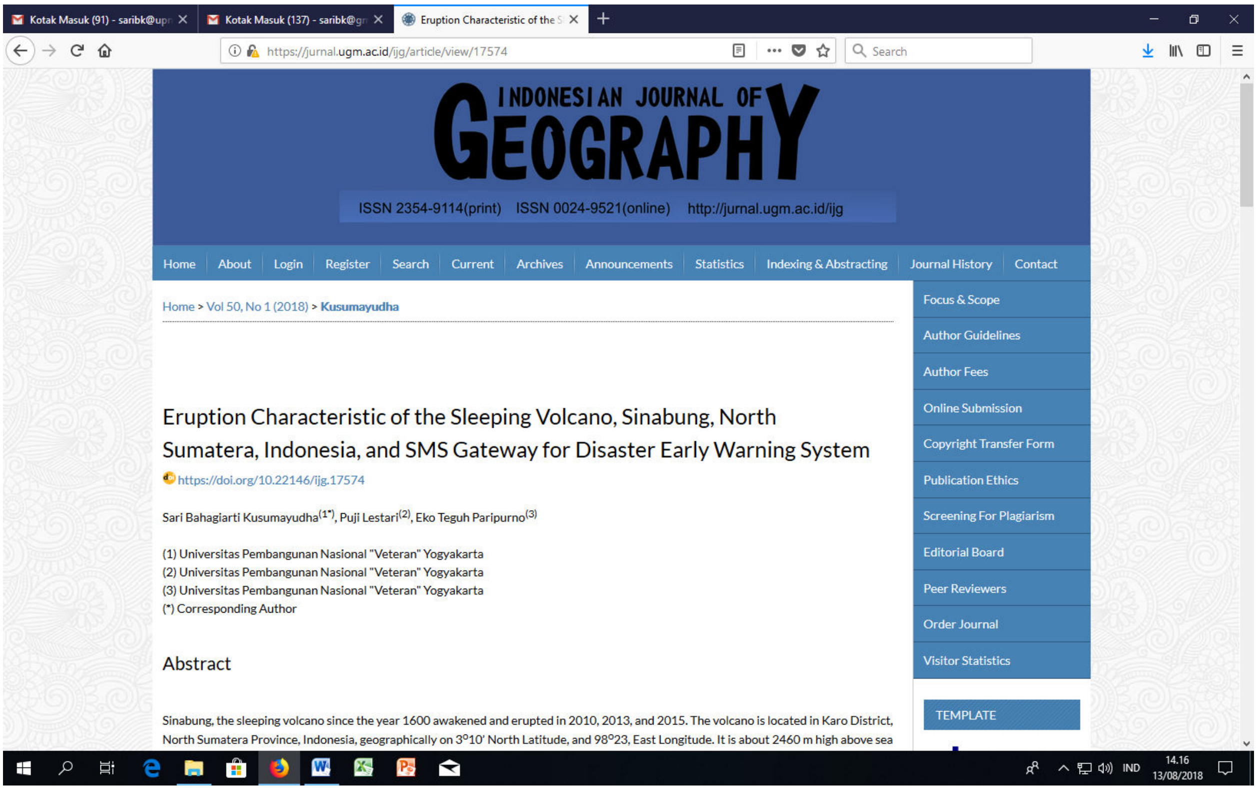

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Original Research Articles

Hendra Kurnia Febriawan, Carla Maria da Silva Sodre

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Abstract

Sinabung, the sleeping volcano since the year 1600 awakened and erupted in 2010, 2013, and 2015. The volcano is located in Karo District, North Sumatera Province, Indonesia, geographically on 3°10' North Latitude, and 98°23, East Longitude. It is about 2460 m high above sea level, and the highest volcano of Sumatera. Sinabung has been estimated about 400 years long inactive, therefore categorized as B type of volcano. It was astonishing; Sinabung erupted on 27 August 2010, again on November 2013, and in May to June 2015. Awakening of the volcano hypothetically has been triggered by last decade earthquakes happened in North Sumatera and surrounding area, including the great earthquake and tsunami of Aceh, December 2004 that caused about 115,000 people died. Because of the volcano has been slept for a long time, people live in the surrounding area were not prepared yet to facing the eruption. In order to reduce the risk such a countermeasure should be developed especially that directly involving local people participation. In this case such an environmental communication system is needed to be developed, it is SMS gate way for disaster early warning system.

