Emerald Insight

Disaster Prevention and Management

Informational capital and disaster resilience: the case of Jalin Merapi
Justyna Tasic Sulfikar Amir

Article information:

Users who downloaded this article also downloaded:

(2016),"Monitoring and evaluating disaster risk management capacity", Disaster Prevention and Management: An International Journal, Vol. 25 Iss 3 pp. 412-422 http://dx.doi.org/10.1108/DPM-01-2016-0002

(2016),"Assessing the benefits of organized voluntary emergency services: Concepts and evidence from flood protection in Austria", Disaster Prevention and Management: An International Journal, Vol. 25 Iss 3 pp. 298-313 http://dx.doi.org/10.1108/DPM-09-2015-0203

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

Informational capital and disaster resilience: the case of Jalin Merapi

Justyna Tasic
Institute of Catastrophe Risk Management, Interdisciplinary Graduate School, Nanyang Technological University, Singapore, and
Sulfikar Amir
Division of Sociology, School of Humanities and Social Sciences, Nanyang Technological University, Singapore

Abstract

Purpose – The purpose of this paper is to present a concept of informational capital to explain the interplay between social capital and information technology in community-based disaster management. It aims to discuss the role and formation of informational capital in community disaster resilience.

Design/methodology/approach – Based on an exploratory case study focusing on the 2010 eruption of Merapi volcano in Central Java, Indonesia, the paper seeks to analyse the emergence of disaster response fully organized by grassroots groups in Yogyakarta. In advancing the concept of informational capital, this paper analyses how the grassroots groups were able to mobilize resources for disaster mitigation, through which social capital became the foundation of community-based disaster response and recovery. Furthermore, the mobilization of social capital was significantly enhanced by mutual interactions facilitated by the use of information technology. This is evident in the role of Jalin Merapi, a web-based organization formed to respond to the crisis after the volcano eruption.

Findings – The concept of informational capital revolves around the ways in which social capital and information act as crucial assets when a disaster strikes. Through informational capital, strong community bonds and ties are transformed into organized information that effectively facilitates collective action to face the emergency crisis.

Originality/value – This paper presents a new concept of informational capital and highlights its key role in facilitating disaster management processes and contribution to community disaster resilience.

Keywords Social capital, Disaster management, Information technology, Community resilience, Developing societies, Disaster resilience, Emergency communications, Informational capital

Paper type Case study

Introduction

Understanding how communities respond to and recover from disasters is vital not only for governments, social scientists, and disaster researchers, but also for communities themselves. One key factor in disaster management is information. It is a crucial asset that defines the effectiveness of disaster management. This paper aims to shed light on the impact of information technology on disaster resilience. Specifically, this paper explores how information technology plays a key role in mobilizing social capital for disaster relief. It seeks to theorize the interplay between social capital and information technology in building disaster resilience capacity. To explain how social capital and information technology are inextricably intertwined in enhancing community disaster resilience, we offer the concept of "informational capital" a form of capital that we argue is able to improve practices in disaster governance. By bringing up the concept of informational capital, we hope to provide useful insights

for community-based organizations, residents, local policy makers, planners, and other practitioners involved in governance and reinforcement of disaster resilience capacity.

To advance the concept of informational capital, the paper draws on a case study located in Central Java, Indonesia. We specifically observe the formation of informational capital in the aftermath of 2010 Merapi volcano eruption that severely affected the local community. This paper is structured as follows. First, we present the concept of social capital and discuss its application in disaster management studies. Second, we highlight the meaning of information and information technology in disaster response processes, and formulate a new concept of informational capital. This is followed by a discussion of empirical evidence of the formation of informational capital in which its significant role in building the community disaster resilience is examined. The conclusion summarizes the characteristics of informational capital, and suggests policy recommendations for future disaster management.

Informational capital: a concept

To understand what we mean by informational capital, it is instructive to begin with a discussion of social capital. As a response to the shortcomings of "capital" by Marx (1990/1867), the concept of social capital was introduced to assert that modern society is built and shaped not only by material conditions, but also by shared meanings formed by mutual interactions and cohesion, which are manifested in social networks. Putnam (2000, p. 19) refers social capital to "connections among individuals – social networks and the norms of reciprocity and trustworthiness that arise from them". Social capital is considered to have many advantages for building mutual support, cooperation, and organizational effectiveness, and even happiness. The core of social capital lies in trust. According to Coleman (1990, p. 307) "social capital is a system of mutual trust".

In further applications, researchers began to underline substantial importance of social capital in providing a basis for disaster management (Pardasani, 2006; Wilson, 2012; Tierney, 2014; Aldrich and Meyer, 2015). The capital-based approach in disaster management studies underlines societal resources as being necessary for proper community functioning in any emergency situation. This is because disasters devastate not only natural and physical environment, but also disrupt social fabrics in the affected area (Erikson, 1994). The concept helps to understand how people manage resources through social networks and what motivates them to take up collective action in a moment of emergency situation. Studies in this field reveal the importance of non-financial resources such participation, trust, self-help, emotional support, and sheltering (Tierney, 2014). Pre-existing connections between community members provide the community with critical level of resilience needed to withstand disaster crises. According to several researchers, communities with strong social capital are more likely to form community-based organizations and emergent community networks (ECN) (Bankoff and Bender, 2004; Wisner, 2004; Birowo, 2012). The emergent structures are either constructed as a new form of response to disaster, or they are transformed from the already existing social formations such as volunteers, neighbouring communities, rescue groups, aid provision groups, NGOs, etc. (Quarantelli, 2003; Tierney, 2014).

