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REVIEW

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Volcano disaster risk management during crisis: implementation of risk communication in Indonesia

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Abstract

Volcano disaster risk management during a crisis requires continuous and intensive risk communication with the public. However, to have the desired public response during a crisis, it is necessary to improve the community's understanding of volcanoes. Knowledge, experience, risk perception, communication, and drills shape good community responses. These require a bottom-up process of communication and involvement of the community in decision-making and engagement with the government. Thus, proper crisis management requires top-down and bottom-up communication and joint work between the scientists, decision-makers, and the community. The response from the community can be improved through community-based preparedness with a culturally sensitive approach that facilitates a strong relationship and participation of community members according to their customs. The Wajib Latih Penanggulangan Bencana (WLPB: Compulsory Disaster Management Training Program) and the SISTER VILLAGE Program in the Merapi Volcano community are good examples of community-based preparation in Indonesia.

An effective volcano early warning protocol includes risks analysis, volcano monitoring, hazards analysis and forecasting, dissemination of alerts and warnings, and community response according to the warning. Alert levels can also be increased during the unrest, so actions are also associated with this and not just related to the impacts of an eruption. Therefore, the alert level alone is not helpful if it is not appropriately communicated with an action plan in place to improve community awareness. Moreover, personal communication between scientists and decision-makers and between scientists and the community is essential to instill self-responsibility and a sense of belonging. Personal communication describes the trust of community members or certain decision-makers to scientists to obtain more detailed explanations of volcanic activity. Such communication is already occurring in communities that have experienced a long history of eruptions, and/or continuous eruptions, such as at Merapi and Sinabung volcanoes.

The disaster management system in Indonesia includes institutions that manage science and institutions responsible for social aspects, such as evacuations, refugee handling, rehabilitation, and reconstruction. The National Disaster Management Agency (NDMA, Badan Nasional Bencana, BNPB in Bahasa Indonesia) of Indonesia coordinates all disasters to integrate management of and facilitate communication between stakeholders.

In addition to a well-established system, effective and good disaster management needs to be supported by policies related to public needs before, during, and after the disaster. After disasters, a review of previous strategies is also necessary to develop a better strategy and obtain a better result. Establishing SISTER VILLAGES is an excellent strategy

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to meet the needs during a crisis. However, this needs to be supported by regulations related to collecting data, the evacuation process and facilitation, and infrastructure, communication, and coordination.

Here, we present good risk communication practices around Indonesia's volcanoes related to how people receive and understand early warning information and take action with the support of the government through capacity improvement and learning from experiences.

Keywords Volcano, Disaster management, Early warning, WLPB, SISTER VILLAGE, Communication, Coordination, Crisis, Community response, Policy, Strategy review

Introduction

Volcano disaster risk management is the implementation of disaster risk reduction policies and strategies to prevent the disaster risk associated with volcanic activity (UNISDR). In Indonesia, there are 127 active volcanoes, of which 77 are classified as Type A, 29 as Type B, and 21 as Type C. Type A volcanoes are those classified as very active and have a high probability to erupt (Andreastuti et al. 2018). This classification is used to decide the priority level of volcano monitoring.

Volcano disaster risk management during a crisis involves a wide range of stakeholders from various sectors, including National, Provincial and Local Disaster Management Agencies, the Indonesian Army and Police, Transportation, Social, Public Work, and Health Ministries. Adequate disaster prevention effort, and disaster management actions during and post disaster need effective communication channels and understandable information. The manner in which this happens varies a lot according to the country, cultures and past experience of volcanic activity (e.g. Martinez-Villegas et al. 2021; Becker et al. 2018). In Indonesia, in addition to a central and local government and stakeholders, this process also involves the local communities. According to law, Disaster Management includes policies for the development of disaster risk areas, disaster prevention activities, emergency response, and rehabilitation.

The implementation of disaster mitigation activities is coordinated by the National Disaster Management Agency (NDMA) (BNPB in Bahasa Indonesia). In the event of disaster, the management is coordinated by BNPB or Provincial Disaster Management Agency (PDMA)/Badan Penanggulangan Bencana Daerah (BPBD) Provinsi or Regional Disaster Management Agency (RDMA)/ Badan Penanggulangan Bencana Daerah (BPBD) Kabupaten/Kota according to the scale of disaster. Determination of Disaster Emergency Status for the national level is set by the President, and at provincial level by the Governor, or Major/Regent in accordance with the level of disaster (Presidential Decree Number 17 Year 2018). Mitigation of each individual hazard is given to Ministry or Agency, i.e. flooding is the mandate of Ministry of Public Works and Housing, volcano and landslide is the mandate of Ministry of Energy and Mineral Resources, through the Centre for Volcanology and Geological Hazard Mitigation (CVGHM), earthquake and tsunami is the mandate of the Meteorological, Climatological, and Geophysical Agency, (Badan Meteorologi, Klimatologi dan Geofisika BMKG) and others. In this paper, we discuss the mitigation of volcanic hazard in Indonesia. Here, we present good examples of best practices of communication between scientists, decision makers and the public through the WLPB and SISTER VILLAGE initiatives at Merapi, Agung and Sinabung.

The importance of capacity building of communities within hazard zones of volcanoes

Indonesia, with its large number of volcanoes and a high density population living on their slopes, requires efforts to increase the capacity of communities to deal with future eruptions. Volcanoes are monitored continuously, however the risks caused by volcano hazards are very dynamic. This is influenced by the development of residential areas and facilities around active volcanoes, which tend to grow near the source of hazards. Efforts are being made to reduce the risk of volcanic eruptions, through, among other initiatives, strengthening capacity of communities so that they are able to respond at the time of eruption. This research aims to understand factors involved in risk communication, and the best practices learned during the crisis and how these affect disaster risk management processes. Based on experiences of previous eruption in several locations of past disasters, we improved risk communication within communities through a cultural-based, egalitarian, empathetic approach. To identify problems in communication we also used method of meeting, briefings, workshops, and direct interviews with key persons from scientific institutions, disaster management agencies, and local governments. The result led to the proposal of a social system created by the community through Wajib Latih Penanggulangan Bencana (WLPB) and SISTER VILLAGE and supported by decision-makers. The outcomes also include an understanding of volcanic hazards and communication and coordination as discussed in the following sections.

Volcano disaster prevention activities

Disaster prevention aims to reduce vulnerability and exposure (United Nation Disaster Risk Reduction (UNDRR) 2016), and can be carried out for example through physical mitigation measures or regulation. Disaster prevention activities carried out by CVGHM include programs such as volcano monitoring and hazard assessment, preparation and socializing of volcanic hazard maps, dissemination of information including alert levels through the MAGMA (Multiplatform Application for Geohazard Mitigation and Assessment) Indonesia application and website (https://magma.esdm.go.id), preparation and maintenance of early warning systems, and education. The monitoring activities are carried out at 69 type-A volcanoes through 74 volcano observatories. Seventy-one volcanic hazard maps have been distributed as hard copies to stakeholders and the public. Hazard maps are also accessible online via the MAGMA Indonesia application and website. According to the law, a hazard map is suggested as the basis for spatial planning. Of 77 type A volcanoes, four volcanoes are submarine, and the rest are remote volcanoes, those are difficult to access.

Dissemination of volcano information is carried out through MAGMA Indonesia (https://magma.vsi.esdm.go.id/index.php n.d.), which is an application of geological disaster information in real-time to stakeholders and the public. Besides volcano information, MAGMA Indonesia also provides information related to the mitigation of landslides, earthquakes, and tsunamis. Information disseminated through MAGMA Indonesia consists of scientific information (Volcano Activity Report/VAR, Volcano Eruption Notice/VEN, Volcano Observation Notice for Aviation/VONA, Volcano Activity Evaluation for volcano above Normal Level), and information for the general public (press releases, educational information, interactive communications, etc.).

Monitoring data collection, processing and information

Volcano monitoring data retrieved from the observatories are reported routinely to CVGHM. The report includes the visual and instrumental data the volcanologists will analyze further. The workflow included in the process (Fig. 1) involves scientific information about the volcano and eruption. This information is evaluated and complemented by the geological record and previous eruptions, hazard maps, hazard modeling, and event tree analysis. The resulting information is processed and communicated to stakeholders and public through the Volcano Alert Level and its recommendation of the potentially affected areas (see Table 1 below for more details). During a crisis, the hazards map, hazards information, exposure of the potentially affected areas, and risk information are communicated to and followed up by the BNPB and BPBD. In case of an indication of increasing activity, the local BPBD will be contacted directly by a volcano observer from the respective volcano.