Keywords

Sleeping volcano; eruption; environmental communication system; SMS gate way

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INDONESIAN JOURNAL OF GEOGRAPHY

Eruption Characteristic of the Sleeping Volcano, Sinabung, North Sumatera, Indonesia, and SMS gateway for Disaster Early Warning System

Sari Bahagiarti Kusumayudha, Puji Lestari and Eko Teguh Paripurno

Received: Jan 2017/ Accepted: June 2018

Abstract Sinabung, the sleeping volcano since the year 1600 awakened and erupted in 2010, 2013, and 2015. The volcano is located in Karo District, North Sumatera Province, Indonesia, geographically on 3o10' North Latitude, and 98o23, East Longitude. It is about 2460 m high above sea level, and the highest volcano of Sumatera. Sinabung has been estimated about 400 years long inactive, therefore categorized as B type of volcano. It was astonishing; Sinabung erupted on 27 August 2010, again on November 2013, and in May to June 2015. Awakening of the volcano hypothetically has been triggered by last decade earthquakes happened in North Sumatera and surrounding area, including the great earthquake and tsunami of Aceh, December 2004 that caused about 115,000 people died. Because of the volcano has been slept for a long time, people live in the surrounding area were not prepared yet to facing the eruption. To reduce the risk, such a countermeasure should be developed especially that directly involving local people participation. In this case, such an environmental communication system is needed to be developed; it is SMS gate way for disaster early warning system.

Keywords: Sleeping volcano, eruption, environmental communication system, SMS gate way

Abstrak *Sinabung, gunung api tidur sejak tahun 1600 terbangun dan meletus pada tahun 2010, 2013, dan 2015. Gunung berapi ini terletak di Kabupaten Karo, Provinsi Sumatera Utara, Indonesia, secara geografis pada 3o10 'Lintang Utara, dan 98o23, Bujur Timur. Tingginya sekitar 2460 m di atas permukaan laut, dan gunung berapi tertinggi di Sumatera. Sinabung diperkirakan berumur sekitar 400 tahun tidak aktif, oleh karena itu dikategorikan sebagai tipe B gunung berapi. Itu mengherankan; Sinabung meletus pada tanggal 27 Agustus 2010, lagi pada November 2013, dan pada Mei hingga Juni 2015. Kebangkitan gunung berapi secara hipotetis telah dipicu oleh gempa bumi dekade terakhir yang terjadi di Sumatera Utara dan daerah sekitarnya, termasuk gempa bumi besar dan tsunami Aceh, Desember 2004 yang menyebabkan sekitar 115.000 orang meninggal. Karena gunung berapi telah tertidur dalam waktu yang lama, orang-orang yang tinggal di daerah sekitarnya belum siap menghadapi letusan. Untuk mengurangi risiko, penanggulangan seperti itu harus dikembangkan terutama yang secara langsung melibatkan partisipasi masyarakat setempat. Dalam hal ini, sistem komunikasi lingkungan semacam itu perlu dikembangkan; Ini adalah cara gerbang SMS untuk sistem peringatan dini bencana.*

Kata kunci: *Gunung berapi tidur, letusan, sistem komunikasi lingkungan, gateway SMS*

1. Introduction

Sinabung, the sleeping volcano since the year 1600 has awakened and erupted in 2010, 2013, 2015, 2016, and 2018. The volcano is located in Karo District, North Sumatera Province, Indonesia (Figure 1), geographically on 3o10' North Latitude, and 98o23', East Longitude. It is about 2460 m high above sea level, and the highest volcano of Sumatera. Sinabung volcano has been estimated about 400 years long inactive, therefore categorized as B type of volcano [Kusumadinata, 1979; Kusumayudha, 2013]. It was astonishing; Sinabung erupted on 27 August 2010, again on November 2013, in May to June 2015, in May 2016, and in February – April 2018. Awakening of the volcano hypothetically has been triggered by last decade earthquakes happened in North Sumatera and surrounding area, including the great earthquake and tsunami of Aceh, December 2004 that caused about 115,000 people died.

