Merapi. Discussion on the next chapter (Chapter 5) on an evacuation analysis indicated a particular response given by one hamlet (Pelemsari) in the study area. This hamlet is argued to be distinct since the community living refused to evacuate during an evacuation order in 2006. Thus, the two models were run using all data and data except the distinct hamlet. The first model was run using all data while the second model was run using data except from the Pelemsari hamlet (Figure 4-3). All data were run using SEM software, AMOS 7.0.

The hypothesized model was analyzed using data that were collected from the survey to people living in southern flanks of Mt. Merapi. Earlier study on evacuation analysis indicated a particular response given by one hamlet (Pelemsari) in the study area (Sagala and Okada, *in review*). This hamlet was argued to be distinct since they indicated a refusal of the community living there to evacuate during an evacuation order in 2006. For that purpose, two models were run using all data and data except the distinct hamlet. The first model was run using all data while the second one was run using data except from one hamlet (figure 3). All data were run using an SEM software, AMOS 7.0.

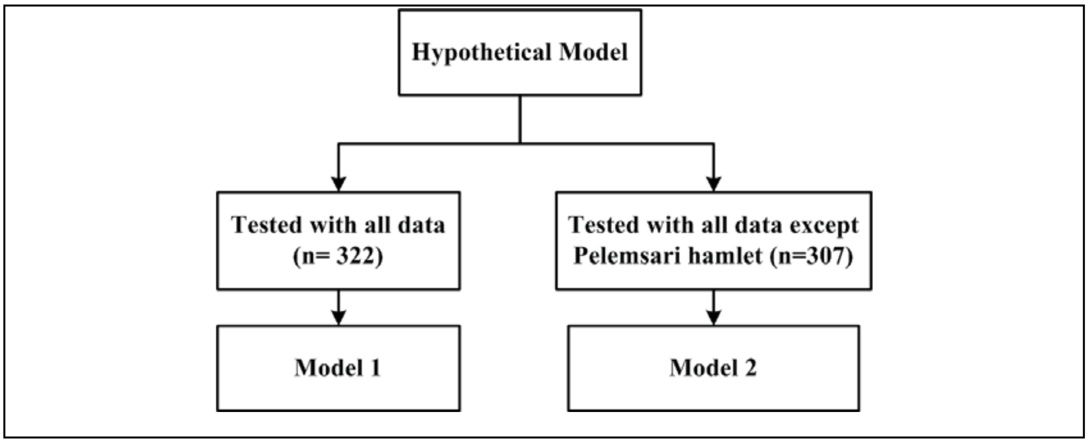

Figure 4-3 Conceptual Analysis

The overall interactions of variables of the two models are summarized in table 3. The detailed of relationships in model 1 and model 2 are depicted in Figure 4-1 and 4-2 respectively. The results of the model one is shown in left-hand side of the table while the results of the model two is shown in right-hand side. The model one indicates all paths from NOE are non-significant while one path from POE is non-significant. Non-significant paths are also found for some relationships originating from CE.The model two illustrates that all paths originating from individual level variables (outcome expectancy) are non-significant. In addition to that, the paths from CE to IP and CP to E are found non-significant. All the non-significant path in both model is completely omitted in the 'assumed' model as indicated in Figures 4-1 and figure 4-2.

Table 4-3 The details of each path in the finding

*ns = non-significant, * significant at 0.05, ** significant at 0.01, Source: Analysis*

Path	S	Model 1 (n=322)		Model 2 (n= 307)	
		P value	Estimate	P value	Estimate
POE → CP	β_{75}	ns	-	ns	-
POE → IP	β_{70}	0.06	0.18	ns	-
POE → CE	β_{74}	*	0.22	ns	-
NOE → CP	β_{65}	ns	-	ns	-
NOE → IP	β_{60}	ns	-	ns	-
CE → CP	β_{45}	*	0.29	ns	0.23
CE → E	β_{43}	ns	-	**	0.39
CE → ISI	β_{41}	ns	-	*	0.23
CE → IP	β_{40}	*	0.17	ns	-
CP → E	β_{41}	**	0.29	ns	-
CP → IP	β_{50}	ns	-	*	0.14
E → T	β_{32}	*	0.5	**	0.45
T → ISI	β_{21}	**	0.28	0.06	0.17
ISI → IP	β_{10}	**	0.75	**	0.57

4.5.1. Model 1 (result from n= 322)

The detailed result of Model 1 is available in Appendix 2. The estimated of the Model 1 (Figure 4-4) indicated three paths of direct relation to variable intention to prepare. The paths are from intention to seek for information (ISI), collective efficacy (CE) and positive outcome expectancy (POE) variables. The estimated results confirm the validity of the model as a predictor on volcanic hazard preparedness.

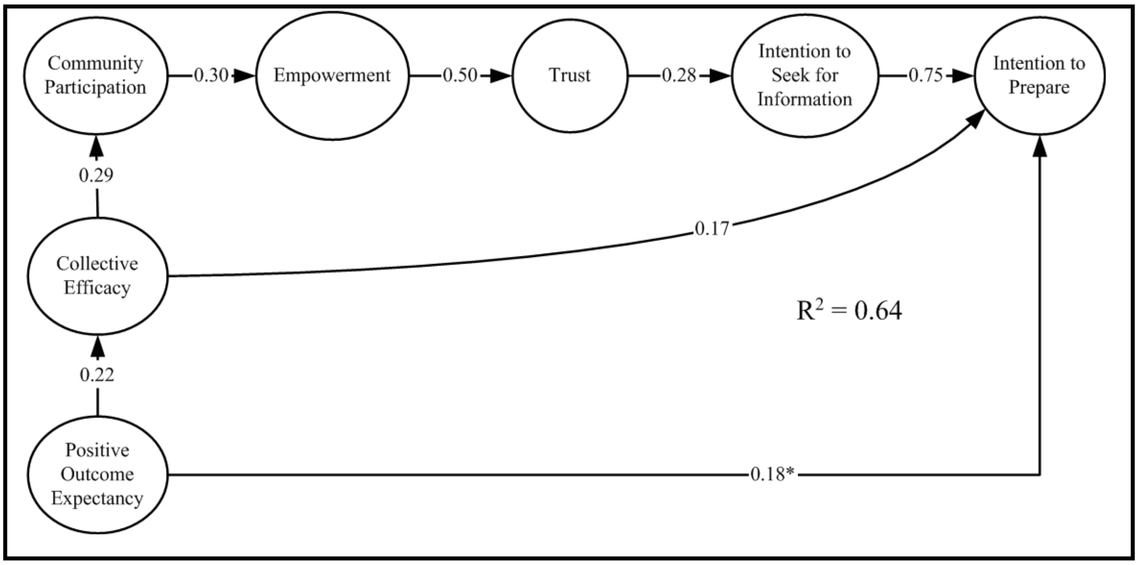

Figure 4-4 Model 1 of Social Resilience in Mt. Merapi
(χ^2 = 193.88, df = 222, p = 0.91), RMSEA = 0.00, NFI = 0.88, GFI = 0.96.
*all paths are significant at 0.05, except * significant at 0.07*
Source: Analysis

The Goodness-of-Fit statistics for the model 1 are: (χ^2 = 193.88, df = 222, p = 0.91), RMSEA = 0.00, NFI = 0.88, GFI = 0.96. The p value of 0.91 indicates that the difference between the actual and estimated model is non-significant. Thus, the estimated model is a close fit to the data. Furthermore, other measures (RMSEA, NFI and GFI) also verify the validity of the model. In general, the model explains 64% of the variance in 'intention to prepare' for volcanic hazards. The Normed Fit Index (NFI) illustrate an indication of the improvement (1-NFI). Thus, an NFI of 0.88 indicates a measure of improvement of merely 0.12. The overall goodness of fit of the model supports the value of the model as a means for understanding how community members make decisions about preparing for volcanic hazard risks.

4.5.2. Model 2 (result from n = 307)

The detailed result of Model 1 is available in Appendix 3. The estimated of the Model 2 (Figure 4-5) indicated two significant paths of direct relation to IP. The paths are from ISI, CP variables. The model indicates contributions from community and institutional variables but no direct relationship exists from any personal variable in this model. Thus, personal level variables are omitted in the model. The model two suggests that the ‘intention to prepare’ (IP) is mainly predicted by community participation (CP) and intention to seek for information (ISI). ISI, however, is predicted by both the ‘collective efficacy’ (CE) and ‘trust’ variables. The figure clearly suggests the central role of CE as the start of the model.

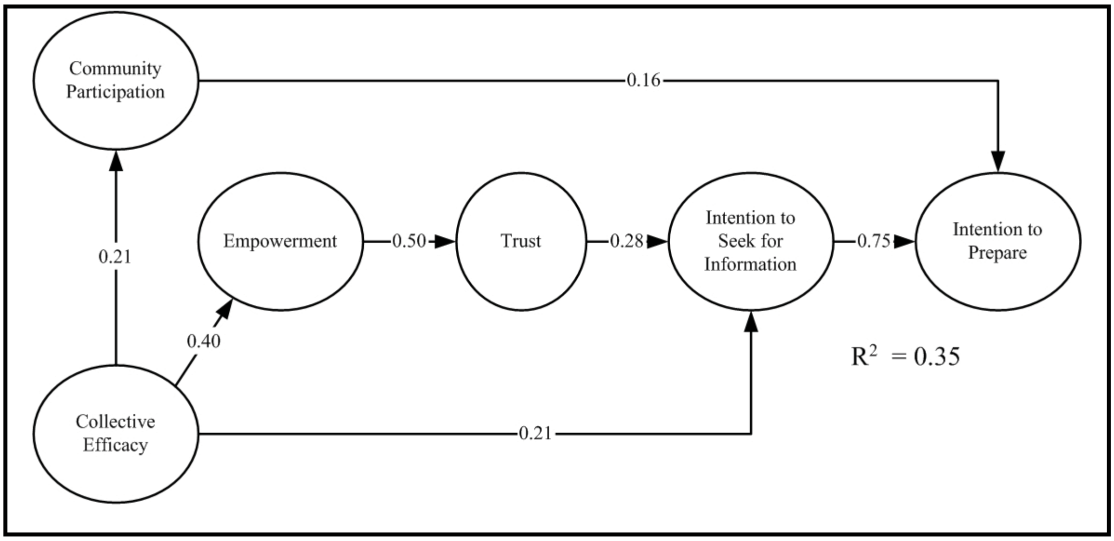

Figure 4-5 Model 2 of Social Resilience in Mt. Merapi
(χ^2 = 331.9, df = 340, p = 0.61), RMSEA = 0.00, NFI = 0.83, GFI = 0.94
Source: Analysis

The Goodness-of-Fit statistics of the Model 2 are: (χ^2 = 331.9, df = 340, p = 0.61), RMSEA = 0.00, NFI = 0.83, GFI = 0.94. The p value of 0.61 indicates that the difference between the actual and estimated model is non-significant. Thus, the estimated model is a close fit to the data. Other measures (RMSEA, NFI and GFI) also confirms the strength of the model. In general, the model accounts for 35% of the variance in ‘intention to prepare’ for volcanic hazards. The Normed Fit Index (NFI) illustrates an indication of the improvement (1-NFI). Thus, an NFI of 0.83 indicates a measure of improvement of merely 0.17. The overall goodness of fit of the model supports the value of the model as a means for understanding how community members make decisions about preparing for volcanic hazard risks.

4.6. Discussions

The estimated Model 1 and Model 2 show that intention to prepare is directly primarily predicted by three variables: “intention to seek for information”, “collective efficacy” and “positive outcome expectancy”. Evidence for the mediating role of community-level variables (i.e. community participation and collective efficacy) supports the view that relationships between people in the community play a highly significant role in facilitating disaster preparedness. Indeed, community participation has long been typical of community activities in Indonesia which can be seen in the form of *gotong royong* or ‘communal labour’ (Wall, 1996) which literally means “working together” to clean ones own neighborhood or village. Thus, the finding suggests that promoting the disaster preparedness activities at community level will be crucial to the development of effective risk management strategies for this population.

Both models reveal that individual-level variables were considerably less important than collective processes (e.g., community participation) and competencies (e.g., collective efficacy) in predicting intention to prepare. These findings reflect the fact that in a more collective society, preparedness is a collective activity that emerges when community members share their views with their neighbours or with those who share values with them. These findings are important. It highlights the importance of basing disaster management and preparedness strategies on community engagement, with the community being a significant resource for influencing the actions of its members.

4.6.1. Personal Variables

Model 1 indicated that amongst members of communities in collectivistic cultures, like those living in the vicinity of Merapi Volcano, individual-level predictors play significantly a less significant role in preparedness decision making than is the case in members of more individualistic cultures. There is a direct relationship between POE to IP in the model 1. As such, it offers tentative support for the existence of this direct path in the hypothesized model. The Model 2, however, it is argued that neither NOE nor POE makes a significant contribution to intentions, either directly or indirectly through community and institutional variables (Figure 4-5). Thus, both NOE and POE variables were omitted in the model 2. For example, both models 1 and 2 indicate that the hypothesized inverse relationship between NOE and intentions was not supported by the analysis. Thus they were omitted in the estimated models (Figures 4-4 and 4-5).

While the direct relationship between POE and intention to prepare just failed to reach significance in Model 1, the hypothesis that its relationship with intentions would be mediated by community and institutional variables was supported (Figure 4-4). Positive Outcome Expectancy had an indirect effect that was mediated by collective efficacy, community participation, empowerment, trust and intention to seek information. Thus the degree to which community members believe that intention to be effective in mitigating hazard consequences, the more likely it is that community competencies will be mobilized in ways that increase levels of preparedness. This also indicates that individual-level beliefs about hazard mitigation, especially when dealing with complex and potentially catastrophic hazard effects can be influential in a collectivistic culture.

4.6.2. Community Variables

As predicted, the community variables (collective efficacy and community participation) in both models confirm the vital role of social interactions with other people who face similar threats (share the living location), beliefs and values plays in influencing community members risk management decisions. This finding is not surprising, but indeed important, as this confirms the real condition of the society in Mt. Merapi. Collective efficacy had a direct influence on community participation and intention to prepare in the model two while it has a direct influence on community participation, empowerment and intention to seek for information.

The strong roles of collective efficacy in the model signify the fact that some people look to learn from their community capabilities before they take action to prepare. This is true in the context of collective society, like Indonesia. People look at their relatives, close friends and neighbors before they make major decisions such as those involved in preparing for a disaster that will have community wide implications. No direct relationship between community participation and intention to prepare was found in model 1. This was unexpected since the spirit of "working together" is apparent in this community. However, the result is different in model 2, which supports a direct relationship between community participation and intention to prepare.

That no direct relationship between community participation and intention to prepare in Model 1 was found is a surprising finding. This was unexpected since the spirit of "working together" is apparent in this community. Two separate, but related, explanations can be proposed to account for this. One is that, with regard to confronting novel problems (such as preparing from volcanic hazards), the spirit of "working together" has a more enduring impact on collective efficacy. Thus the discourse that occurs in community participation serves to identify new information or resource needs that arose from the exercise of their problem solving (collective efficacy) competencies. This observation is consistent with the findings of Paton et al. (2008). It is possible that the infrequent nature of volcanic hazards means that community members do not have all the information or resources that they require, increasing the need to obtain these from formal sources. This is consistent with the finding that the relationships between community participation and intention is mediated by empowerment. Only when the needs and expectations of community members are met through their interaction with formal agencies (empowerment), they will effectuate their preparedness planning.

4.6.3. Institutional Variables

As predicted, paths from institutional variables (empowerment and trust) show significant relationships in the Model 1. The findings of the roles of empowerment and trust illustrate that the communities need institutional supports to facilitate their knowledge of disaster risk. Community members are empowered by the actions of the civic agencies. Surprisingly, variable trust has a low level of significance with intention to seek for information in model 2. For example, during the periods of evacuation, community members tend to be dependent on the assistance of the government that guides them to the shelter and provides a sufficient evacuation shelter. Positive experiences with agencies under these circumstances will engender trust.

The evidence relationships between that community and institutional variables support the view that the people tend to feel they are empowered by institutions, the more they trust these institutions are sources of information, and, consequently, the more likely they are to seek information from these sources and to use it to formulate their disaster preparedness plans (intentions). In this case, it is noteworthy to mention the role of hamlet leader (*kepala dusun*) as a vocal point that the residents refer to prior to taking action. The existence of variable trust in this model illustrate the high level of trust by the local people to the current disaster response. Based on the observation in the field, trust to the government institutions and officials, including the agency handling the disaster until the local level, such as the chief leader, receive great trust from the communities. Taken together, the above discussion suggests that, with the exception of the Negative Outcome Expectancy variable, similarity between the Merapi model and the original model supports the existence of cross-cultural equivalence for this model. Further evidence can be gleaned from other sources. .

4.7. Model Comparisons with Cases in Auckland and Kyoto

In this section we compare the results we obtained on Mt. Merapi case with the other models obtained from the previous areas (Auckland and Kyoto) (see Figure 4-6 of the comparison between models in Mt. Merapi, Auckland and Kyoto). When applying the model to a New Zealand case study, Paton et al (2008) found a strong contribution of outcome expectancy (variables at personal level), followed by community participation and articulating problems (variables at community level) and by empowerment and trust (variables at institutional level). The findings in New Zealand tend to illustrate the condition in a western culture in which the community is characterized by more individualized society and thus it also reflects in the context disaster prevention where preparedness decisions are predominantly the result of decisions made by individuals. However, even in this individualistic culture, interaction with other community members informed individual choices. The opposite pattern was found in a Japanese sample.

The most noticeable difference between the Merapi model and those in Kyoto and Auckland concerned the role of individual variables (see Figure 4-6). This was absent in Merapi, but present in the other two samples.

While more research will be required to identify why this might be the case, a tentative explanation can be offered here. This could be due to relatively more frequent volcanic episodes increasing appreciation of the benefits of preparing (which would be less apparent in the other areas as a result of the considerably lower frequency of hazard events). Another explanation concerns the possible existence of a stronger relationship between appreciating the benefits of living in the shadow of an active volcano (e.g., fertile soils) and the need to develop ways of co-existing with this beneficial, but occasionally hazardous, aspect of their living environment.

In the Japanese context, Bajek (2007) found that collective efficacy and community participation made stronger contributions to the model (see Figures 2-10, 2-11 & 2-12 in Chapter 2). This finding is consistent with the cultural predisposition in Japanese society for preparedness decisions to be carried with reference to what the communities do in general. For example, some people will carry out preparedness after seeing or confirming on how others see the problem and what actions are carried out to solve problems.

The models in Merapi indicate the strong contribution of collective efficacy and community participation variables. These are shown by the direct relationship from collective efficacy to "intention to prepare" in model 1 and "intention to seek for information" in model 2. In similar way, the models in Kyoto also indicate the strong contribution of collective efficacy variable. As indicated in previous section, the findings from the Mt Merapi communities differed in some respects from those in Auckland and Kyoto. In Merapi, community and institutional variables played a more significant role in determining the intention to seek for information and intention to prepare than in Japan. Nevertheless, similar findings between Kyoto and Merapi indicate the major role of community variables as would be expected in more collectivistic societies. Overall, the structural relationships between the Merapi, Kyoto and Auckland models showed sufficient similarity to warrant their being considered as demonstrating cross-cultural equivalence.