In the post-disaster response, the most crucial element is the production and dissemination of information, which is allowed by a high level of trust between information producers and information users, and available technology. As noted by a number of researchers, information is a key to taking actions in the time of crisis (Coleman, 1990; Lindell and Perry, 2004; Dynes, 2006; Sagala *et al.*, 2009). During disaster crisis, a community often faces scarcity of information. Recently, the

significant role of information technology in disaster management has been stressed by researchers (Islam and Chik, 2011; Birowo, 2012; Ryan, 2013). These studies describe how information technology reinforces efforts for disaster management activities in order to reduce human and economic losses. Accordingly, informational capital responds to an urgent need for community to receive and access information necessary to understand and evaluate the crisis situation, prepare evacuation, distribute aid, etc. However, information itself does not guarantee executing an action. The accumulation of social capital is essential to take up collective action in order to response to the emergency situation. Social interactions, common beliefs, and values shape risk perception and decision making in the face of disaster hazards (Lavigne *et al.*, 2008; Sagala *et al.*, 2009). Thus, collective efficacy and community participation are necessary to develop adequate programs for disaster preparedness (Sagala *et al.*, 2009).

It is in the interface of social capital and information technology that informational capital is introduced as a useful concept for disaster resilience. Informational capital refers to the amount of mutual trust and genuine participation in the production and dissemination of information in response to a disaster crisis by a community (Figure 1). In this light, emergency communication depends on social collaboration and utilization of technology, knowledge, and skills through a collective means. Combining the notion of social capital and information technology resources, informational capital emphasizes how information is perceived to be trustworthy by the community for disaster mitigation. It can be assessed through an in-depth analysis of three variables. First, community features, such as type of culture (individualistic or collectivistic), common beliefs and values, community networks (collective efficacy), participation, empowerment and trust. Second, member characteristics in terms of hazard knowledge and awareness, belief in community strength and spirit. And third, available information technology accompanied by necessary skills.

The main argument is that a community empowered by trustful social networks and better access to information is in a position to reduce harmful consequences of disaster. This is the core of informational capital, which plays a key role in enhancing
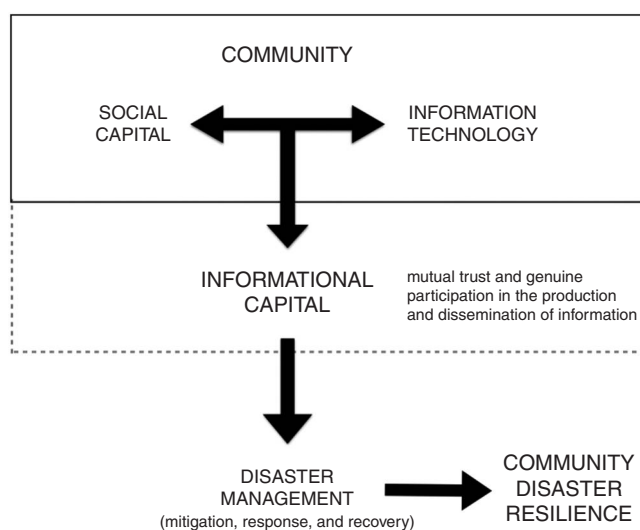

Figure 1.
Fundaments of informational capital and community disaster resilience

community disaster resilience (see Figure 1). In the aftermath of disaster, informational capital accelerates and lubricates processes and mechanisms in communication, cooperation, and coordination carried out to assist affected groups and communities. Furthermore, informational capital links the community with accesses to various important resources of information such as updates on current situation, aftershock warnings, evacuation instructions, distributions of relief aid, etc. Intensive and diverse social networks, community participation, strong feelings of trust, and empowered access to information are the fundamental components of informational capital that in time increases preparedness, improves coping capacities, and minimizes risk of misinformation and miscommunication. In sum, informational capital strengthens trustful exchanges of information that enhance disaster resilience capacity of a community.

Mount Merapi

Java is the most populated island in Indonesia. Over 140 million people – around 56 per cent of the country's population – live in the island. Having more than 40 active volcanoes renders Java the most volcanic island in the world. Specific geographic and topographic location of Java makes it prone to many kinds of natural hazards such as earthquakes, volcano eruptions, tsunami, landslides, etc.; in the last decade alone, several disasters have impacted the island. Standing at 2,965 m above sea level, Java's Merapi is one of the most active and hazardous stratovolcanos in the world (Surono *et al.*, 2012). It is located in the northern part of the Yogyakarta Province, 25 km north from the urban area (Figure 2).

The modern record since 1,548 shows that Merapi erupts regularly. Small-scale eruptions occur with average intervals of four to six years (Surono *et al.*, 2012), and large ones every one or two centuries (Voight *et al.*, 2000). The 2010 eruption was the largest and the most explosive eruption of Merapi in the last century, triggered by tectonic movements in the region (Surono *et al.*, 2012). The severe eruption process started on
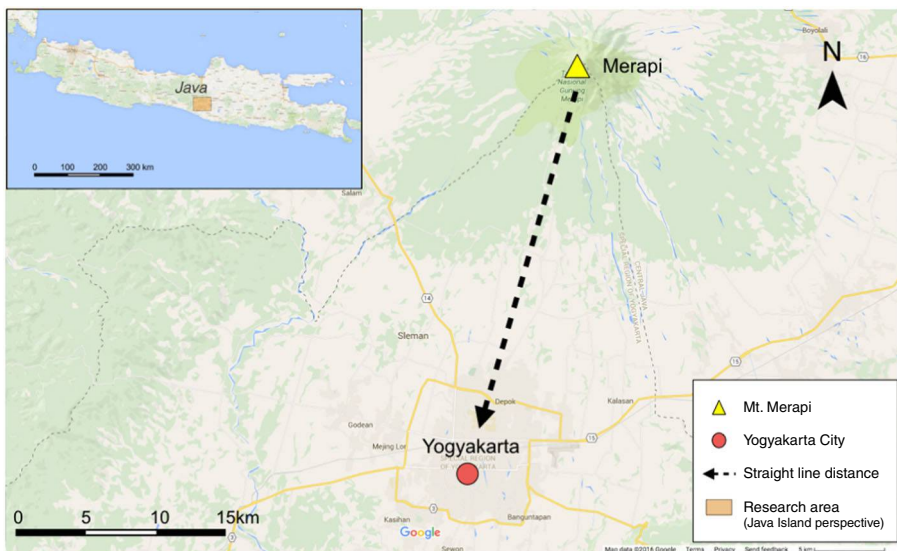

