印尼火山爆發受災社區復原力的比較研究

Comparative Study of Community Resilience to Volcanic Hazards in Indonesia

沙特 · 沙加拉 印尼萬隆理工學院助理教授

Saut Sagala
Assistant Professor of School of Architecture, Planning and Policy Development at Institute of Technology Bandung (ITB), Indonesia
Email: saut.sagala@rdi.or.id

亞斯米納 · 伍蘭達理[1] 阿里 · 德理根[2]
加文 · 沙利文[3] 羅錦福[4]

1 理學士 , 印尼復原力發展中心
2 博士 , 印尼復原力發展中心
3 博士 , 英國考文垂大學
4 教授 , 澳洲查爾斯達爾文大學

Yasmina Wulandari[1] Ari Tarigan[2]
Gavin Sullivan[3] Douglas Paton[4]

1 BSc, Resilience Development Initiative
2 Dr., Resilience Development Initiative
3 Dr., Coventry University
4 Professor, Charles Darwin University

摘要

印尼境內至少有100座活火山，因此，社區經歷火山災害的風險是相當高的。因為火山爆發類型、過去火山爆發史、及社區特質的不同，火山災害對社區造成各種不同的影響。本文介紹在日惹 (Yogyakarta) 的默拉皮火山 (Mt. Merapi) 和北蘇門答臘 (North Sumatra) 的錫納朋火山 (Mt. Sinabung) 的受災社區所進行的研究，以呈現物理及社會因素與社區復原力的關係，不同層級間的關係：個人、社區、國家也在社區復原力扮演重要的角色，了解這些關係對規劃印尼火山災害易致災區的降低社區災害風險政策是重要的。

關鍵字：社區、韌性、印尼、火山

Abstract

Indonesia is a country of some 100 active volcanoes. Therefore, exposure to volcanic hazards is high in communities. Volcanic hazards have diverse impacts on communities, with the nature of the consequences depending on, for example, the type of eruption, past eruption history, and the characteristics of communities affected. This chapter presents a study of communities exposed to eruptions at Mt. Merapi (Yogyakarta) and Mt. Sinabung (North Sumatra) to illustrate how interaction between physical factors and those at individual, community/social and institutional levels influence community resilience. Understanding these relationships will play an important role in developing disaster risk reduction policy for communities susceptible to experiencing volcanic hazards in Indonesia.

Keywords: community, resilience, Indonesia, volcano

Introduction

Studies of resilience have highlighted the importance of examining how people prepare for, respond to, and cope with natural disasters. Ronan and Johnston (2005) argued that "resilience is linked to how well a community can bounce back after a major disaster." However, the latter definition fails to consider not only the scale of events, but also their duration. This is especially important for events with long term impacts, such as drought or prolonged volcanic eruptions. Recognition of the latter makes it important to appreciate the important role that enduring social correlates of social resilience. Social resilience can be explored from socio-psychological, (Paton, 2003; Paton et al., 2008; Sagala et al., 2009), socio-ecological (Adger, 2000; Adger et al., 2005; Holing, 1973), and recovery perspectives.

Previous large-scale disasters remind us of the important role knowledge, actions and resources play in resilience (Kelman, 2006). Knowledge must translate into action whether for mitigation (e.g., creating earthquake proof structure) or for community preparedness (Sagala et al., 2012), with both the latter being low. A major reason for this low level of uptake is lack of resources (e.g., budget for earthquake proofing, retrofitting buildings and shelters etc.).

Furthermore, community resilience is also affected by institutional settings, policy and programs. Public institutions consist of national, sub-national and local governments, with each carrying different DRR responsibilities. One role of local government is disaster risk reduction, through raising public awareness on hazard impacts. That is, through disaster education, local government seeks to facilitate public access to necessary information (e.g., via social media, apps, broadcast) on disaster threats and how to deal with their consequences. Consequently, models of community resilience must encapsulate these levels of analysis. If they are to be systematically examined, robust models are required.

One example of robust modelling come from Paton et al. (2008). This work was applied in Indonesia (Sagala et al., 2009; Paton et al., 2010). According to this work, people's interpretation of the manageability of their risk, interacts with

social constructionist processes and their beliefs about their relationship with civic risk management agencies to determine whether they act to manage their risk and increase their response capacity. Because the specific characteristics of the social context in which risk beliefs are developed and enacted are unique, understanding the specific characteristics of the social context are important in developing community resilience.