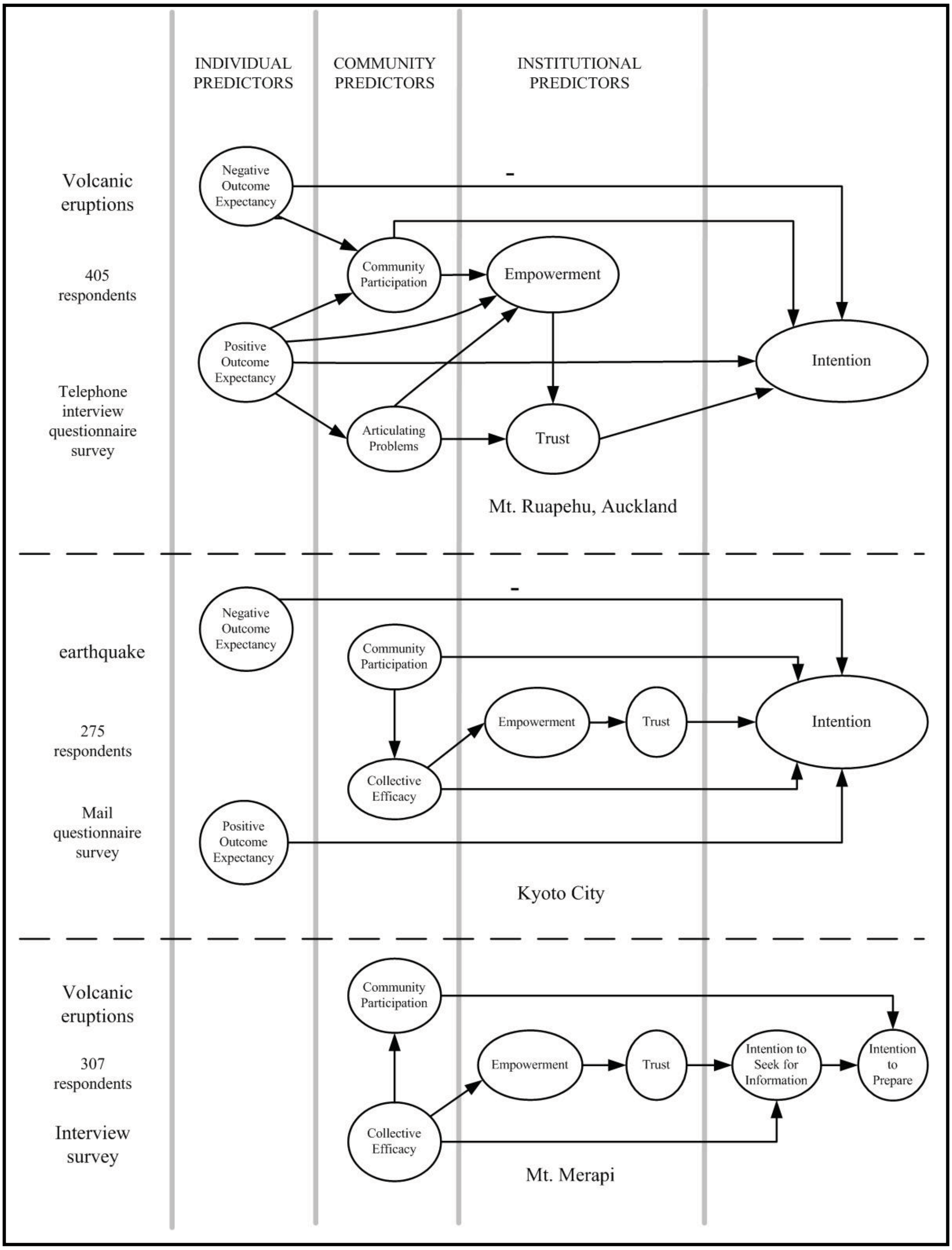

Figure 4-6 Comparison between models in Auckland, Kyoto and Mt. Merapi
Source: Paton et al (2008), Paton et al (2009) and Sagala et al. (2009)

The observed differences between Auckland, Kyoto and Merapi case could also be due to differences in the characteristics of target area. While in Auckland and Merapi the source of hazard (volcano) is observable by the residents, the source of hazards (earthquake) in

Kyoto is more unpredictable. Findings from these three case studies highlighted that the quality of relationships between people, communities and civic agencies influence whether individuals intent to carry out disaster preparedness.

4.8. Summary

This chapter has demonstrated the systematic analysis of socio-psychological variables contributing to the development of social resilience. While the social resilience is measured by 'intention to prepare', the model brought us the idea of the variables and how they contribute to the social resilience. The uniqueness of this approach is that we could expect to increase the social resilience by 'manipulating' the value of some variables. For example, having identified the roles of collective efficacy and community participation, an emergency manager may realize to be better engaging the communities from the beginning instead of only distributing a dozen of information through normal medias and or with pamphlets.

The results of the models in Mt. Merapi are indifferent to the both data (with and without one hamlet). Still we found that the main contributors are community variables. On the other hand, the reduced number of data from Pelemsari hamlet might contribute to the development of data at personal level (outcome expectancy). How and why this happen, of course, need a further investigation. A plausible explanation for this is the respondents in the particular hamlet were those who did not evacuate during the evacuation in 2006. This indicated that they had their own self-confidence in which they were more dependent to other variables instead of 'normal variables' as what was found in the rest of the hamlets.

Findings in this study are important in developing a suitable risk communication for communities in Mt. Merapi and other communities facing similar condition. The findings suggest right messages should be communicated through risk communication method which is adjusted to the level of understanding of the communities. A clear message from this study is that communication in the people will work through others or members in the groups.

This thesis discussed the testing of a model of disaster preparedness for volcanic hazards in communities living around Mt. Merapi, Indonesia. The findings confirmed that, in members of a collectivistic society, preparing is a process that is carried out collectively, with variables such as "community participation" and "collective efficacy" derived from everyday life being particularly important. These findings imply that community-based approaches to risk management in Indonesia (and in other collectivist societies) will be more effective than those targeting individuals.

The literature provides many examples of community based disaster management in the developing countries (Allen, 2006; Luna, 2001; Purnomo et al., 2005; Suyanto et al., 2001).

So-called community based activities are commonly initiated by either local champion in a community or by organizations in the form of NGO, either local or international. The findings from the present study can be used to inform how these agencies work with communities. It allows them to target their intervention (e.g., ensuring hazard issues are identified and discussed in community groups, providing risk management activities in ways that increase collective efficacy). However, evidence suggesting that individual beliefs do play a role suggest that some attention should be directed to this level of intervention. Identifying the contents of intervention at this level must, however, await additional work.

Currently, public hazard education and risk management promotion are carried out on a project basis or soon after a disaster occurs. Because this approach defines disaster preparedness as a process that is separate from people's daily activities, it lacks the condition necessary to facilitate community members' ability to identify and discuss hazard issues in the context of normal community activities. Thus, after a program or campaign, people are not motivated to apply the information into disaster preparedness. Our findings suggest, it is important to integrate risk management and community development for improving disaster preparedness in more collective society. The inclusion of risk management program in community daily activities will significantly increase their capabilities (e.g., collective efficacy) and relationships (empowering) within the communities. Our findings also highlight the roles of institution (local government, emergency managers) to empower the communities. Appropriate coordination between local institutions and communities will increase trust and subsequently motivate people to search for information and carry out preparedness.

Our study suggests that if one aims to increase a social resilience of a society, it is important to understand socio-psychological variable that governs the individuals' decisions in the society. Our data, which are originating from the context of a more collective society, suggest that community variables are the major contributors to the development of social resilience. This finding confirms the real condition of the study area where more collective society are found. In this matter, we propose that an approach to increase social resilience should be carried out and integrated with the particular attention on community variables. Only by doing so, the sustainable and acceptable concept will work.

References

Adger, W., 2000. Social and ecological resilience: are they related? Progress in Human Geography, 24(3): 347-364.

Adger, W., Hughes, T., Folke, C., Carpenter, S. and Rockstrom, J., 2005. Social-Ecological Resilience to Coastal Disasters Science. Science Magazine, Accessed from www.sciencemag.org, December 3, 2006, 309.

Allen, K., 2006. Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines. Disasters, 30(1): 81-101.

Bajek, R., 2007. Development of Evaluation for Community - based Participatory Risk Management - with a focus on Social Earthquake Resilience, Kyoto University, Kyoto.

Ballantyne, M., Paton, D., Johnston, D., Kozuch, M. and Daly, M., 2000. Information on Volcanic and Earthquake Hazards: The Impact on Awareness and Preparation, Institute of Geological and Nuclear Sciences Report, No. 2.

Byrne, B., 2001. Structural Equation Modelling with AMOS: Basic Concepts, Applications and Programming. Lawrence Erlbaum Associates Publishers, New Jersey.

Cheng, E., 2001. SEM being more effective than multiple regression in parsimoniuous model testing for management development research. Journal of Management Development, 20(7): 650-667.

Duval, T. and Mulilis, J., 1999. A person-relative-to-event (PrE) approach to negative threat appeals and earthquake preparedness: a field study. Journal of Applied Social Psychology, 29: 495-516.

Eng, E. and Parker, E., 1994. Measuring community competence in the Mississippi Delta: the interface between program evaluation and empowerment. Health Education Quarterly, 21: 199-220.

Klein, R., Nicholls, R. and Thomalla, F., 2003. Resilience to natural hazards: How useful is this concept? Environmental Hazards, 5: 35-45.

Kline, R., 1998. Principles and Practice of Structural Equation Modeling. The Guilford Press, New York.

Lindell, M. and Perry, R., 2004. Communicating Environmental Risk in Multiethnic Communities. Sage.

Lindell, M. and Prater, C., 2002. Risk Area Residents' Perceptions and Adoption of Seismic Hazard Adjustments. Journal of Applied Social Psychology, 32(11): 2377-2392.

Lindell, M. and Whitney, D., 2000. Correlates of Household Seismic Hazard Adjustment Adoption. Risk Analysis, 20(1): 13-25.

Luna, E., 2001. Disaster Mitigation and Preparedness: The Case of NGOs in the Philippines. Disasters, 25(3): 216-226.

McLure, J., Walkey, F. and Allen, M., 1999. When an earthquake damage is seen as preventable: attributions, locus of control and attitudes to risk. Applied Psychology: An International Review, 48: 239-256.

Mulilis, J. and Duval, T., 1995. Negative threat and earthquake preparedness: a person relative-to-event (PrE) model of coping with threat. Journal of Applied Social Psychology, 25: 1319-1339.

Okada, N. and Matsuda, Y., 2006. Community Diagnosis for Sustainable Disaster Preparedness. Journal Of Natural Disaster Science, 28(1): 25-33.

Paripurno, E., Setiabudi, H., Sofyan., Raharyono, D., Susanto, A. and Nawitaningrum, F., 1999. Merapi bertutur: Tentang Musibah awan panas 22 Nopember 1994 (Merapi depicts: The pyroclastic flow of November 22nd 1994.

Paton, D., 2000. Emergency Planning: Integrating Community Development, Community Resilience, and Hazard Mitigation. Journal of the American Society of Professional Emergency Planners,, VII.

Paton, D., 2003. Disaster preparedness: a social-cognitive perspective. Disaster Prevention and Management, 12(3): 210-216.

Paton, D., 2008. Risk Communication and Natural Hazard Mitigation: How Trust Influences Its Effectiveness. International Journal of Global Environmental Issues, 8(1): 2 - 16.

Paton, D. and Johnston, D., 2001. Disaster and communities: vulnerability, resilience and preparedness. Disaster Prevention and Management, 10(4): 270-277.

Paton, D., Smith, L., Daly, D. and Johnston, D., 2008. Risk perception and volcanic hazard mitigation: Individual and social perspectives. Journal of Volcanology and Geothermal Research, 172: 179-188.

Paton, D., Smith, L. and Johnston, D., 2005. When good intentions turn bad: Promoting disaster preparedness. The Australian Journal of Emergency Management, 20(1).

Paton, D., Sagala, S., Okada, N., Jang, L. and Gregg, C., 2009. Natural hazard resilience and sustainable development: All-hazards and cross cultural perspectives, International Conference on Disaster Prevention Technology and Mitigation Education, Taiwan, September 24, 2009.

Purnomo, H., Mendoza, G. and Prabhu, R., 2005. Analysis of local perspectives on sustainable forest management: an Indonesian case. Journal of Environmental Management, 74: 111-126.

Quarantelli, E., 1997. Ten Criteria for Evaluating the Management of Community Disasters. Disasters, 21(1): 39-56.

Ratdomopurbo, A., Subandriyo, Sulistiyo, Y. and Suharna, 2006. Prekursor Erupsi Gunung Merapi (in Indonesian).

Sagala, S. and Okada, N., *in review*. How do hazard-related factors and traditional cultural beliefs affect evacuation? A case study: Communities in Mt. Merapi, Indonesia. Disasters.

Sagala, S., Okada, N. and Paton, D., 2009. Modeling the Social Resilience of Mountain Communities under Volcanic Risks: A case study of Mt. Merapi, Proceeding of IEEE Internation Conference on Systems, Man and Cybernetics, Special Session on Conflict Resolution, October 11-14, 2009.
Sagala, S., Okada, N. and Paton, D. Predictors of intention to prepare for volcanic risks in Mt. Merapi, Indonesia, Journal of Pacific Rim Psychology (*in press*)
Speer, P. and Peterson, N., 2000. Psychometric properties of an empowerment scale: Testing cognitive, emotional and behavioral domains. Social Work Research, 24: 109-118.
Suyanto, S., Applegate, A. and Tacconi, L., 2001. Community-based fire management, land tenure and conflict: insight from Sumatra, Indonesia, Paper presented at the International Conference on Community Involvement in Fire Management, Balikpapan, Indonesia.
Whitney, D., Lindell, M. and Nguyen, H., 2004. Earthquake Beliefs and Adoption of Seismic Hazard Adjustments. Risk Analysis, 24(1): 2004.
Wisner, B., Blaikie, P., Cannon, T. and Davis, I., 2004. At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge, London.
Zaccaro, S., Blair, V., Peterson, C. and Zazanis, M., 1995. Collective Efficacy. In: J. Maddux (Editor), Self-efficacy, adaptation and adjustment. Plenum Press, New York, pp. 305-328.

Chapter 5. Household Evacuation Decisions in Mt. Merapi

This chapter[2] demonstrates the systematic analysis of factors affecting decision to evacuate under volcanic risks. Using the data from questionnaire surveys conducted by the authors in communities living in the Southern of Mt. Merapi (n=322), this study examines the relationship between decision to evacuate with two groups of factors: hazard-related (hazard proximities, disaster experience and natural signals) and cultural belief factors. In general, the analysis found some systematic patterns of evacuation in the study area which indicates that some people take hazard-related factors into consideration for their evacuation decision, except for one hamlet located very near to Mt. Merapi. For this hamlet, cultural beliefs are found to be an important factor to explain the reason. The findings on the roles of hazard-related factors and cultural beliefs provide an important basis for making better risk communication strategies. Further implication for development of disaster education program that accommodates these findings is discussed.

5.1. Introduction

Being located on the "ring of fire", the Indonesian archipelago becomes a country with over one hundred active volcanoes. Among these active volcanoes, Mt. Merapi has been reported as the most active volcano and thus making it as the most dangerous volcano in Indonesia. Moreover, the risks from Mt. Merapi have become increasingly high due to the steady population growth on the flanks of the volcano as people need more space for agriculture, settlements and tourism activities (Lavigne and Gunnell, 2006). To date, more than 1.6 million people have been affected directly and indirectly by Mt. Merapi's activities.

In the case of imminent volcanic eruptive condition, evacuating all the communities at risk to the safer area is very essential. The catastrophic casualties a volcano could cause to the people and surrounded environments are huge that evacuation may be the only

[2] This chapter has been prepared on the basis of the following articles: (1). Sagala, S. and Okada, N. (2009), Statistical Analysis of Correlation Between Hazard-Related Factors and Household Evacuation Decisions in Mt. Merapi, Indonesia, *Annual Conference of Institute of Social Safety Science*, Mie, Japan and (2). Sagala, S. and Okada, N. How do hazards-related factors and traditional cultural beliefs affect evacuation decisions? *Disasters* (in revision).

way to survive. However evacuation is not a simple matter since it is time consuming, costly and another important issue is the refusal by the communities themselves to evacuate from the threatened area. Therefore, the topics of evacuation have long been a major area of interest to policymakers seeking comprehension of why public opposes to evacuate. Such concern about the policy implication of evacuation has induced research on evacuation behavior such as in hurricanes (Aguirre, 1991; Baker, 1991; Gladwin et al., 2001; Peacock et al., 2004; Riad et al., 1999), floods (Zhai and Ikeda, 2006) and yet, still understudied, is the volcano (Lavigne et al., 2008; Tobin and Whiteford, 2002). These aforementioned studies mainly examined the relationships between the evacuation behavior and decisions that are affected by hazards related factors. For example, some studies have attempted to examine the relationships between hazard proximity, hazard experience and hazard natural signals (sounds, wind flows, tremor) prior with people' decision on evacuation (McAdoo et al., 2006).

Notwithstanding the considerable literature on evacuation in many types of hazards, much less discussion has been paid to the evacuation processes taking place in developing countries although many recent catastrophic disasters have mainly happened in the developing countries (i.e. tsunamis in Indian Ocean 2004, earthquakes in Pakistan 2005, earthquakes in Indonesia 2006, cyclone Nargis in Myanmar 2008, and earthquakes in China 2008). Thus, there is an urgent need to comprehend the problem of evacuation in developing countries in order to derive appropriate policies in the emergency situation. Furthermore, there is a unique setting which mainly occurs in the developing country where a decision to evacuate could be related to the socio-cultural context of the community. For example, recent studies related to volcanic perception in Philippines (Gaillard and Le Mason, 2007) and Indonesia (Schlehe, 1996; Schlehe, 2007) reported on the main influence of traditional cultural beliefs of the communities to their way of viewing the volcano and subsequently affects their decisions to react. In this respect, the way people view the volcano risks should be taken into account prior to making an order to evacuate or in setting up the evacuation process itself.

To cope with these neglected issues, this chapter presents a brief review of evacuation behavior studies and proposes a set of hypothesis to examine how the hazards related factors and cultural beliefs affect decision to evacuate under volcanic risks. Following sections demonstrate to what extent the data from Mt. Merapi, Indonesia, confirms our hypotheses and discuss the implication of the results for future research and in emergency conditions.

5.2. Hypothesis

To guide the analytical framework for this chapter, we developed two groups of hypotheses. The first group of hypotheses is concerned with factors related to hazards, such as: hazard proximities, disaster experience and natural signals as has been discussed in section 2.4.1. The second group is concerned with factors related to people' traditional beliefs that might affect the evacuation decisions.

The hypotheses related to hazards are developed as follows:

- H1: People's decision to evacuate will be positively correlated with the hazard proximity. The closer the distance of the hazards to their house, the higher is their willingness to evacuate from their house. Since the sources of hazards may originate from the volcano and from the river, this hypothesis is divided into the following sub-hypothesis:
  - H1a: People's decision to evacuate will be positively correlated with the distance to the volcano
  - H1b: People's decision to evacuate will be positively correlated with the distance to the river which channels the lava.
- H2: People's decision to evacuate will be positively correlated with their experience with hazards. Those who previously experienced hazards are likely to evacuate from their area should a hazard occur.
- H3: People's decision to evacuate will be affected by the existence of natural signals of the volcanic eruptions. As people live near the volcano, therefore this hypothesis assumes that some people will wait for the natural signals from the volcano before evacuate their houses.

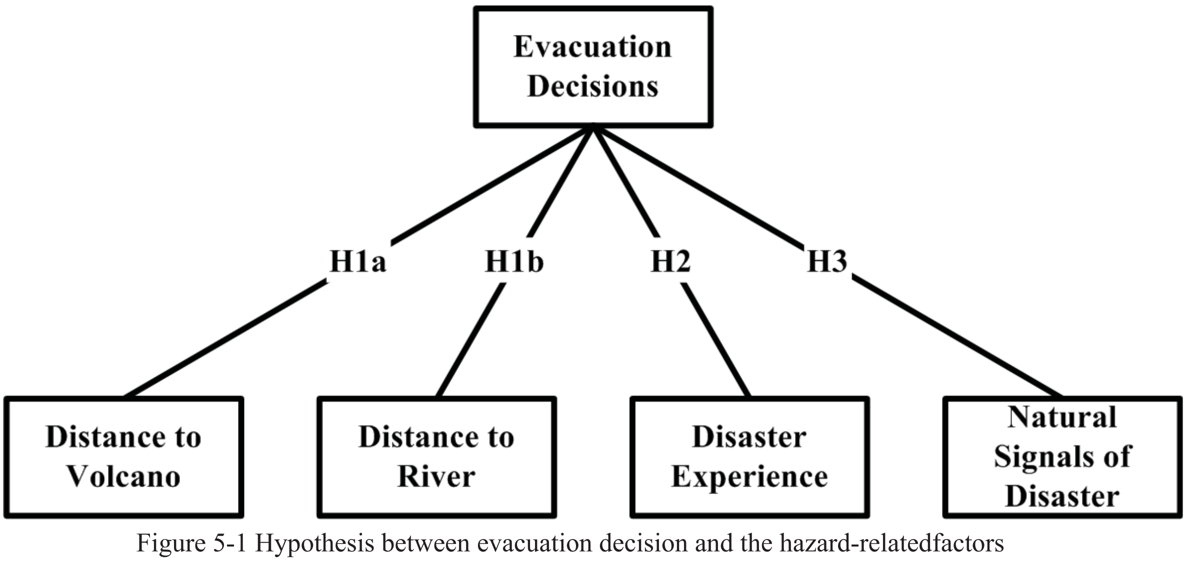

Figure 5-1 Hypothesis between evacuation decision and the hazard-relatedfactors

The hypotheses related to traditional cultural beliefs are developed as follows:

- H4: People who hold cultural beliefs related to natural hazards will be less likely to evacuate when there is a disaster event.
- H5: People who hold cultural beliefs related to natural hazards in Mt. Merapi are those who reside close to the key-holder's house.