Figure 2.
Location of Merapi

Source: Google Maps (2016)

26 October 2010 and the high-volcano activity continued for more than a month. The magmatic phase lasted seven days and pyroclastic streams were ranging from 8 to 16 km (Surono *et al.*, 2012). The eruption had a severe direct impact on area surrounding the volcano in the range of 30 km and resulted in damage and disruption of everyday life of the local community. The 2010 eruption claimed almost 400 fatalities and razed over 150,000 buildings, bringing an estimated loss of more than US$300 million (Table I). Approximately 400,000 people were evacuated from the surrounding areas to refugee camps. The disaster severely struck the districts of Sleman (south flank), Magelang (west-southwest flank), Klaten (southeast-east flank), and Boyolali (northern flank) (GVM and IAVCEI, 2015). Pyroclastic flows and lahars (mud and debris flows) damaged hundreds of houses, many dams, bridges, and roads (Surono *et al.*, 2012).

Like many other Indonesian communities living in the shadow of volcano, the community of Mt. Merapi developed its own culture, based on mystical traditions, rituals, and beliefs in natural forces (Schlehe, 1996, 2008; Lavigne *et al.*, 2008; Mei *et al.*, 2013). With oral traditions and knowledge gained through direct experience with disaster, the community build up the capacity and adopted own ways to deal with the disaster (Dove, 2008; Lavigne *et al.*, 2008; Schlehe, 2008). Indeed, the volcanic culture influences on their disaster perception and the way they behave during the crisis (Dove, 2008; Lavigne *et al.*, 2008; Schlehe, 1996, 2008). The traditional culture helps the community to build up coping mechanisms and provides spiritual disaster explanations (Schlehe, 2008; Lavigne *et al.*, 2008). The spiritual volcanic culture of Merapi community represents informational capital in its traditional form, which differs from the modern concept of informational capital presented in this paper.

Perhaps not only because of its spiritual experience with the volcano, the community living at the foot of Merapi demonstrates a high level of disaster preparedness. There are also a number of social capital factors that facilitate disaster management processes (Sagala *et al.*, 2009; Birowo, 2012; Mei *et al.*, 2013), and which contributed to appropriate

Year	Volcanic explosivity index (VEI)	Life loss	Characteristics and claimed damages
1994	2	66	Pyroclastic block-and-ash flows up to 7.5 km Damage to villages and crops 6,000 evacuees
1997	2	6 missing, several injured	Damage to crops and a spring-water source Pyroclastic flows spread up to 4 km 5,000 evacuees
2001	2	2	Ash-falls covered the villages in 20 km radius Pyroclastic flows extended up to 7 km
2006	2	2	Pyroclastic flows and ash-falls up to 5 km 14,000 evacuees
2010	4	386	Pyroclastic flows spread up to 16 km Ash-fall was reported in the areas distanced up to 240 km 150,000 buildings destroyed; 200,000 building damaged; 2,000 home destructions 400,000 evacuees Estimated loss of more than US$300 million

Sources: Thouret *et al.* (2000), Voight *et al.* (2000), Subandriyo (2011), GVM and IAVCEI (2015), Global Volcanism Program (1994, 1997, 2001, 2006, 2011, 2014)

Table I.
Summary of last
Merapi activity and
eruptions
characteristics

response to the 2010 eruption. According to Mei *et al.* (2013), the community of Merapi possesses very strong bonding social capital. The sense of collectivism, community values, solidarity, and harmonious life were deeply rooted in the everyday life of the community, which is predominantly Javanese ethnic. During the disaster crisis, the households with limited financial resources needed community assistance. Both physical aid (e.g. rebuilding houses) and emotional support of local community were significant for getting back to "normal". Traditional community values encouraged people to help each other, especially under severe circumstances such as volcano disaster. One traditional value strongly shared by the community was "gotong royong" (loosely translated as mutual cooperation). Motivated by the spirit of gotong royong, community members helped each other to build refugee shelters in their private homes, which afterwards turned into solidarity refugee camps (Saputro, 2014). As a result, the community was able to properly respond to the disaster and to recover quickly. As explained by one of the volunteers:

> The spirit of gotong royong was very strong. It was the time for us to help others when they were in trouble – as the survivors who were displaced from their houses […] We were highly motivated to help the victims, because we consider them our brothers and sisters, and we felt their pain[1].

Prior to the eruption, the community was already educated on volcanic hazards. An educational programme for building capacity of the people living near the volcano was launched shortly before the 2010 eruption (GVM and IAVCEI, 2015). Many of the educational activities were organized in April and August of 2010 (Mei *et al.*, 2013). Volcano Investigation and Technology Development Office (BPPTK), worked together with local government, research institutions, and NGOs to give the community a series of training to improve their knowledge and awareness about natural hazards, and to build necessary skills to anticipate eruptions. The local community was even encouraged to participate in organizing the educational programmes, which is crucial to build disaster capacity and response. This example of cooperation between the community and local authorities confirms existence of linking social capital and community empowerment. The results were significant, as well-organized disaster response activities, such as distribution of warnings, necessary information, and organizing evacuations, saved between 10,000 and 20,000 lives when a disaster struck the area (GVM and IAVCEI, 2015). The role of community-based organizations should be emphasized because it bridged and linked social capital, especially in managing communication, and information production and distribution during the disaster crisis. The activity of Jalin Merapi Network (JMN) deserves the highest attention.