This chapter discusses how this process of applying specific community characteristics can be conducted using case studies of communities exposed to Mt. Merapi (Yogyakarta) and Mt. Sinabung (North Sumatra). The main hypothesis is that the relationship between different levels: individual, community and institutional would play significant roles for the community resilience. Understanding the relationships will be important to propose disaster risk reduction policy to communities exposed to volcanic hazards in Indonesia. Taking two active volcanoes in Indonesia as case studies, these two study areas provide different setting in term of social and physical conditions, that later can affect the community resilience.

Literature Review

Community Resilience

Community disaster resilience and disaster risk reduction (DRR) are emerging fields within disaster research (Miles, 2015; Twigg, 2009). Thus, a solid and unanimous definition of community resilience remains to be established. The UN body responsible for coordinating global disaster risk reduction efforts, UNISDR (The United Nations Office for Disaster Risk Reduction, 2007), defines resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions." Alternatively, Twigg (2009) defined community resilience as comprising a capacity to anticipate, minimize and absorb potential stresses or destructive forces through adaptation

or resistance; manage or maintain certain basic functions and structures during disastrous events; and to recover or 'bounce back' after an event.

Volcano Impact

According to Tilling (2005), some 10% of the world's population reside nearby active and potentially active volcanoes. Despite the potential impacts from a volcano, and the importance and necessity of community readiness (Chester, 1993), levels of community preparedness remain low (Gregg et al., 2004). A similar state of affairs prevails in communities living on Mt. Merapi (Lavigne et al., 2008). One common preparedness measure is developing evacuation and temporary relocation centers (Keller & Blodgett, 2008; Smith & Petley, 2009). Smith and Petley argued that evacuation paths and relocation shelters should be prioritized for development. In general, community preparedness for a volcanic disaster includes preparing some instruments prior to an eruption, such as: a mask to prevent ash hazard from inhaling, a tool to clean up the ash and an evacuation drill, provision of shelters, etc.

1. Volcano Disasters in Indonesia.

Indonesia's geographical location as an archipelago located at the juncture of three tectonic plates, namely Indo Australia Plate, Eurasia and the Pacific, consequently potential to cause earthquake when plates collide. Indonesia has 129 active volcanoes. Ever since the 2004 Indian Ocean Tsunami, there has been significant increase in geological disasters in Indonesia. Up until September 2016, some 1,707 hazard events were recorded, with these being responsible for 411 dead or missing, causing the displacement of over 2 million people, and causing damage to 25,578 residential structures. Of all the disasters, there are a few that stand out: earthquakes, tsunamis, and volcanic eruptions. These disasters caused high number of damages and loss in just one event compared to floods and landslides that happened more frequently. Some 46% of economic losses are caused by earthquakes and 26% of the combined economic losses can be attributed to tsunami. The 2004 Indian Ocean Tsunami remains as macro disaster, with the highest death toll (170,000 deaths). The 2010 Merapi Volcanic

Eruption is the highest mezzo disaster, causing 353 deaths and resulting in the displacement of 350,000 people. Indonesia has experienced several volcanic disasters since 2005, among others: Mt. Kelud (2007 and 2014), Mt. Sinabung (2010-2017), Mt. Merapi (2006 and 2010). The following sub-sections will discuss two very active mountains that have huge impacts on both local populations and the economy.

2010 Mt. Merapi Eruption

In 2010, Mt. Merapi erupted. It is known as '100' year's event which brought devastating disaster for the community who lives around its flanks. It generated tephra plume that reached 12 km altitude, released SO2 emissions larger than any of its recorded eruptions (from 1992 to 2007), resulted more than 280 lahar events along 13 rivers, and produced pyroclastic density flow currents that cruised 8 km down the Kali Gendol River and Kali Kuning River drainages channel on the south flank of the volcano (Surono et al., 2012). 367 people were killed, 400,000 people were evacuated, and 2,300 houses were collapsed.

