

The effectiveness of community-based early warning system of Kelud volcano eruption 2014

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Abstract. Kelud Volcano is an active volcano in Indonesia. About 150 million meter cubic has erupted on 13 February 2014 at 22.30. People were successfully responded to the most significant eruption in history without any fatalities, by doing less than 2 hours evacuation, from 21.15 to 22.50. This research was conducted to show the success of the community in building the resilience process by applying a good system of community-based early warning. The study was conducted through documentary review and field assessment with participatory research methods, including mapping, transects, and historical studies. The result of research show that the community has four aspects of early warning system has been successfully fulfilled by communities. Those four aspects are (1) Knowledge of risk; (2) Monitoring and warning service; (3) Dissemination and communication; (4) Ability of the people to respond. Systematic data collection and risk assessment, with its pattern and tendency factors, ensured that disaster and vulnerability are well-known. Monitoring parameter to create accurate and timely pre-estimation has been ensured by disaster monitoring and early warning service. Communicating information and early warning ensured that the warning could be received by everyone that affected by disaster, risk, and its warning can be understood and useful. Establishing the people's responsibility to ensure the response must be renewed, ability and local knowledge can be utilized, and people are ready to response warning. Simulation and training activities were implemented by the people within the disaster-prone area. Finally, the powerfulness of community preparedness can manage the tremendous level of a volcano eruption.

1 Introduction

Kelud Volcano is one of the active volcanoes in East Java province. It is geographically located in 7°56'00" SL and 112°18'30" EL and administratively belongs to the 3 districts of Blitar Regency, Kediri and Malang. Kelud Volcano experienced 31 times eruptions since the year 1000 to 1990. The eruptions were claimed about 15,000 lives. Eruption dated February 13th, 2014 at 22:30 spewed 150 million cubic meters. Figure 1 is an aerial image of Kelud Volcano eruption which taken by USGS on 18 February 2014.

Most of the victims were exposed to hot clouds (pyroclastic surge), pyroclastic flow, and especially eruption lava. The deadliest eruption was occurred in 1856, victimized about 10,000 inhabitants, while the eruption in 1919 swallowed more than 5,000 casualties. During the 20th century, the death toll of Kelud Volcano's eruption in 1919 (5,115 fatalities) was ranked fourth highest after Mount Pelee in Martinique (29,000 fatalities), Nevado del Ruiz in Colombia (24,442 fatalities) and Santa Maria in Guatemala (11,000 fatalities). The death toll from Kelud Volcano was almost four times higher than Merapi eruption (1,369 fatalities) during the same century. Kelud as categorized as a volcano with St. Vincent eruption type. The height of eruption fumes can reach more than 10 km and spew

out 150-200 million cubic meters of tephra in less than ten hours, on 10 February 1990's eruption. The eruption of volcanoes that have a crater lake such as Kelud Volcano is an explosive eruption from inside the crater with buried material sized ash, lapilli, and block. Prior to magmatic eruptions, eruption activity may begin with steam eruptions (phreatic eruptions), which then develop into eruption forming a volcano bomb. Every eruption activity always ends with the formation of a lava plug on the crater of the mountain [1,2].

KeludVolcano eruption on February 13, 2014, spewed 150 million volcanic materials in the form of ash, sand, and gravel reached the radius of 30 kilometers, especially to the western region to the southwest of the crater Kelud Volcano. Ash and sand on the layer of 1,500 m in the air were carried by the wind to the northeast, at layer 5,000 m were carried to the northwest, and at layer 9,000 m were carried to the west [3]. According to information from various mass media, rain was reportedly spread to Pasuruan, Surabaya, Sumenep, Solo, Boyolali, Yogyakarta, Cilacap, Ciamis, Bandung, and Sukabumi.