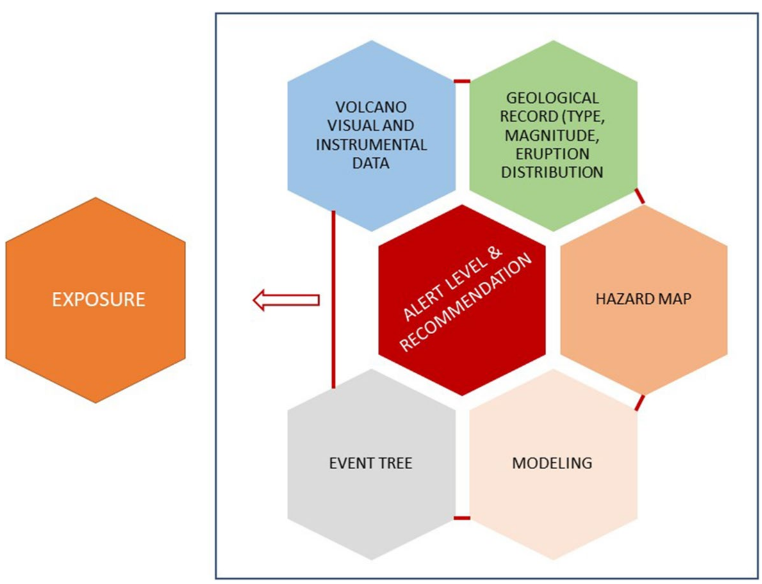

Fig. 1 Components of Hazard Assessment during a volcanic crisis. The output of hazard assessment is an alert level and technical recommendation (right). The alert level and recommendation are then applied to threatened community (left)

Table 1 Volcano alert level as developed in Indonesia and the linked community response (modified from Andreastuti et al. 2019)

Level of Volcanic Activity	Indication	Community Response	Frequency of report
Normal Level (I)	Visual observations and instrumental records show normal fluctuations and no change of activity. Hazards in the form of poisonous gas may be present near vents, depending on the volcano's characteristic activity	Communities in Hazard Zones (HZs) I and II may carry out daily activities. Communities in HZ III may carry out daily activity as long as they are in compliance with regulatory requirements from local government according to the technical recommendation of the Geological Agency, Ministry of Energy and Mineral Resources	Monthly
Waspada Level (II, Advisory)	According to visual observations and instrumental records, there are indications of increasing volcanic activity	Communities in HZ I and II may carry out their normal activities, but must keep alert. For communities in HZ III it is recommended that they do not carry out daily activities in areas near summit craters or other vents	Biweekly
Siaga Level (III, Watch)	According to visual observations and instrumental records, there are prominent indications of increasing volcanic activity. Eruptions may take place, but do not threaten settlements and/or activities of communities near the volcano	Communities in HZ I should improve their awareness and must not carry out activities along river valleys that originate at or near the volcano's summit Communities in HZ II should start to prepare for evacuation and await an evacuation order from the local government according to the technical recommendation of the Geological Agency, Ministry Energy and Mineral Resources. Community in HZ III are not permitted to carry out daily activities and should prepare to evacuate	Daily
Awas Level (IV, Warning)	According to visual observations and instrumental records, there are significant indications of ongoing volcanic activity, with eruptions that potentially threaten settlements and or communities around the volcano	Communities in HZ I, II, and III are to immediately to evacuate by the order of local government, according to technical recommendation from Geological Agency, Ministry Energy and Mineral Resources	Every 6 h

Indonesia volcano alert level

Based on Andreastuti et al. (2018), a volcano alert level is the level of the hazard potential of volcanic activity at a particular time. Indonesia uses a scale with four alert levels, from the lowest to the highest: Normal (Level I), Waspada (Advisory; Level II), Siaga (Watch, Level III), and Awas (Warning, Level IV). The volcano alert levels are applicable for all monitored volcanoes. In Indonesia, the alert levels have been implemented since 1996 (Direktorat Vulkanologi, 1996). The volcano alert levels and their recommendations are sent to stakeholders, such as NDMA (BNPB), PDMA (BPBD Provinsi), and RDMA (BPBD Kabupaten/Kota), where the potential volcanic hazards are located. Alert levels are also disseminated to the public through the MAGMA Indonesia application and website. The report dissemination frequency is monthly, biweekly, daily, and every 6 h, depending on the alert levels. The higher the volcano alert level, the higher the reporting frequency. The implementation of volcano alert levels as part of an early warning system in Indonesia describes the potential impact of volcanic behavior on nearby communities, as shown by exclusion zones. This is also supported by community capacity as communities are involved in the implementation of actions during volcanic crises and eruptions according to alert level (Andreastuti et al. 2018).

The Merapi volcano community has implemented a community-based early warning system through Wajib Latih Penanggulangan Bencana (Compulsory Disaster Management Training Program, WLPB) (Rahman, et al. 2016). This program has been implemented for people living in HZ III around Merapi during Normal (Level I), since 2016. The main core of WLPB is to strengthen community capacity through knowledge improvement and community skills to be able to identify safe places, carry out rescues, and be independent (Indonesia National Standard no 8039 2018). The system was also implemented in the Kelud (Paripurno and Nugroho 2018) and Agung communities (https://mmb.upnyk.ac.id/berita/peningkatan-kapasitas-masyarakat-gunung-agung n.d.). It includes four key elements: 1) risk knowledge, 2) monitoring as well as hazard assessment and forecasting of the hazards, 3) communication or dissemination of alerts and warnings, and 4) community response, as mentioned in United Nations International Strategy for Disaster Reduction, UNISDR (2009). Therefore, alert level information is only useful if it is understood by the community and stakeholders.

Communicating scientific information and advice to decision makers should include several requirements such as clear, acceptable and understandable information with a description and type of hazard potential, as well as the possible magnitude and likely area affected. This communication is followed by activities of warning to the relevant stakeholders and communities, intensive communication with the community at risk, review of a contingency plan, community exercise and evacuation drill. During a crisis, the community with their capacity is challenged to take proper response or action according to hazard information and level of activity, because their action depends on several factors such as psychological condition, leadership and preparedness culture which is built during evacuation drills.

An integrated disaster risk management system in Indonesia

An integrated Disaster Risk Management System is a series of activities related to disaster risk mitigation involving a multi-stakeholder (PentaHelix), multi-disciplinary approach, across different levels of government, global, regional, national, local, and individual efforts. These activities are in accordance with the four priorities of the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 n.d., namely (i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience and; (iv) Enhancing disaster preparedness for effective response, and to “Build Back Better” in recovery, rehabilitation, and reconstruction.

WLPB is a program implemented in Merapi since 2016, initiated by the Merapi Forum. It is a multi-stakeholder forum across four regencies in Central Java (Magelang, Boyolali, and Klaten Regencies) and Yogyakarta (Sleman Regency) Provinces for handling the Mount Merapi risk. The forum was established in 2007. The activities represent the four priorities of SFDRR and aim to encourage collaboration between residents on the slopes of Merapi and stakeholders such as the government (including CVGHM), media, private sector, and donor agencies. The forum’s goal is both to reduce the risk associated with an eruption at Merapi Volcano and to manage its natural resources. The WLPB aims to improve knowledge and community skill in disaster risk management and is part of Community-based Disaster Risk Management. The substance of the WLPB program includes (1) basic disaster management, (2) hazard character assessment, (3) risk assessment, (4) inclusive early warning, and (5) evacuation planning. WLPB has been implemented at volcanoes such as Merapi, Kelut, Bromo, Semeru (Adi et al. in Paripurno ed. 2015) and Agung.

Another form of Community-based Disaster Risk Management is the SISTER VILLAGE program, which has started to be implemented at several volcanoes in Indonesia, such as Merapi, Kelud, Agung, and Sinabung. SISTER VILLAGE is a program in which a village located in a High Hazard Zone (Hazard Zone III) is paired with a safe village outside the hazard zone for the emergency plan (Mei 2013), including an evacuation place (Astriani 2017). According to the BPBD of Magelang Regency (2016) in Elysia and Widahanto (2018), the creation of a SISTER VILLAGE considers the *close relationship between the two villages, the readiness of the partner village, accessibility, potential for development and sustainability, and security.* This concept prioritizes communication and coordination to meet needs and sustainable development in the face of future volcanic eruptions.

The rapid growth and expansion of population in a country with a high number of volcanoes such as Indonesia can have an effect on livelihood and social hardship and even political complexity. According to Gaillard (2008), there are two views on how people respond to volcanic hazards. One considers mainly the volcanic phenomena and associated risk, and the other takes into account the economic, social and political aspects. Bridging between the two views is even more complicated in disaster management, although cooperation between the various stakeholders can address the problem and facilitate better communication. The NDMA (BNPB) is the coordinator for disaster management in Indonesia and can handle and facilitate the communication between stakeholders, as it is the recognized agency in disaster management (see Fig. 2).