There are 129 active volcanoes in Indonesia including Sinabung of North Sumatera [Kusumadinata, 1979, Kusumayudha, 2013]. Now Sinabung becomes to be the most active volcano on the world. The techtonic setting of Indonesia that is generated by the interactions of Eurasia plate in the north, India-Australia plate in the south, and Pacific plate in the east brings about the country turns to be rich of active volcanoes [Kusumayudha, 2013]. Activity characteristics of such a volcano is influenced by their magmatic properties especially volatile and silica (SiO_2) contents. Volatile and silica contents of the magma will result in gas pressure and viscoucity of the magma, that defining volcanic eruption type. Based on gas pressure and viscousity of the magma, volcanic eruptions can be classified as illuatrated in Figure 2.

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The objectives of this study was to assess the eruption characteristics of Sinabung volcano and apply a model of such a communication systems for early warning in the disaster-prone areas by SMS gateway. The use of this communication model is expected able to increase public and government awareness in order to reduce risk and disaster victims. Field surveying, interview, focus group discussion (FGD), descriptive qualitative analyses, model testing and training were applied in this study.

2. The Methods

Method to be applied in this study is analytical using primary and secondary data. It was started by assessment of the existing data such as geological map prepared by Geologic Survey of Indonesia, disaster-prone area map, and reports on the impact of eruption by the local government, then followed with field surveys. Such field works were carried out to check the match of existing geological maps with the actual conditions and situation in the study area. Observation and field analyses were also accomplished to collect data on physical properties, and the spreading of eruption deposits, as well as to acquire data related to social aspects of the disaster impact. Furthermore, to complete this study, a structured communication system based on information technology called SMS Gateway has been developed. SMS gateway is intended to assist the communities in early warning system that hopefully able to reduce disaster risk of Sinabung eruptions.

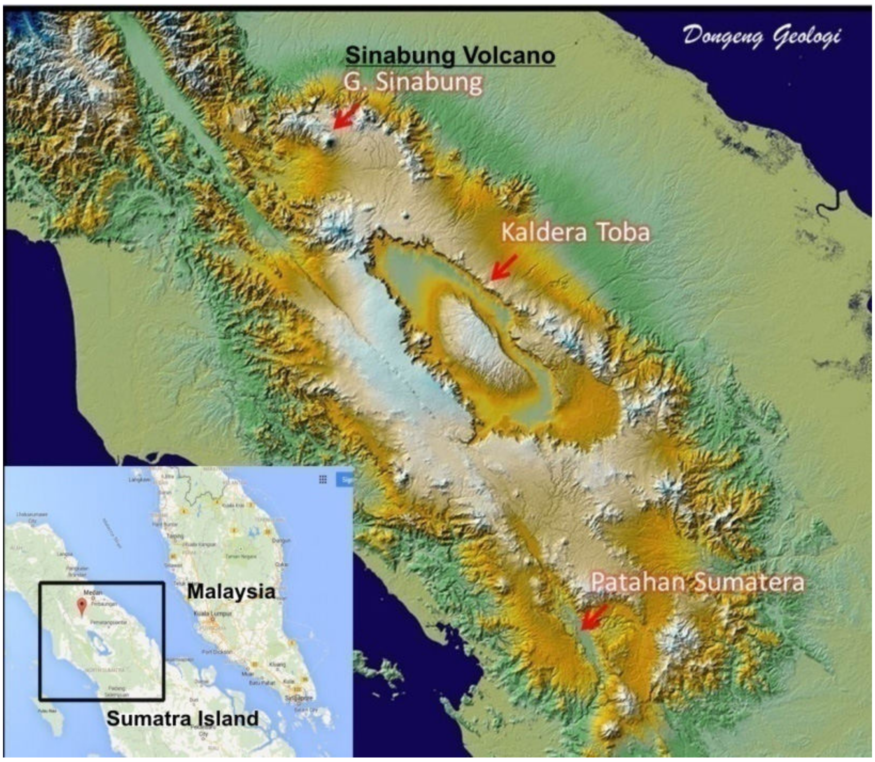

Figure 1. Map showing Location of Sinabung volcano.