Rise of Jalin Merapi

JMN (*Jaringan Informasi Lingkar Merapi* – Information Network Around Volcano Merapi) was founded in 2006, following the Bantul earthquake, a tragic disaster that killed almost 5,000 people and caused a mid-eruption of Merapi. The network emerged as a bottom-up initiative of three community-based radio stations located around the volcano, two community radio networks, and four local NGOs (Saputro, 2016). Learning the lessons from the 2006 earthquake, and taking the advantages of information technology advancement, JMN was founded to support disaster response action in the 2010 eruption.

There were two main strategic domains of the JMN activity: first, production and dissemination of crisis information; and second, support of disaster relief aid

distribution. The decision to take a grassroots action was driven by, first and foremost, the spread of unreliable information delivered by mass media (streamed by authorities). They were also concerned with risk of unequal distribution of aid in which main refugee camps received more media attention while less visible areas suffered. This was exacerbated by a discrepancy between the aids and the true needs of the survivors. Facing this problem misinformation and miscommunication, the network sought to build reliable connections between survivors and donors from all over the country due to weak disaster management at local government level (lack of financial resources, lagging bureaucratic procedures) (Dewi and Nasir, 2012; Saputro, 2016).

To accomplish its goals, JMN carried out a set of activities as its main programme. First, it aimed to deliver necessary and accurate information to the communities; second, it sent out reports on the real and immediate needs, especially from the areas with less media attention; third, it raised funds for relief aid; fourth, it built direct connection between donors and volunteers and refugees (in-person donation); and fifth, it gathered information about refugees conditions (Dewi and Nasir, 2012; Saputro, 2016). Depending on activity they performed, volunteers were engaged into two types of functional groups, namely, media centre operators and field volunteers (including information volunteers and citizen journalists) (Saputro, 2016). When the disaster struck, JMN launched an open call for volunteers and received 2,770 applications (Saputro, 2014). The selected information network of active volunteers comprised 700 active volunteers (Saputro, 2016), who were located around the Merapi. The volunteers operated 24/7 during the period of one, five-month crisis. The volunteers decided to help because they simply felt this was the right way to do. Some of them experienced support of the network during the earthquake in 2006 and decided to pay back the debt. Ambar Sari Dewi shares her experience:

> When I saw people running for their safety, I told to myself – I have to help them […]. In 2006, when there was an earthquake in my region in Bantul, the people of Jalin Merapi helped me to rebuild our house and recover our environment. This was the time to repay (see footnote 1).

Many of the volunteers originated from the volcano area and were closely connected to the local community (Saputro, 2014). According to Dewi, strong ties and bonds deeply motivated Jalin Merapi volunteers due to shared experience and strong cultural ties. While the media centre – together with the social media and hotline divisions – was located in Yogyakarta City, the field volunteers were placed in refugee camps where they gained direct contact with the survivors and built trustful relationship (Saputro, 2016). The centre itself was responsible for coordination of all main activities of the network, i.e. compilation, validation and dissemination of information, placement of volunteers, and support of relief aid distribution. Because the information produced by JMN was essential for disaster management decision-making on emergency coordination and aid distribution, it was crucial to deliver it as fast and accurate as possible. However, as in crisis communication, time plays an essential role, which renders the speed of delivery a top priority. In addition, the media centre was responsible for the quality of distributed information. Hence, before dissemination, each activity of communication was cross-validated between the media centre, volunteers stations, the database, and the public. As explained by one key volunteers:

> We had to validate the information and make sure that the information is true because at that time Jalin Merapi was the only source in information for people and they relied on us. We did not want to disappoint them by sharing false and incorrect information (see footnote 1).

Since the primary mission of JMN was to bridge the information and relief aid from many sources, and to link them with the local communities suffering from the disaster, apart from the information received from volunteers placed in the refugee camps there were many other sources such as community-based radio stations, donors, and general public. It is worth noting that JMN was assisted with the information from government institutions responsible for volcano activity monitoring, national forces for search and rescue, humanitarian organizations, local government, and regional disaster management agencies[2]. This means the government was fairly in favour of the mission this grassroots network sought to complete. With continued support from government agencies, JMN was able to disseminate information on important issues, including current volcano conditions (situational reports based on visual observation of the peak), evacuation warnings and danger zone communicates, relief aid calls (what and where is needed, along with contact information).

Most of the dynamic and efficient information exchange was conveyed through Twitter accounts (in Indonesian and English). The presented snapshots of tweets provide the examples of information that was disseminated in the period of two weeks after the eruption had started, that is, when the crisis situation was the hardest:

(1) information on demand:

(Food, blanket, rice, and medicine have been supplied to Srumbung post, but more donation is needed for school equipment and clothes.)

(2) information on offered supply:

(3) information on transport:

(Requesting transport support to bring supplies to Cepogo BYL district that is lacking logistics.)

via [blank] : #SUPPLY #TRANS for those who need transport,we have either truck and pick up for 16 n 17.

14 Nov 2010

(4) information on volcano conditions, forecasts, potential dangers, and size of the evacuation zone:

IINFO:bedakan AWAN PANAS dg DEBU VULKANIK.Bahaya lgs #merapi adl AWAN PANAS. DEBU VULKANIK menjangkau wil luas krn tebawa angin<-pake masker

3 Nov 2010

(Warning about hot cloud and volcanic dust, which can reach a wide area because of wind. Appeal to use masks.)

RT [blank] i 3 #Merapi 16/11 00:00-06:00 AWAS,Level 4 status.Danger zone from summit:Sleman 20km,Magelang 15km,Boyolali 10km,Klaten 10km

15 Nov 2010

Indeed, information from volcano-monitoring institutions was trustworthy. However, it was insufficiently frequent and often failed to reach a majority of people in the remote areas. Besides, "the focus of the mainstream media and government were only on the Merapi activity instead of the needs of people who lived on the slopes of Merapi. These people were miserably neglected by mainstream media (see footnote 1)". Hence, the network focused its activity on isolated and overlooked areas. The results were profoundly effective, as the local communities affected by the disaster confirmed that the information delivered by JMN was faster, more reliable and more relevant than the information shared by information outlets operated by the local governments (Saputro, 2014).