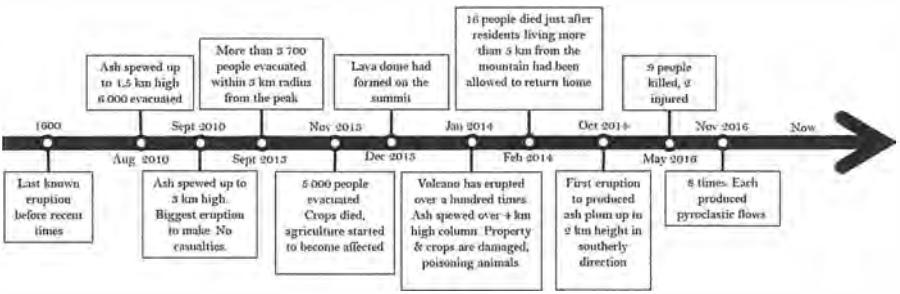
Eruptive events	Type of eruption	Life Loss PF / DF	Affected Villages
1672	Ex, PF, DF	3000	
1822-1823	Ex, PF, DF, D	100	
1832-1835	Ex, PF, LF, D	32	
1849	Ex, PF, LF	Hundreds	
1871-1872	Ex, Tf, PF, LF	200	
1902-1904	Ex, D, LF, PF	16 (PF)	3
1920-1921	Ex, PF, D, DF	35 (PF)	1
1930-1931	Ex, PF, LF, D, ps, 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 dead	
November 2010	Ex, PF, D	353 dead	

Source: Thouret 2000, PVMBG, 2012

2010 & 2013-present Mt. Sinabung Eruption

Mt. Sinabung is unique. Its eruption in 2010 was the first after it lying dormant for 400 years. It is now Indonesia's most active volcano. The volcano erupted again in 2013 and hasn't stopped since. The uncertainty caused by this long-duration eruption at Mt. Sinabung has resulted, so far, in the displacement

of 2,592 families and 9,319. Some villages have been relocated to a safer place, but some face enduring uncertainty, unable to return home yet not knowing where to go next.



Timeline of Mt. Sinabung Eruption

Research Location & Method

Research Locations

The case studies we discuss examine communities affected by Mt. Merapi and Mt. Sinabung (Figure 1). Mt. Merapi is the home for many residents who live and earn their living from the volcano. People in Mt. Merapi rely for their livelihood on farming, animal husbandry, sand mining and tourism (Sagala et al., 2012). Frequent eruption at Mt. Merapi volcano means people are aware of the activity of the volcano. Thus, the community resilience may also increase as communities learn from their environmental experience. Mt. Sinabung is in Karo District, North Sumatra Province, Sumatra Island. The capital of the province is Medan City. Medan, Binjai, Deliserdang, and Karo are considered as one of the emerging metropolitans in Indonesia (Tarigan et al., forthcoming). People live in Mt. Sinabung work as farmers. Their agriculture products are sold to Medan and other big cities in Sumatra and Java.

Data Collection

Several field works have been carried out in these two volcanoes. Research in Mt. Merapi has been initiated since 2008 – 2012. There have been a number of field works carried out during these periods by the first author of this paper as the principal investigators. Survey in 2008 gathered about 350 questionnaire data where 322 where used for the analysis. After that, in 2011 another field work was conducted gathering 250 respondents on their perception towards lahar impacts.

Field research works in Mt. Sinabung were carried out in 2016 and 2017. Survey in 2016 gathered about 350 questionnaires from three groups of location in Mt. Sinabung: (i) assisted relocation, (ii) voluntary relocation and (iii) non relocation. In addition to the questionnaire, qualitative data were also collected. In 2017, some field visits for observation and interviews to temporary shelters were also carried out.