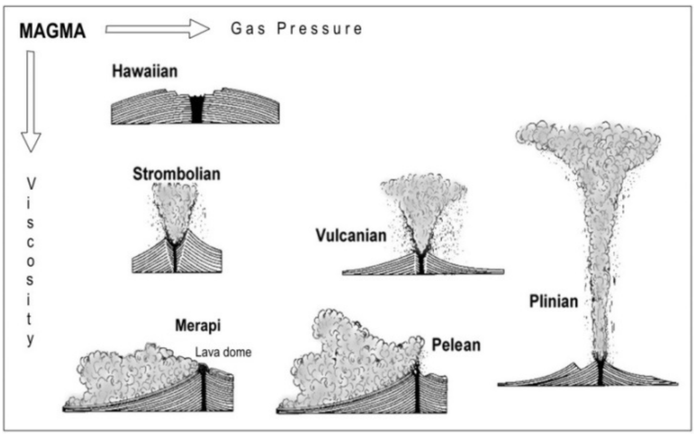

Figure 2. Volcanic eruption classification [Kusumayudha, 2013, modified from MacDonald, 1989]

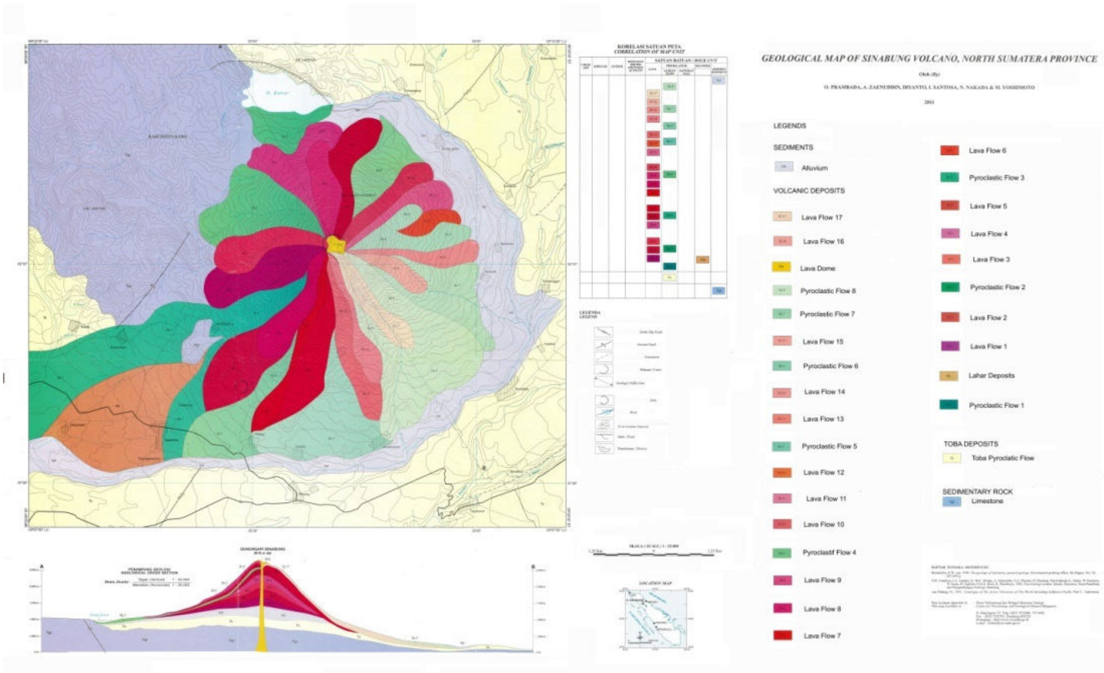

Figure 3. Geologic map of Sinabung Volcano (Geologic Agency of Indonesia, 2011)

3. Result and Discussion

Geology

Sinabung volcano is located in the weak zone at the eastern of Sumatera fault segment. Its eruptions produce volcanic rocks deposits that can be grouped into 25 units [Geological Agency of Indonesia, 2015]. There are 25 units of primary eruption products, and one unit of secondary volcanic activity as lahar deposits. In general the stratigraphy of Sinabung and surrounding area can be divided into two rock units, they are unit of Plio-Pleistocene and unit of Quaternary aged rocks. Unit of Plio-Pleistocene rock consists of andesitic to basaltic volcanic rock, tuff, breccias, and lahar deposits, and intrusions comprises aphanitic hyolite basalt dike, and porphyry andesite (Geological Agency of Indonesia). Unit of Quaternary rock is composed of sedimentary rocks, volcanic deposits and alluvial deposit.

Sinabung volcano occurs at the northwest of Old Toba basin. There is a strike-slip fault dissecting almost all of the rock formation along the west edge of Toba basin [Geologic Agency of Indonesia, 2011]. Besides the occurrence of strike-slip fault, there is a normal fault found at Danau Kawar. In the study area, geologic structure pattern shows southwest-northeast axis, as well as the crater structure of Sinabung volcano that is also northwest-southeast orientation. Geologic map of Sinabung and the surrounding area, developed by the Geological Agency of Indonesia [2011] is shown in Figure 3.