JMN utilized a range of different communication channels and a plenty of information technology tools to produce and disseminate information. These include live-streaming community-based radio stations, a website[3], social media platforms (Twitter, Facebook), handheld transceivers, fixed and mobile phones, CCTV, and a seismogram (Dewi and Nasir, 2012). In fact, the JMN information services have been run by a local NGO[4], which since 2001 has supported community media development and utilization of information technology in the region. As we observe from the 2010 eruption, the use of information technology tools made immediate disaster response possible. Modern channels and techniques of information dissemination, such as social networks and micro-blogging, brought a wider group of information receivers. JMN's social media accounts, especially Twitter and Facebook were followed by thousands of Indonesian netizens. Likewise, its website was frequently visited by information-seeking users per day. Thus, it constituted the main information hub.

It was equipped with a livestream messenger, where live observations of the volcano were broadcasted everyday 24 hours. It also possessed a geo-tagging map with locations of volunteer groups, a real-time database with survivors' needs, a shoutbox, a SMS gateway, and an e-mail box. This combination of various media of information technology allowed general public to participate, contributing new information to the hub. Thanks to the close cooperation and mutual trust between locally-based Centre for a Research and Development of Volcano-related Technology (BPPTK), Radio of Republic of Indonesia in Yogyakarta, and local community radios, real-time updates on the volcano status as well as disaster mitigation were transmitted through radio channels (Saputro, 2014).

Apart from information production and dissemination, distribution of relief aid also constituted the core of programme JMN activists were committed to. The main concern focused on the accuracy and relevance of aid distribution. The network coordinated supply and distribution of the aid in the form of basic goods (food, medication, sanitary detergents, basic equipment, animal's food, etc.), services (e.g. transportation), and financial support (bank and online PayPal transfers). The field information volunteers who were placed in the refugee camps gathered information from the survivors about what they immediately needed. This information was later relayed to donors and humanitarian organizations within and without Yogyakarta. An online database was available to show locations and items that were needed along with contact information. The database updates were kept in real-time using a Google Docs spreadsheet[5]. In this way, donors were able to deliver the aid directly to the people in need, which profoundly shortened distribution time. The fact that many of the donors belonged to personal or professional networks of the survivors (Saputro, 2016), demonstrates how the bonding social capital of the Merapi communities was evident.

Although its operation to distribute information and to support disaster relief was successful during the 2010 response, it is by no means that JMN had not encountered problems. There were a few constraints that JMN had to overcome in terms trust and legitimacy. Because disaster crisis information was commonly seen as a governmental domain, it did take some time for JMN to gain people's trust and to build up credibility. The key element in acquiring public trust was direct contact with the survivors and deep knowledge of local context. Additionally, in order to strengthen the trust, JMN volunteers refrained from wearing uniforms or any recognizable badges, as these "official" symbols were not perceived well and would have created personal distance between volunteers and survivors (see footnote 1). As such, it created no boundaries between volunteer groups and disaster survivors. Due to its active response and reliability, JMN was able to appear legitimate to the government. As noted above, much of the information about the volcano status and disaster warning were received from governmental agencies. Officials from these agencies realized the important role of community-based organizations such as JMN played in making disaster relief more effective. As a matter of fact, JMN was considered a partner by the provincial disaster management agency due to its ability to distribute information and aid directly to those affected by the disaster. Such a conducive environment for JMN to cooperate with government agencies is not uncommon. After the end of the New Order authoritarian regime, the role of grassroots organization in many sectors of development became prominent due to the realization that the government has a limited capacity to handle complex issues in the society. Certainly democratization has opened up new possibilities for civil society groups to contribute to public services, including disaster mitigation (Nyman, 2006).

Aside from trust and legitimacy, technical and financial constrains were also present. For instance, after creating a Facebook account and discussion groups[6] the activity on the JMN account rose quickly. Such high activity was notified by the provider as malicious behaviour, resulting in security suspension of one of the discussion groups. Fortunately, JMN was able to overcome the issue by creating new groups and distributing members in accordance with a discussion topic. Another constraint was a lack of PayPal account, which is necessary for receiving international transfers. This issue was solved when a foreign student came to offer help to set up an account. Furthermore, JMN met another dilemma regarding information validation in which the speed of information delivery and accuracy were against each other. In any case, the delivery time was considered to be more important. This was resolved by an interactive platform in which information inputs are subject to multiple-validation by members of the network such to avoid incorrect and false information affecting disaster relief process. Finally, manpower and financial limitations, to some extent, affected the operation of JMN, especially after the situation became normal and volunteer students went back to school. That meant much less field volunteers were available to help. As the media centre was maintained by a local NGO, financial support was substantially limited and eventually finished in the end of the year (Saputro, 2014).

Despite these constraints, JMN was able to make significant contribution to the disaster relief in the aftermath of the 2010 Merapi eruption. The activities of this information technology-based network shows how informational capital exercised by JMN had substantial impacts on community disaster resilience. We will discuss this issue in the following section.

Disaster resilience

From what we have discussed above, the communities living at the foot of Merapi exhibited remarkable signs of resilience to the 2010 eruption. As argued in this paper, the community disaster resilience was in part due to well-developed informational capital. The informational capital was introduced in its modern and unique preface, which, as mentioned, differs from the traditional one grounded on spiritual volcanic culture of Merapi. More specifically, apart form its coping advantages; the traditional informational capital brings also potential risk underestimation (Dove, 2008), subjective feeling of security (Schlehe, 2008), and the blind belief that the disaster can be mitigated through spiritual activities (Schlehe, 1996). In contrast, through the unique activity of JMN, the concept of informational capital is presented as strong social capital reinforced by powerful proprieties of information technology. In this manner, the informational capital bridged affected communities with external resources, such as information and relief aid, which were crucial for proper disaster response and recovery. Our analysis highlights the following components of the informational capital as playing an essential role in building resilience: community trust, empowerment, strong community bonds and participation, emergent network cooperation (collective efficacy), disaster awareness, effective real-time monitoring, quick dissemination of information and well-organized distribution of aid facilitated by information technology.