Disaster is a complex mix of natural hazards and human action (Wisner et al. 2014, UNDRR, 2016); therefore, disasters are a consequence of hazardous events interacting with conditions of exposure, vulnerability and capacity (UNDRR 2016) of people in their normal lives. Based on Erfurt-Cooper (2018), vulnerability can be a result of people being unaware or ignoring the potential risk while visiting an unsafe place. An extreme example was the eruption of Sinabung Volcano, Indonesia on 1 February 2014. The eruption occurred at 10:30 am local time, produced pyroclastic flows which extended up to 4.5 km. Sixteen people from outside the areas entered the exclusion zone up to 3 km from the summit in the south flank at Sukameriah Village and all of them died because of pyroclastic flows. By that time, it was prohibited to enter exclusion zone up to 5 km radius from the summit to the south (Andreastuti et al. 2019).

In terms of the two views mentioned above (Gaillard 2008), even though the Sinabung eruption was not extreme, it highlights two examples of cultural degradation and political intervention through social media during a crisis.

The first example relates to the involvement of volunteers to help prepare meals for evacuees during the Sinabung crisis, which disturbed the local customs because the local people could no longer participate (Andreastuti et al. 2019). In the evacuation place, when a community stays in a jamhur (local building for people gathering) of another village, the host village will prepare a meal for several days. After that, the evacuees will take turns filling their needs. However, the involvement of people from outside disrupted this custom, affecting the character of the evacuation place.

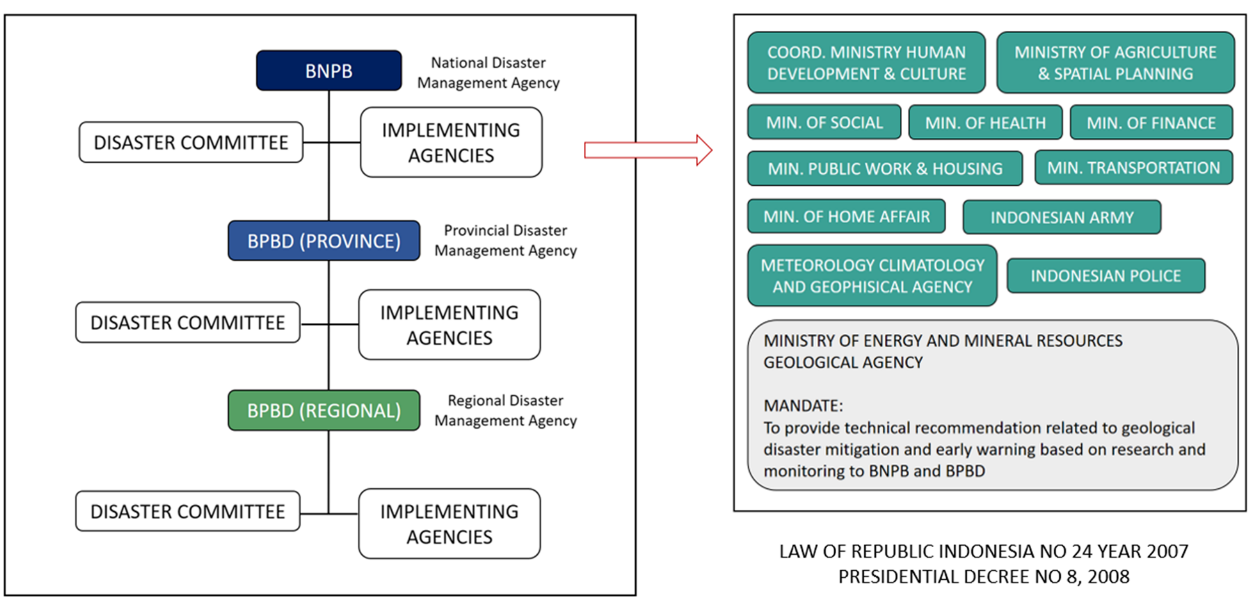

Fig. 2 Disaster Management structure in Indonesia and the implementation agency (Presidential Decree Number 8 Year 2008). BNPB in the left panel, and the implementing agencies at national level (right panel)

The second example relates to the refusal of SBY (Susilo Bambang Yudhoyono, the Indonesia President, 2004–2014) to declare Sinabung as a national disaster, provoking public outrage against his social media presence (#unfollowSBY). This was an indicator of declining external political efficacy based on government responses (Parent et al. 2005, in Chatfield and Reddick 2015). The decision meant that that the local government could not receive the aid of the central government for the affected villagers. Even though, according to the impact of the Sinabung eruption, it was classified as a local disaster, in other words did not meet the requirements to receive assistance from the central government (Presidential Decree Number 17 Year 2018).

The dense population combined with the needs for livelihoods force people living in the vicinity of a volcano to move closer to the source of the hazard. Therefore, the risk increases due to higher exposure. To reduce volcanic disaster risk, it requires not only to understand the volcano and its processes, but also to prepare the community in anticipation of the event.

The structure of disaster management in Indonesia contains a disaster committee and implementing agencies (Fig. 2). The committee consists of 9 people from the professional community who are appointed by the respective Local Government based on the proposal of BPBD. The implementing agency covers ten ministries and agencies. CVGHM is under the Ministry of Energy and Mineral Resources, Geological Agency, with the mandate to provide technical recommendations and volcano early warning to BNPB and BPBD. Therefore, alert level information and recommendation are sent to BNPB and BPBD regularly according to the location of volcanoes.

The system of decision making in Indonesia's volcano disaster mitigation has a clear separation between institutions that have a mandate to handle mitigation in the field of science (CVGHM), and the institution that is responsible for the social aspects of the disaster i.e., evacuating the population (BNPB, Coordinated Ministry of Human Development and Culture, Ministry of Finance, Ministry of Transportation, Indonesian Army and Indonesian Police), facilitating refugees (BNPB, Coordinated Ministry of Human Development and Culture, Ministry of Social Affairs, Ministry of Health, Ministry of Finance), conducting rehabilitation and reconstruction (BNPB, Coordinated Ministry of Human Development and Culture, Ministry of Public Work and Housing, Ministry of Home Affairs, Ministry of Energy and Mineral Resources, Ministry of Land and Spatial Planning, Indonesian Army and Indonesian Police) (Table 2). Each level of disaster management agency is supported by implementing agencies according to the level. For its activities, BNPB is supported by 11 institutions at the ministry level, including the Coordinated Ministry of Human Development and

Table 2 Summary of decision-making agency/ministry in handling volcano disaster mitigation in Indonesia

Agency/Ministry	Science	Information	Social		
			Evacuation	Facilitating refugees	Rehabilitation and reconstruction
National Disaster Management Agency			v	v	v
Coordinated Ministry of Human Development and Culture			v	v	v
Ministry of Energy and Mineral Resources	v (Through the Center for Volcanology and Geological Hazard Mitigation)			v	
Ministry of Finance			v	v	v
Ministry of Transportation			v		
Ministry of Information and Informatics		v			
Ministry of Social Affairs				v	
Ministry of Education				v	
Ministry of Health				v	
Ministry of Public Work and Housing					v
National Search and Rescue Agency			v		
Indonesian Red Cross			v	v	
Ministry of Home Affairs,				v	v
Ministry of Land and Spatial Planning					v
Indonesian Army			v		v
Indonesian Police			v		v

Culture, the Ministry of Land and Spatial Planning, the Ministry of Social Affairs, the Ministry of Health, the Ministry of Finance, the Ministry of Public Work and Housing, the Ministry of Transportation, the Ministry of Home Affairs, the Ministry of Energy and Mineral Resources, the Indonesian Army, and the Indonesian Police (Fig. 2).

In Indonesia, there are regulations that apply to disasters because of their association with social, economic and livelihood of the community. Disaster management is therefore the responsible of all parties.

Communication

Communicating hazard information is a full-time consuming process, as the interaction between community (social) and scientists (physical perspectives) and disaster management agencies (policy and practice) requires equity in hazard perception (Andreastuti et al. 2018). A shared understanding of hazard leads to understanding the needs and how to meet them, and this is therefore a key component of risk communication.

According to Fearnley and Beaven (2018), communication between scientists and decision makers depends on credibility of information, needs of the groups, and appropriateness of information and communication processes. Credibility of information is challenged by evidence of past experience, availability of data, and source of information. Therefore, the time needed for communicating the risk depends on many factors: experience, data, the means to communicate, and trust. Establishing a two-way communication process and dialogue is better than just providing information (Stewart et al. 2018).