- H6: People who hold cultural beliefs are mainly those who are old.

5.3. Data

The data for this chapter are from the survey in Mt. Merapi, January – February 2008 to the respondents living at the southern flanks of the volcano. There were two methods of survey carried out in this research study. The first survey method was conducted by using the questionnaire survey administered to the communities in Merapi Volcano in January – February 2008 in fourteen hamlets on the southern flanks of Merapi volcano (see figure 2). The questionnaire was intended to collect data on the evacuation decision and factors related to hazards. The respondents for the questionnaire survey were selected randomly. In total, there were 322 respondents interviewed. This number of respondents represented about 10 – 15 percentage of the total households in the hamlets that were selected for the case study area. To make sure the respondents clearly understood our questions, in each meeting we had assistance from 5-6 facilitators guiding the respondents, and each respondent handled four to six respondents.

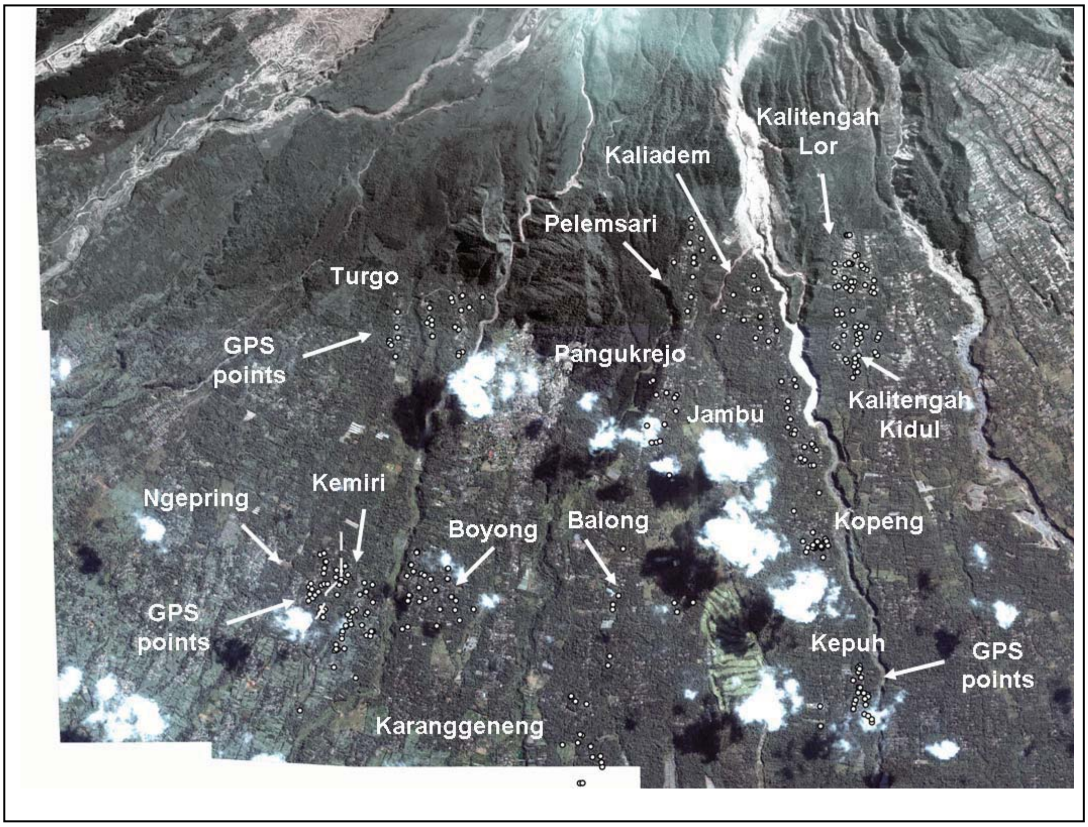

Figure 5-2 Map of GPS Position of the respondents
Source: Analysis

The second survey method was carried out by doing in-depth interviews with 42 respondents. The in-depth interviews were intended to collect detailed information of cultural beliefs. The in-depth interviews lasted for around two hours for each respondent and therefore the number of respondents for in-depth interview was smaller than the number of respondents for the questionnaire survey. The respondents for in-depth interviews were selected from the people did the questionnaire survey and some other people during the field visits. The in-depth interview was aimed to provide deeper information of cultural beliefs and to support findings from the questionnaire survey.

After the questionnaire surveys and the in-depth interviews had been completed, the GPS positions of all respondent houses were collected. The intention was (1), to check and to record all location of the houses and housing distribution, (2) to get information about the distance to the sources of hazards and to the evacuation shelter. The results of the GPS coordinates from our observation indicate that the location of each respondent' house is equally distributed in each hamlet (Figure 5-1).

We collected the following socio-demographic variables: age, gender, income, education, type(s) of occupation, household size, type of house (Concrete/Wood), length of stay in the area. For the hazards related factors, we gathered information on disaster experience in 1994 and 2004 (Yes/No), evacuation (Yes/No). This information is summarized in table 1.

The data for the cultural beliefs were obtained from in-depth interviews with 42 respondents. The questions we mainly we asked were on: “Do you believe that Merapi is controlled by the Spirits living there?”, “Was your decision to evacuate / not to evacuate affected by the decision of the key-holder of Merapi?”

The data of proximity of respondent’s houses to hazard sources and to evacuation shelters were measured using geographical information system. The GIS positions of the respondents’ houses were transported into point type and then overlaid with the location of Mt. Merapi, rivers and locations of the evacuation shelter. The distance to the evacuation shelter is measured by the length of the existing main road-networks in the area, while distance to sources of hazard is measured by direct distance. Decision to evacuate was measured by asking the respondents to mention (No = 0; Yes = 1) whether they evacuated or stayed at their houses during the last eruption in 2006.

The data in this study is examined by using cross-tabulation and chi-square (χ^2) analysis. Using the combination of the questionnaire data and the coordinates from GPS, spatial analysis is conducted as well.

5.4. Evacuation Decisions in Mt. Merapi

Our data indicate that the respondents are dominated by male (96%). This is inline with our initial intention which is to understand the evacuee's decisions as a family. The distribution income of the respondents mainly falls into either less than 110 USD or 110 – 220 USD, which is similar to the figure given by the Sleman District (2008). This amount is slightly similar or above of those minimum income in regional or national level. The average number of household size is about 3-4 persons in a family.

The evacuation process in 2006 was arranged by the Sleman District Government. The district government provides trucks at a safe point in each hamlet and officers to guide the evacuees to the evacuation shelters. About only 9% of the respondents who experienced the eruption in 1994, which is dominated by respondents from Turgo hamlet. 63% of the respondents reported they evacuated at the eruption in 2006. Of those who evacuated, about 96% reported that they stayed at the evacuation shelter while about a small number (4%) evacuated to family members. Most of the evacuees reported that they commuted to their houses while they were in the evacuation shelter. About 67% of the evacuees reported that they returned to their hamlets to feed their cattle, and check their belongings in the house. This commuting is possible since the distance from their evacuation shelter to their hamlet is within the range of 1.5 – 8 km (see table 2). Local government provided some trucks to the people two times a day: in the morning when sent people to come back to their hamlets and in the afternoon while picked them up back to the shelter.

Table 5-1 Average distance from each hamlet to evacuation shelter, volcano and the river

Source: Analysis

No	Hamlet	Evacuation in 2006 (%)	Average distance from hamlet to		
			Evacuation Shelter (km)	Volcano (km)	River (m)
1.	Turgo	89	8.2	6	150
2.	Ngepring	23	4.5	9	500
3.	Kemiri	16	4.8	9	175
4.	Boyong	35	3.2	9	100
5.	Pelemsari	33	5.2	5	150
6.	Pangukrejo	86	3.3	6.5	150
7.	Balong	0	1.2	8.5	300
8.	Karanggeneng	24	0.6	10	400
9.	Kaliadem	80	4.2	5.5	200
10.	Jambu	90	3	6.5	150
11.	Kopeng	96	1.6	8	150
12.	Kepuh	87	0.4	9.5	150
13.	Kalitengah Lor	100	8.3	5	300
14.	Kalitengah Kidul	94	7.3	6	250

Table 5-2 List of main questions

Source: Analysis

Factors	Option (Scale)	
Evacuated in 2006	Yes (1)	No (0)
Distance to the volcano	Within 6.5 km (1)	Outside 6.5 km (0)
Distance to the river	Within 150 m (1)	Outside 150 m (0)
Experienced of disaster in 1994	Yes (1)	No (0)
Depended their decisions based on observation to the natural signals	Yes (1)	No (0)

Table 5-3 Pearson Statistical Correlation of All Factors

*** correlation is significant at 0.01, * correlation is significant at 0.05*

Source: Analysis

	Mean	SD	E	DV	DR	E	N
Evacuated in 2006 (E)	0.63	0.48	1				
Distance to volcano within 6.5km (DV)	0.52	0.50	-0.45*	1			
Distance to volcano within 150m (DR)	0.52	0.50	-0.21**	0.02	1		
Experience of 1994 eruption (E)	0.09	0.28	0.16**	-0.32**	-0.32**	1	
Decision based on natural signals (N)	0.65	0.48	-0.06	-0.08	-0.12*	0.04	1

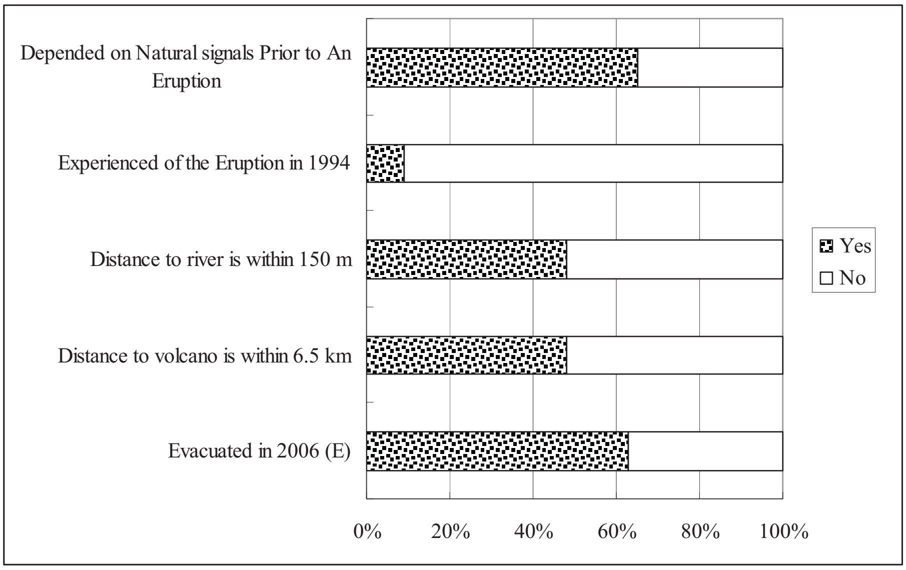

Figure 5-3 Values of hazards related factors and the evacuation decision

5.5. Results

In the following section we discuss the results obtained from the analyses.

5.5.1. Evacuation Decisions and Hazards Related Factors

As predicted by hypothesis 1, a significant relationship is found between disaster experience and decision to evacuate (χ^2 = 9.41; p = 0.004). Respondents who had an earlier experience of disaster in 1994, as found mainly in Turgo, reported that they evacuated during the 2006 volcanic eruption (90%). Though the eruption in 2006 mainly took place in the areas near to upstream of Gendol River, which is located far from their hamlets (see figure 3), the residents in Turgo hamlet evacuated from their hamlet to the evacuation shelter as well. This motivation could be due to their experience of the previous eruption in 1994.

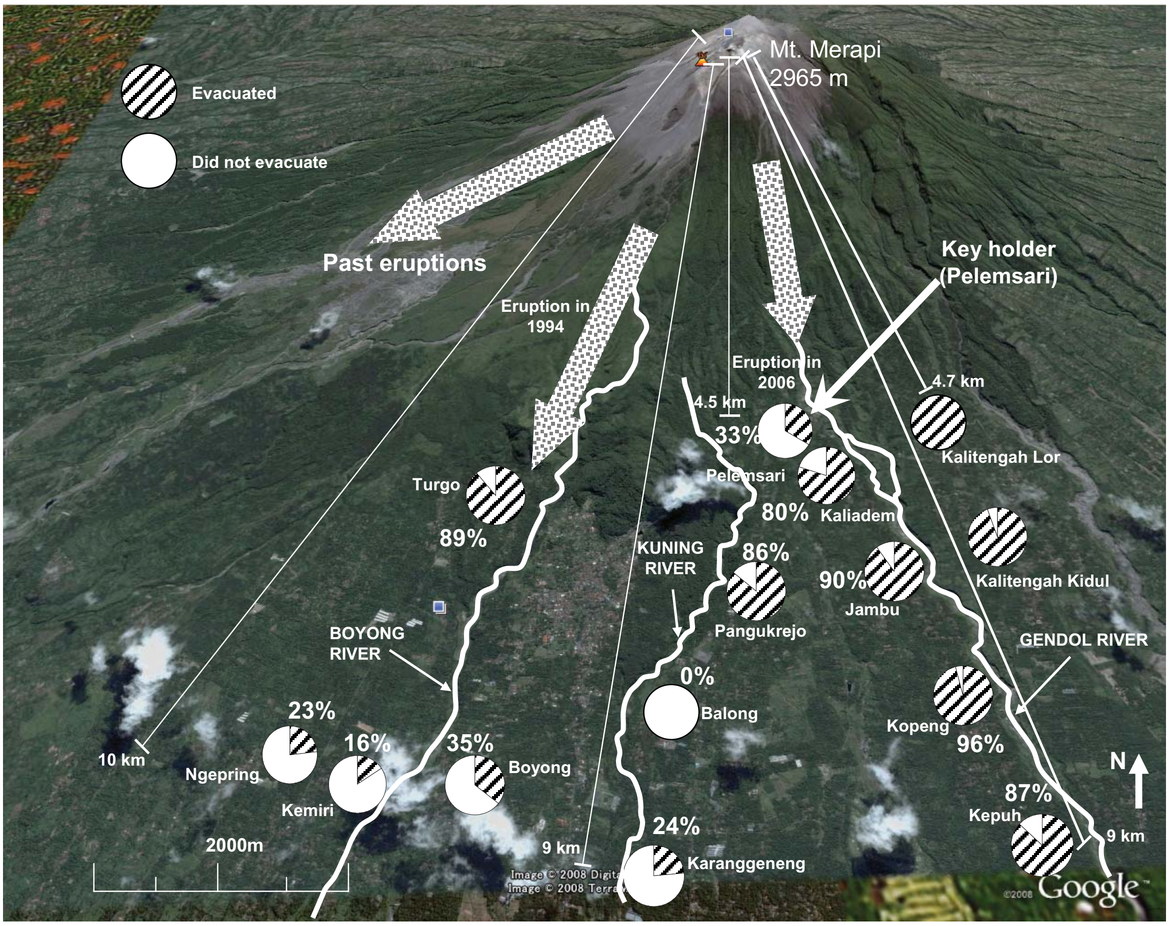

Figure 5-4 Spatial Distribution of Evacuation in 2006 in Each Hamlet in the Study Area
Source: Analysis

Consistent with our hypothesis 2a, there is a significant relationship between people's decision to evacuate and the distance of hamlet to the volcano. The relationship is observable spatially as shown in figure 3. Figure 3 explains that those who live in hamlets within 6.5 km from the volcano (Turgo, Kaliadem, Kalitengah Lor, Kalitengah Kidul, Jambu and Pangukrejo, except Pelemsari) evacuated from their areas to the evacuation shelter.

Consistent with the hypothesis 2b, the distance to the river that could pose hazards by flowing volcanic debris / materials also shows a significant relationship with the decision to evacuate. For example, mainly respondents in Kopeng and Kepuh hamlets (see figure 3) reported that they evacuated although the hamlet's distances to Mt. Merapi are about 8 and 9 km, respectively. Nevertheless, these two hamlets are located within 150m from Gendol River, a river which channeled the lava and lahars in 2006 (see table 2 and figure 3). The close distance to Gendol river caused these two hamlets highly prone to the lava and lahars produced during and after a volcanic eruption. This phenomenon also supported by the fact in the hamlets which are located close to the rivers that did not channel the lava and lahar in 2006 eruption. Respondents from Ngepring, Kemiri, Boyong, Balong and Karanggeneng Hamlets did not evacuate (see the down left side on figure 3) during the volcanic eruption.

Consistent with our initial hypothesis 3, some respondents mentioned that they depend on the natural signals of the volcanic eruption before evacuating from the danger. For example, respondents in Kalitengah Lor hamlet reported that many heads of the households would wait for signals in the form of huge sounds, tremors, high temperature, and dark clouds before they decided to evacuate. For example, if a cloud visualizing a sheep-like occurred, they will immediately evacuate since it is the common signs of the pyroclastic flows.

5.5.2. Evacuation Decisions and Proximity to Source of Hazards

The results of cross-tabulation analysis between the evacuation decision and proximity to source of hazards are presented in table 3 and table 4. Table 3 explains the relationship between household evacuation decision and the distance to the volcano. The pattern indicates that the closer the distance to the volcano, the higher the willingness to evacuate (132 people), while the further the distance to the volcano, the lower is the willingness (96 people). Thus, it confirms our hypothesis (H1a) that there is a significant relationship between people's decision to evacuate and the distance of hamlet to the volcano (χ^2 = 65.078, df =1, p = 0.000). Similarly, table 4 indicates that the closer the distance to the river, the higher the willingness to evacuate (113 people) while the further the distance from the river, the lower the willingness to evacuate (77 people). This also confirms our hypothesis (H1b) that the distance to the river that could pose hazards by flowing volcanic debris / materials also shows a significant relationship with the household evacuation decision (χ^2 = 13.403, df =1, p = 0.000).

Table 5-4 Cross-tabulation between Evacuation Decisions and Distance to Volcano
(χ^2 = 65.078, df =1, p = 0.000), Source: Analysis

		Evacuated in 2006		
		Yes	**No**	**Total**
Distance to volcano	within 6.5 km	132	22	154
	more than 6.5 km	70	96	166
	Total	202	118	320

Table 5-5 Cross-tabulation between Evacuation Decisions and Distance to River
(χ^2 = 13.403, df =1, p = 0.000), Source: Analysis

		Evacuated in 2006		
		Yes	**No**	**Total**
Distance to river	within 150m	113	41	154
	more than 150 m	89	77	166
	Total	202	118	320

The existence of correlation between distances to source of hazard and evacuation decisions is important (H1a and H1b). The finding illustrates that people who reside closer to the source of hazards, which means higher exposures, would have higher awareness of the potential threat. This finding suggests two detailed explanation.

First, this finding applies for the areas located within 6.5 km from the top of the volcano (H2a) or is also regarded as hazard zone three by Indonesian Volcanological Agency (Ratdomopurbo et al., 2006). If an eruption occurs, a pyroclastic flow could reach an area of 6.5 km within several minutes as reported in the eruption in 1994 (Paripurno et al., 1999). The respondents mentioned that their decisions were due to the fear of the coming of pyroclastic flow which is known as 'awan panas' (literally means hot clouds or in fact referring to a pyroclastic flow). In addition to the pyroclastic flow, the danger of lahar to the down stream (i.e. areas along the rivers and located more than 6.5 km from the volcano). The understanding that they are prone to a pyroclastic flow and could be soon affected might affect their willingness to evacuate.

Second, hazard proximity could mean distance to an area which possibly channel the possible lava and lahars (H2b). The understanding that people are prone to lahar might affect their decisions to evacuate from their area to the safer place. This phenomenon was observed in Kepuh and Kopeng hamlets. The local people at downstream received news from the people at upstream who reported the current condition. As the situation indicated the increasing of volcanic activity might flow along Gendol River, the observers reported to people at the downstream by communication radio. Subsequently, the people at the downstream were more willing to evacuate. On the other hand, residents from other hamlets (Ngepring, Kemiri, Boyong, Karanggeneng and Balong) which were located close to the other rivers (Boyong River and Kuning River) did not evacuate since these two rivers did not channel the lahars of 2006 eruption. These indicate that since the residents felt that they were not prone to risks, they did not evacuate.

Taken together, distance to the volcano and distance to the river conveys that proximity to hazard sources has been found to be also a factor of people decision to evacuate. Nonetheless, the knowledge on presence of environment does not always mean a full comprehension of the environmental phenomenon, including the risks. Noteworthy to mention also that this knowledge should be supported by enough information of potential risks involved. For example, during in depth interview in Kaliadem Hamlet, some respondents reported that they came closer to Gendol River, instead of running away, to observe the pyroclastic flow in the 2006 eruption. Fortunately, the pyroclastic flow filled up the upstream of Gendol River and did not continue to surge to the nearby hamlets (Pelemsari and Kaliadem).