As noted above, strong social capital is the basis of informational capital. This means it is important for a community to have proper amount of bonding, bridging and linking social capital prior to the crisis. The Merapi communities had developed all three types of social capital (Figure 3), which allowed them to create a powerful emergent community network that assisted disaster relief processes. The strong social bonds promoted trust, shared values, and reciprocity gave the community members the feeling
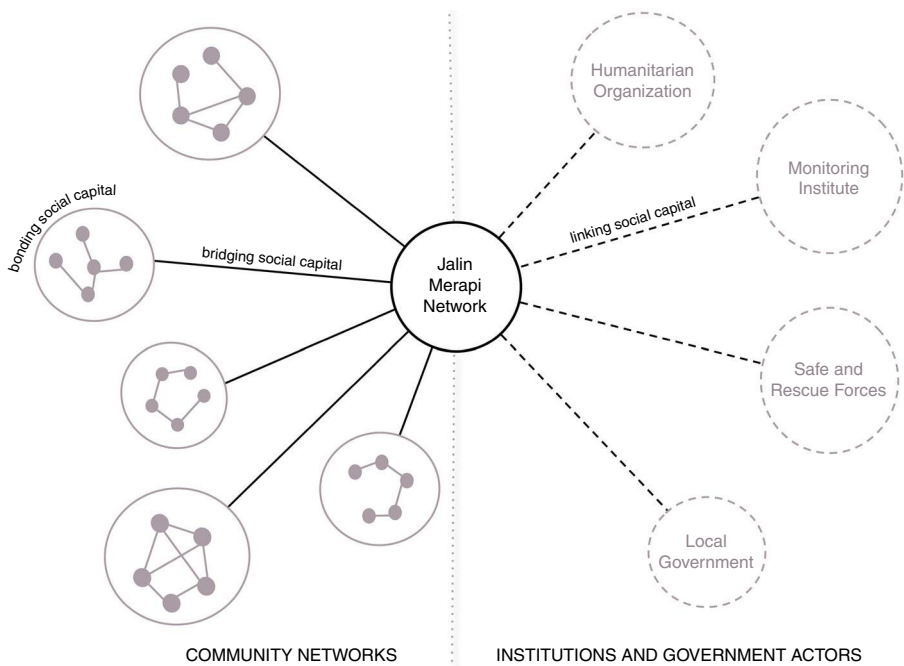
Notes: This is a conceptual model of the JMN ties. In order to maintain transparency of the
network some of the actors and ties are omitted

of community cohesion, belonging, and stimulated mutual help and adaptation. Bridging
ties motivated and encouraged the communities to initiate collective action, which
essentially gave rise to JMN. The network embodied both strong bridging social capital
and strong linking capital (also called vertical bridging social capital). Interestingly,
we found JMN as a boundary-spanning network, for it is rich of bridging ties. It comes as
no surprise that JMN was able to foster the information and aid flows in previously
unconnected communities. Equally important is the fact that JMN contributed to building
the feeling of mutual trust indispensable to take up collective actions. The individuals
constituting the group originated from all walks of life. They came from different
backgrounds, including local communities, local governmental offices, civil society
organizations, research centres responsible for monitoring volcano activities, safe and
rescue forces, humanitarian organizations, academic researchers, etc. The actors were
tied together in the empowered network, allowing them to work together to fulfil the
common mission. The presence of JMN allowed these groups to gain strategic links to
cooperate with various actors and to use their help and resources. In this view, JMN
represented strong linking social capital by integrating heterogeneous actors and
leveraging network resources that were beyond the community range.

In a time of crisis when the level of uncertainty grows and urgent needs come about,
new ECN and organizations will arise. According to Dynes (2006), emergent structures
connect elements of community structure together to fulfil new tasks and take up
collective action. Furthermore, they emerge when traditional structures are insufficient
or incapable to respond to a crisis. These emergent organizations tend to be flat,

organic, and task oriented with a goal to solve ad hoc problems (Stallings and Quarantelli, 1985; Quarantelli, 2003). As we observe, these are exactly the striking features of JMN as it performed the characteristics of emergent structures in response to unreliable infrastructures and inefficient information and relief aid distribution. The network activities were concentrated on realization of specific tasks to respond to the crisis situation. The organizational structure of JMN was considerably flat, which resulted from non-hierarchical relations built by the pioneering actors (Dewi and Nasir, 2012; Saputro, 2014). The distribution of organizational authority follows the functional division, consisting of two types of volunteer groups. This is because most of the tasks needed to be performed at hand, as the disaster situation was highly dynamic and uncertain. The bottom line is that the emergent structure of JMN came from pre-existing social capital, which was manifested in resilience capacity when combined with a proper utilization of information technology.

As has been studied by many researchers, information is an important asset during the disaster crisis and a crucial element of resilience (Dynes, 2006). However, it is not enough to deliver the information. A high level of trust between the producer and the user is required to ensure reliability of messages circulated during a crisis. Only social networks with mutual trust are able to effectively disseminate information for disaster relief. Having sufficient amounts of informational capital that came from trusted networks and astute skills in utilizing information technology, JMN was able to contribute to strengthening resilience of the Merapi community. Through direct contact in the affected area, JMN's field volunteers built the relationship and bonds with the survivors, which became the basis for mutual trust. Furthermore, the information messages disseminated by JMN were always as much fast, clear, and accurate as possible. Each volunteer typically possessed adequate knowledge of the local specifics (topography, volcanic ash distribution, traffic conditions, local people beliefs, etc.). In this way, JMN appeared to be the most efficient in supporting the local communities at the moment of disaster crisis. With its accumulated informational capital, JMN proved to have made significant contributions to disaster mitigation during the 2010 Merapi eruption, enhancing resilience of the community in an unprecedented way.