Recent developments in communication technology have influenced the means of communication between stakeholders. Beside using fax, telephone, text messages, communication is also carried out through specific WhatsApp Groups (WAG), e.g. Pastigana (Pusat Analisis Situasi Siaga Bencana, Center for Disaster Alert Situation Analysis, owned by BNPB), Info Kebencanaan Geologi (Geological Disaster Information, CVGHM), and locally Diseminasi Penanggulangan Bencana Jawa Barat (Dissemination of West Java Disaster Management, West Java Province).

The advantage of having these restricted but efficient groups for communication, is that stakeholders involved can share the information according to their mandate, and can also more effectively ask for information needed from other stakeholders. Communications with the decision maker is done also through regular meetings, workshops or informal meetings. In the case of crises, communication can be carried out both through regular meetings and anytime needed. It includes communication on a briefing sheet, explanations of exclusion zone, alert level, hazards potential and potential threatened areas.

It is important to build long-standing relationships between scientists, stakeholders and the community to communicate volcanic hazard. The communication should start early on, during the preparedness time (Komorowski et al. 2018). Preparedness in anticipating volcanic hazard includes preparation of hazard information, including the type of hazard, hazard potential, potential threats, means of socialization, formulation of a contingency plan, understanding the evacuation process, community exercises including evacuation drills, Table-top exercises for disaster management officials and Command Post Exercise following the formulation of contingency plans. During the process of capacity improvement in the preparedness stage, fostering communication and networking between individuals and groups encourages the development of trust. A clear example is the formulation of contingency plans. In the process of capacity building, taking different cultures into account is an important aspect in communication and in understanding hazard (Gabrielsen et al. 2018, Andreastuti et al. 2018, Marsh 2014, Bignami et al. 2012). Lowenstern et al. (2022) proposed that scientists need to understand local conditions, social cultures and priorities). The role of culture in Indonesia varies from place to place. According to Balasubramanian (2018), the establishment of a culture is supported by geography. Culture and geography are connected in the way that culture represents the characteristic of people within an area. This is why, for example, religion and languages are different in many places and how other identities of culture are produced. Therefore, the wide distribution of volcanoes across areas with different community cultures in Indonesia necessitates a range of communication approaches according to local culture.

Here, we present good practices from Merapi, Agung and Sinabung in relation to evacuation and local culture.

Merapi

Referring to Mei et al. (2013), there were total of 24,024 people from 12 villages within hazard zone III that were evacuated on 26 October 2010, according to CVGHM recommendation. These villages are Purwobinangun, Wonokerto, Girikerto, Hargobinangun, Umbulharjo, Kepuharjo, Glagaharjo and Kaliurang Villages (Sleman Regency); Balerante, Sidorejo, and Tegalmulyo Villages (Klaten Regency); and Kemiren Village (Magelang Regency).

Here, we took lessons learned from Deles Hamlet, Sidorejo Village (4 km from the Merapi summit to the southeast), Fig. 3. During the Merapi eruption in 2010, the head of Deles Hamlet took the initiative to evacuate

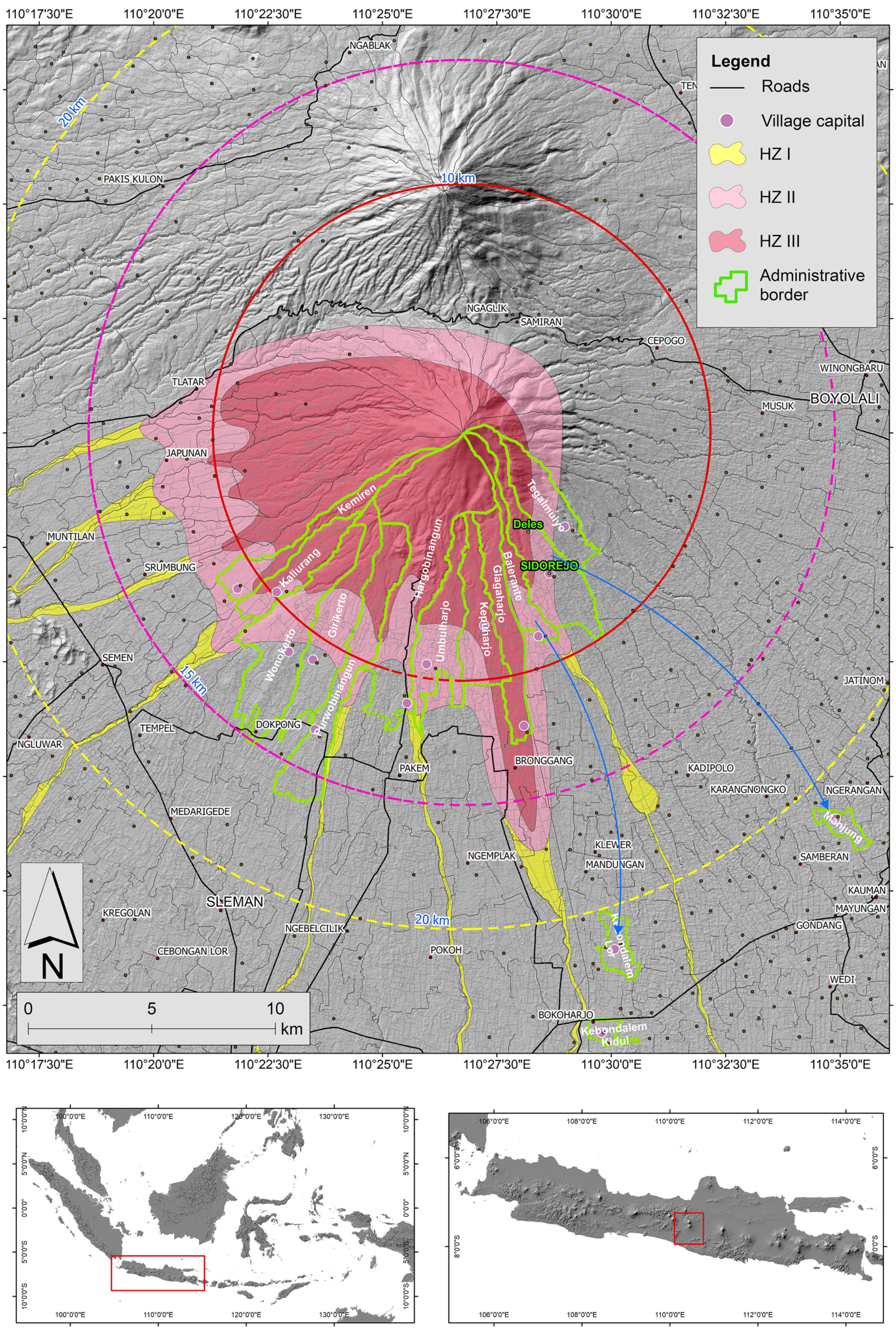

Fig. 3 Hazard map of Merapi Volcano (updated after the 2010 eruption). Red, pink and yellow colors on the map describe the Hazard Zone III (the highest), II (moderate) and I (the lowest). Dashed yellow, pink and red circle lines represent 10 km, 15 km and 20 km exclusion zones during the 2010 crisis. Blue solid lines showed the route of evacuation from Deles Hamlet to Manjung, and from Balerante to Kebondalem Village

his citizens to Kemalang District on 26 October 2010, one day after the level was raised to Level IV (Pramono 2012), and livestock was evacuated on 27 October 2010 to the same place. The evacuation of the population was completely managed shortly before an eruption hit Kaliadem Village in the south of Merapi, where 'Mbah Marijan', the volcano gatekeeper of Merapi was one of the casualties. When the eruption was getting bigger, and all evacuees needed to move outside a 20 km radius from the summit, people from Deles Hamlet and Petung Village were reluctant to go without their livestock. Finally, they headed to Manjung Village (21 km from Merapi summit) with their livestock and lived there until the activity of Merapi was back to normal. In fact, on the way to Manjung, several villages were passed, but they could not accept them because the evacuees brought their livestock with them during their evacuation, and the villages they passed were not able to provide facilities, because livestock need mainly space, food, and water. During their stay, all activities and facilities were coordinated by the head of Manjung Village. This independent evacuation is currently known as SISTER VILLAGE and represents a good example of the two-way communication process, and how dialogue can result in a better outcome for disaster risk mitigation.

During the 2010 Merapi crisis, people from Balerante Village (about 5 km from Merapi summit to the south) were evacuated since 26 October 2010. At that time, there was one person who stayed in the village and did not want to evacuate who then finally died because of pyroclastic flows from the 5 November 2010, the peak of Merapi eruptions. This village was partly affected by the eruption; therefore, people from the unaffected village were still going back and forth to their village to take care of their livestock. Learning from this experience, since 2012 the community has been preparing a livestock evacuation to support people's evacuation in the case of a Merapi eruption in the future. This program was executed due to the reluctance of residents to evacuate because they were encouraged to leave their livestock at their homes during the 2010 eruption. Therefore, the community has been preparing for the Temporary and Final Livestock Evacuation located about 5 km at Balerante Village, Kemalang District, Klaten Regency, and 7 km from the summit at Kebondalem, Prambanan District, Klaten Regency (Fig. 3).