Kelud Volcano eruption in 2104 claimed 4 deaths. On February 15th, 2014, the number of refugees reached 56,089 people. The refugees were spread over 89 assembly points, with 10,895 people from Kediri Regency at 38 assembly points, 11,084 people from Batu

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City at 26 assembly points, 8,193 people from Blitar Regency at 3 assembly points, 25,150 people from Malang Regency at 17 assembly points and 767 people from Jombang Regency at 5 assembly points. During that time, the number of areas affected by the eruption of Kelud Volcano covered 35 villages, 9 sub-districts, and 3 districts at the radius of 10 km. 201,228 people (58,341 families) with details of 96,843 people (28,003 families) in Blitar, 58,842 people (17,134 families) in Kediri, and 45,543 people (13,204 families) in Malang were exposed during Kelud eruption as shown in Fig.1.

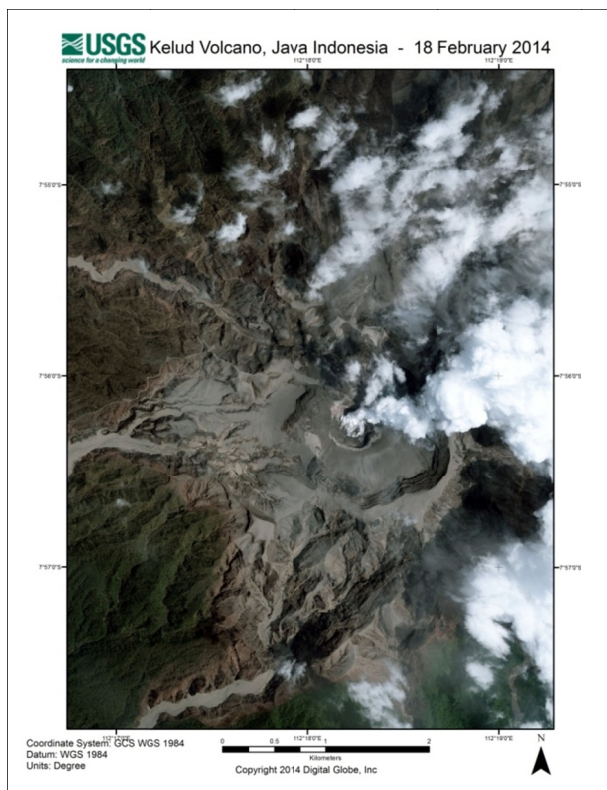


Fig. 1. Aerial image of Kelud Volcano eruption on 18 February 2014 (USGS)

2 Methodology

This research aimed to reveal the success of residents in the eruption-prone area of Kelud Volcano, as well as to achieve another success in applying community-based early warning system. This research has been implemented through documentaries and explorative study on community practice and relevant parties both before and after emergency condition.

Documentaries study has been implemented by rereading the program document which is implemented together with the people in the disaster-prone area. Document review was conducted to reveal the process flow of community empowerment. Community empowerment in disaster-prone areas was conducted during 2014 - 2017. The study of exports with a series of participatory research and eyewitness interviews were implemented to triangulate the information on the effectiveness of early warning systems, the evacuation process, and the process of returning to safe areas.

Participatory research methods were implemented, including mapping, transects, and historical studies.

3 Result and discussion

Looking back to the past, increasing the status of Kelud Volcano until the eruption in which lava dome was produced in 2007, there has been an evacuation of people to several places that were considered safe enough by the government. The displacement was carried out between 3 until 7 days. The process of citizens' evacuation and the management during the evacuation place left certain stories within the community and the government.

When Kelud Volcano's status increased in 2007, the Indonesian Naturalist Society (KAPPALA), Study Disaster Research and Management Centre (DREAM) of University of Pembangunan Nasional Veteran Yogyakarta and Oxfam Great Britain (OGB) had the opportunity to enter Sugihwaras and Sempu, as disaster-prone villages in Kediri District, and Penataran and Sumberasri villages in Blitar. From the discussion with the people, it was found that the community commanded the preparedness by building a shelter from woven bamboo in front of their respective house which will be used as a shelter in case of an eruption. They will not leave their house, not after the eruption is incomplete. These woven bamboos prevented the roof from the material and heavy loads.