Concluding remarks
Today JMN is still running as an active group that seeks to contribute to reducing disaster risks for the people in Yogyakarta and the surrounding areas. It has now evolved into a more stable organization with continued support from local and non-local communities. Information technology remains the core infrastructure of JMN with a growing number of community-based radio stations located around the volcano joining the network. Furthermore, JMN develops further cooperation with various agencies and organizations in order to broaden the spectrum of actors and participants to deliver more comprehensive information to the Merapi community.

As argued in this paper, what JMN has accomplished exemplifies the formation of informational capital, which is embodied in the production and dissemination of information to respond to a disaster crisis. Furthermore, we have highlighted how informational capital is formed by social capital and information technology in facilitating disaster management processes. Analysing the catastrophic event, we have underlined the critical functions of community networks, collective action, trust, and empowered information access in disaster response and recovery. The case study also shows how informational capital is potential to enhance community network and information access, and boosts community capacity for disaster response.

Although the concept of informational capital is sufficiently introduced in the preceding sections, it certainly requires further elaboration beyond what is examined in this paper. Our goal here is to present a preliminary conceptualization of informational capital as a key factor in disaster resilience. Hence, we would like to encourage further research on informational capital. Future studies should continue to tease out the ways in which informational capital facilitates community disaster resilience at broader scales and in more complex situations. In addition, worth exploring are new approaches to assess and measure the impact of informational capital on building disaster resilience at different levels.

To conclude this paper, we identify several policy implications drawing on our conceptualization of informational capital and its relevance to disaster governance. First, the presence of adequate information infrastructures is fundamental to allow communities to build emergent networks among themselves. Second, free flow of information among citizens needs to be widely available to support social access to the production and dissemination of information. Furthermore, informational capital must be given an important place in disaster management in which information technology solutions for emergency warning systems have to be popularized and implemented. Moreover, the three types of social capital have to be strengthened to enhance community disaster resilience. Bonding social capital has to be preserved by promoting social cohesion, solidarity, and protection of community common spaces. Bridging social capital, embodied in ECN, has to be recognized and empowered in disaster risk reduction policy. Finally, linking social capital should be pursued through building mutual trust between government and community, and promoting public participation in disaster governance.

Acknowledgements

Notes

1. Skype interview with Ambar Sari Dewi, 29 April 2015.

2. Presentation of Jalin Merapi project: http://bit.ly/21WVeTO

3. JMN website: http://merapi.combine.or.id/ (accessed 15 December 2015).

4. Combine Resource Institution website: www.combine.or.id/

5. Google Docs spreadsheet: http://bit.ly/1MokKbp (accessed 15 December 2015).

6. At that time each discussion group could have just 250 members.

References

Aldrich, D.P. and Meyer, M.A. (2015), "Social capital and community resilience", *American Behavioral Scientist*, Vol. 59 No. 2, pp. 254-269.

Bankoff, G. and Bender, S. (2004), "Conclusion: vulnerability analysis as a means of strengthening policy formulation and policy practice", in Bankoff, G., Frerks, G. and Hilhorst, D. (Eds), *Mapping Vulnerability: Disasters, Development, and People*, Earthscan, London, pp. 194-205.

Birowo, M.A. (2012), "Community media and civic action in response to volcanic hazards", in Hagar, C. (Ed.), *Crisis Information Management: Communication and Technologies*, Chandos Publishing, Oxford, pp. 139-153.

Coleman, J.S. (1990), *Foundations of Social Theory*, Belknap Press of Harvard University Press, Cambridge.

Dewi, A.S. and Nasir, A. (2012), "Solid@rity from the crowd: collective action and the use of ICT in disaster in Indonesia", paper presented at CITS-ICT4D International Working Paper Series Conference, Yogyakarta, October (unpublished).

Dove, M.R. (2008), "Perception of volcanic eruption as agent of change on Merapi volcano, Central Java", *Journal of Volcanology and Geothermal Research*, Vol. 172 No. 3, pp. 329-337.

Dynes, R. (2006), "Social capital: dealing with community emergencies", *Homeland Security Affairs*, Vol. 2 No. 2, pp. 1-26.

Erikson, K. (1994), *A New Species of Trouble: The Human Experience of Modern Disasters*, W.W. Norton and Company, New York, NY.

Global Volcanism Program (1994), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 19 No. 10, Smithsonian Institution, Washington, DC, available at: http://goo.gl/dmunmb (accessed 14 December 2015).

Global Volcanism Program (1997), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 22 No. 6, Smithsonian Institution, Washington, DC, available at: http://goo.gl/MSuqhH (accessed 14 December 2015).

Global Volcanism Program (2001), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 26 No. 10, Smithsonian Institution, Washington, DC, available at: http://goo.gl/AbRWIx (accessed 14 December 2015).

Global Volcanism Program (2006), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 31 No. 5, Smithsonian Institution, Washington, DC, available at: http://goo.gl/LKAK5z (accessed 14 December 2015).

Global Volcanism Program (2011), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 31 No. 5, Smithsonian Institution,, Washington, DC, available at: http://goo.gl/k8BjnZ (accessed 14 December 2015).

Global Volcanism Program (2014), "Report on Merapi (Indonesia)", in Wunderman, R. (Ed.), *Bulletin of the Global Volcanism Network*, Vol. 39 No. 10, Smithsonian Institution, Washington, DC, available at: http://goo.gl/rfT3ri (accessed 14 December 2015).

GVM and IAVCEI (2015), "Global volcanic hazards and risk. Summary background paper prepared for the UNISRD global assessment report on disaster risk reduction 2015", UNISDR, Geneva, available at: http://goo.gl/n8oH5G (accessed 14 December 2015).