Agung volcano

The volcanic crisis at Mount Agung occurred in 2017–2019 after more than 50 years of dormancy. Insufficient knowledge and false information stating that an eruption was imminent resulted in inappropriate response and unnecessary independent evacuation of the community during the crisis. A strategy to involve the community and religious leaders in public communication had an important role in improving trust in CVGHM (Syahbana et al. 2019).

For some people in the Mt. Agung community, the 1963 large eruption left a deep trauma because of the wide impact, especially on the community around the volcano. It was a violent (Volcano Explosivity Index, VEI 5) eruption, and the eruption products and subsequent lahar were distributed to the north, southeast, and southwest resulting in more than 1000 fatalities (Global Volcanism Program, GVP).

During the 2017 – 2019 crisis, the total number of evacuees during the crisis reached 70,967 people distributed into 240 evacuation points (BPBD Provinsi Bali). The process of evacuations was organized by the local government, but there were also independent evacuations carried out by the community. During these independent evacuation processes, people considered kinship, customary similarities (e.g., languages, habits), and past eruption experiences (Bagiarta, personal communication). Those people who experienced the 1963 eruption and their families went to the same place during the 2017–2019 crisis, such as from Geriana Kauh to Gunaksa Village, in the southwest – west or from Pucang to Tejakula or to Bondalem in north east—north. The long-distance journey to the final destination is due to the experience of the 1963 eruption during which the impact did not reach these places. This experience reflects that oral tradition occurred within the community. Figure 4 shows the examples of long evacuation routes because they avoided hilly areas and roads that were difficult to access.

Sinabung volcano

On August 10, 2010, a phreatic eruption occurred at Sinabung volcano after about 1200 years of dormancy (Prambada et al. 2010). The activity has been continuing and increasingly intensive. In 2013, lava flows began to appear and lasted about three years (Nakada et al. 2017). Currently, the activity of Mount Sinabung is relatively low (at the time of writing this article, at the Alert Level II). At the beginning of the activity, the knowledge and response of the community to anticipate the eruption were still lacking due to the volcano's long repose time.

The increasing activity from August 2010 to 2014 resulted in the impact of pyroclastic flow on southern flank villages, such as Sukameriah, Bekerah, and Simacem villages. Sukameriah was the first village impacted by pyroclastic flows. During their evacuation, there were similar routes taken by the Sukameriah people. The route

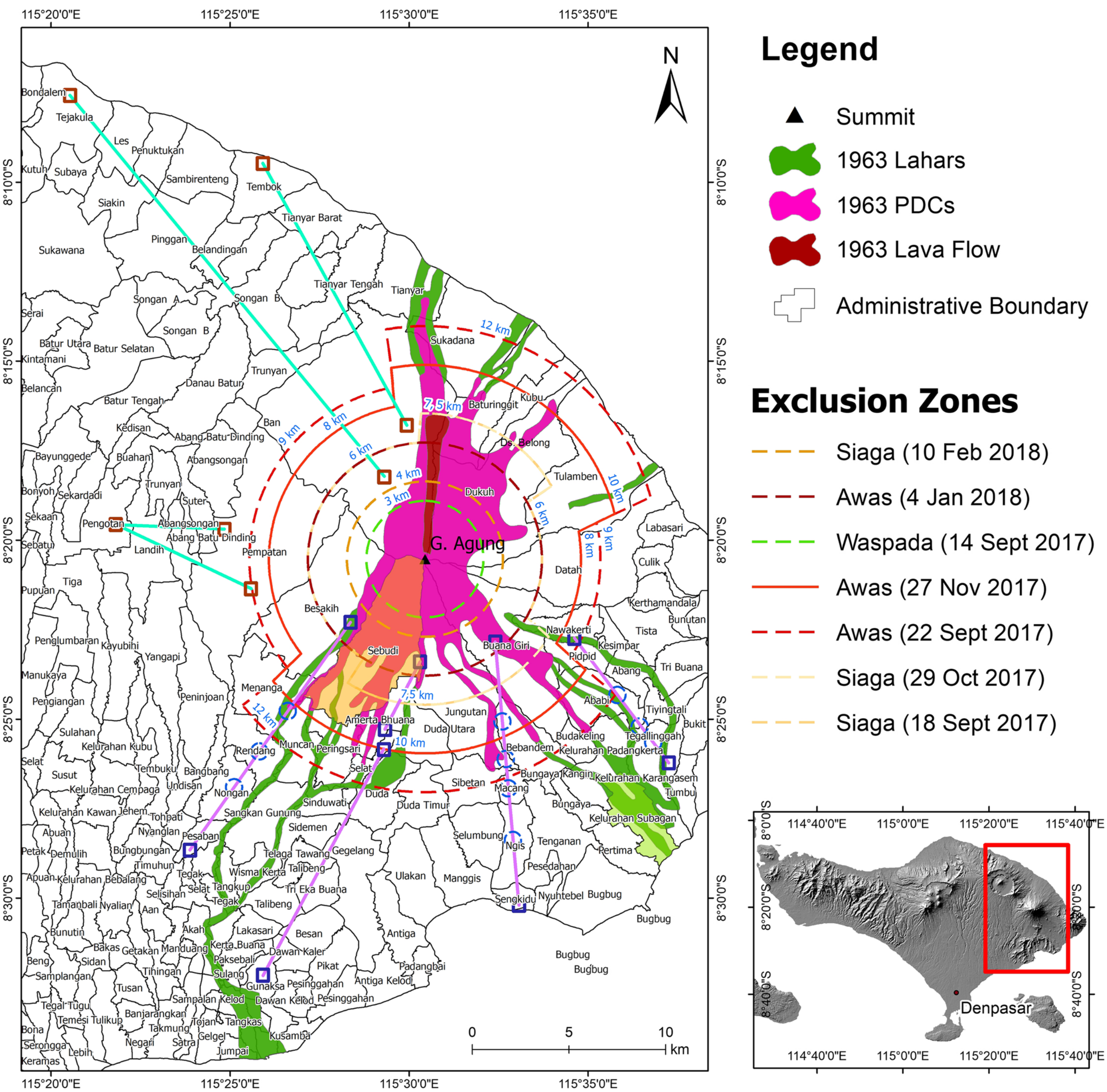

Fig. 4 Map showing the distribution of eruption products and subsequent lahar of Agung to north, southeast and southwest flank (GVP, Syahbana et al. 2019). Solid and dashed circle lines showed the exclusion zones during the 2017–2019 crisis (Syahbana et al. 2019). Light blue and purple solid lines are the evacuation routes considering people's experience from the 1963 eruption. Yellow and light green areas indicate the few locations of casualties due to the 1963 eruption

was to Gukinayan Village, and in case the eruption was getting bigger, they moved further to Sipayung Village (Fig. 5).

From 2010 to 2015, in most cases, the Sinabung community managed to evacuate after an eruption occurred, which was represented by the number of evacuees during the Sinabung crisis (https://web.karokab.go.id/profile/illustration-umum). This situation implies a lack of understanding of hazard and its risk. In response to Sinabung activity, capacity improvement of the Sinabung community has been carried out, and it is still in progress. Several efforts have been done including formulation of a contingency plan for eruption and lahar, evacuation drills, training for volcano facilitators and preparation of disaster resilience villages.