5.5.3. Evacuation Decisions and Disaster Experience

Table 6 explains the relationship between evacuation decision and disaster experience. It suggest that only a few respondents (24 people) reported that they experienced 1994 eruption and evacuated during the 2006 eruption. This finding confirms hypothesis 2 that a significant relationship is found between disaster experience and decision to evacuate ($\chi^2 = 8.409$, df = 1, $p = 0.004$).

Table 5-6 Cross-tabulation between Evacuation Decisions and Disaster Experience

$\chi^2 = 8.409$, df =1, p = 0.000, Source: Analysis

		Evacuated in 2006		
		Yes	**No**	**Total**
Disaster Experience of 1994 eruption	Yes	24	3	27
	No	178	115	293
	Total	202	118	320

Respondents who had an earlier experience of disaster in 1994, as found mainly in Turgo, reported that they evacuated during the 2006 volcanic eruption (90%). Though the eruption in 2006 mainly took place in the areas near to upstream of Gendol River, which is located far from their hamlets (see figure 3), the residents in Turgo hamlet evacuated from their hamlet to the evacuation shelter as well. This motivation could be due to their experience of the previous eruption in 1994.

The evidence of a significant relationship between disaster experience and decision to evacuate (H1) is important since it indicates the community takes lessons learned from prior experience and increases their awareness of the imminent volcanic risks. This finding supports the previous arguments, on the strong relationships between disaster experience and disaster preparedness, which was carried out in other countries, such as in United States (Lindell and Hwang, 2008). If this finding is true in general, it could be expected that people who were exposed to a disaster would be more willing to evacuate should a disaster occur.

On the other hand, having a focus on disaster experience alone as a factor related to the decisions to evacuate could be misleading. If the previous disaster was at high risk or claimed many casualties and injuries, people would consider the future disasters as a high priority as what has happened in Turgo hamlet. Thus, people tend to be more alert to disasters than before (Lindell and Perry, 2004). However, if a past disaster previously hit at a small intensity and posed a small risk, risk perception would tend to decrease (Paton et al., 2008) and this would let them less aware to the next disaster. For example, the Merapi eruption in 2006 did not claim a huge toll in terms of loss of life and might decrease the people risk perception of the future eruption.

5.5.4. Evacuation Decisions and Natural Signals of Disasters

Consistent with our initial hypothesis 3, some respondents mentioned that they depended on the natural signals of the volcanic eruption before evacuating from the danger. For example, respondents in Kalitengah Lor hamlet reported that many heads of the households would wait for signals in the form of huge sounds, tremors, high temperature, and dark clouds before they decided to evacuate. If a cloud visualizing a sheep-like occurred, they will immediately evacuate since it is the common signs of the pyroclastic flows (obtained from interview to respondents in Kalitengah Lor, 2008).

Table 5-7 Cross-tabulation between Evacuation Decisions and Natural Signals
χ^2 = 1.281, df =1, p = 0.258, Source: Analysis

		Evacuated in 2006		
		Yes	**No**	**Total**
Natural Signals	Yes	126	81	207
	No	178	115	293
	Total	202	118	320

The finding on the reliance of some people on the natural signals (sound, sight, temperature, etc) prior to an eruption is important (H3). In the absence of official warning, maintaining this knowledge is good and crucial because people can take immediate action or leave the danger place. For example in 1994 eruption, Paripurno et al (1999) reported that the Turgo residents observed the above phenomenon yet did not leave the place because they had not had such knowledge earlier. Depending on this knowledge alone could be unsafe since a pyroclastic flow might be developed immediately after the natural signals occur. Therefore it is important to integrate this knowledge with the existing volcanic warning systems.

5.5.5. Evacuation Decisions and Traditional Cultural Beliefs

Contrary to hypothesis 4, cultural beliefs were not significantly correlated with the decisions to evacuate ($\chi 2$ = 0.243, p = 0.622). The cross-tabulation indicated that those who hold cultural beliefs also evacuated from their place during the eruption in 2006 (see table 3).

Interestingly, a special pattern of decision to evacuate is found for Pelemsari hamlet where the key-holder resides. Only 37% of the respondents in this hamlet reported that they evacuated despite the 4.5 km distance to the volcano and the location of pyroclastic flows in 2006 (1 km) (see figure 3 and table 2). 90% of the respondents in Pelemsari hamlet reported they felt that their hamlet was safe while only 10% said due to being afraid of losing their belongings.

Table 5-8 Percentage of Beliefs, Evacuation and Age Group
Source: Analysis

		Percentage of Evacuate (n = 42)				Percentage of age group (n = 42)					
		Yes	No	Total		20s	30s	40s	50s	60s & more	Total
Belief	Yes	14	7	21		0	5	2	5	10	21
	No	45	33	79		14	14	12	24	14	79
Total		60	40	100		14	19	14	29	24	100

Table 5-9 Correlation between evacuation, belief and age

		Mean	SD	Belief	Evacuate	Age
Belief	Pearson Correlation	1.79	0.42	1	0.08	-0.29
	Sig. (2-tailed)				0.63	0.07
Evacuate	Pearson Correlation	1.40	0.50	0.08	1	-0.16
	Sig. (2-tailed)			0.63		0.32
Age	Pearson Correlation	46.79	14.10	-0.29	-0.16	1
	Sig. (2-tailed)			0.07	0.32	

While some respondents from the other hamlets also hold cultural belief, there was no significant relationship found between holding the cultural beliefs and the decision to evacuate. For example, people in Turgo still evacuated though many of them also hold strong the cultural beliefs.

Contrary to hypothesis 5, cultural beliefs are not significantly related with the distance to the key-holder house ($\chi2 = 13.491$, $p = 0.411$). This is also supported by the evidence that there are some respondents living far from the key-holder house but also hold cultural beliefs.

Inconsistent with our hypothesis 6, age is not significantly related with the cultural beliefs ($\chi^2 = 3.988$, $p = 0.408$). The overall figure indicates those who do not hold cultural beliefs vary from age 20s – 60s (see table 5.8). However, among those who hold cultural beliefs (those who answered 'yes'), the number seems to be dominated by those whose age is above 50s.

5.6. Discussion

The overall findings in the previous section point out that in general hazards related factors (disaster experience, hazard proximities and natural signals) play dominant roles in influencing people's evacuation decision. These findings are important since they illustrate that the communities in Mt. Merapi also take action as what found in research studies which relates evacuation decisions and hazards related factors. Nonetheless, the cultural belief factor also affects evacuation decision but in a limited area and community as indicated in the previous section.

The presence of correlation between distances to source of hazard and evacuation decisions is important (H1). The finding illustrates that people who reside closer to the source of hazards, which means higher exposures, would have higher awareness of the potential threat. This finding suggests two detailed explanation. First, this finding applies for the areas located within 6.5 km from the top of the volcano (H1a) or is also regarded as hazard zone three by Indonesian Volcanological Agency (Ratdomopurbo et al., 2006). This fact has also been realized by respondents who live within 6.5 km from the volcano. If an eruption occurs, a pyroclastic flow could reach an area of 6.5 km within several minutes as reported in the eruption in 1994 (Paripurno et al., 1999). The respondents mentioned that their decisions were due to the fear of the coming of pyroclastic flow which is known as 'awan panas' (literally means hot clouds or in fact referring to a pyroclastic flow). In addition to the pyroclastic flow, the danger of lahar to the down stream (i.e. areas along the rivers and located more than 6.5 km from the volcano). The understanding that they are prone to a pyroclastic flow and could be soon affected might affect their willingness to evacuate.

Second, hazard proximity could mean distance to an area which possibly channel the possible lava and lahars (H1b). The understanding that people are prone to lahar might affect their decisions to evacuate from their area to the safer place. This phenomenon was observed in Kepuh and Kopeng hamlets. The local people at downstream received news from the people at upstream who reported the current condition. As the situation indicated the increasing of volcanic activity might flow along Gendol River, the observers reported to people at the downstream by communication radio. Subsequently, the people at the downstream were more willing to evacuate. On the other hand, residents from other hamlets (Ngepring, Kemiri, Boyong, Karanggeneng and Balong) which were located close to the other rivers (Boyong River and Kuning River) did not evacuate since these two rivers did not channel the lahars of 2006 eruption. These indicate that since the residents felt that they were not prone to risks, they did not evacuate.

Taken together, distance to the volcano and distance to the river conveys that proximity to hazard sources has been found to be also a factor of people decision to evacuate. Nonetheless, the knowledge on presence of environment does not always mean a full comprehension of the environmental phenomenon, including the risks. Noteworthy to mention also that this knowledge should be supported by enough information of potential risks involved. For example, during in depth interview in Kaliadem Hamlet, some respondents reported that they came closer to Gendol River, instead of running away, to observe the pyroclastic flow in the 2006 eruption. Fortunately, the pyroclastic flow filled up the upstream of Gendol River and did not continue to surge to the nearby hamlets (Pelemsari and Kaliadem).

The evidence of a significant relationship between disaster experience and decision to evacuate (H2) is important since it indicates the community takes lessons learned from prior experience and increases their awareness of the imminent volcanic risks. This finding supports the previous arguments, on the strong relationships between disaster experience and disaster preparedness, which was carried out in other countries, such as in United States (Lindell and Hwang, 2008). If this finding is true in general, it could be expected that people who were exposed to a disaster would be more willing to evacuate should a disaster occur.

On the other hand, having a focus on disaster experience alone as a factor related to the decisions to evacuate could be misleading. If the previous disaster was at high risk or claimed many casualties and injuries, people would consider the future disasters as a high priority as what has happened in Turgo hamlet. Thus, people tend to be more alert to disasters than before (Lindell and Perry, 2004). However, if a past disaster previously hit at a small intensity and posed a small risk, risk perception would tend to decrease (Paton et al., 2008) and this would let them less aware to the next disaster. For example, the Merapi eruption in 2006 did not claim a huge toll in terms of loss of life and might decrease the people risk perception of the future eruption. In anticipating the reduce of risk perception, it is important for the district government to carry out a regular risk communication to keep the awareness of the local people.

The finding on the reliance of some people on the natural signals (sound, sight, temperature, etc) prior to an eruption is important (H3). In the absence of official warning, maintaining this knowledge is good and crucial because people can take immediate action or leave the danger place. For example in 1994 eruption, Paripurno et al (1999) reported that the Turgo residents observed the above phenomenon yet did not leave the place because they had not had such knowledge earlier. Depending on this knowledge alone could be unsafe since a pyroclastic flow might be developed immediately after the natural signals occur. Therefore it is important to integrate this knowledge with the existing volcanic warning systems.

The weak correlation between cultural beliefs and evacuation decision is surprising (H4). Previous studies (Lavigne et al., 2008; Schlehe, 1996; Schlehe, 2007) and mass medias (Kompas 16/05/06, Kompas 29/04/06, BBC 18/05/06) suggested that people refused to evacuate which might be due to their traditional beliefs. Our finding implies that, to the majority of the respondents, decision to evacuate is not mainly affected by the cultural beliefs. This result might illustrate the decreasing trust to cultural beliefs. Therefore, though some people still hold cultural beliefs, they are inferior to other factors. For example, a respondent (M) whom we interviewed in Turgo (January 2008) hamlet recalled the following condition.

> *"I received a dream in year 2006 before the eruption. After this dream, I interpreted that the lava would not flow to Turgo. Therefore initially I felt hesitate to evacuate. However I also decided to evacuate since the condition was not certain and other family members also evacuated."*

The above case indicates that people do not solely depend on their cultural beliefs but also other factors: condition and observation from other family members. An interview we carried out to respondent A (January 2008) also indicated similar responses as follows.

> *"Prior to the eruption in 1994, I used to believe that Mt Merapi would reveal something through dreams and natural signals. But that day November 22nd 1994) we did not receive any signal and thus we were not alert at all (to the eruption). After that experience, I have been keener to the advice by the government and my own observation (to the condition)."*
>
> Respondent A lives in Turgo, whose house is about 6.5 km from Mt. Merapi. He suffered severely burned skins due to the pyroclastic flow in 1994.

On the contrary, a special case was found in Pelemsari hamlet. Despite being located as one of the closest hamlet to Mt. Merapi and thus bearing the possibility to be at very high risk, the number of respondents who evacuated from the hamlet was surprisingly low (37%). Indeed, a possible explanation for this was the presence of the key-holder during the alert condition of the volcano activities. This phenomenon might refer to the term called underived beliefs described by Pajares (1992). Underived beliefs is described as beliefs which earned "through direct encounter with the belief object", while derived beliefs are "learned from others" can be attributed to the term connectedness of beliefs which is defined by Rokeach (1968). The key-holder's refusal to evacuate might have increased the confidence of the people as well as their "feeling of safety". It is strengthened by one of residents' opinions in Pelemsari during the volcanic eruption in 2006.

> *"Son, if Mbah Merapi is about to clean himself (flowing out the lava) or make-up (being active), the dirt will not be thrown to the front ground (to the south direction where the Sultan' Palace is located)."*
>
> Cipto, a resident lives in Pelemsari Hamlet (Kompas 09/05/06).

The local people call the volcano as Mbah Merapi to show a respect to the volcano. The statement above implies that the Mt. Merapi will not erupt to the Southern direction in which where people resides now. The South direction also means to the direction where Yogyakarta City is located, a city where the Sultan lives. This statement also reflects the similar feeling of other people who hold the cultural beliefs in other hamlets.

The summary of discussions above is presented in table 5-10.

Table 5-10 Summary of the findings

	Type	**Hamlet**	**Influenced by**
A	Respondents who experienced disaster and held beliefs are likely to trust more on their disaster experience	Turgo	Hazard-related factors: disaster experience
B	Respondent who reside in the key-holder hamlet tend to trust on cultural beliefs	Pelemsari	Cultural belief factor
C	Respondent who did not experience disaster but resided close to the sources of hazards.	Kalitengah Lor, Kalitengah Kidul,, Kaliadem, Kopeng, Jambu, Kepuh and Pangukrejo	Hazard-related-factors: hazard proximities and natural signals
D	Those who stayed far from the volcano (8-10 km) and far from the key-holder did not evacuate	Ngepring, Kemiri, Boyong, Karanggeneng and Balong	Hazard-related factors: Hazard proximities

No relationship was found between economic factors and decision to evacuate in this study. As most respondents have similar amount of income, no clear distinction can be differentiated based on economic condition. Our finding indicated that the head of the households were among the late who left their houses and the earliest commuted to their houses. This finding is clearly related to economic reason as the head of household returned to his house in order to take care the left belongings and cattle.

The results of this study largely contribute to the understanding of evacuation decision among few literature in this topic in the context of developing countries. These findings obtained in this research largely meet with some findings with of the previous research studies conducted in developed country (Lindell and Perry, 2004) that evacuation decisions are significantly related with hazards related factors. The special findings, such as roles of cultural beliefs in evacuation and commuting evacuation, contribute to a special context which may merely occur in developing country. This information is vital in creating a more adaptive risk communication way and emergency process. For example, the commuting evacuation needs a further investigation of how to provide an optimal time and cost for commuting. Similarly, the finding on cultural beliefs suggest that the cultural leader needs to be heavily involved in the process of risk communication. The fail of persuasion to some people might occur because they trust more to cultural leaders as compared to the local government.

Ultimately, this study argues that the communities have different characteristics in dealing with disasters. Thus, disaster education program should be adjusted to the needs of each community. For example, for communities where there is much influence of cultural beliefs, it is important to educate the people on the potential of imminent disaster, such as pyroclastic flows. That the past pyroclastic flow did not reach into their hamlet does not mean that there is no possibility in the future. As the role of cultural leader (key-holder) is prominent in this hamlet, it is important to approach the message from the key-holder. For the hamlets where hazards related factors play a significant role, it is important for the emergency manager to remind people to keep their level of awareness. Further detailed information of how pyroclastic flow might occur should be conveyed to people living in these hamlets so that they understand how dangerous the pyroclastic flow is.

5.7. Summary

This study demonstrates the systematic analysis of factors affecting decision to evacuate under volcanic risks. The results of this study sustain the previous findings of evacuees' behaviors (Baker, 1991, Lindell and Perry, 1993, Lindell and Perry, 2004, Johnston et al., 1999, Miller et al.,1999, Peacock et al, 2004, Perry, 1979, Perry and Godchaux, 2005, Perry and Lindell, 2008, Riad et al 1999, Ronan et al, 2000, Sorensen, 1987, Sorensen, 1991, Whitney et al 2004) that hazards related factors are affecting people' decisions to evacuate. Nevertheless, this study widens the perspective of those findings by revealing that cultural beliefs are still perceived related with the volcano by a certain segment of the communities. The continuing importance of cultural belief in disaster response for some people in Merapi remains a challenge for emergency managers.

Findings in this study are important in developing a suitable risk communication for communities in Mt. Merapi and other communities facing similar condition. The findings suggest right messages should be communicated through risk communication method which is adjusted to the level of understanding of the communities. For example, to the people in Vanuatu, Solomon Islands, Cronin et al. (2004) suggested to include the cultural symbols and simple hazard maps to communicate with the local people. Similarly, for people who hold cultural beliefs it is important to take into consideration their cultural beliefs in such a way to increase their preparedness against the volcanic risks. Noteworthy is to approach and to include the cultural leader (key-holder) for disaster education to the residents.

The finding on commuting evacuation is another challenge for emergency managers. The fact volcanic eruptions may last for long time might make the possibility of commuting evacuation. Future work should address how commuting evacuation can be done safely and economically. Moreover, this study only addresses the people living in Southern part of Merapi. It is essential to widen the study area to other parts of the volcano in order to get the whole picture how people perceive the volcanic risks and what sort of preparedness has been applied.

References

Aguirre, B., 1991. Evacuation in Cancun during Hurricane Gilbert. International Journal of Mass Emergency and Disasters, 9(1): 31-35.

Baker, E., 1991. Hurricane evacuation behavior. International Journal of Mass Emergency and Disasters, 9(2): 281 - 310.

Cronin, S., Gaylord, D., Charley, D., Alloway, B., Wallez, S. and Esau, J., 2004. Participatory methods of incorporating scientific with traditional knowledge for volcanic hazard management on Ambae Island, Vanuatu. Bulletin of Volcanology, 66: 652-668.

Gaillard, J. and Le Mason, V., 2007. Traditional Societies' Response to Volcanic Hazards in Philippines. Mountain Research and Development, 27(4): 313-317.

Gladwin, C., Gladwin, H. and Peacock, W., 2001. Modeling hurricane evacuation decisions with ethnographic methods. International Journal of Mass Emergency and Disasters, 19(2): 117-143.

Gregg, C., Houghton, B., Johnston, D., Paton, D. and Swanson, D., 2004a. The Perception of volcanic risk in Kona communities from Mauna Loa and Hualalai volcanoes, Hawaii. Journal of Volcanology and Geothermal Research, 130: 179-196.

Gregg, C., Houghton, B., Paton, D., Swanson, D. and Johnston, D., 2004b. Community preparedness for lava flows from Mauna Loa and Hualalai volcanoes, Kona, Hawaii. Bulletin of Volcanology, 66: 531-540.

Gregg, C., Houghton, B., Paton, D., Swanson, D., Lachman, R. and Bonk, W., 2008. Hawaiian cultural influences on support for lava flow hazard mitigation measures during the 1960 eruption of Kilauea volcano, Kapoho, Hawaii. Journal of Volcanology and Geothermal Research.

Johnston, D., Bebbington, C., Houghton, B., Lai, C. and Paton, D., 1999. Volcanic hazard perceptions: comparative shifts in knowledge and risk. Disaster Prevention and Management.

Lavigne, F., De Coster, B., Juvin, N., Flohic, F., Gaillard, J., Texier, P., Morin, J. and Sartohadi, J., 2008. People's behaviour in the face of volcanic hazards: Perspectives from Javanese communities, Indonesia. Journal of Volcanology and Geothermal Research, 172: 273-287.

Lavigne, F. and Gunnell, Y., 2006. Land Cover Change and Abrupt Environmental Impacts on Javan Volcanoes, Indonesia: A Long-term Perspective on Recent Events. Reg Environ Change, 6: 86-100.

Leonard, G., Johnston, D., Paton, D., Christianson, A., Becker, J. and Keys, H., 2008. Developing effective warning systems: Ongoing research at Ruapehu volcano, New Zealand. Journal of Volcanology and Geothermal Research, 172: 199-215.