Based on the story, KAPPALA took the initiative to create a bamboo ladder, roof cleaning tool in the form of coconut shell stuck with a long stalk, and cover in the form of woven bamboo, which can be used by residents to clean roof in case Kelud Volcano spews material.

In the middle of 2008, KAPPALA with DREAM, OGB and Troicare built preparedness, which is Disaster research reduction (DRR), in Kelud Volcano area. Activity begins with:

1. District level dissemination. District-level dissemination activities were carried out in three districts of Kediri, Blitar, and Malang. The purpose of this activity is to submit an action plan that will be implemented around Kelud Volcano and ask for some input in the implementation process.
2. Village level dissemination. Village level dissemination was carried out in 10 villages: Sumberasri, Penataran, Candirejo villages in Blitar District; Sempu, Sugihwaras, Sepawon, and Besowo villages in Kediri Regency; villages of Pondok Agung, Ngantru, Pandansari in Malang Regency. This activity delivered the condition of Kelud Volcano after the 2007 eruption and plan activities that need to be done. To encourage public awareness, KAPPALA involved PasagMerapi, (community-based disaster risk management organization from Merapi Volcano area) to tell what strategy that they have done in Merapi, to maintain the preparedness in disaster-prone areas.

3.1 Building synergies

Efforts to build community and government synergies are conducted through workshops in district level, series of training, capacity building, and drafting the working groups of each district.

1. District-level workshops. This activity is carried out in each district through the meeting between the community and government representatives. The discussion was conducted to discuss the management of Kelud Volcano post-eruption 2007. From this activity, it was agreed who should be involved in the upcoming activities both representatives from the government as well as from the community, as well as the process of delivering invitations.
2. Training / capacity building series. Several activities for capacity building on disaster management, emergency management, gender in DRR, training of contingency planning and mapping of digitization are conducted jointly between government and community representatives. The training aims to build synergy in disaster reduction activities between government and society. The process of building synergy between the community and the government is also done outside the training room by exercising together. This activity is carried out in the hope of removing the partition between government and society.
3. Working groups of each district. To strengthen the relationship between the community and the government by forming a working group in each district by scheduling meetings to formulate a work plan that can be done [4,5].

3.2 Building community preparedness

Capacity building process and awareness building on disaster risk management in the community started in 12 villages with local trainers at the village level. Facilitators of DRR actors are selected to encourage public awareness. PasagMerapi was asked to be a facilitator and also a motivator for Kelud Volcano residents to conduct Community Based Disaster Risk Management (CBDRM) activities. Indonesia Red Cross (IRC) is requested to submit the First Aids in cooperation with Community Medical Service (Puskesmas) and community with other elements in DRR activities. These training concluded the risk analysis document, evacuation plan, Standard Operation Procedures (SOPs), mapping and formed the village alert team. Work at the community level continues through the establishment of local facilitators, developing villages, integrating DRR materials in schools, and building models and props, with the following details :

1. Local facilitators. The spreader of CBDRM becomes an option to speed up and simplify the process. Representatives of Village Alert Team (VAT) are training to become facilitators of virus spreaders in new villages with CBDRM and First Aid materials.
2. Developing of the village. The training was conducted in villages around Kelud Volcano facilitated by members of the village alert team who

had trained as facilitators, from the first 12 villages that had formed the VAT developed into 36 villages, in addition to the new villages also doing local coaches in the old village in order to increase the alert team.