Eruption History

Based on some references reviewed, since the year 1600 to 2009 Sinabung volcano had been recorded and informed as no eruption. Therefore the volcano was categorized and classified into B type. According to the Center of Volcanology and Geologic Disaster Mitigation (CVGDM) of Indonesia, there are three types of volcano in Indonesia, as described in Table 1.

On 27th August 2010 Sinabung volcano was suddenly smoky and sprayed volcanic ash out, classified as a phreatic eruption [Sutawidjaja et.al, 2013]. On 29 August early morning, about 00.15 a.m. local time, lava extruded and flowed from the crater of the volcano. Therefore CVGDM stated the status of the volcano to be "alert". Eruption of this time sprayed volcanic dust, while the sound of explosion was able to be heard from 8 km distant [Kusumayudha, 2013]. During 2010 Sinabung activity about twelve thousand people who live in the surrounding area of the volcano were evacuated. In that time the volcanic ash mostly blown by the wind to northwest direction. Parts of Medan, the capital city of North Sumatera Province were covered by ash. Sinabung erupted without signing any significant warning. On 3rd September 2010 there were twice eruption, the first was at 04.45 a.m. spraying volcanic dust up about 3 km high over the crater, while the second was at 6.00 p.m., coinciding with earthquake that can be identified from 25 km radius around the volcano.

Eruptions of Sinabung 2010 and 2013 were characterized by moderately high gas pressure upward, and can be classified into vulcanian type. But lately, in 2014/2015, 2016, and 2018 with the occurrence of lava dome and avalanche pyroclastic flow, the eruption of Sinabung changes to be the combination of Merapi and vulcanian types. Area which is highly threatened by Sinabung hazards is Karo District, North Sumatera, where the study was conducted (Figur 4).

Table 1. Volcano classification based on its magmatic activity (CVGDM)

Type of Volcano	Description
A	The volcano had ever magmatically erupted at least once after the year 1600. The volcano should be taken into account because probably active any time and threatening human life
B	The volcano had never magmatically erupted since 1600, but still showing phreatic activity such as solfatar and fumaroles
C	The volcano has been unknown to erupt, no historical record on its eruption, but there are such tracks on its activity in the past, such as solfatar field in the very low level.


a


b


c


d

Figure 4. Mount Sinabung (a), eruption 2015 impact at Sukanalu village (b), lahar deposits (c) and eruption 2016 social impact (d)

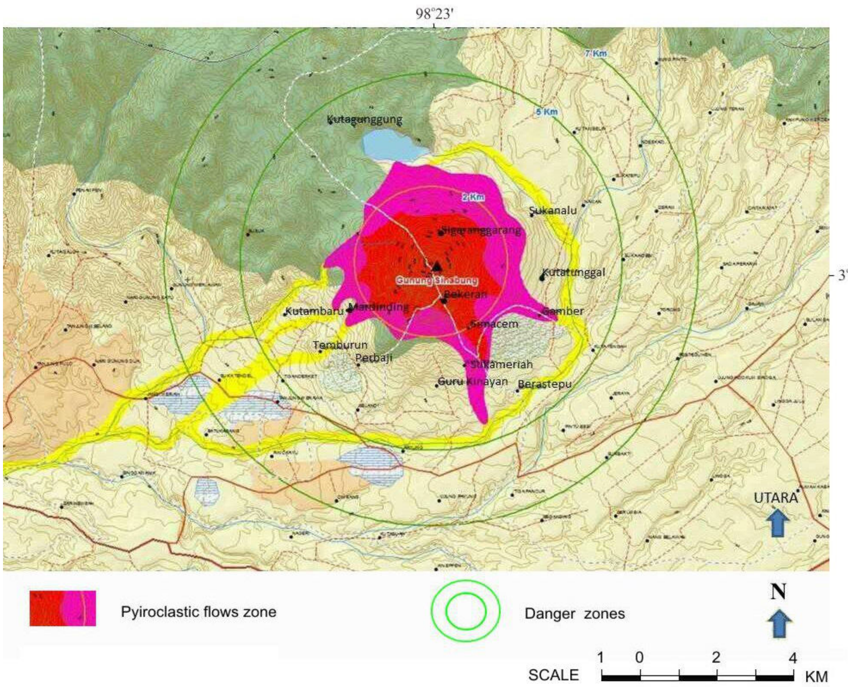

Figure 5. Map showing disaster prone area of Mount Sinabung (BNPB, 2015)