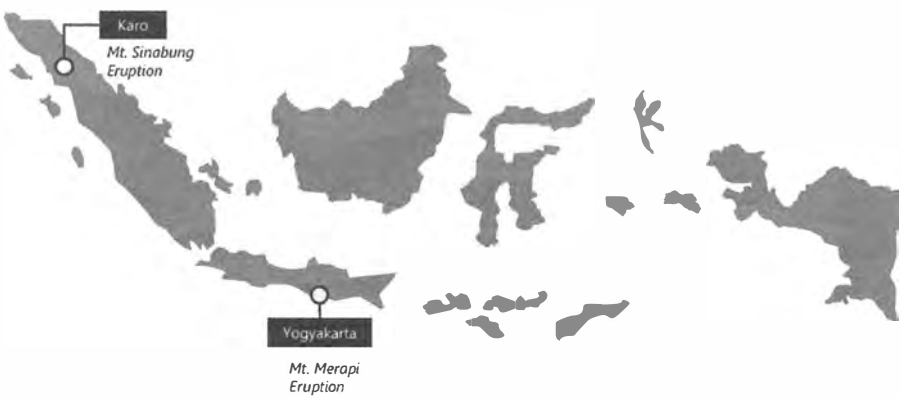


Figure 2. Location of Mt. Merapi and Mt. Sinabung

Analysis

This study employed variables discussed in Paton et al. (2008), and include individual, community and institutional factors. Individual community consists of outcome expectancy (negative and positive). Negative outcome expectancy is a belief that hazard consequences are too difficult to handle. Consequently, if people hold positive outcome beliefs and possess the necessary knowledge and resources to prepare, they will act.

Community level variables include collective efficacy and community participation. Participating in community activities provides access to information from people that share one's interests, values and expectations, a measure of "community participation" (Eng & Parker, 1995). In addition, community members' ability to identify the information, resource and planning needs required to advance their disaster preparedness was examined (Zaccaro et al., 1995). Collective efficacy is a good indicator of the co-operation and assistance available within a community (Paton & Johnson, 2001). Institutional level variables include empowerment and trust. Empowerment was assessed using a measure developed by Speer & Peterson (2000). In addition, "trust" was assessed with a measure used in Paton et al. (2005).

Finally, the model argues that the relationship between trust and action is mediated by intentions. Lindell and 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). The hypothetical model is presented in Figure 2.

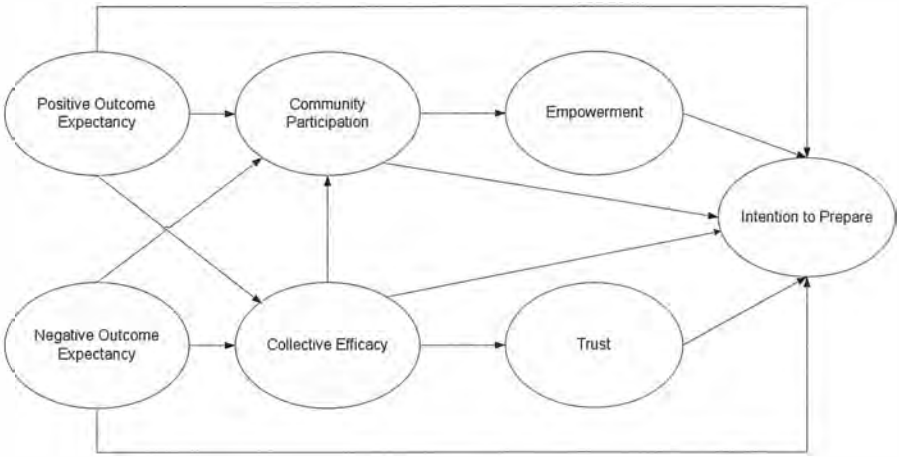


Figure 2: Structural Equation Model of Community Resilience

Results

The following section explains the results of the study based on running AMOS Structural Equation Model Software. Structural Equation Model (SEM), as the analytical tool, needs several rounds of simulation before coming to the final model.

Social Factors on Community Resilience in Mt. Merapi

In Mt. Merapi, intention to prepare is directly contributed 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' 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.

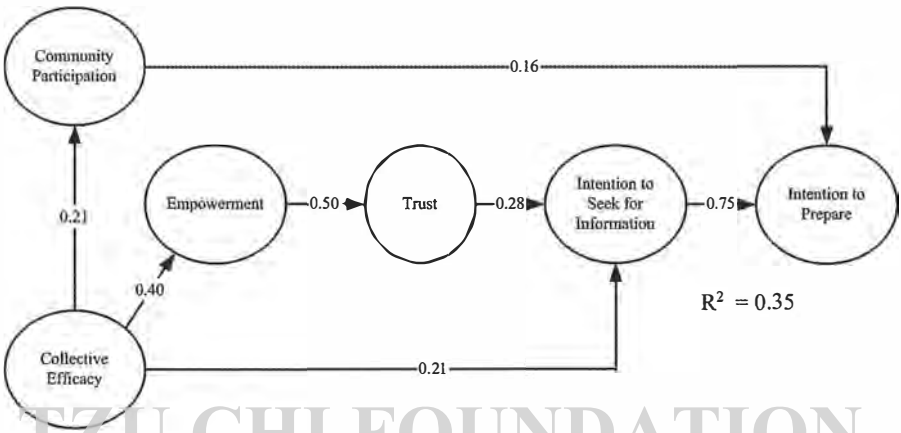


Figure 3 Social Resilience Model in Mt. Merapi (*Sagala et al 2009*)