3. Integrate DRR materials in school subjects. To become a disaster-prone area is not enough with the activities in the village but must involve all parties located Kelud Volcano area. Schools are among the parties involved, involving representatives of teachers in DRR training so as to be able to analyze their school risks and prepare preparedness plans as well as integrating DRR materials on subjects.
4. Developing properties in the children's DRR. Dolls become one of the tools for delivering DRR materials for children, kindergarten and elementary school teachers practicing together about DRR and playing puppets as a method to convey to their students, practice moving puppets, making stories and interacting with their students.
5. Compile modules. By practicing and practicing recording what has been done, the facilitators write their experiences in facilitating the local trainer into a standard module. The hope can be used as guidance and reading materials for other people to do local training. [6]

3.3 Building community capacities

JangkarKelud believes that good disaster risk reduction is the responsibility of all parties and is carried out all the time before the disaster occurs, during, after the disaster, disaster risk reduction activities should be community-based, as the beneficiary directly. Even the weakest community still has the ability to conduct DRR activities. The community ought to be understood about their territory, but it does not cover the role of other parties either government, the business community, or other institutions committed in the case of DRR. Fig 2 shows Disaster Prone Area of Kelud Volcano

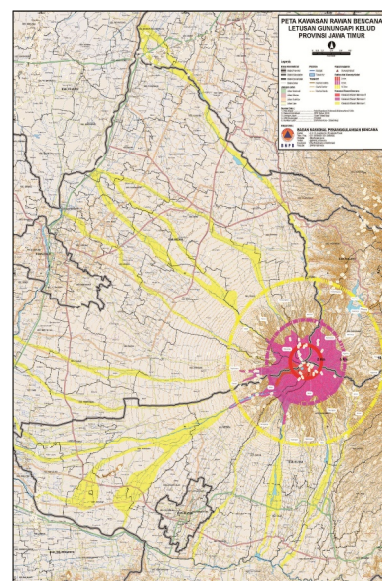


Fig. 2. Disaster Prone Area of Kelud Volcano

Together with KAPPALA, DREAM, JangkarKelud (community-based disaster management organization of Kelud Volcano area) conducts capacity building programs for DRR:

1. Community-based disaster risk reduction training. Local training activities conducted in each village aimed at understanding disaster, recognizing threats, their characteristics, analyzing risks, capacities and vulnerabilities, creating village disaster management protocols / SOPs, creating Action Plans, creating district maps, and agreeing on an early warning system.
2. Local emergency response workshops. First aid is the strengthening of community capacity in subscribing patients before getting medical treatment. Thus, it is expected that the community has the ability to provide first aid adequately before being handled by the medical.
3. Mapping of disaster risk areas. Each village is mapping its territory to determine the location, boundaries, vulnerability, distance from threats, capacities and vulnerabilities from 6 aspects of life (human, social, political, infrastructure, economy, environment) as well as evacuation routes, become the source of information for the community as well as other parties.

3.4 Disseminating programme

1. Institutional strengthening of the VAT. In community-based disaster risk reduction activities, institutions have an important role. Village alert teams, which the team of people who have skills and knowledge about CBDRR and First Aid, are the coordinators and executors of the disaster at the village level.
2. Working group JangkarKelud. Working group is a place to gather and discuss all elements of society, government, business, and mass organizations that involved in disaster risk reduction Kelud Volcano in Blitar, Malang, and Kediri. It is to develop a work plan and improvement activities that have been done for the better management of Kelud Volcano disaster in the future.
3. Field Simulation and Field Rehearsal. From village alert teams who have skills and knowledge in DRR activities, together with all elements of the community conduct joint exercises to test the SOP that has been developed and also to hone the skills and preparedness of the village alert teams. By conducting regular field activities, it is desirable to have sensitivity from all elements of society in an emergency.
4. School-Based Disaster Risk Management Training. Numbers of schools were located in the area of disaster-prone. These were to create separate management of the school in handling disasters that occur in school. Thus, it is a necessary school-based disaster risk reduction activities. Activities include capacity building of teachers on DRR and First Aid,

preparing school protocols, preparing EWS in schools as well as integrating DRR materials in subjects.