Table 2. Characteristic and Impact of Eruption of Sinabung Volcano
(from various sources of news papers and webs)

Year	Eruption Characteristic	Impact	
		People	Land & Infrastructure
2010	Initially the type of eruption was classified as phreatic, but continued by magmatic activity. The volcano blowed ash and dust material up, throwed glowing blocks and bombs. There also lava flows and glowing clouds. The spreading of the volcanic deposits reached 2 km away from the summit.	More than 12,000 people from 21 villages were evacuated. One died due to respiratory disease	Agricultural, horticultures damages, of Karo Region. Medan city that located at 80 kilometers distant eastern was impcated with ash rains
2013	The eruption is categorized as magmatic, Vulcanian type. Throws volcanic materials up to 5000 meter high; glowing clouds, resulting ash rain spread abaout 5 km radius.	No human victim	Agricultural, horticultures damages, in 7 (seven) districts of karo Region. About 5000 houses/buildings damages.
2014	Magmatic eruption, Vulcanian type and Merapi type. It throws pyroclastics up to more than 5000 meter high. Glowing clouds of avalance with 2 km distance from the center of eruption, relatively southward direction.	15 died.There are 2.053 families or about 6.179 people stay at temprary residence.	Houses damages, agricultural damages in 7 districts of Karo region. Losses of food plants and horticultures of 2.959 Ha. For the horticultures consist of 2.063 Ha vegetables, 860 Ha fruits, and 1 Ha flowers
2015	Combination of Vulkanian and Merapi types of eruption with more than one hundred times of avalance pyrocstic flow, more than 14 times volcanic earthquake/ shakes. The pyroclastic flows reaches 3 - 3,5 km southeastward. The high of ash column ranges from 2000 to 3.000 meter. Lahar begins to occur. There is around 3 million cubic meter of volcanic materials on the top of the volcano that potential to glide down as lahar.	200 people of Sukanalu vilage were evacuated	Agricultural damages in 7 districts of Karo region.
2016	Upward eruption (Vulkanian type) and avalance (Merapi type), as happens in 2015 activities.	7 people died, 2 injuried by pyroclastic flow. They were doing activity in the red zone.	Agricultural damages

Impact of Eruption

Impact of Sinabung eruption since its first eruption in 2010 up to now, can be broken down as writen in the Table 2.

Refers to the fact that people do not like to transfer for another place that is safe, such a method to help the people for awareness during Sinabung active priod is needed to be developed. They demand an early warning system very much, especially for an easy way and cheap one. Therefore this study propose a simple and inexpensive model of early warning system for disaster management of Sinabung, by SMS gateway.

SMS Gateway for Early Warning System

Disaster management is in general well understood and run by most Indonesian people (Government, NGO, academician, and community), especially who live in such vulnerable areas of geologic hazards including earthquake, tsunami, landslides, and volcanic eruption [Kusumayudha, 2012]. Theoretically, disaster management can be operated by steps of activities, involving Pre-disaster, during disaster, and Post-disaster [Paripurno, 2014].

Especially for Sinabung and the surrounding area, disaster management is less understood yet, because there have been assumed to be no threat from volcanic activity since about 400 years ago. When the volcano suddenly erupted in 2010, this caused much loses. People started awake for the existence of hazard nearby their life. This is the reason of why the study needs to be conducted in order to contribute such a countermeasure in volcanic disaster management of Sinabung. Related to disaster mitigation, the two phases of management needed are risk management and crysis management (Paripurno, 2014). The risk management includes preparedness, mitigation, and prevention, that will produce such a protection, life, security, and confort for all the people live in the surrounding area of Mount Sinabung [Lestari, et al, 2014].

Actually early warning systems are complex and require inter-relationship between many disciplines, such as natural and social sciences, engineering, governance and public services, disaster management arrangements, the mass media, and community assistance [Paripurno et. al., 2011]. Thus, the development and maintenance of warning systems and coordination require a wide array of individuals and institutions contribution. Without the involvement of stakeholders, such as authorities and government agencies of various levels, disaster risk community, civil society organizations or non-governmental organizations (NGOs) and private sector, the early warning system will be ineffective (Sitanggang, 2010). Whether the warning is delivered to the public in the disaster risk area or not, it depends on the awareness and ability to carry out the roles and responsibilities of all actors in the chain of communication [Lestari, et. Al, 2014].