Social Factors on Community Resilience in Mt. Sinabung

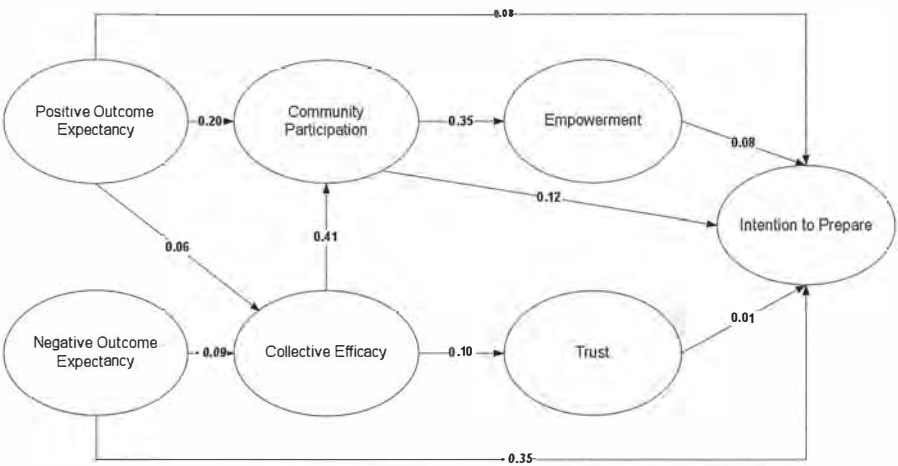


Figure 4: Community Resilience in Mt. Sinabung

Figure 4 suggests that individual, community and institutional variables all contribute to intention to prepare. The direct contribution of POE to intention to prepare is small. The negative value from negative outcome expectancy to collective efficacy and intention to prepare shows at individual level, the communities in Mt. Sinabung believe that individually, when they think the hazard is manageable, members are likely to prepare. Positive and large contributions from community level variables (community participation and collective efficacy) indicate that community level variables play important roles in people's intention to prepare.

Institutional level variables show low results. The low value of trust in Mt. Sinabung is not surprising. During the eruption and emergency response period, a political dispute was occurring in Karo District. During the dispute, the Head of Karo District was sacked by President of Indonesia. The dispute created considerable uncertainty regarding aid distribution. Moreover, the local government department responsible for disaster management was not functioning during the early emergency response of Mt. Sinabung. Furthermore, during the asset compensation provided for relocation there have been many conflicts; the communities affected by the Sinabung Volcanic eruption went on strike.

Community Participation's Role in Community Resilience

The social resilience model in Mt. Sinabung revealed that the contributing variables to the model are predominantly personal and community variables. The contribution from institutional variables is non-significant. In contrast, the social resilience model in Mt. Merapi found significant influence from community and institutional variables, with non- or less-significant influences from personal variables. The difference between the two studies highlights the need for and benefit of comparing the perceptions of residents living in their volcanic prone areas.

Both models reveal that community level variables, namely collective processes (e.g., community participation) and competencies (e.g., collective

efficacy), play important roles. These findings reflect the fact that preparedness decision making is a collective activity that emerges when community members share their views with their neighbors 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.

In both Mt. Merapi and Mt. Sinabung communities, community participation plays an important role in DRR. However, how it is operationalized can vary from one place to another. In Mt. Sinabung, community participation is shown with the common activities taking place in and near Jambur (multipurpose building). In Mt. Merapi, the role of leader (head of hamlet and head of village) is very important. Karonese culture is driven by the ethnic relation formed by the same family and by marriage among families.

Anwar et al (2017) suggests considering internal and external factors to assess resilience. Internal factors are capacity and vulnerability factors, while external factors are governance and spatial planning. Gotong royong is a communal work and a social tradition of solidarity in Indonesia, which has historically been part of many communities (Kusumawardhani, 2015). Gotong royong is another form of community participation. Gotong royong increases community coping capacity and so functions to strengthen resilience.