5. Early Warning System. The information is fast and from the right source. It is beneficial in the preparedness of people who are in disaster-prone areas. For preparedness, JangkarKelud has the agreement of communication line by using handy talky (HT) and community radio; there are 120 HT spread in 36 villages and 9 frequency modulation radio that joined in Community Radio Network of JangkarKelud.

3.5 Maintaining sustainability

Eliminating dependency can only occur if institutional sustainability in the community and disaster risk management activities is carried out continuously.

1. Standby team meetings. This event is held with joint training on the readiness of competing First Aid between villages. Specific competition to raise the activities of village alert teams is held, and gift in the form of tools such as megaphone and HT are given also
2. Break-fasting together and *Halal Bi Halal*. In the month of Ramadhan, the members of the JangkarKelud team perform a Break-fasting event together. This event is a place-to-place event, with the aim to establish togetherness and awaken the spirit of the standby team. The place is usually chosen by less active villages in the hope that they can be more active in the future. *Halal bi Halal* is used as a meeting place for alert team members in 3 districts to know each other and learn together. The event was held to invite stakeholders of Local Disaster Management Agency (LDMA) at district and provincial level, Centre of Volcanological and Geological Hazard Mitigation (CVGHM) and other parties who had joint activities both institutionally and individually.
3. Establish a community-style early warning system. Quick information from the right sources means that communication between the village alert teams around Kelud Volcano is a common need. Thus, selected HT and community radio are needed. There are 2 HTs in each village managed by the village alert team and 3 radiuses mounted on the slopes of Wilis Volcano (west side), on the slopes of Kawi Volcano (east side) and on the slopes of Arjuno Volcano (north side). There are also 9 transmitting stations. Through community radio, it is aimed to be used for information and campaign on DRR during safe and early warning condition. For example, when there is an increase in the status of the mountain.
4. Build networks. This activity is done by visiting each other (*SambangSedulur*) and sharing experiences with other regions and other groups. (1) *SambangSedulur* is an activity to visit and study together with other communities. That is often done in every activity; PasagMerapi, PanjerManikoro, KobarBromoSemeru have visited each other as network building to share experiences with other

regions and other groups. (2) Sharing experiences. It is a way to learn together to increase knowledge and awareness in disaster management. Some areas that have been studied together are the flood-prone community of Ngasinan watershed in Trenggalek Regency, Community of Bromo and Semeru Volcano in Malang, Pasuruan, Lumajang and Probolinggo districts, Nahdlatul Ulama Volunteer of Kediri Regency and Madiun Regency, and East Java Church Community of Pagu in Kediri Regency.

4 Lessons learned

Analysis on the process of building resiliencies showed that all aspects of early warning system had been accomplished by the community and local authorities. Those four aspects are (1) risk knowledge, (2) monitoring and warning service, (3) dissemination and communication, and (4) response ability.

4.1 Maintaining sustainability

A systematic data collection and risk assessment showed that hazard and vulnerability had been known well. Pattern and trend of each factor are known. Furthermore, data provision and risk mapping have been widely arranged. In 2013, National Disaster Management Agency (NDMA) obliged DREAM to arrange a blueprint for disaster management plan of volcanic eruption and targeted Kelud Volcano as one of the priority. CVGHM were always monitored and researched it.

In community level, risk assessment, hazard introduction, and influencing factors have been implemented since 2008. Meanwhile, series of disaster management training; emergency response training, school-based disaster management; community-based disaster management, first aid, workshop and training on risk mapping and disaster contingency has been implemented within July 2008 - May 2010. CVGHM, with KAPPALA and DREAM were always involved in every capacity strengthening of JangkarKelud.

Those series of training were understood in the form of relation between volcano status and community's responsiveness, related to volcano status. CVGHM's recommendation and essential activities in the community were the formulae that were developed in Community Based Volcano Disaster Preparedness Training of Merapi Volcano with Geological Disaster Technology Research and Development Center (GDTRDC) and Forum Merapi, PasagMerapi, DREAM, and KAPPALA.