Islam, S.M.T. and Chik, Z. (2011), "Disaster in Bangladesh and management with advanced information system", *Disaster Prevention and Management: An International Journal*, Vol. 20 No. 5, pp. 521-530.

Lavigne, F., De Coster, B., Juvin, N., Flohic, F., Gaillard, J.C., 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*, Vol. 172 Nos 3-4, pp. 273-287.

Lindell, M.K. and Perry, R.W. (2004), *Communicating Environmental Risk in Multiethnic Communities*, SAGE Publications, Thousand Oaks, CA.

Marx, K. (1990/1867), *Capital:Volume 1: A Critique of Political Economy* (Trans. by B. Fowkes), Penguin Books, London, pp. 247-269.

Mei, E.T.W., Lavigne, F., Picquout, A., de Bélizal, E., Brunstein, D., Grancher, D., Sartohadi, J., Cholik, N. and Vidal, C. (2013), "Lessons learned from the 2010 evacuations at Merapi volcano", *Journal of Volcanology and Geothermal Research*, Vol. 261, pp. 348-365.

Nyman, M. (2006), *Democratising Indonesia: The Challenges of Civil Society in the Era of Reformasi*, Vol. 49, NIAS Reports, Nias Press, Copenhagen.

Pardasani, M. (2006), "Tsunami reconstruction and redevelopment in the Maldives: a case study of community participation and social action", *Disaster Prevention and Management: An International Journal*, Vol. 15 No. 1, pp. 79-91.

Putnam, R.D. (2000), *Bowling Alone: The Collapse and Revival of American Community*, Simon & Schuster, New York, NY.

Quarantelli, E.L. (2003), "A half century of social science disaster research: selected major findings and their applicability", available at: http://udspace.udel.edu/handle/19716/297 (accessed 14 December 2015).

Ryan, B. (2013), "Information seeking in a flood", *Disaster Prevention and Management: An International Journal*, Vol. 22 No. 3, pp. 229-242.

Sagala, S., Okada, N. and Paton, D. (2009), "Predictors of intention to prepare for volcanic risks in Mt Merapi, Indonesia", *Journal of Pacific Rim Psychology*, Vol. 3 No. 2, pp. 47-54.

Saputro, K. (2014), "Engaged audiences in the mediated disaster of Mount Merapi in Indonesia 2010", unpublished PhD thesis, Shefielled Hallam University, Sheffield.

Saputro, K. (2016), "Information volunteers' strategies in crisis communication: the case of Mt Merapi eruption in Indonesia 2010", *International Journal of Disaster Resilience in Built Environment*, Vol. 7 No. 1.

Schlehe, J. (1996), "Reinterpretation of mystical traditions: explanation of a volcanic eruption in Java", *Anthropos*, Vol. 91, pp. 391-409.

Schlehe, J. (2008), "Cultural politics of natural disasters: discourses on volcanic eruptions in Indonesia", in Casimir, M. (Ed.), *Culture and the Changing Environment: Uncertainty, Cognition, and Risk Management in Cross-Cultural Perspective*, Berghahn, Oxford, pp. 275-299.

Stallings, R.A. and Quarantelli, E.L. (1985), "Emergent citizen groups and emergency management", *Public Administration Review*, Vol. 45, Special Issue, pp. 93-100.

Subandriyo, M. (2011), "Sejarah Erupsi Gunung Merapi dan Dampaknya Terhadap Kawasan Borobudur", in Sutopo, M. (Ed.), *Menyelamatkan Candi Borobudur dari Erupsi Merapi*, Balai Konservasi Peninggalan Borobudur, Magelang, pp. 86-96.

Surono, J.P., Pallister, J., Boichu, M., Buongiorno, M.F., Budisantoso, A., Costa, F., Andreastuti, S., Prata, F., Schneider, D., Clarisse, L., Humaida, H., Sumarti, S., Bignami, C., Griswold, J., Carn, S., Oppenheimer, C. and Lavigne, F. (2012), "The 2010 explosive eruption of Java's Merapi volcano – a '100-year' event", *Journal of Volcanology and Geothermal Research*, Vols 241-242, pp. 121-135.

Thouret, J.C., Lavigne, F., Kelfoun, K. and Bronto, S. (2000), "Toward a revised hazard assessment at Merapi volcano, Central Java", *Journal of Volcanology and Geothermal Research*, Vol. 100 Nos 1-4, pp. 479-502.

Tierney, K. (2014), *The Social Roots of Risk: Producing Disasters, Promoting Resilience*, Stanford University Press, Stanford.

Voight, B., Constantine, E.K., Siswowidjoyo, S. and Torley, R. (2000), "Historical eruptions of Merapi Volcano, Central Java, Indonesia, 1768-1998", *Journal of Volcanology and Geothermal Research*, Vol. 100 Nos 1-4, pp. 69-138.

Wilson, G. (2012), *Community Resilience and Environmental Transitions*, Routledge, Abingdon and Oxon, ML.

Wisner, B. (2004), *At Risk: Natural Hazards, People's Vulnerability and Disasters*, Routledge, London.

About the authors

Justyna Tasic is a PhD Researcher at Institute of Catastrophe Risk Management, Interdisciplinary Graduate School, Nanyang Technological University. She is also a Researcher at Singapore-ETH Centre, as a part of the Future Resilient Systems (FRS) Programme. Her main research interests are: disaster resilience, organizational interdependencies, sustainability, and urban development. Justyna Tasic is the corresponding author and can be contacted at: justyna.tasic@gmail.com

Sulfikar Amir is an Assistant Professor at the Division of Sociology, School of Humanities and Social Sciences, Nanyang Technological University. His research focuses on science and technology studies (STS), sociology of disaster, risk and resilience, and city studies. He is the Author of *The Technological State in Indonesia: The Co-constitution of High Technology and Authoritarian Politics*. Currently, he is involved as one of the Principal Investigators in the Future Resilient Systems (FRS) Programme.