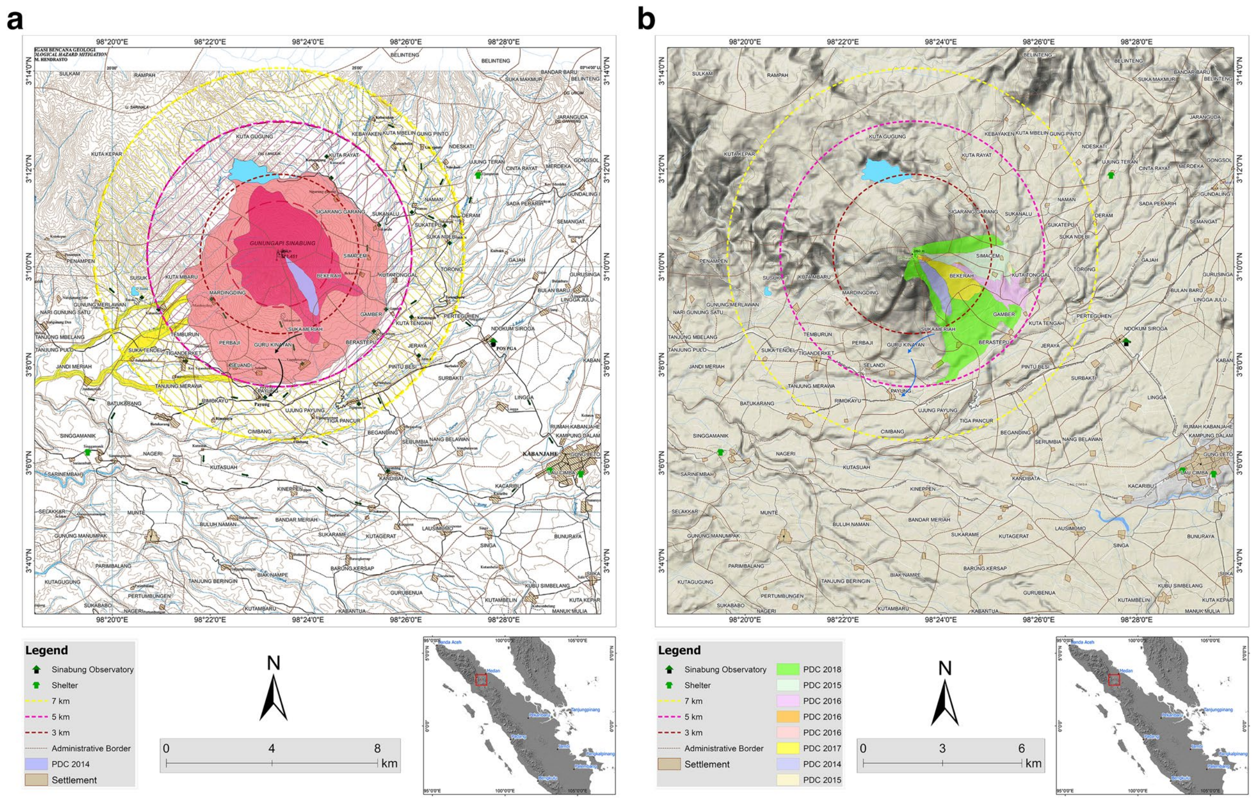

Fig. 5 **a** (left). Hazard Map of Sinabung (Gunawan 2013). The 2014 PDC was produced at the beginning of magmatic activity (light purple color). Red, pink and yellow color represent Hazard Zone III (the highest), Hazard Zone II (moderate) and Hazard Zone I (the lowest). Dashed red, pink and yellow circles represent areas affected by fall deposits. Long red dashed circle indicates is the exclusion zone (3 km radius). Evacuation route from Sukameriah to Gurukinayan to Sipayung villages is shown in black solid lines. **b** (right) describes the progress of PDC distribution from 2014 to 2018

Discussion

Indonesia is a country prone to geological disasters, including volcanic eruptions. In 2022, there were about ten eruptions that occurred per month (CHGHM Internal report 2022). The frequent occurrence of volcanic eruptions from different volcanoes provides a unique opportunity to learn lessons, not only from the scientific point of view itself but also from the characteristics and behaviours of communities surrounding each individual volcano. The response of community from Merapi, Agung and Sinabung volcanoes to alert level information and how they took action reflected different capacity and disaster experience of the community. However, all of them implemented communication according local culture, such as in finding a suitable village as an evacuation site.

Kinship is the dominant factor in culture communication in order to find better solutions mainly during difficult times such as in a volcanic crisis. The word of *Gotong royong* (mutual cooperation) is part of local wisdom that has been developed as a heritage in Indonesia, to be implemented within communities to obtain positive outcomes by consensus and mutual deliberation (Effendi 2013). The examples of evacuation processes in Merapi, Agung and Sinabung also reflect the importance of *Gotong royong* within the community. Communication and coordination were carried out before, during and after the process of evacuation in informal, egalitarian, and emphatic manners. The nature of residents who have the intention of helping each other causes residents who live on the lower slopes (e.g. Manjung Village, Merapi Volcano; Tejakula Village, Agung Volcano; Sipayung Village, Sinabung Volcano) to help residents from the upper slopes (Deles Hamlet, Merapi Volcano; Pucang, Agung Volcano; Sukameriah, Sinabung Volcano); this was implemented in the evacuation process. The activities of *Gotong royong* reflect social capital that prioritizes common interests. Social capital also incorporates trust (Fukuyama 1995) and the value of social networks. In a society with a strong tradition, communication to decide important issues usually uses consensus and deliberation, whether the communication is between the members of the community, or between informal and formal leaders. This approach has also been implemented in disaster mitigation to improve capacity building of communities and has led to increased preparedness and resilience (Andreastuti et al. 2019). Consensual and deliberation approaches have also been used by the Popocatépetl Scientific Committee in assessing the activity of Popocatépetl (de la Cruz-Reyna 2018). Moreover, improved awareness also occurs with updated and continuous information mainly during crisis and non-crisis (De la Cruz-Reyna et al. 2018).

Disaster experiences of communities are also a contributing factor to take action in response to volcanic eruption. The main problem for communities when it comes to evacuate is the unwillingness to leave their belongings, namely livestock and plantations, therefore, some people who stayed in the shelter wanted to go back to their village to check their possessions. Evacuation of Merapi communities during the crisis had been encouraged by local government, however due to no facilitation for livestock evacuation, the Deles people initiate an independent evacuation that included their livestock. On the other hand, the experience of the large eruption of Agung community in 1963 resulted in some people displaced to the same villages during the volcanic crisis in 2017–2019. Figure 4 shows the distribution of deposits from the 1963 eruption. That area was safe from the effects of the 1963 eruption (e.g. the displacement from Pucang to Tejakula and Bondalem Villages, at the north east of Agung). Similarly, the Sinabung community followed the same paths when an eruption was getting bigger and an evacuation needed. Evacuation being repeatedly carried out from Sukameriah to Gurukinayan and to Sipayung Villages indicates kinship and good communication between those villages.

In Indonesia, the alert level includes the relations and communication of the different actors involved and community preparedness during volcanic crisis (Andreastuti et. al. 2018, p.309, p.318). As alert level III issued by CVGHM and is informed to BNPB and BPBD, they will follow up the information by coordinating stakeholders to prepare for the need and facilities, such as evacuation and preparation of shelter, etc. According to the Presidential Decree of the Indonesia Republic Number 17 Year 2018, disaster emergency status includes Siaga Darurat (Emergency Alert), Tanggap Darurat (Emergency Response), dan Transisi Darurat ke Pemulihan (Emergency Transition to Recovery). Communication between stakeholders and preparation of communities is started at Emergency Alert when CVGHM issues Alert Level III. In Level IV, BNPB/BPBD will activate the contingency plan and order the evacuation. Each alert level is associated with an activity of the community, which represent the needs and resources that shall be provided in a contingency plan. The stakeholders involved in an Emergency Alert and Emergency Response can be seen in Fig. 2.

The community's need and resources for potential evacuation (level III), is calculated based on recommendations of the Exclusion Zone on the hazard map. For example, in Fig. 6, the potential direction of the eruption products and the threatened area, illustrates the number of people in the potentially affected area. These needs are described in the contingency plan of Sinabung. The hazard map is commonly presented in increasing detail according to the current potential hazard and the progress of activity (e.g., development of sector-specific pyroclastic flows, such as in Sinabung, see Fig. 6). Maps are commonly adjusted as a crisis progresses, such as at Merapi (Lavigne et al. 2018).

The current hazard potential can be seen from the exclusion zone (red dashed line) and the possible threatened villages can be identified, and the needs and resources estimated, for contingency planning. The contingency plan is formulated by stakeholders with the involvement of the community. This is a good strategy to strengthen the capacity of the community in decision making. Strengthening the community capacity using a bottom-up approach (e.g., Andreastuti et al. 2018) cannot work smoothly without the support of the government officials (top down) (Cadag et al. 2018, Lavigne et al. 2018). According to the Law of the Republic Indonesia Number 24 Year 2007, concerning Disaster Management and Government Regulation No 21 Year 2008, Government and Local Government shall have Disaster Management Plans which are updated every five years. The Disaster Management Plan is integrated with National Development Plans. Formulation of Disaster Management Plans is coordinated by Disaster Management Agency according to the level (National, Provincial, Local). It includes recognition and evaluation of disaster threat, vulnerability, evaluation of disaster impact, risk analysis and education, mechanism of preparedness and management on disaster impact.