4.2 Monitoring and warning system

Monitoring and early warning system ensured the truth of monitored parameter, created a scientific and robust basis to make the prediction, and created an accurate and on-time warning. CVGHM implemented some dissemination of information. Spatial dissemination has been delivered in disaster risk mapping of Kelud

Volcano. For 2014, information has been disseminated accurately. Status changing from Normal into Advisory was delivered on 2 February 2014; status is changing from Advisory into Watch was delivered on 10 February 2014; status is changing from Watch into Warning was delivered on 13 February 2014 at 21.15, and an eruption occurred at 22.30.

4.3 Dissemination and communication

Communication and early warning system have ensured that the warning can reach everyone and affected them. Thus, disaster risk and its warnings should be understood, and it has clear and useful information. In community level, early warning system training in every river stream was delivered in January 2009. Management, broadcasting, community radio technique training was implemented in December 2011 - June 2012. Meanwhile, the radio information operating system and its communication tools were delivered in April 2011.

A good information system delivered from one source through a specific way. The community can receive the information as one definition and interpretation. Afterward, a good information system goes from communication radio, community radio, and cell phone. In 2014 eruption, monitoring post of Kelud Volcano communicated some changes from Watch into Warning to amateur radio organization, such as Amateur Radio Organization of Republic Indonesia (ARORI) and Indonesian Communication Radio (ICR) Kediri, and to JangkarKelud. Furthermore, JangkarKelud disseminated the information through phone, communication radio, and community radio into second-order communication. Short communication order from monitoring post to the community has been delivered well.

There is 13 community radio, 9 of them are Community Radio Network of JangkarKelud, prepared by KAPPALA since 2010. Meanwhile, Kediri has community radio located in various locations; SugihWaras village (Kelud FM), Siman village (Adevo FM), Sempu village (Sempu Raya FM) and Satak village (JKS FM); In Blitar, they have community radio at Candirejo village (CandiKelud FM), Modangan village (LintasKelud FM) and Soso village (Estu FM); Then, in Malang community radio are located in Pondok Agung village (Pandawa FM) and Ngantru village (Smart FM). Each of them supported by communication radio (handy talky).

In 2013, there were 25 villages that reached by the communication network, and now there are 63 villages. The radio is held by coordinator and representatives of each Standby village, as each of them has 20 members within. To ensure that information can be received, those communication radios are united by three repeaters which managed by JangkarKelud on the downhill of Wilis Volcano, Kawi Volcano, and Ngantang mountains. Meanwhile, Kediri has one repeater which built on Kelud Volcano.

4.4 Response ability

Building community responsiveness has been done by ensuring the response plan, which is always up-to-date. Then, local wisdom and knowledge can be utilized as a response to the warning. Communication network within 63 villages may enable them to work well. Simulation and training activity was implemented by the community in the various village; Sempu, Sumbersari, Pondok Agung, Besowo, Candirejo, Pandansari, Ngantru, and Kepung. Those activities were held together by KAPPALA from 2009-2011 and by Nadlatul Ulama Volunteer Team in 2012 as their readiness to encounter the eruption. (Fig. 3.)



Fig. 3. Increasing capacity for response ability

5 Conclusion

This research involved KAPPALA, DREAM, JangkarKelud, and WAT in Blitar, Malang and Kediri regency that helped to overcome the series of participatory assessment. All government organizations and communities involved in the process of strengthening the Kelud Volcano community since 2007 - 2014.

Effectiveness and success in 2014 Kelud Volcano eruption can be achieved through all parties who fulfill all aspects of early warning system; (1) Risk knowledge, (2) Warning ability and system, (3) Dissemination and communication, and (4) Response-ability.

Fulfillment of all aspects of early warning system was a long process of all parties, worked with the community around the prone area of Kelud Volcano since 2008.

Good practice of early warning system in Kelud Volcano must be acknowledged as learning that resiliency is not an instant product; it is also improving knowledge that early warning system is not just a communication matter.

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