This study created a model of disaster environmental communication for supporting early warning by using SMS gateway system. To operating the system, it involves some stake holders such as the Board of National Disaster Mitigation (Indonesia: Badan Nasional Penanggulangan Bencana (BNPB), Board of Regional Disaster Management (BPBD), Head of Social Office, Communication and Information Office (Kominfo), Unit of National and Society Protection (Kesbanglimas), Police, Indonesian National Army (TNI), head of district chairman, head of village, disaster care communities, and local society. The scheme of disaster environmental communication system is drawn in Figure 7.

SMS gateway as a model of environmental communication system indicates that in order to dealing with disaster, such management phases are needed. In disaster mitigation of Sinabung volcano, there are two things that interdependent one another, including human and environment. In the communication system, all of the stakeholders have their own role to participation.

SMS gateway system has been built by a team of Information Technology, namely COMBINE Resource Institution with Universitas Pembangunan Nasional (UPN) "Veteran" Yogyakarta, with online address at http://sms.combine.or.id/sinabung. Operating system and application server SMS enabled in COMBINE are connected to the internet with public selular phones. Sinabung SMS Gateway Services is published by a number 0823-1315- 9900. Related to application of this system, the parties in Karo district were trained to use it after the dissemination of ideas and concepts carried out in March 2014 [Lestari et al, 2014].

SMS gateway system is built in two parts, namely the technical application and the program management. It was constructed through several stages, including: Dissemination process of ideas and concepts to the system maintained by stakeholders and citizens; The collection and management of mobile phone number in the system; Media Management Center as a source of information (in this case is Sinabung Volcano Observatory); Socialization and training on how to use the system for the user; Preparation of Standard Operating Procedure (SOP) in the use and management of information systems.

In order to preparing the system, it needs to build an information media by mapping users who will be act as the target groups, such as printed and electronic media. There are two audiences/key target groups, namely government, and the society. Government, as an SMS recipient, has the role as the policies decision-maker. For the meantime, the community is expected to obtain the decision for the security and safety of themselves, their families, and the environment based on the SMS information. Both groups get information from Volcano Observatory of Sinabung as the media center or SMS gateway administrator for Early Warning of the eruption. Categories and the nature of information for these two groups are different. Government gets detailed and essential information, which is necessary for regional policy decisions, such as evacuation instructions. On the other hand, SMS information to the community groups focused more on information related to the volcano. The information will be about the knowledge and disaster education for the community and their family provided by government, directly to the people. On the other hand, SMS information about the status of the volcano, such as emergency or alert can be disseminated directly to the people with approval from the local government. The user parties among others were the representatives of local government, Department of Communication and Information Technology, and the affected communities. Although in its implementation there are still found some obstacles faced by persons who perform as the operator, because it is only an additional jobs among other duties. In relation to this, the operation of SMS gateway still needs to be mentored.

4. Conclusions

Since the year 1600 to 2009, Sinabung had been recorded as no eruption. Therefore it was categorized into B type volcano. But, now Sinabung is becoming the most active volcano of Indonesia, even on the world. It erups every year. The last eruption is in last October 2016.

In its activities of 2010 and 2013, Mount Sinabung eruptions were characterized by moderately high gas pressure upward, and classified into Vulkanian type. But lately, in 2015 with the occurrence of lava dome and avalanche pyroclastic flow, the eruption changes to be combination of Merapi and Vulkanian types. Area which is highly threatened by Sinabung volcanic hazards is Karo District, North Sumatera.

SMS gateway can be applied for early warning system in Sinabung area. The information about the status of the volcano, such as emergency or alert can be disseminated by Volcano Observatory directly to the people with the local government approval. In its implementation there are still found some obstacles faced by persons who perform as the operator, because it is only an additional jobs among other duties. In relation to this, the operation of SMS gateway still needs to be mentored.

5. Acknowlegdement

The authors wish gratefully acknowledged to the Ministry of Research Technology and Higher Education through the Directorate of Research and Community Service for their support to this research. A special gratitude is also dedicated to the local government and communities of Karo region for their permission and cooperation during the process of study. And many thanks are presented to Combine Resource Institution that in its collaboration with UPN "Veteran" Yogyakarta establish the system, and role as the server of SMS gateway.

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