Lindell, M. and Hwang, S., 2008. Household perceived personal risk and responses in a multihazard environment. Risk Analysis, 28(2): 539-556.

Lindell, M. and Perry, R., 1993. Risk area residents' changing perceptions of volcano hazard at Mt. St. Helens. In: J. Nemec (Editor), Prediction and Perception of Natural Hazards. Kluwer Academic Publisher, pp. 159-166.

Lindell, M. and Perry, R., 2004. Communicating Environmental Risk in Multiethnic Communities. Sage.

McAdoo, B., Dengler, L., Prasetya, G. and Titov, V., 2006. Smong: How an Oral History Saved Thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 Tsunamis. Earthquake Spectra, 22(S3): s661-s669.

Miller, M., Paton, D. and Johnston, D., 1999. Community vulnerability to volcanic hazard consequences. Disaster Prevention and Management, 8(4): 255-260.

Paripurno, E., Setiabudi, H., Sofyan., Raharyono, D., Susanto, A. and Nawitaningrum, F., 1999. Merapi bertutur: Tentang Musibah awan panas 22 Nopember 1994 (Merapi depicts: The pyroclastic flow of November 22nd 1994.

Paton, D., Johnston, D. and Houghton, B., 1998. Organisational response to a volcanic eruption. Disaster Prevention and Management, 7(1): 5-13.

Paton, D., Millar, M. and Johnston, D., 2001. Community Resilience to Volcanic Hazard Consequences. Natural Hazards, 24: 157-169.

Paton, D., Smith, L., Daly, D. and Johnston, D., 2008. Risk perception and volcanic hazard mitigation: Individual and social perspectives. Journal of Volcanology and Geothermal Research, 172: 179-188.

Peacock, W., Brody, S. and Highfield, W., 2004. Hurricane risk perception among Florida's single family homeowners. Landscape and Urban Planning, 73: 120-135.

Perry, R., 1979. Incentives for evacuation in natural disaster research based community emergency planning. Journal of American Planning Association, 45(4): 440-447.

Perry, R. and Godchaux, J., 2005. Volcano Hazard Management Strategies, Fitting Policy to Patterned Human Responses. Disaster Prevention and Management, 14(2): 183--195.

Perry, R. and Lindell, M., 2008. Volcanic risk perception and adjustment in a multi-hazard environment. Journal of Volcanology and Geothermal Research, 172: 179-188.

Ratdomopurbo, A., Subandriyo, Sulistiyo, Y. and Suharna, 2006. Prekursor Erupsi Gunung Merapi (in Indonesian).

Riad, J., Norris, F. and Ruback, R., 1999. Predicting evacuation in two major disasters: Risk perception, social influence, and access to resources. Journal of Applied Social Psychology, 29(5): 918-934.

Ronan, K., Paton, D., Johnston, D. and Houghton, B., 2000. Managing societal uncertainty in volcanic hazards: a multidisciplinary approach. Disaster Prevention and Management, 9(5): 339-348.

Schlehe, J., 1996. Reinterpretation of Mystical Traditions: Explanation of a Volcanic Eruption in Java. Anthropos, 91: 391-409.
Schlehe, J., 2007. Cultural politics of natural disasters: Discourses on volcanic eruptions in Indonesia. In: M. Casimir (Editor), Culture and The Changing Environment: Uncertainty, cognition and risk management in cross-cultural perspective, Berghahn, Oxford/ New York.
Sorensen, J., 1987. Decision-making uncertainties in emergency warning system organizations. International Journal of Mass Emergency and Disasters, 5(1): 33-61.
Sorensen, J., 1991. When shall we leave? Factors affecting the timing of evacuation departures. International Journal of Mass Emergency and Disasters, 9(2): 153-165.
Tobin, G. and Whiteford, L., 2002. Community Resilience and Volcano Hazard: The Eruption of Tungurahua and Evacuation of the Faldas in Ecuador. Disasters, 26(1): 28-48.
Whitney, D., Lindell, M. and Nguyen, H., 2004. Earthquake Beliefs and Adoption of Seismic Hazard Adjustments. Risk Analysis, 24(1): 2004.
Zhai, G. and Ikeda, S., 2006. Flood risk acceptability and economic value of evacuation. Risk Analysis, 26(3): 683-694.
Zhang, Y., Prater, C. and Lindell, M., 2004. Risk Area Accuracy and Evacuation from Hurricane Bret. Natural Hazards Review, 5(3): 115-120.

Indonesian language newspaper and online news

Kompas, 2006, Menjaga Merapi Tetap Tenang, 16 Mei
Kompas, 2006, Merapi Tetap Siaga, 29 April
Kompas, 2006, Tak akan Merapi buang kotoran ke pelataran, 9 Mei
BBC 2006, Merapi more than just a mountain, May 18th, accessed on May, 2007 from http://news.bbc.co.uk/2/hi/asia-pacific/4994464.stm

Chapter 6. Social Resilience of Residents in Mt. Sakurajima

This chapter[3] examines the social resilience of the residents living in three cities of Kagoshima Prefecture, Japan. These three cities, Kagoshima, Sakurajima and Tarumizu, are among the closest cities to Sakurajima Volcano and therefore they are prone to the risks when the volcano is going to erupt. This chapter seeks for the social resilience of residents in these three cities using a method that was earlier applied in Auckland, New Zealand (Paton et al., 2008) and Mt. Merapi, Indonesia (Sagala et al., *in press*), this chapter studies what variables govern the social resilience in Mt. Sakurajima. Personal and community variables contribute significantly in influencing intention to prepare under volcanic risks, while no significant contribution is found from institutional variable to intention to prepare. This finding is different from what was found in the earlier studies in Mt. Merapi Indonesia and in Auckland. Further discussions and comparison with the case study in Mt. Merapi to seek for detailed reasons was also carried out. Some interpretation and policy implication of the findings are provided in the final part of this chapter.

6.1. Introduction

The previous discussions in chapters 4 and 5 on social resilience and evacuation decision in Mt. Merapi inform us what variables mostly influence the social resilience and household evacuation decisions. In those chapters, the roles of community participation and institutional variables are found to be significant variables that contribute to social resilience of people to carry out preparedness. In order to find the common variables that may work at a different setting, a further study was carried out in communities affected by volcanic hazards posed by Mt. Sakurajima, Kagoshima, Japan. The activity of this volcano reminds of those of Mt. Merapi that the local inhabitants may observe the condition of the volcano either intentionally or unintentionally. What makes difference clearly is due to the measures provided by the governments. However, other variables which are of analytical interests include the social resilience of the residents. How the residents perceive of dangers posed by the

[3] This chapter has been prepared on the basis of the following article: Sagala, S., Okada, N. and Paton, D. Comparative Study of Intention to Prepare between Communities in Mt. Merapi and Mt. Sakurajima (*under preparation*)

volcano? Do they take information provided by the government into account and subsequently motivate them to carry out further preparedness?

As mentioned in the previous chapters, Lindell and Prater (2002), Lindell and Whitney (2000), Paton et al. (2008) and Paton et al.(2005) suggest the role of socio-psychological variables in determining people preparedness or intention to prepare. Having this background in mind, this study also attempted to check the roles of these socio-psychological variables in preparedness in communities affected by Sakurajima volcanic risks. To carry out this, this study applied the same assumptions and constructed a similar model as the case of Mt. Merapi with a reference to the earlier works made by Paton et al (Paton et al., 2005) and Paton et al (2008).

While studies on physical aspects of volcanoes have existed enormously, to the best of the author's knowledge, yet only few studies (Fukushima and Ishihara, 2004; Fukushima and Ishihara, 2005; Ishihara, 2006) have attempted to the issue of social aspects of the volcano in Sakurajima, such as how the governments and the residents respond to the disaster. The issues of social aspects, such as risk perception and disaster preparedness, will be important for a risk manager to understand how communities think of the volcano and to prepare in case an extreme eruption is going to occur. Additionally, such knowledge will help for better preparation in making appropriate risk communication.

6.2. Theoretical Framework

Social studies related to disaster perception have existed in Japan, especially related to earthquake preparedness after the Kobe Hanshin Awaji Earthquake (Shaw and Goda, 2004; Shaw et al., 2004). In addition, the participatory community activities, so-called Jishu-Bosai Soshiki, have also become popular (Bajek et al., 2008) as well as the issue of social capital (Nakagawa and Shaw, 2004) in the context of disaster management. However, those above studies did not address the social resilience of the societies in the context of volcano disaster preparedness. Modeling the social resilience is important since it provide information on significant variables which could be monitored to improve the social resilience of the residents. Unfortunately, to the best of author's knowledge, there has been no study on modelling the social resilience of communities prone to volcanic risks in Japan.

6.3. Data

As mentioned earlier in chapter 3, the current chapter uses the data surveys carried out at three cities (Kagoshima, Sakurajima and Tarumizu) in Kagoshima Prefecture collected in May – June 2009. Data collection process and sample selection are presented in details in section 3.4.2. In total 400 filled questionnaires was received from the respondents until June 14, 2009 out of 2800 questionnaires that were distributed to the residents living in these three cities. This means the rate of response return is about 15% which is good representation of the targeted respondents.

6.4. Measures

To assess the social resilience and the variables contributing to social resilience in Mt. Sakurajima, this chapter has developed a hypothesis model as shown in Figure 6-1. This model shares similarities with those of Paton et al (2008) and Sagala et al (*in press*) in which the model starts from personal level variables (negative and positive outcome expectancies and critical awareness), community level variables (collective action coping of place, collective action coping of interests, collective efficacy and community participation) and institutional level variables (empowerment and trust). The two additional variables: “collective action coping of place” and “collective action coping of interests” are included in this model since they are particularly representing community activities that are commonly found in Japan (Bajek, 2007).

The individual variables are directly linked to the intention variable. Critical awareness (CA) measures how frequent people think and talk about volcano in their community. This measure is hypothesized to have a positive relationship with intention. The more people think and talk about the disaster (volcano), the more their concern is on the volcano issues and the higher likeliness that action (preparedness) will be carried out (Lindell and Perry, 2004). Similar to discussions in the previous chapters, positive outcome expectancy is assumed to have positive contribution to intention, while in contrast, negative outcome expectancy is assumed to have negative contribution to the intention.

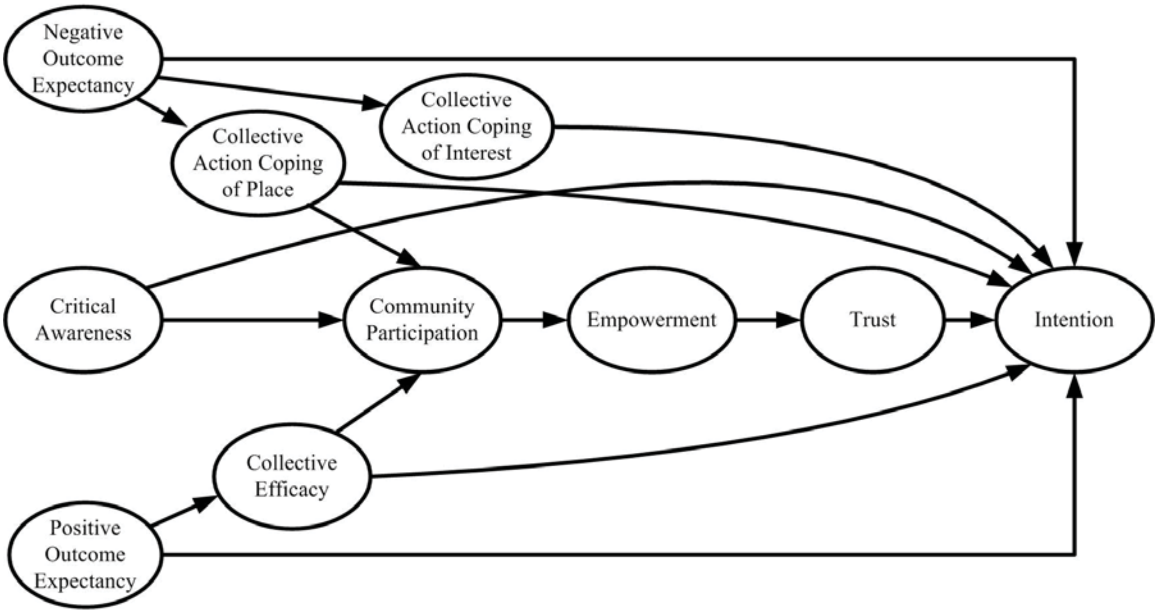

Figure 6-1 A proposed structural equation model for Mt. Sakurajima
Two measures: "collective action coping of interests" and "collective action coping of place" are added to the figure. Source: adapted from Paton et al (2008)

The additional community variables, namely collective action coping of place (CACP) and collective action coping of interests (CACI) are assumed to have positive contribution to the intention variable. These hypotheses are accommodated by introducing direct arrows from CACP and CACI to intention. However, since CACP takes place inside of the community, it is assumed that it has a direct positive contribution to community participation (CP) variable. Therefore a direct arrow is assigned from CACP to CP.

Empowerment and trust serve as the institutional variables that contribute to intention. Those who active in the community through community participation and get empowered by the government through empowerment variable will trust the government and carry out intention. Therefore the direct arrows are assigned from community participation to empowerment and trust variables to intention variable.

The whole model starts from personal level variables that directly contribute to intention and indirectly through community level variables and institutional variables. All the relationship is checked of it's significant value and only the significant paths are presented. All the data from the questionnaire were inputted to the SPSS spreadsheet and run with AMOS 7.0 software using the schematic developed in Figure 6-1.

6.5. Social Resilience Model in Mt. Sakurajima

The result of the analysis of social resilience in Mt. Sakurajima run by AMOS 7.0 is presented in Figure 6-2. The detailed result is available in Appendix 4. This model accounts for 30% variance of the model which is showing a good level of variance (Cohen, 1988) as the cut-off value 0.25 means a large effect of statistical power (Abraham and Russell, 2008). The model shows a direct relationship from four variables (negative and positive outcome expectancy, critical awareness and community participation) to intention. Some variables that were first assumed in the model (collective efficacy, collective action coping of interests, empowerment and trust) were omitted from the model since they fail to show any significant contribution in the model.

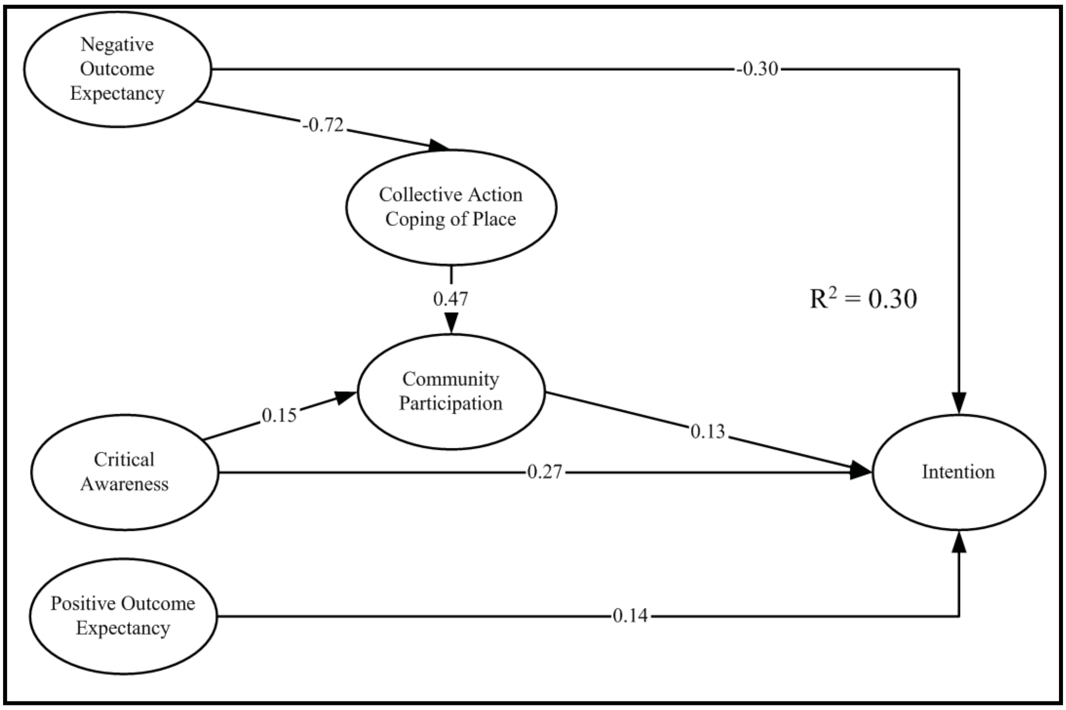

Figure 6-2 Structural Equation Model of Social Resilience in Mt. Sakurajima

χ^2 = 229.6, df = 224, p = 0.385, GFI = 0.95, NFI = 0.95 RMR = 0.038, RMSEA = 0.009

Source: Analysis

The goal of SEM, as also described in chapters 2 and 4, is to find the non-significant difference between the actual data and the model. Additionally, it also needs some more goodness of fit before we conclude which model better fit to represent the data. The data confirmed a good fit for the model as the p value is larger than 0.05, which means the difference between the model and the data are non significant. The Goodness of Fit Statistics are: (χ^2 = 229.6, df = 224, p = 0.385, GFI = 0.95, NFI = 0.95, RMR = 0.038, RMSEA = 0.009). The measures suggests how well the data fit the hypothesized model. The p value of 0.385 explains that the model is not does not have any significant difference with the data. Therefore the model shows good representation of the data. Additionally, the values of both GFI and NFI, which are larger than 0.90, suggest that the model has strong significance. This is also further confirmed with the values of RMR and RMSEA which are smaller than 0.05.

6.5.1. Personal Variables

The direct contribution from all personal variables tested in the model (NOE, POE and CA) to intention is significant. These value suggest that the personal variables need to be carefully examined for the development of disaster preparedness and risk communication in residents affected by Sakurajima volcano. The plausible explanations are given as follows.

Negative Outcome Expectancy

The relationship between "negative outcome expectancy" and "intention" is negative, as hypothesized earlier. The negative value of contribution (-0.30) from NOE to intention variable (see Figure 6-2) confirms the hypothesis and research findings by Paton et al (2005) and Paton et al (2008) that argue those who hold "negative outcome expectancy" are less likely to have intention to prepare.

A negative relationship between negative outcome expectancy and collective action coping of place is also found indicating that those who hold negative outcome expectancy are less likely to have willingness to collectively carry out preparedness with other members of the group. The high value contribution from negative outcome expectancy to intention indicate that some respondents still hold negative outcome expectancy or at least they believe that their disaster preparedness is less likely to have influence over the hazards posed by Sakurajima Volcano. This could mean that they believe the volcanoes are too difficult to be tackled by themselves or rather they simply leave it.

Figure 6-3 suggests the details of distribution of respondent answers related to variable "negative outcome expectancy" (NOE) as represented by each of respective questions raised. Each of the questions in this variable is depicted by four pie-charts that represent four questions involved in this variable. For each question the answer ranges from 1 to 5 standing for "strongly disagree" to "strongly agree" respectively. In all of the four questions, the general pattern indicates those who oppose the statements given in the NOE questions are less than 40%. In other words, those who are either support (strongly agree or agree) or neutral to the statements are dominant (more than 60%). Therefore, this is inline with the high value of significant negative contribution between NOE and intention (0.30).