Experience of volcanic crisis has proven to influence hazard perception and to improve the awareness of the community (Andreastuti et al. 2018, McKee et. al. 2018), and has led to independent evacuation. As an example, before the Kelud eruption on 13 February 2014 at 22:50, the Kelud community evacuated independently due to high autonomy and participation of the community (Sudarmanto, 2020). Part of the communication amongst people around Kelud was through radio communication and informal socialization (Lestari et al. 2017). This activity was carried out willingly by the community members and coordinated by official leaders (Sub-District Chief of Ngancar) (Nugroho et al. 2015). The use of local

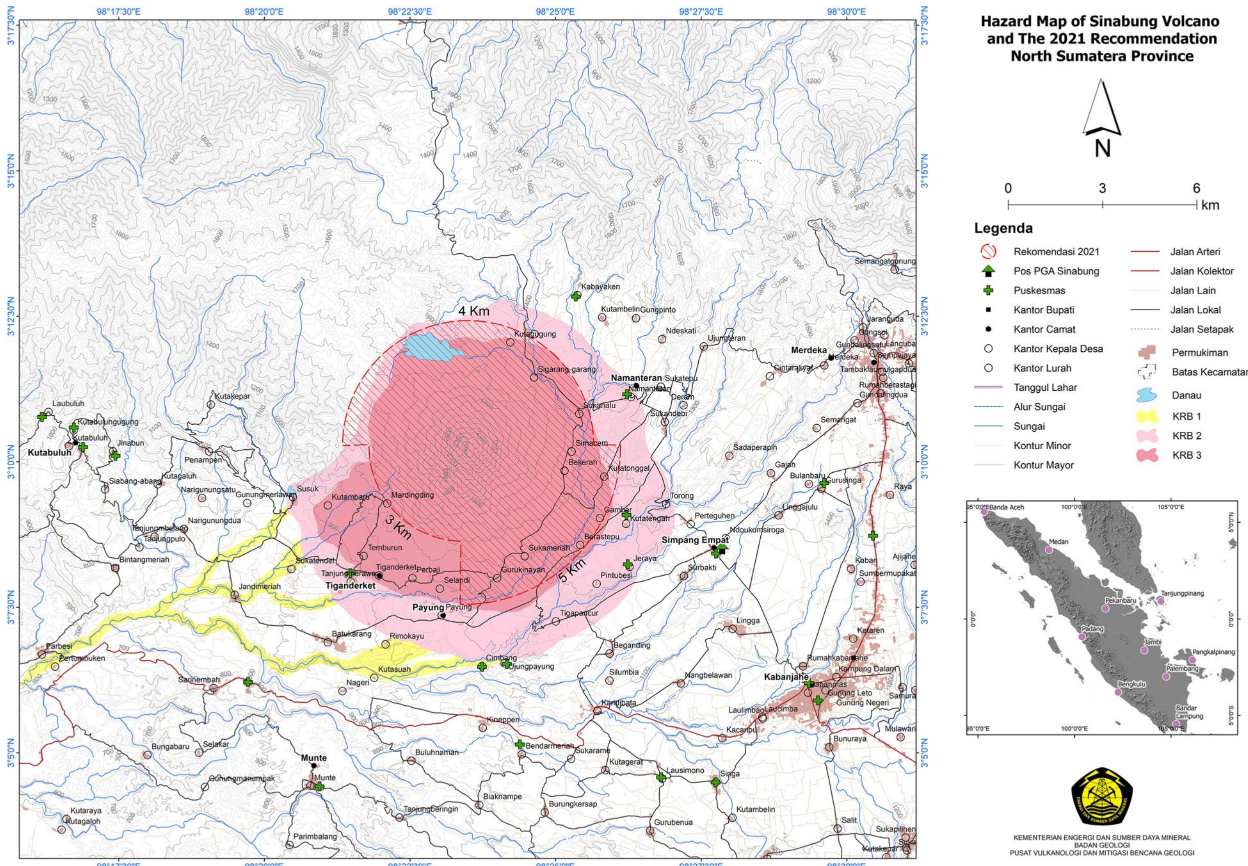

Fig. 6 Hazard map of Sinabung (Gunawan et al. 2015). The current hazard potential (exclusion zones) is shown by sectoral distance in each sector, represented by red dashed lines. Color Symbols: red is Hazard Zone III (highest), pink is Hazard Zone II (medium) and yellow is Hazard Zone I (lowest)

radio stations to facilitate interactive communication was also successfully used at Mt Cameroon (del Marmol et al. 2018).

Learning from good communication

Communication with the decision makers can be via formal and/or informal ways. Sometimes direct personal communication is more effective, especially during crisis times (Newhall and Solidum 2018). A valuable learning experience of this occurred during the activity of Merapi in 2010. The personal involvement of the Governor of Jogjakarta to displace people due to the extension of exclusion zone from 10 to 15 km resulted in a much more organized and faster evacuation of Merapi community because of the order of decision maker (Sayudi, personal communication 2019).

Personal communication can also be implemented through the local community as ‘volcano watchers’ such as in Sinabung, Merapi, and Kelud. People from the community can play a role as photographers (Fig. 7), journalists, or by providing information to CVGHM about anomalies in activity or changes in morphology. In Indonesia, these ‘volcano watchers’ exist at volcanoes that have experienced eruptions in the past.

Improvement of the capacity of the community occurs with their participation and the role of local leader. On the other hand, participation can also be used to identify problems within the community, such as ‘actual’ level of knowledge, capacity and their understanding of hazard. According to Cadag et. al (2018) participation will encourage communities to empower and build dialogue. In this way, participatory risk management involving community leaders and the population is most appropriate to bridge between traditional practices, local realities, and the implementation of risk management policies and strategies (Lavigne et al. 2018).

Cronin et al. (2004), used the method of participation (Participatory Rural Approach, PRA) on Ambae Island, Vanuatu, to identify problems of the local community through traditional knowledge. These problems include volcanic hazards visualization, communication systems, gender and hierarchy conflicts. Andreastuti et al. (2019) proposed that communication and participation of the community can be improved through the

Fig. 7 Morphology of Sinabung summit before and after the 13 May 2021 eruption. Photos taken by CVGHM staff (left) and by 'volcano watcher' Sugeng Nuryono (Maz Yons, right)

characteristics of the community as represented by culture, disaster experience, local capacity and vulnerability, and supported by the presence of local leaders, and social networking. However, Miles et al. (2018) argued that experience of disaster is significant in shaping the behavior of disaster managers, and that risk communication can shape community resilience and non-compliance of the community, as reported from experiences at Mt Cameroon volcano.

Another manner of personal communication is through WAG. This is different from WAG mentioned before, which are at national and provincial level. Some WAGs are composed of decision makers of local districts, local heads of police, Regional Disaster Management Agency (such as Sinabung, Kelimutu, Iya), which is owned by Sinabung, Kelimutu and Iya Observatory Posts. Kelimutu and Iya are examples of volcanoes in East Nusa Tenggara that at the time of writing are at Normal level I, but have already established communication with local stakeholders from government institutions, including the Regional Disaster Management Agency, and local and cultural leaders.

Communication of volcano alert level

According to the Presidential Decree of Indonesia Number 8 Year 2008 concerning National Disaster Management Agency, Early Warning activities include:

1) observing the disaster characteristics,
2) analyzing the data of observation results,
3) making decisions based on analysis results,
4) dissemination of decision results, and
5) taking action by the community.

This describes the span of process from science information, decision making and implementation to the community. The Volcano Alert Level is part of early warning and the result of the first three activities.

For proper implementation of a scale of volcanic activity in each country, in addition to the scientific aspects, it is necessary to also take into consideration the existing systems or regulations applicable in the given country. The character of each individual volcano has a big influence on the determination of the alert level. In countries with a high number of volcanoes such as Indonesia, a general definition of alert levels is more applicable.

In Indonesia, the aims of having an alert level system are to communicate volcano hazard information and to provide recommendations for decision making, stakeholders, and the community, as well as to prepare action plans depending on the state of volcanic activity. According to Papale (2017), the alert level is used by volcanologists to communicate the condition or state of the volcano. He also highlighted that such system did not have a predictive capacity, and that it did not include the confidence levels of the knowledge of volcanologist according to the alert level. The skill and knowledge of volcanologists are important, but other parameters also need to be considered, not only scientific, and also the importance of how it is communicated to the decision maker and community. As it is mentioned above, the alert level is not useful if it is not properly communicated to the stakeholders and public, and if it does not include an action plan to improve the awareness of community. Fearnley and Beaven (2018) emphasized the importance of communication between scientists and stakeholders to ensure that the information and its processes are valid and acceptable by all involved.