Conclusion

This study shows that there are similar variables that determine community resilience in a collectivistic society, such as Indonesia. The findings suggest that it is important to appreciate how community characteristics play key roles in the development of social resilience in Indonesia. That is, the value of "community participation" and "collective efficacy" is significant. Furthermore, it is important to understand that they derived from people's experience in everyday life (Sagala et al., 2009). It is the collectivistic resources, through gotong royong and kinship (cf. social capital) that help in achieving individual and community

goals. The findings discussed here reiterate that community-based approaches to risk management in Indonesia, as suggested by Sagala et al. (2009) will be more effective than those targeting individuals.

The limited influence of institutional level variables posts a warning for institutions (formal authorities). This finding means that DRR policy, if developed in a purely top-down manner, would be less influential at a community level than actions developed using community-based DRR policies and practices. Thus, increasing the trust of the communities to the local government would be very important, and doing so through facilitating the integration of understanding and approaches between the individual, community and institutional variables will be more effective as a means of promoting sustainable community resilience.

References

Anwar, H. Z., Yustiningrum, E., Andriana, N., Kusumawardhani, D. T. P., Sagala, S., & Sari, A. M. (2017). Measuring community resilience to natural hazards: Case study of Yogyakarta Province. In *Disaster risk reduction in Indonesia* (pp. 609-633). Springer International Publishing.

Adger, W. (2000). Social and ecological resilience: Are they related? *Progress in Human Geography*, 24(3), 347-366.

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

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

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. & Blodgett, R. (2008). *Natural hazards: Earth's processess as hazards, disasters, and catastrophes*. Upper Saddle River, NJ: Pearson/Prentice Hall.

Lindell, M. & Perry, R. (2004). Communicating environmental risk in multiethnic communities. *Social Work Research, 24*, 109-118.

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

Paton, D., Sagala, S., Okada, N., Jang, L. J., Bürgelt, P. T., & Gregg, C. E. (2010). Making sense of natural hazard mitigation: Personal, social and cultural influences. *Environmental Hazards, 9*(2), 183-196.

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

Ronan, K., & Johnston, D. M. (2005). *Promoting community resilience in disasters: The role for schools, youth, and families*. New York: Springer.

Sagala, S., Okada, N., & Paton, D. (2009). Predictors of intention to prepare for volcanic risks in Mt Merapi, Indonesia. *Journal of Pacific Rim Psychology, 3*(2), 47-54.

Sagala, S., Rosyidie, A., Pratama, A., Wimbardana, R., & Wijayanti, A. (2012). Promoting volcano tourism in hazard zone area for rebuilding local economy: Case study of tourism in Cangkringan Sub-District, Mt. Merapi, Yogyakarta. Paper presented at International Conference on "Sustainable Built Environment," Islamic University of Indonesia, Yogyakarta, Indonesia.

Smith, K. & Petley, D. (2009). Environmental hazards: Assessing risk and reducing disaster. London: Routledge.

Speer, P. & Peterson, N. (2000). Psychometric properties of an empowerment scale: Testing cognitive, emotional and behavioral domains. *Social Work Research, 24*, 109-118.

Tarigan, A., Samsura, D., Sagala, S. & Pencawan, A. (forthcoming). Medan City: Development and governance under the decentralisation era. *Cities Journal*.

Thouret, J., Lavigne, F., Kelfoun, K. & Bronto, S. (2000). Toward a revised hazard assessment at Merapi Volcano, central Java. *Journal of Volcanology and Geothermal Research, 100*, 479-502.

Yustiningrum, E. (2015). Bencana dan Politik di Indonesia: Problematika Terkait Kerentanan Masyarakat Paska Bencana Alam, Masyarakat Tangguh Bencana : Pendekatan Sosial Ekonomi, Tata Kelola dan Tata Ruang. Edisi 1, Anwar, H. Z. (Ed.). *Pusat Penelitian Geoteknologi LIPI*.

Zaccaro, S., Blair, V., Peterson, C., & Zazanis, M. (1995). Collective efficacy. In J. Maddux (Ed.). *Adaptation and adjustment* (pp. 305-328). New York, NY: Plenum Press.