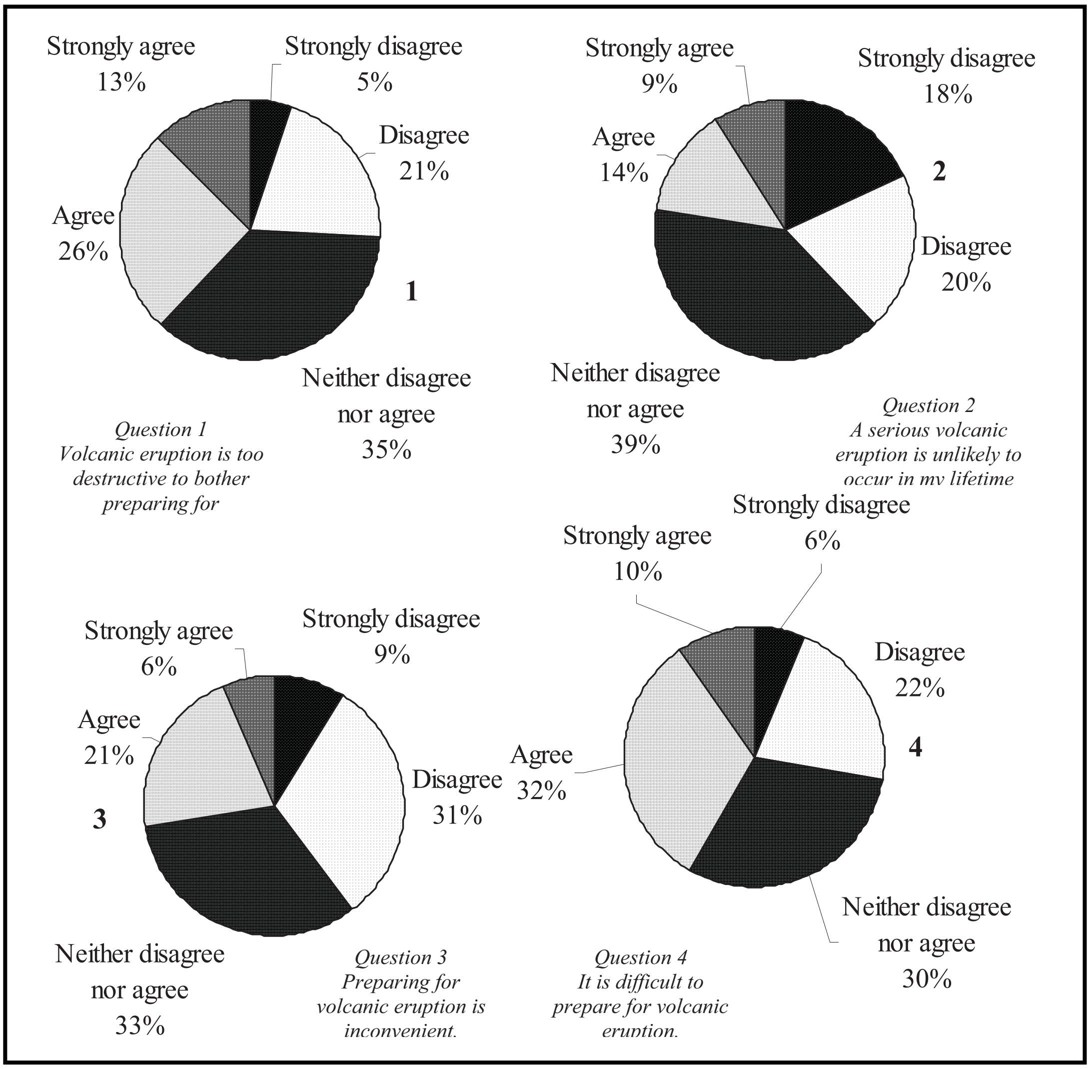

Figure 6-3 Comparisons between variables of Negative Outcome Expectancy in Mt. Sakurajima
Data are from Sakurajima sample (n = 337). The details of the questionnaire can be found in Appendix 1. Source: Analysis

Positive Outcome Expectancy

The positive value (+ 0.14), but low, from POE to intention variable in the model (Figure 6-2) confirms the hypothesis that those who hold POE will be likely to prepare. However this low number suggests only a few people hold this beliefs. To find out the distribution of those who hold POE in Mt. Sakurajima the percentages of the answers for each question are presented by pie-charts in Figure 6-4. The POE variable is represented by three questions. Similar to questions for NOE, in POE each question the answer also ranges from 1 to 5 standing for “strongly disagree” to “strongly agree” respectively.

In two questions of POE (Q1 and Q2 in Figure 6-4), about less than 22% of the respondents support (strongly agree or agree) the statements, while in one question 41% the respondents support the statements. Therefore, in general the respondents do not support the statements provided in questions related to positive outcome expectancy. Thus, although the contribution from POE to intention is significant the contribution is low (0.14).

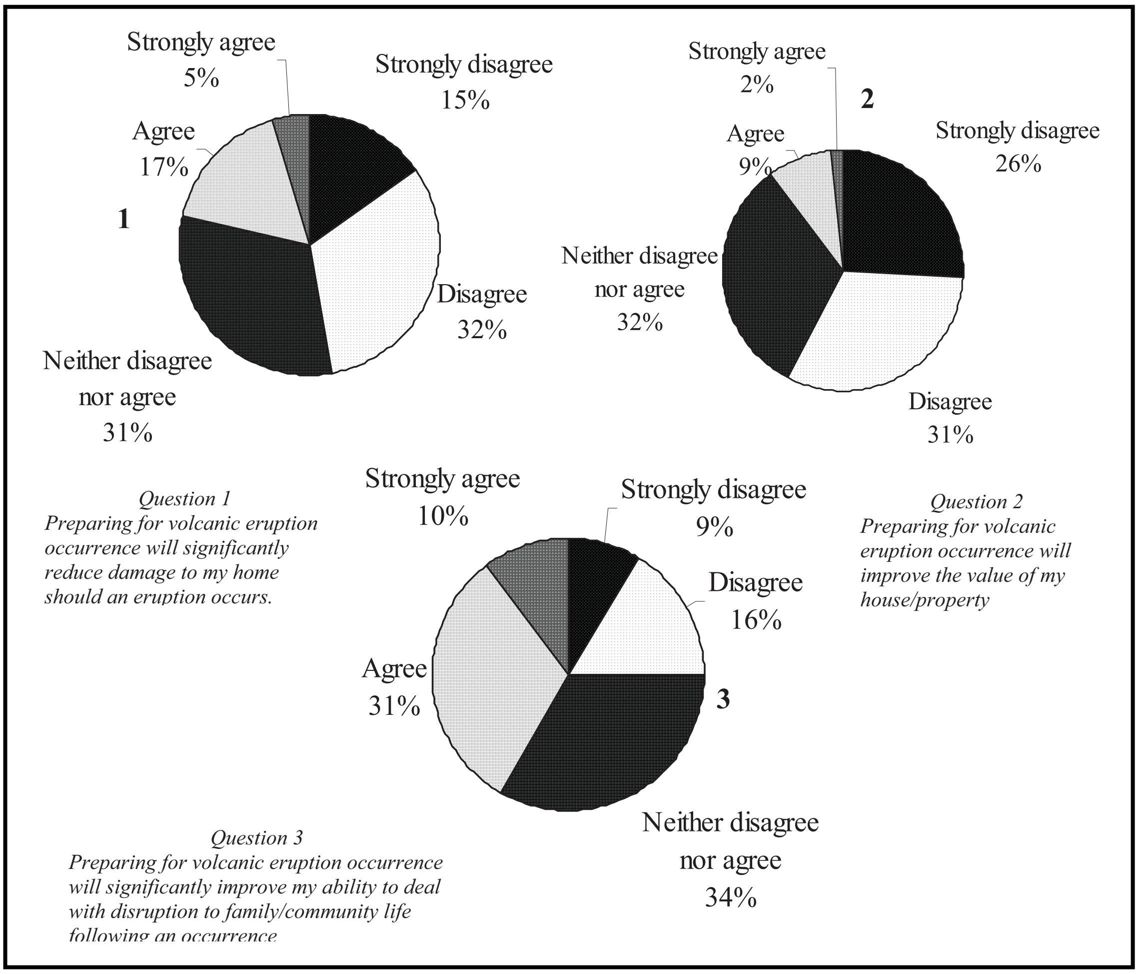

Figure 6-4 Variables of Positive Outcome expectancy in Mt. Sakurajima

Data are from Sakurajima sample (n = 337). The details of the questionnaire can be found in Appendix 1. Source: Analysis

Critical Awareness

The critical awareness variable contributes positive and significant values to intention variable in the model. This suggests that those who “think” and “talk” about the volcano issues are likely to carry out preparedness. The distribution of those who hold CA is presented in Figure 6-5.

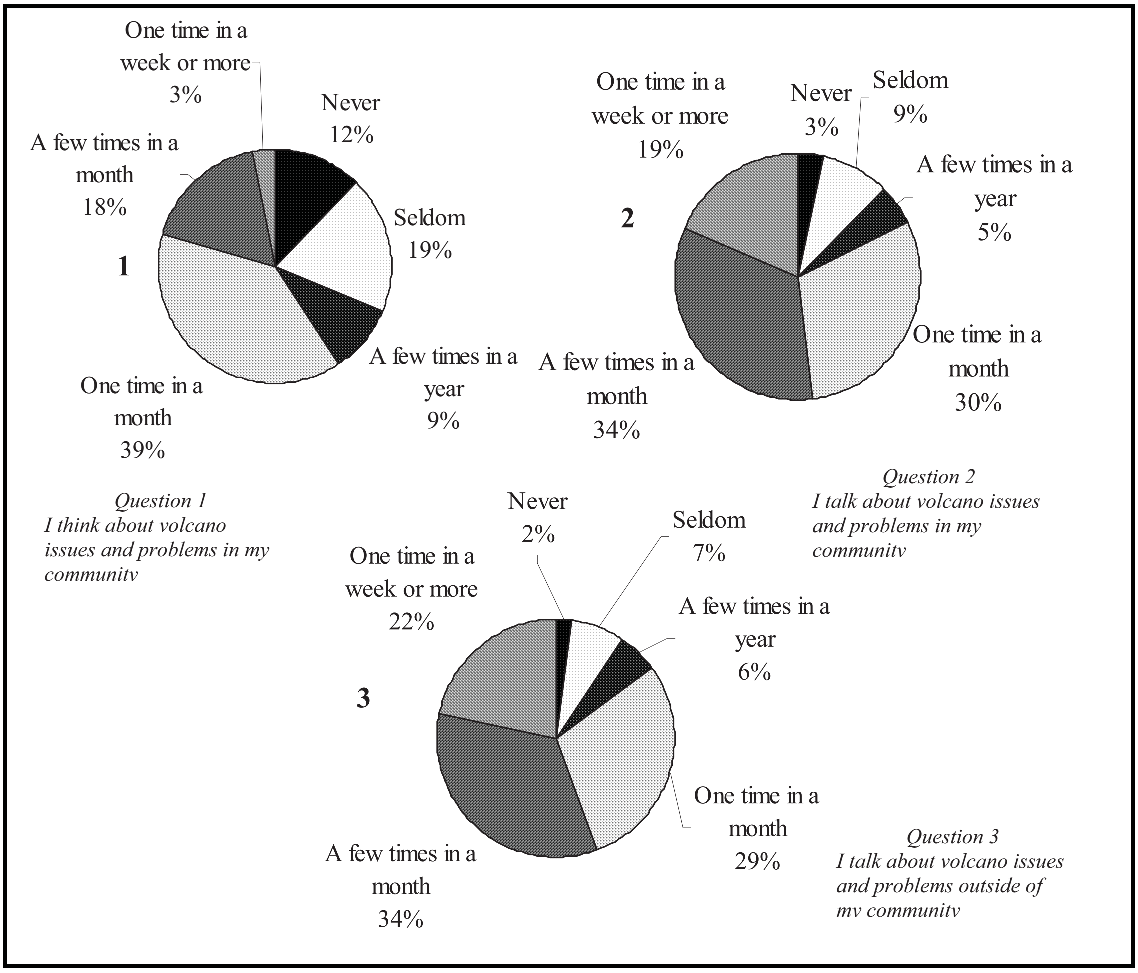

Figure 6-5 Comparison of Questions for Critical Awareness in Mt. Sakurajima

Data are from Sakurajima sample (n = 337). The details of the questionnaire can be found in Appendix 1. Source: Analysis

Overall, the strong contribution of personal level variables to intention variable also indicates some level of confidents among the residents in the face of volcanic risks. The residents see that their intention to prepare depend much on their own beliefs, either they could manage or they could not manage. This could be due to the sufficient information or knowledge provided by the government through non-structural measures which were earlier discussed in chapter 3. Additionally, the regular experience of volcanic consequences in Mt. Sakurajima (experiencing volcanic ashes) could increase resident's understanding on the volcanic phenomena. This experience and the education provided by the government are subject to sufficiently increase people' belief on the personal variables to affect their intention.

Despite the strong contribution from personal variables to intention variable, the high number of people who hold negative outcome expectancy need to be addressed properly. To this people, the knowledge provided by the government have not influenced them to be more prepared. Therefore, to increase the intention to prepare, it is important to reduce or remove the negative outcome expectancy, especially targeting those who hold this belief (NOE).

6.5.2. Community Variables

Two community variables (collective action coping of place and community participation) tested in the model contribute significantly to intention variable (see Figure 6-2). Additionally, the paths from personal variables to the two community variables were found significant. However, two other variables (collective efficacy and collective action coping of interest) that were first set in the hypothesis fail to reach a significant level.

The significance contribution from community variables to intention variable indicate that the respondents in Mt. Sakurajima are motivated to get engaged in volcano reduction activities through seeing their neighbours and their community (community participation). They also feel they are capable when they observe that together with their neighbourhood they could do something or to prepare to fight against volcanic risks (collective action coping of interest). However, their engagement in outside activities with organization related to hobbies and other things is not likely to motivate them to carry out preparedness.

In the following section we will discuss in detail the contribution of each question that composes the variables of community participation and collective action coping of interest variable (see Figure 6-6 and Figure 6-7).

Community participation

The direct contribution from community participation to intention in the model indicates the benefit of social engagements in promoting and sharing their concerns to risk perception including possible preparedness measures (Earle, 2004; Lion et al., 2002), though the value found is small yet significant direct contribution to intention.

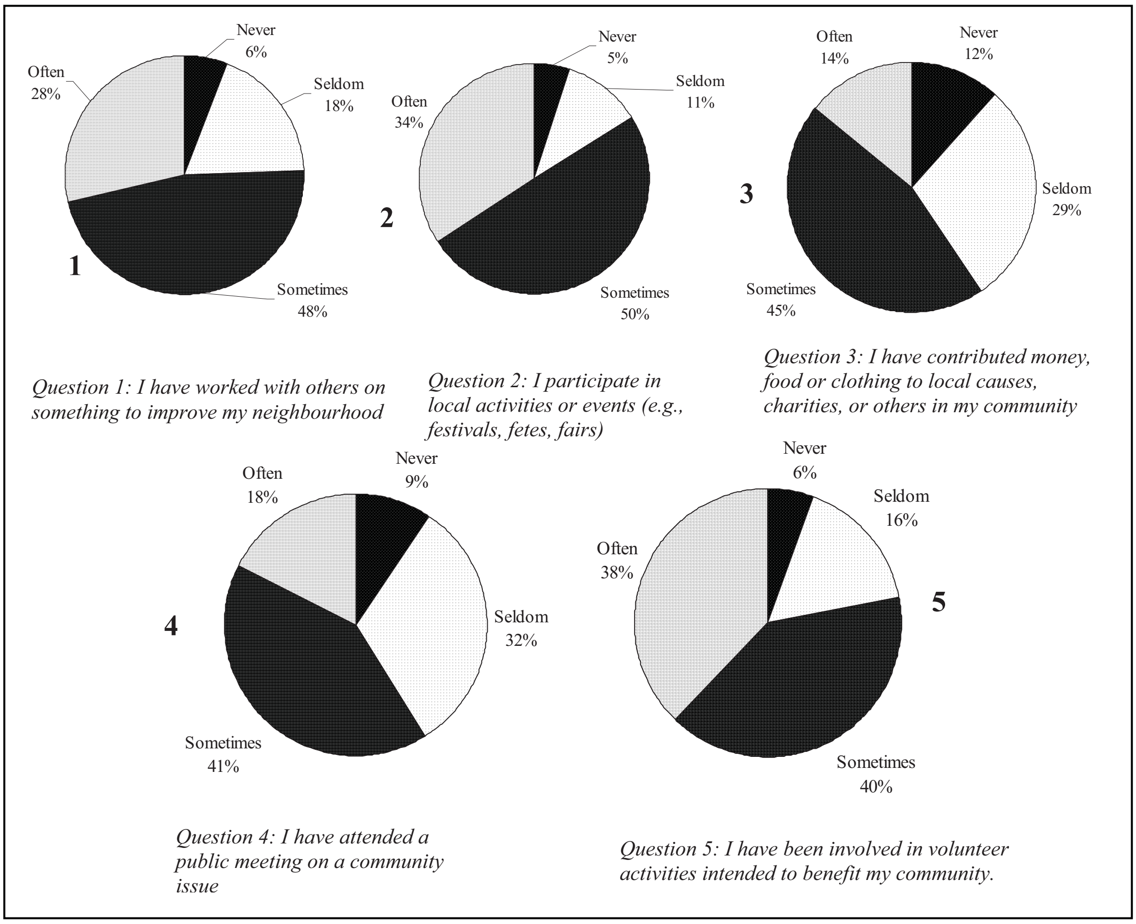

Figure 6-6 Comparison of Questions for Community Variables in Mt. Sakurajima
Source: Analysis

Community participation is still found to be an important variable that contributes to intention yet with a low value of contribution (+0.13). However, the role of collective efficacy which was found significant in the previous case study (Mt. Merapi) is not found significant in Mt. Sakurajima case and therefore is omitted in the final model. It also be possible to interprete that the role of "collective action coping of place" may be tapping into a similar process to collective efficacy and cause the variable collective efficacy in the current model to be less significant.

Collective action coping of place

Collective action coping of place does not have a direct influence to intention yet it indirectly contributes through community participation. The fact that CACP contributes to intention is supported by it's high value of the path to community participation variable (+0.47). This result suggests that the respondents feel that interaction and the capacity of their own neighbourhood are able to motivate them to carry out preparedness. For those of community members who do not believe that preparation could reduce the damage, such as those who hold the NOE, may be motivated through their communities. Thus, they will still be motivated to carry out preparedness.

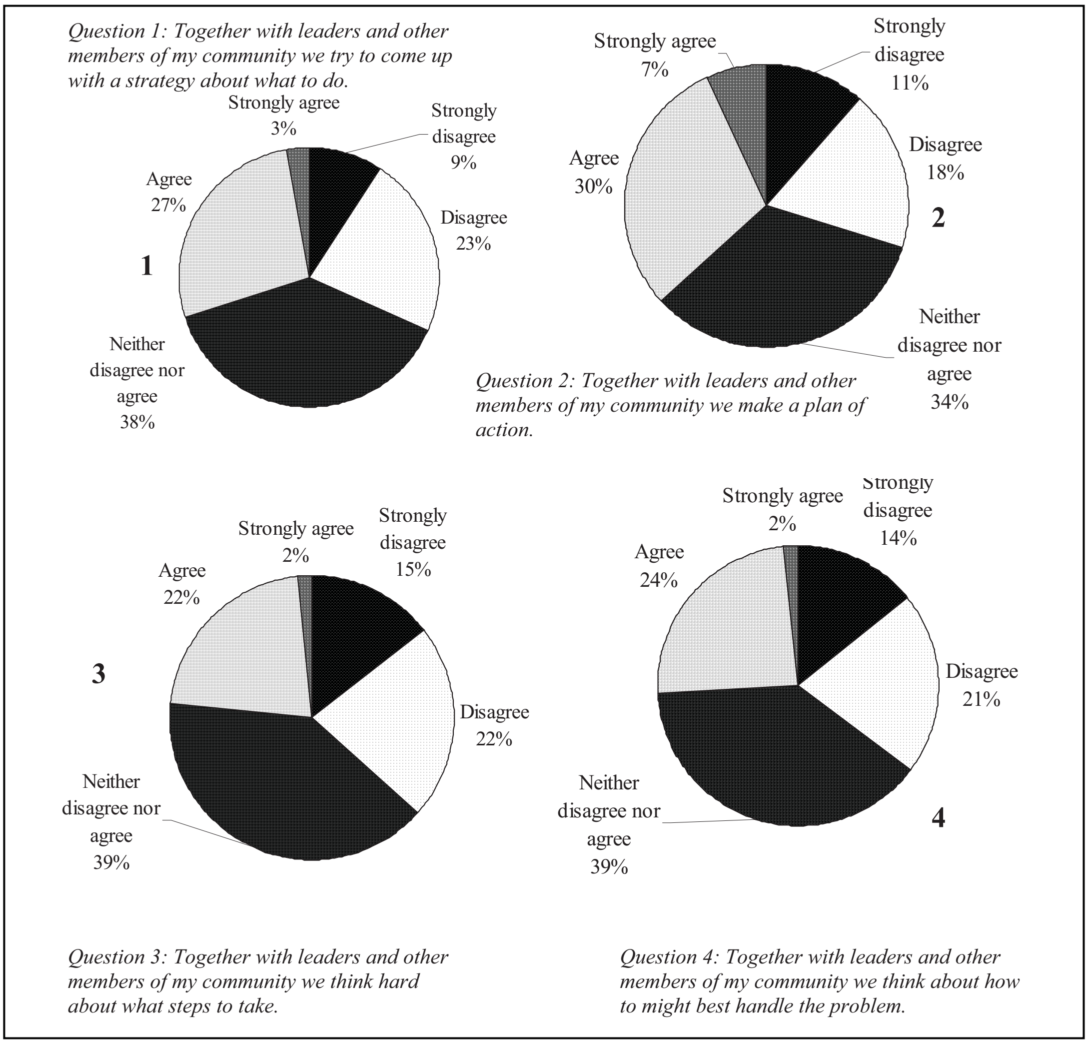

Figure 6-7 Comparison of Questions for Collective Action Coping of Place in Mt. Sakurajima

Source: Analysis

The contribution of collective action coping of place to community participation supports this finding. This suggests that the more the society thinks that they have capacities to handle the external shocks or community problems, the more they will share their beliefs and get engaged in activities which are supporting to the disaster risk reduction.