A good example of the importance of and successful use of an alert level system was in the eruption of Pinatubo in 1991 (Punongbayan et al. 2012, Newhall and Solidum 2018). The alert level system was able to provide simplified information according to the level of volcanic activity that was able to address a large and diverse population, with various degrees of knowledge of hazard. Taking into account the case examples of Indonesia and the Philippines, we find that the alert level is a suitable system to use in case of increasing of volcanic activity. Papale (2017) notes that *alert level tables are dominantly developed and used through an 'intuitive approach', rather than through rational thinking that should drive scientific evaluations.*

Referring to above quotation, an alert level is a simple form of communication between scientists, stakeholders and the general public that aims to provide directive information that makes people understand what to do without having to make their own interpretation. People can have different perceptions about probability percentages even if it is more logical from volcanologists' points of view. For example, during the 2015 Raung volcano crisis, CVGHM issued recommendation of 3 km exclusion zone. However, local BPBD (Jember, Banyuwangi and Bondowoso Regencies) were influenced by the opinion of independent research institutions, which cannot be scientifically justified. They prepared a contingency plan with a 20 km radius of exclusion zone. This situation mislead the community and caused a chaotic situation. For this reason BNPB forced BPBD to resolve the issue by following the CVGHM recommendation. Alert levels are qualitative in nature but are inferred from quantitative analysis of scientific monitoring data. Determination of eruption probabilities requires experience and careful consideration, including educational level and cultural factors in a particular area.

Information of an alert level and its associated recommendations is given regularly to stakeholders according to the volcanic activities (Table 1). It is complemented by evaluation of activity of volcanoes above normal level. The involvement of stakeholders is carried out during the formulation of a contingency plan. At the end of the activity, this is tested by simulations (TTX, Table-top Exercise).

In the case of crisis, the eruption scenario is only shared among limited people (e.g. Incident Commander/IC and key stakeholders/local government, BNPB and BPBD). During a crisis, several scenarios are prepared and the IC needs to know all scenarios in order to arrange needs and resources in the event of an eruption. Each scenario is developed according to the estimated activity based on a hazard assessment. However, only general information is shared with the public, including the least technical data, in order to minimize confusion. If the eruption scenario changes, this information will be shared with the public, complemented by a directive recommendation. Each scenario reflects the intensity of the eruption and different areas of potential hazards and is therefore related to the plan of action led by the IC.

A well-established alert system may also reduce a biased interpretation, and as well as increase the speed and accuracy of information. When the level of activity is provided by agencies that are not involved in monitoring, in addition to possible interpretations of the volcano status, it will take longer to make decisions and thus increasing the risk of the threatened community. The main point of communicating the alert level during times of high activity is to provide recommendations and a strategy to minimize casualties within a short time frame. This communication is challenged by technical needs, bureaucracy, the time frame, competing agencies, and trust. These parameters may hinder the process. Sophisticated language and delicate science need to be avoided during communication to decision makers. At the end, the decision maker only needs to know the trusted and relevant outcome and to act according to the result.

Community preparedness and response

Risk communication in Indonesia is not only the responsibility of the Government, but also the task of disaster management agency, private sector agencies, and the community. Therefore, capacity building of all groups is important. Cooperation from various sectors is necessary to achieve effective and optimal disaster mitigation.

A communication gap between the scientists, decision makers, and the community

Why is there a gap of communication between the scientists and the community? The gap exists mainly due to the level of knowledge related to volcano hazard. An example was found in the Sinabung community at the beginning of activity in 2010 – 2012. A gap between scientists and decision makers was identified, as the decision makers responded slowly, did not understand the time pressure and urgency of needs during a crisis. This happened in Sinabung, North Sumatera and the 2013 Egon eruption in East Nusa Tenggara. In the Egon community, most people wanted to evacuate without considering whether they did or did not live in the hazard zone.

The communication gap can relate to the question: how to convey proper and understandable information? There are two main ways to think about how to better convey information. The social scientist can learn about the volcano and translate the information to the community, or the volcanologist learns how to communicate with the decision makers and the community. According to Leonard and Potter (2015), the incorporation of social science and volcano information can be effectively used to lessen the risk of volcanic hazards to society. On the other hand, Marty (2015) proposed that direct communication between scientist and public is able to influence the risk perception and the public confidence. Communicating risk to a threatened community by both social scientists and volcanologists can be done as long as they understand the information and have sufficient communication skills to approach the population, uphold the value of equality, and use inclusive and emphatic manners. In reality, good communication between scientists and the decision makers and the community occurs with experience and through a good network, as it needs trust between parties. The more frequent and continual the communication, the more trust and connection that is built. This process needs to be supported by good cooperation between community and agencies involved in risk management. On the other hand, straightforward and non-technical language is needed to have effective communication. In the case of Indonesia's communities, it is important to approach the community through its culture, and this varies from place to place. There are some examples of high trust between the public and scientist/governments, such as in Kelud (Andreastuti et al. 2019) and Merapi (Subandriyo et al. 2019). Risk communication also should be maintained during normal situations when there is no crisis, in order to facilitate communication during a crisis (Donovan and Oppenheimer 2018). The communication between scientist, stakeholders and the community needs to be carried out in a direct or indirect manner during periods of quiescence. This can be done through joint Disaster Risk Reduction Program, such as WLPB or other related activities (e.g. SISTER VILLAGE), so that communication can be established long before a crisis occurs.

Conclusion

The system of volcano alert levels used in Indonesia describes the potential impact of the volcanic behavior to the surrounding communities, including the exclusion zones, potentially threatened areas, and actions that need to be taken. Communication of volcano hazards to stakeholders and the community is critical for planning measures and for action to be taken. The alert level system alone is not useful if it is not communicated and followed by an action plan to improve the awareness of the community. This can be carried out through community-based preparedness activities. Community-based preparedness includes using a culture-based approach, facilitating strong relationships and participation as the community learns and improves its capacity according to its customs.

Previous experience shows the need to protect livestock without compromising personal safety, encouraging the community to take the initiative to innovate risk reduction and better evacuation planning.

Independent evacuation of the Deles community in Merapi and the Kelud community reflect a strong relationship and leadership that is able to see the needs of the citizens and make the right decisions to save lives. The important key to self-evacuation compared to being evacuated is awareness of the risks where the population understand what to do. The WLPB and SISTER VILLAGE programs are examples of community-based preparedness and represent a learning process to identify and fulfil needs through communication and coordination.

Personal communication between scientists and decision makers, and between scientists and the community is very useful to build community resilience through self-responsibility and a sense of belonging. This process has already happened in communities that have to coexist with many, or/and long and/or continuous eruptions (e.g. Kelud and Merapi).

Consensus and deliberation in risk communication is a bottom-up process, involving the community in decision making and engagement with the government. At the end, it is a joint effort between scientists, decision makers and the community. In the long-term, facilities and infrastructure need to be developed together with the improvement of capacity and progress in spatial planning to strengthen resilience to volcanic hazards.

During a volcano crisis, the response to volcanic phenomenon and its impact to social, economic and politic aspects cannot be separated, and thus proper actions need to include various sides and stakeholders. During the implementation of the response, an agency needs to bridge between all these components as coordinator in order to facilitate communication and have an effective and successful outcome. The NDMA of Indonesia has this function in order to facilitate an integrated action in disaster management. Indonesia has a system of institutions that manage science, and others that are responsible for social aspect, including evacuation, refugee handling, rehabilitation, and reconstruction. All these aspects of disaster risk need policies to support public needs before, during, and after a crisis occurs. This includes availability and access to information, social protection, education, training and skill development for disaster management. Finally, each individual volcano provides unique lessons and occasionally raises new questions and problems that need to be solved. Therefore, it is necessary to carry out reviews on previous strategies after a disaster has occurred to obtain a better result in the future.

Abbreviations

BNPB	Badan Nasional Penanggulangan Bencana (National Disaster Management Agency/NDMA)
BPBD Provinsi	Provincial Disaster Management Agency
BPBD Kabupaten/Kota	Regional Disaster Management Agency for Regency/City
CBDRM	Community-based Disaster Risk Management
CVGHM	Centre for Volcanology and Geological Hazard Mitigation
BMKG	Badan Meteorologi, Klimatologi and Geofisika (Meteorological, Climatological and Geophysical Agency
GVP	Global Volcanism Program
IC	Incident Commander
MAGMA	Multiplatform Application for Geohazard Mitigation and Assessment in Indonesia
SFDRR	Sendai Framework for Disaster Risk Reduction
SBY	Susilo Bambag Yudhoyono
UNDRR	United Nation Disaster Risk Reduction
UNISDR	United Nations International Strategy for Disaster Reduction
VAR	Volcano Activity Report
VEN	Volcano Eruption Notice
VON	Volcano Observation Notice for Aviation,
VEI	Volcano Explosivity Index
WLPB	Wajib Latih Penanggulangan Bencana (Compulsory Disaster Management Training Program)

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Authors' contributions
SA prepared the first and second manuscripts, Figs. 1 and 2, EP contributed on the discussion of risk communication and CBDRM, SS contributed on WLPB, DS prepared detailed discussion on alert level to improve the manuscript, AP prepared Figs. 3, 4 and 5. The author(s) read and approved the final manuscript.

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Declarations

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