6.5.3. Institutional Variables

The institutional variables (empowerment and trust) relationship with the intention fail to become significant in Mt. Sakurajima model. After trying several possibilities of the two institutional variables, we still do not find any relationship from the institutional variables to intention. The absence of relationship between community and institutional variables suggest that people do not see their relationship with the institutions (trust) have effects to their intention to prepare. This finding seems to say that there is no relationship or a significant contribution that a citizen's trust to government will cause them use the information provided by the government to formulate plans to manage their risk by preparing for hazard consequences. Similarly, this finding suggests that the “trust” to the government does not necessarily motivate people to use the information and subsequently to carry out preparedness. This finding is surprising but this seems to suggest that the individuals find to be more confident on their own capacities in dealing with the uncertainties from the volcanic risks.

The absence of relationship between community and institutional variables suggest that people do not see their relationship with the institutions (trust) have effects to their intention to prepare. The institutional variables (trust) relationship with the intention has no significant contribution in Mt. Sakurajima model. This findings seems to say the people would not use the information provided by the government to formulate plans to manage their risk by preparing for hazard consequences. Or, it suggests that the "trust" to the government does not necessarily motivate people to use the information and subsequently to carry out preparedness.

6.6. Comparing Social Resilience Models of Mt. Merapi and Mt. Sakurajima

To find out the common and un-common variables among the social resilience carried out in two case studies, this section discusses the differences among the models in Mt. Sakurajima and in Mt. Merapi and find out the plausible explanation. As mentioned in the previous sections, the social resilience model in Mt. Sakurajima found that the contributing variables to the model are by personal and community variables while the contribution from institutional variables are non-significant. In contrast, the social resilience model in Mt. Merapi found that the significant variables are from community and institutional variables while non- or less-significant were found from personal variables. The difference of the results between the model of social resilience for the communities in Mt. Merapi and those in Mt. Sakurajima provides some insights in comparing the perceptions of the residents living in their volcanic prone areas.

Model 2 from Chapter 4 is selected to represent Mt. Merapi as it excludes some bias due to traditional cultural beliefs as discussed in Chapter 5. The comparison between the model in Mt. Sakurajima and Mt. Merapi is presented in Figure 6-6. In Mt. Merapi model, we could not get a significant model by using a combined intention, while in Mt. Sakurajima this could be done. Therefore, the social resilience in Mt. Sakurajima is measured by using a combined intention.

As it stands, Figure 6-6 shows that the social resilience in Mt. Sakurajima is predicted significantly by personal and community variables while the social resilience in Mt. Merapi is predicted by community and institutional variables. The absence or lack of significant value of personal variables in Mt. Merapi could be due to the characteristics of the society in Indonesia, where communal works normally take place, rather than an individual one (Sagala et al., *in press*). Therefore when one wants to carry out preparedness, he/she will consider more about the concern of community prior to taking any decision. On the other hand, the residents in Mt. Sakurajima seem to have confidences in their decisions related to volcanic preparedness. This is confirmed by three significant relationships from personal variables to intention variable. This could be due to the state of well informed community. The sufficient knowledge could be due to the thorough intense information provided by the local governments on volcanic preparedness. However, the fact that the number of those who hold NOE is high in Mt. Sakurajima means not all of those who are informed will be motivated to prepare. There should be another approach to encourage those who hold NOE belief to increase their preparedness.

The differences between the model in Mt. Sakurajima and the model in Mt Merapi are important but not surprising. Respondents living around Mt. Sakurajima receive such a regular experience of volcanic consequences that they can understand the implications and have experience of the effectiveness of recommended measures. Therefore they believe that they do not face so much uncertainty in dealing with the hazards. The level of uncertainty may become lower because the hazard that they deal with are “visible” or the hazard has signs that people may observe directly in contrast to other types of hazard, such as earthquake or tsunami which may happen at anytime without prior notice. Consequently, the institutional variables such as trust and empowerment become less important since people do not have to rely on external experts or agencies for information.

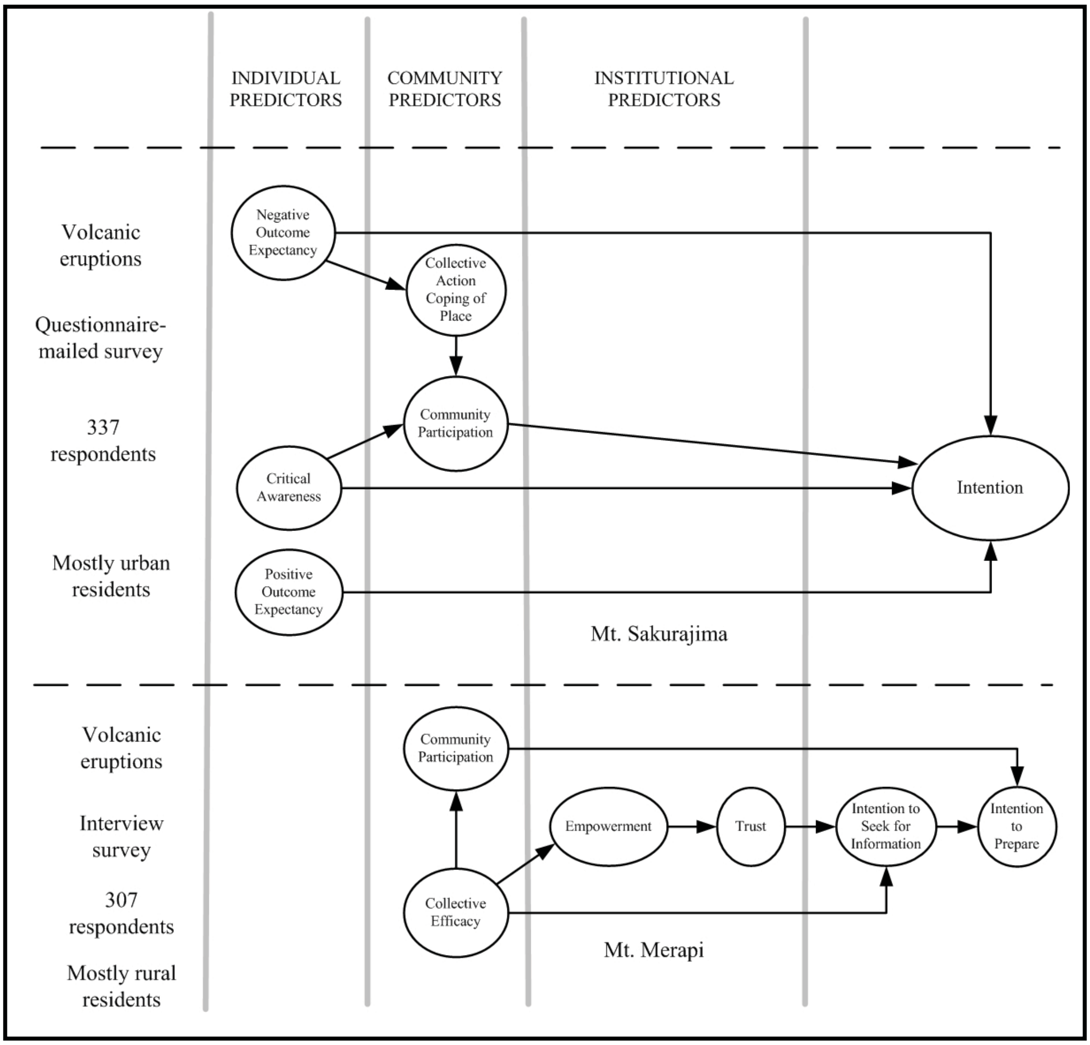

Figure 6-6 Comparison between Social Resilience Models in Mt. Merapi and in Mt. Sakurajima
Source: Analysis

As a result, in Mt. Sakurajima, however, the motivation to prepare for the hazard can be influenced by information directly given to the individual / persons. This is shown by the strong value of POE relation to intention, since the POE relationship to intention is significant, which depict that motivation would likely to arise given the sufficient knowledge is provided. In contrast, for communities in Mt. Merapi, risk communication will work better through both community and institutional variables rather than through personal variables due to the low significance of POE and NOE.

Nevertheless, there are similarities between the communities in Mt. Merapi and Mt. Sakurajima. One of them is the role of community variables (community participation and collective action coping of places). The direct contribution from community participation to intention in the model indicates the benefit of social engagements in promoting and sharing their concerns to risk perception including possible preparedness measures (Earle, 2004; Lion et al., 2002). Although the value is small (+0.13), direct contribution to intention should be noted. The contribution of collective action coping of place to community participation supports this finding. This suggests that the more the society thinks that they have capacities to handle the external shocks or community problems, the more they will share their beliefs and get engaged to activities which are supporting to the disaster risk reduction.

Both communities (Mt. Merapi and Mt. Sakurajima) could observe the signals given by the close distance to the volcano. However the geographical condition and location of the residents in Mt. Sakurajima and the residents in Mt. Merapi are different. In Mt. Sakurajima, the volcano is surrounded by water which means that the lava flows and pyroclastic flow might run to the sea-water rather than directly affected the main cities, such as Kagoshima and Tarumizu cities. Additionally, the residents living at the coast of Sakurajima Island might think they still could soon evacuate to Kagoshima city through evacuation routes and emergency ships provided by the local government to transport them to Kagoshima City.

If a pyroclastic flow occurs in Mt. Merapi the affected hamlets located nearby may be in danger within minutes such as what happened in Turgo in 1994 (Lavigne et al., 2008; Paripurno et al., 1999). As they are located in a different island, they may think that water can, to some extent, reduce the impacts of the volcano. The dangerous may occur from ash falls, yet this does not bring a deadly impact to the people. Thus, the level of certainty is higher.

6.7. Summary

The findings in this chapter suggest the social resilience of each communities differs from one to another. There are similarities among communities which could be due to the characteristics of the society and the comprehension of the hazards. The characteristics of the society are influential in determining what variables that affect and contribute to intention to prepare.

The role of “personal variables” at Mt. Sakurajima case may differ from the roles of “personal variables” for the Auckland case. In Auckland, though the volcano eruptions are not frequent, the personal variables remain high. This could be due to the characteristics of the individualistic society. On the other hand, the personal variables that exist in Mt. Sakurajima may suggest that they are influenced by what is considered to be their clear understandings of the hazard. In other words, this means the level of uncertainty is found to be lower for people in Sakurajima. This is supported by their familiarity on volcano characteristics and the preparation (measures) provided by the local government.

While the hazards are the same with for the case in of Mt. Merapi, the people perceive they do not have their own capacity to deal with their problems. In this sense, they look more to external sources, such as government, NGOs and other organizations that could empower them.

In Mt. Merapi, most of the people depend their livelihoods from the volcano. In Sakurajima, however, many people earn their living from the tourist visits. But the occupations not as risky as those in Mt. Merapi, e.g. sand mining from the deep river or taking grasses from the slope of the volcano.

This chapter has illustrated how the motivation to deal with disaster is influenced by their internal assessment of the hazards and perception to the external helps. The motivation is also found to be influenced by how the communities have developed their understanding about the hazards. When a community is (still) uncertain on how the hazard is likely to occur or when they lack of capacity to deal with the hazards, the roles of community and institutional variables seem to be dominant as what found in communities in Mt. Merapi. On the other hand, when a community is certain and well-informed of how the hazard will occur, the motivation to carry out preparedness will be likely influenced by personal and community variables rather than by external variables, such as institutional bodies.

References

Abraham, W. and Russell, D., 2008. Statistical Power Analysis in Psychological Research. Social and Personality Psychology Compass, 2(1): 283-301.

Bajek, R., 2007. Development of Evaluation for Community - based Participatory Risk Management - with a focus on Social Earthquake Resilience, Kyoto University, Kyoto.

Bajek, R., Matsuda, Y. and Okada, N., 2008. Japan's Jishu-bosai-soshiki community activities: analysis of its role in participatory community disaster risk management. Natural Hazards.

Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Lawrence Erlbaum Associates, Hillsdale, NJ.

Earle, T., 2004. Thinking aloud about trust: a protocol analysis of trust in risk management. Risk Analysis, 24: 169-183.

Fukushima, D. and Ishihara, K., 2004. Practical research on educational dissemination for volcanic disaster prevention: A case study based on the ecomuseum concept, Annuals of Disaster Prevention Research Institute, Kyoto University, No 47C.

Fukushima, D. and Ishihara, K., 2005. Volcanic disaster prevention and community development, Annuals of Disaster Prevention Research Institute, Kyoto University, No 48C.

Ishihara, K., 2006. Volcanic information and response of local authorities in case of the 2006 Sakurajima Eruption, Annual Conference of Disaster Prevention Research Institute, Kyoto University, 50C.

Lavigne, F., De Coster, B., Juvin, N., Flohic, F., Gaillard, J., Texier, P., Morin, J. and Sartohadi, J., 2008. People's behaviour in the face of volcanic hazards: Perspectives from Javanese communities, Indonesia. Journal of Volcanology and Geothermal Research, 172: 273-287.

Lindell, M. and Perry, R., 2004. Communicating Environmental Risk in Multiethnic Communities. Sage.

Lindell, M. and Prater, C., 2002. Risk area resident' perceptions and adoption of seismic hazard adjustments. Journal of Applied Social Psychology, 32(11): 2377-2392.

Lindell, M. and Whitney, D., 2000. Correlates of Household Seismic Hazard Adjustment Adoption. Risk Analysis, 20(1): 13-25.

Lion, R., Meertens, R. and Bot, I., 2002. Priorities in information desire about unknown risks. Risk Analysis, 20: 13-25.

Nakagawa, Y. and Shaw, R., 2004. Social capital: A missing link to disaster recovery. International Journal of Mass Emergency and Disasters, 22(1): 5-34.

Paripurno, E., Setiabudi, H., Sofyan., Raharyono, D., Susanto, A. and Nawitaningrum, F., 1999. Merapi bertutur: Tentang Musibah awan panas 22 Nopember 1994 (Merapi depicts: The pyroclastic flow of November 22nd 1994.

Paton, D., Smith, L., Daly, D. and Johnston, D., 2008. Risk perception and volcanic hazard mitigation: Individual and social perspectives. Journal of Volcanology and Geothermal Research, 172: 179-188.

Paton, D., Smith, L. and Johnston, D., 2005. When good intentions turn bad: Promoting disaster preparedness. The Australian Journal of Emergency Management, 20(1).

Sagala, S., Okada, N. and Paton, D., *in press*. Predictors of Intention to Prepare for Volcanic Risks, A case study of Mt. Merapi. Journal of Pacific Rim Psychology.

Shaw, R. and Goda, K., 2004. From Disaster to Sustainable Civil Society: The Kobe Experience. Disasters, 28(1): 6-40.

Shaw, R., Shiwaku, K., Kobayashi, H. and Kobayashi, M., 2004. Linking experience, education, perception and earthquake preparedness. Disaster Prevention and Management, 13(1): 39-49.

Chapter 7. Conclusion and Recommendation

This chapter summarizes all the findings and policy implications derived from all analyses in this thesis. In terms of research methodology for data collection, there are some differences between the field study in Mt. Merapi and the field in Mt. Sakurajima. These differences in field survey approach were considered important from the view point of reflecting local conditions. In this study, two kinds of analyses have been carried out: “structural equation model” and “statistical tests”. The main analysis applied a structural equation model to depict the causal-relationship variables that predict the intention of the communities (social resilience) in dealing with volcano hazards. Additionally, the second analysis for the case in Mt. Merapi more data were available to carry out statistical analysis related to evacuation decisions by the households in the 2006 volcanic eruption.

Chapter 2 has provided the literature review and the baseline discussion of social resilience in this study. As mentioned earlier, the framework of social resilience in this study refers to socio-psychological variables that were earlier used by Paton et al (2008) in volcanic areas in Auckland, New Zealand. The ability of this framework or model to predict the intention to prepare is to be later checked in chapter 4 for Mt. Merapi and in chapter 6 for Mt. Sakurajima.

Chapter 3 devoted space to closely discussing the study areas and the methodology. From discussion in chapter 3 we could identify that the respondents in Mt. Sakurajima were characterized by more urbanized population. On the other hand, the respondents in Mt. Merapi were characterized by more rural population. They depend much on the volcano as the sources of livelihoods since the volcano provides fertile land and some materials that could be used for construction.

Chapter 4 has examined the social resilience variables in Mt. Merapi. The model of social resilience obtained in this study area was characterized by the dominant variables of community variables and institutional variables. This also means that the respondents in Mt. Merapi depend to the assistance given by the government.

Chapter 5 has analyzed the factors that are correlated with the evacuation decisions of the respondents in Mt. Merapi. It found that three factors are strongly correlated (negatively and positively) to the evacuation decisions. Two factors that are negatively correlated are the proximity to the volcano and the proximity to the river. Meanwhile, the positively correlated factor with evacuation decision is the disaster experienced. Having the information of this correlation in mind, risk managers could map more properly the distribution of potential evacuation in the future.

Chapter 6 has examined the variables that contribute to the social resilience in Mt. Sakurajima. Different from the results obtained for the case in Mt. Merapi, model of social resilience in Mt. Sakurajima is dominated by the individual variables and community variables. The reason could be due to the differences in characteristics of the respondents between Mt. Sakurajima and in Mt. Merapi, such as between urbanized vs non-urbanized (urban vs rural), different types of society, different types of measures provided by the government as discussed in detailed in chapter 6..

7.1. Conclusion

This study has found that the social resilience of a person or a household in each community could be influenced by many factors. Testing the hypothesis that was developed earlier on the causal relationship between personal, community and institutional variables in affecting one's intention to deal with volcanic hazards, it was found that the role of each variable is relatively different for a different community. Social resilience model is able capture these differences and the interaction between personal level, community level and institutional level variables that affect one's intention to prepare under volcanic risks.

The case studies that were carried out in Mt. Merapi and Mt. Sakurajima have confirmed this argument. While both residents are located near an active volcano, the variables that influence their social resilience are different. In Mt. Merapi, the roles of community variables and institutional variables are more dominant and very less and non-significant contribution from the personal variables. On the other hand, the roles of personal and community variables in Mt. Sakurajima are significant while the roles of institutional variables statistically fail to reach significance.

As discussed in chapter 3 on study area, there are several variables that could be attributable to explain these phenomena. The first reason could be due to the long-term policy that was carried by the government. As the local government in Mt. Merapi focuses more attention on the physical countermeasures, such as constructing sabo dams and shelters, the residents are not given enough knowledge on the volcano phenomenon. Hence, the level of certainty among the residents in Mt. Merapi is still high because they were not clear about the dangers that could be posed by the volcano.

On the other hand, their counterparts in Mt. Sakurajima are provided comparatively with sufficient knowledge of the volcanic hazards by the government and therefore they are more certain on what would happen if the volcano erupts. Thus, the personal level variables among the residents are found to be significant to relate to their intention.

Study on evacuation decision in Mt. Merapi is important and suggests what factors that could be related significantly with the residents' evacuation decisions. Correlation analyses for evacuation decisions provide a detailed example, how geography (proximity) of the respondents, disaster experience and natural signals are related with their evacuation decisions. This finding helps the local government to predict the future pattern of evacuation decisions. Additionally, it helps the local government to address which communities among the residents of Mt. Merapi that needs to be given particular risk communication if their current evacuation decision is slow to respond to the warning provided by the government. The discussions from the model do not mean which one is better as compared to another. It rather attempts to capture how the current community works on and digests the information before coming with their decisions whether to evacuate or not.

7.2. Recommendations

Based on the findings and analyses in the previous chapters, this thesis concludes with a list of further research needs in the future as well as recommendation and policy implications.

Further studies need to cover the following items.

- It is important to carry out more extensive analyses based on the presented social resilience model, by applying to different locations. With a variety of distances up from the volcano, this will bring or test whether the assumption derived in this thesis that people' perception of the hazards are due to the complexity and uncertainty of the disasters. If this is true, we may say familiarity (to a hazard) is an advantage.
- This social resilience model was originally developed and tested for communities with a culture of more individualistic. The socio-psychological theories involved in justifying the indicators were also referring to case studies that were already proven in developed country and western contexts. Thus, applying this model to a different context like Japan and Indonesia needs a careful reservation. This thesis suggests that there could be some other variables that may help to predict the social resilience of the communities. As compared with the case of Auckland, this

can be influenced by the existence of local culture in the communities. While it is difficult to quantify culture, it is important to note and to consider this for further research.

- This study suggests changing some variables that may predict the intention, such as community participation, could change the value of intention. Further could try to simulate this and attempts to capture the phenomenon caused by the changes of the variables.
- It is really important to map the characteristics of the society before carrying out a disaster education program or risk communication. Having done this, one may develop a better suited program and hopefully will bring a greater impact than that of normal disaster education.

Our findings in Mt. Merapi suggest that, it is important to integrate risk management and community development for improving disaster preparedness in more collective society. The inclusion of risk management program in community daily activities will significantly increase their capabilities (e.g., collective efficacy) and relationships (empowering) within the communities. Our findings also highlight the roles of institution (local government, emergency managers) to empower the communities. Appropriate coordination between local institutions and communities will increase trust and subsequently motivate people to search for relevant information and carry out preparedness.

Subsequently, the finding in Mt. Sakurajima suggest that if the government aims to increase the social resilience of the target areas, it could be more effectively done through paying attention to personal variables. This could be done, for instance, by reducing the number those who hold negative outcome expectancy and to increase those who hold positive outcome expectancy. Additionally, as the two community variables (collective action coping of place and community participation) are dominant and significant, it is important to effectuate the message through community based activities that already exist in the community at stake.

Appendix

Appendix 1 Questionnaire Related to Social Resilience

The following items provide the summary of the questions which were used to measure the observed variables. All the scales used in the questions were based on Likert Scale.

Critical Awareness

In regard to what happens in your *community*, please describe the extent to which you agree or disagree with each of the following statements:

Code		Once a week or more	A few times a month	Once a month	A few times a year	Rarely	Never
A_1a	I think about volcanic issues and problems in my community	6	5	4	3	2	1
A_1b	I talk about volcanic problems and issues in my community	6	5	4	3	2	1
A_1c	I talk about volcanic problems and issues outside of my community						

Negative Outcome Expectancy

Please describe the extent to which you agree or disagree with each of the following statements:

Code		Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
A_3a	Volcanic eruptions are too destructive to bother preparing for	5	4	3	2	1
A_3b	A serious volcanic eruption is unlikely to occur in my lifetime	5	4	3	2	1
A_3c	Preparing for volcanic eruptions is inconvenient	5	4	3	2	1
A_3d	It is difficult to prepare for volcanic eruptions	5	4	3	2	1

Positive Outcome Expectancy

Please describe the extent to which you agree or disagree with each of the following statements:

Code		Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
A_4a	Preparing for volcanic eruptions will significantly reduce damage to my home should an eruption occur	5	4	3	2	1
A_4b	Preparing for a volcanic eruption will improve the value of my house/property	5	4	3	2	1
A_4c	Preparing for volcanic eruptions will significantly improve my ability to deal with disruption to family/community life following an eruption	5	4	3	2	1

Intentions

In the next month or so, do you intend to (please circle as appropriate):

Code		No	Possibly	Definitely
A_6a	Check your level of preparedness for volcanic eruptions	1	2	3
A_6b	Increase your level of preparedness for volcanic eruptions	1	2	3
A_6c	Become involved with a local group to discuss how to reduce damage or loss from volcanic hazards	1	2	3
A_6d	Seek information on volcanic risk	1	2	3
A_6e	Seek information on things to do to prepare for volcanic eruptions	1	2	3

COMMUNITY LEVEL

Community Participation

In regard to participating in life in this *community*, please describe how often you undertake each of the following.

Code		Often	Sometimes	Rarely	Never
B_2a	I have worked with others on something to improve my neighbourhood	4	3	2	1
B_2b	I participate in local activities or events (e.g., festivals, fetes, fairs)	4	3	2	1
B_2c	I have contributed money, food or clothing to local causes, charities, or others in my community	4	3	2	1
B_2d	I have attended a public meeting on a community issue	4	3	2	1
B_2e	I have been involved in volunteer activities intended to benefit my community (e.g., fundraising, clean-up days, local groups, Scouts/Brownies).	4	3	2	1

Cognitive empowerment/Collective efficacy

In regard to your general feelings about living in this *community*, please describe the extent to which you agree or disagree with each statement.

Code		Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
B_3a	I can have power in my community only by working in an organized way with other people	5	4	3	2	1
B_3b	Power is collective, not individual	5	4	3	2	1
B_3c	Power lies in the relationship between people	5	4	3	2	1
B_3d	A person becomes powerful through other people	5	4	3	2	1
B_3e	The only way I can have power is by connecting to others	5	4	3	2	1

Collective Action Coping of Place

In regard to your general feelings about living in this *community*, please describe the extent to which you agree or disagree with each statement.

Code		Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
B_5a	Together with leaders and other members of my community we try to come up with a strategy about what to do	5	4	3	2	1
B_5b	Together with leaders and other members of my community we make a plan of action	5	4	3	2	1
B_5c	Together with leaders and other members of my community we think hard about what steps to take	5	4	3	2	1
B_5d	Together with leaders and other members of my community we think about how to might best handle the problem	5	4	3	2	1

Collective Action Coping of Interests

In regard to your general feelings, please describe the extent to which you agree or disagree with each statement.

Code		Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
B_6a	Together with the leaders and other members of non residential community we try to come up with a strategy about what to do	5	4	3	2	1
B_6b	Together with the leaders and other members of non residential community make a plan of action	5	4	3	2	1
B_6c	Together with the leaders and other members of non residential community we think hard about what steps to take	5	4	3	2	1
B_6d	Together with the leaders and other members of non residential community we think about how to might best handle the problem	5	4	3	2	1

INSTITUTIONAL LEVEL INDICATORS

Empowerment

In regard to what happens in your *community*, in general, to what extent do you think that:

	Always	A great deal	Sometimes	Not very much	Not at all
Voting in local elections influences what happens in my community	5	4	3	2	1
Voting in local elections helps solve local problems	5	4	3	2	1
Community groups can get something done about local problems	5	4	3	2	1
I feel that I can influence what happens in my community	5	4	3	2	1
I feel that I see positive results from participating in community activities	5	4	3	2	1
I feel that I have an active part in keeping this community going	5	4	3	2	1
I care about how my community looks	5	4	3	2	1
I feel that what happens in this community can affect my life	5	4	3	2	1
I have strong opinions about the way things are done by elected representatives	5	4	3	2	1
I think that elected representatives seriously consider my opinions	5	4	3	2	1
I think that elected representatives try to influence what goes on in my community	5	4	3	2	1

Trust

In regard to your general feelings about living in this *community*, please describe the extent to which you agree or disagree with each statement.

	Strongly agree	Agree	Neither Agree nor disagree	Disagree	Strongly disagree
I trust my Local Government to respond to meet the needs of its residents	5	4	3	2	1
I trust the community leaders in my community	5	4	3	2	1
I trust the media (newspapers, TV, radio) to report fairly	5	4	3	2	1
I trust my Local Government to do what is right for the people they represent	5	4	3	2	1
I have confidence in the law to protect and maintain order in my community	5	4	3	2	1

Appendix 2 Merapi Regression Weight: Model 1 (n=322)

This table is calculated from data source for Model 1 of Mt. Merapi Social Resilience Model

			Estimate	S.E.	C.R.	P	Label
Collective Efficacy	<---	Positive Outcome Expectancy	.095	.041	2.312	.021	par_16
Community Participation	<---	Collective Efficacy	.223	.078	2.842	.004	par_57
Empowerment	<---	Community Participation	.435	.171	2.539	.011	par_68
Trust	<---	Empowerment	.609	.197	3.083	.002	par_69
Intention to Seek for Information	<---	Trust	.291	.088	3.313	***	par_54
C_2a	<---	Trust	1.137	.168	6.767	***	par_5
Intention to prepare	<---	Positive Outcome Expectancy	.083	.045	1.864	.062	par_52
Intention to prepare	<---	Intention to Seek for Information	.572	.103	5.570	***	par_53
A_6d	<---	Intention to Seek for Information	1.000				
Intention to prepare	<---	Collective Efficacy	.189	.096	1.962	.050	par_56
B_2d	<---	Community Participation	2.384	.432	5.511	***	par_2
C_2e	<---	Trust	1.053	.157	6.706	***	par_6
A_6b	<---	Intention to prepare	1.000				
C_1i	<---	Empowerment	1.560	.493	3.166	.002	par_12
A_4c	<---	Positive Outcome Expectancy	.282	.088	3.215	.001	par_15
C_1i	<---	C_2a	.152	.085	1.798	.072	par_44
C_1i	<---	A_6d	.307	.100	3.083	.002	par_51
A_4c	<---	Collective Efficacy	.557	.189	2.954	.003	par_59
B_2a	<---	Community Participation	1.000				
B_2c	<---	Community Participation	1.484	.290	5.119	***	par_1
B_2e	<---	Community Participation	1.475	.270	5.454	***	par_3
C_2c	<---	Trust	1.000				
C_2d	<---	Trust	1.349	.192	7.016	***	par_4
A_4a	<---	Positive Outcome Expectancy	1.000				
A_4b	<---	Positive Outcome Expectancy	.902	.196	4.595	***	par_7
B_3b	<---	Collective Efficacy	1.000				
B_3c	<---	Collective Efficacy	1.535	.288	5.324	***	par_8
B_3d	<---	Collective Efficacy	1.841	.333	5.526	***	par_9
B_3e	<---	Collective Efficacy	1.595	.301	5.304	***	par_10
C_1a	<---	Empowerment	1.000				
C_1d	<---	Empowerment	1.671	.489	3.420	***	par_11
C_1j	<---	Empowerment	1.656	.487	3.402	***	par_13
C_1b	<---	Empowerment	1.695	.428	3.961	***	par_14
B_3a	<---	Collective Efficacy	1.308	.243	5.380	***	par_17
B_3c	<---	B_2d	-.252	.057	-4.432	***	par_43
A_6c	<---	Intention_to prepare	1.369	.236	5.812	***	par_50
A_6e	<---	Intention to Seek_for Information	1.085	.138	7.873	***	par_55

			Estimate	S.E.	C.R.	P	Label
A_6c	<---	C_1i	-.103	.029	-3.553	***	par_58
B_3a	<---	Empowerment	.236	.190	1.240	.215	par_60
B_3a	<---	A_4c	-.131	.059	-2.207	.027	par_61
B_3a	<---	A_6b	-.153	.060	-2.550	.011	par_62
B_3a	<---	C_2e	.077	.058	1.333	.183	par_63
A_4a	<---	Empowerment	-.448	.209	-2.140	.032	par_64
B_3e	<---	Trust	.217	.125	1.733	.083	par_65
B_3d	<---	Trust	-.208	.116	-1.787	.074	par_66
C_2d	<---	Community_Participation	-.518	.216	-2.397	.017	par_67
C_1j	<---	A_6d	.201	.095	2.120	.034	par_70
A_4b	<---	A_6b	-.190	.080	-2.383	.017	par_71

Appendix 3 Merapi Regression Weight: Model 2 (n=307)

This table is calculated from data source for Model 2 of Mt. Merapi Social Resilience Model

		Estimate	S.E.	C.R.	P	Label
Empowerement	<--- Collective_Efficacy	.651	.204	3.190	.001	par_25
Trust	<--- Empowerement	.436	.110	3.958	***	par_83
C_2b	<--- Trust	.413	.093	4.454	***	par_4
C_1a	<--- Empowerement	1.000				
C_1a	<--- C_2b	-.280	.107	-2.605	.009	par_51
Community_Participation	<--- Collective_Efficacy	.164	.067	2.449	.014	par_62
Intention to_Seek for Information	<--- Collective_Efficacy	.257	.113	2.279	.023	par_87
Intention to_Seek for Information	<--- Trust	.114	.062	1.853	.064	par_88
C_2e	<--- Trust	.913	.125	7.287	***	par_1
C_2a	<--- Trust	1.000				
Intention_to Prepare	<--- Community_Participation	.401	.205	1.960	.050	par_10
Intention_to Prepare	<--- Intention to_Seek for Information	1.050	.205	5.122	***	par_27
C_2e	<--- C_1a	.068	.030	2.307	.021	par_75
B_2c	<--- Community_Participation	1.732	.339	5.104	***	par_6
A_6a	<--- Intention_to Prepare	.472	.153	3.079	.002	par_9
C_1i	<--- Empowerement	1.041	.219	4.753	***	par_17
C_1h	<--- Empowerement	1.164	.251	4.641	***	par_18
C_1g	<--- Empowerement	.167	.072	2.312	.021	par_19
C_1f	<--- Empowerement	1.125	.225	4.993	***	par_20
C_1f	<--- C_2a	-.216	.070	-3.093	.002	par_52
C_1g	<--- C_2b	.163	.046	3.564	***	par_64
A_6a	<--- C_2e	-.122	.055	-2.223	.026	par_76
C_2d	<--- Trust	1.120	.146	7.696	***	par_2
C_2c	<--- Trust	1.002	.141	7.095	***	par_3
B_2a	<--- Community_Participation	1.000				
B_2b	<--- Community_Participation	1.077	.235	4.572	***	par_5
B_2d	<--- Community_Participation	2.719	.546	4.979	***	par_7
B_2e	<--- Community_Participation	1.612	.319	5.047	***	par_8
A_6b	<--- Intention_to Prepare	1.000				
B_3a	<--- Collective_Efficacy	1.000				
B_3b	<--- Collective_Efficacy	1.013	.218	4.651	***	par_11
B_3c	<--- Collective_Efficacy	1.477	.309	4.786	***	par_12
B_3d	<--- Collective_Efficacy	2.057	.414	4.973	***	par_13
B_3e	<--- Collective_Efficacy	1.809	.368	4.910	***	par_14
C_1k	<--- Empowerement	.981	.210	4.659	***	par_15
C_1j	<--- Empowerement	1.696	.327	5.183	***	par_16
C_1e	<--- Empowerement	1.019	.211	4.829	***	par_21
C_1d	<--- Empowerement	.824	.191	4.313	***	par_22
C_1c	<--- Empowerement	.771	.160	4.820	***	par_23
C_1b	<--- Empowerement	1.178	.213	5.537	***	par_24

			Estimate	S.E.	C.R.	P	Label
A_6d	<---	Intention to_Seek for Information	1.000				
A_6c	<---	Intention to_Seek for Information	1.324	.259	5.106	***	par_26
C_1j	<---	C_1h	-.202	.058	-3.490	***	par_53
B_3a	<---	B_2c	.225	.061	3.659	***	par_54
C_1d	<---	B_2c	.259	.077	3.367	***	par_56
C_1j	<---	C_1a	-.177	.054	-3.282	.001	par_57
B_3d	<---	Trust	-.357	.110	-3.252	.001	par_58
C_2c	<---	C_1g	-.235	.081	-2.906	.004	par_61
C_1b	<---	C_2b	.215	.096	2.232	.026	par_65
C_1j	<---	Collective_Efficacy	-.770	.321	-2.394	.017	par_74
C_1e	<---	A_6a	.146	.067	2.193	.028	par_77
B_2a	<---	C_2b	.115	.051	2.234	.025	par_80
B_3c	<---	C_1i	-.074	.032	-2.354	.019	par_85
B_3a	<---	C_1f	.096	.040	2.392	.017	par_86
B_2e	<---	C_1g	-.107	.050	-2.128	.033	par_89

Appendix 4 Sakurajima Regression Weight (n=337)

This table is calculated from data source for Model of Mt. Sakurajima Social Resilience Model

		Estimate	S.E.	C.R.	P	Label
CACP	<--- Negative Outcome_Expectancy	-1.078	.345	-3.122	.002	par_45
A_1a	<--- Critical_Awareness	1.000				
Community_Participation	<--- Critical_Awareness	.106	.043	2.445	.014	par_26
Community_Participation	<--- CACP	.356	.130	2.731	.006	par_42
B_2c	<--- Community_Participation	.672	.064	10.535	***	par_2
Intention	<--- Community_Participation	.113	.050	2.276	.023	par_9
A_3b	<--- Negative Outcome_Expectancy	.745	.124	5.990	***	par_10
Intention	<--- Negative Outcome_Expectancy	-.288	.067	-4.266	***	par_15
Intention	<--- Positive Outcome_Expectancy	.103	.048	2.152	.031	par_16
Intention	<--- Critical_Awareness	.168	.038	4.401	***	par_25
A_3b	<--- A_1a	-.146	.043	-3.430	***	par_41
B_2a	<--- Community_Participation	1.000				
B_2b	<--- Community_Participation	.907	.053	17.226	***	par_1
B_2d	<--- Community_Participation	.806	.061	13.198	***	par_3
B_2e	<--- Community_Participation	.923	.059	15.738	***	par_4
A_6e	<--- Intention	1.000				
A_6d	<--- Intention	.943	.055	17.109	***	par_5
A_6c	<--- Intention	.668	.059	11.312	***	par_6
A_6b	<--- Intention	.701	.067	10.531	***	par_7
A_6a	<--- Intention	.876	.079	11.114	***	par_8
A_3a	<--- Negative Outcome_Expectancy	1.000				
A_3c	<--- Negative Outcome_Expectancy	1.131	.130	8.676	***	par_11
A_3d	<--- Negative Outcome_Expectancy	1.321	.148	8.908	***	par_12
A_4a	<--- Positive Outcome_Expectancy	1.000				
A_4b	<--- Positive Outcome_Expectancy	.894	.096	9.331	***	par_13
A_4c	<--- Positive Outcome_Expectancy	.761	.088	8.691	***	par_14
B_5d	<--- CACP	1.000				
B_5c	<--- CACP	1.026	.027	37.727	***	par_17
B_5b	<--- CACP	1.011	.037	27.475	***	par_18
B_5a	<--- CACP	.867	.036	24.362	***	par_19
A_1c	<--- Critical_Awareness	.966	.082	11.739	***	par_20
A_1b	<--- Critical_Awareness	1.097	.093	11.792	***	par_21
A_4b	<--- A_3b	.143	.037	3.828	***	par_40
A_3a	<--- B_2c	-.082	.112	-.732	.464	par_46

Appendix 5 List of Publication

List of publication produced during the completion of PhD Thesis (chronological order)

1. **Sagala, S.** and Okada, N. How do hazards-related factors and traditional cultural beliefs affect evacuation decisions? *Disasters* (*in revision*).
2. **Sagala, S.**, Okada, N. and Paton, D. Predictors of Intention to Prepare for Volcanic Risks in Mt. Merapi, Indonesia, Journal of Pacific Rim Psychology (*in press*).
3. **Sagala, S.**, Okada, N. and Paton, D. (2009), Modeling Social Resilience of Mountain Communities Under Volcanic Risks. A case study of Mt. Merapi. *IEEE International Conference on Systems, Man, and Cybernetics*, October 11-14, 2009, San Antonio, Texas, USA.
4. Paton, D. , **Sagala, S.**, Okada, N., Jang, L and Gregg, C. Natural hazard resilience and sustainable development: All-hazards and cross cultural perspectives, *International Conference on Disaster Prevention Technology and Mitigation Education*, Taiwan, September 24, 2009 (*accepted*).
5. **Sagala, S.** and Okada, N. (2009), Statistical Analysis of Correlation Between Hazard-Related Factors and Household Evacuation Decisions in Mt. Merapi, Indonesia, *Annual Conference of Institute of Social Safety Science*, Mie, Japan
6. **Sagala, S.** (2007) Risk Communication for Disaster Preparedness of Earthquake and Volcanic Eruption, case study: Yogyakarta, Indonesia, paper for *PhD Summer Academy, Munchen, United Nations University - Institute for Environment and Human Security and MunichRe Foundation*, Jul 22-28, 2007, Munich, Germany

In Kyoto University Publication

1. **Sagala, S.** and Okada, N. (2009), Policy Analysis for Hitting the Right Target: Risk Communication in Mt. Merapi, Annual Conference, 24-25th Feb 2009, Disaster Prevention Research Institute, Kyoto University, Japan
2. **Sagala, S.**, Dwiyani, R., Bajek, R., Takeuchi, Y. and Okada, N. (2008), Examining the Relationship between Earthquake Preparedness Factors at Household Level, Case Study: Nakagyouku Communities, Kyoto City, Annual Conference, 2008, Disaster Prevention Research Institute, Kyoto University, Japan
3. **Sagala, S.** and Okada, N. (2007) Managing Early Warning Systems in Tsunami Prone Communities: The Needs for Participatory Approach (PRA), Annual Conference March 6-7, 2007, Disaster Prevention Research Institute, Kyoto University, Japan, pp (195-204)