PREPAREDNESS AND EMERGENCY RESPONSE FOR VOLCANIC TOXIC GAS, A CASE STUDY OF DIENG PLATEAU, CENTRAL JAVA, INDONESIA

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DISCLAIMER

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Arief Dwi Bimonugroho

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ABSTRACT

Volcanic toxic gas disaster is categorized as a rare disaster in the world. Dieng Plateau, Indonesia, is one of the area that evidenced from a century ago has been emitting CO_2 toxic gas to the earth surface. The infamous occurrence was in 1979, when Timbang Crater burst CO_2 gasses that made 149 people asphyxiated. Meanwhile, the latest occurrence was happened in 2013, where 5,000 people from Batur Sub-District, Banjarnegara, evacuated. In facing the threat of volcanic toxic gas, the local government has preparedness plan that stipulated in Contingency Plan Document of Banjarnegara 2012. This document contains the roles and responsibilities of involved stakeholders in toxic gas disaster management. The disaster management scenario if the disaster occurred also is available.

The main objective of this research is to analyze the past and present chain of warnings and evacuations for toxic gas events in the Dieng volcanic area, and to determine the improvements using modern geo-information techniques. The main method conducted in this research is by using in-depth interview to the stakeholders involved in toxic gas disaster management and to the people affected to the disaster. The respondents are chosen based on expert sampling technique to make sure that the respondents are expert in this field. Meanwhile, when interviewing people affected to disaster, snowball-sampling technique is used.

From the interview result, it is known that there are 44 stakeholders involved in the toxic gas disaster in Dieng. The stakeholder collaboration network shows that the total coordination between stakeholders reaches 133 coordination with BPBD of Banjarnegara as the most important stakeholder with 33 coordination. The establishment of BPBD of Banjanegara in 2012 also makes the toxic gas disaster management in Dieng more organized than before.

To enhance the toxic gas disaster management in Banjanegara, the research also tried to implement Sahana Eden with the base of Contingency Plan Document of Banjarnegara of 2012. Sahana Eden is an open-source software that provides solutions for disaster management stakeholders to minimize the impact of disaster by tracking the needs of people affected to the disaster and coordinating the responding stakeholders and their resources. The result is Sahana Eden can be perfectly implemented in Banjarnegara.

Keywords: *Dieng Plateau, volcanic toxic gas, preparedness, emergency response, Stakeholder Network Analysis, Sahana Eden*

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLE

ABBREVIATIONS

BAGANA	:	Muslim Ansor Volunteer
Bappeda	:	Regional Planning Agency
Bappenas	:	National Planning Agency
BASARNAS	:	National Search and Rescue Agency
BNPB	:	National Disaster Management Agency
BPBD	:	Regional Disaster Management Agency
BPPTK	:	Center for Research and Volcanic Technological Development
BPS	:	Central Agency on Statistic
Dinkes	:	Department of Health
Dinsosnakertrans	:	Department of Social Service, Manpower, and Transmigration
Disbudpar	:	Department of Culture and Tourism
Disbunhut	:	Department of Forestry and Plantation
Disdikpora	:	Department of Education and Sport
Dishubkominfo	:	Department of Transportation, Communication and Informatics
DPSDA dan ESDM	:	Department of Water Resources, Energy and Mineral Resources
DPU	:	Department of Public Work
Kesbangpolinmas	:	National Unity, Politics and Public Protection Office
KLH	:	Environment Office
Kodim	:	District Military Command
KOKAM	:	Muhammadiyah Preparedness Youth Force Command
KRB	:	Disaster Prone Area
ORARI	:	Amateur Radio Organization of Indonesia
PDAM	:	Fresh Water Regional Company
PGA	:	Dieng Observation Post

PLN	:	State-Owned Electric Company
PMI	:	Red Cross
Polres	:	District Police
Polsek	:	Sub-District Police
Puskesmas	:	Health Center
PVMBG	:	Center of Volcanology and Geological Disaster Mitigation
RBI	:	Topographic Map of Indonesia
SAR	:	Search and Rescue
Satpol PP	:	Municipal Police
TAGANA	:	Cadets Volunteer
TRC	:	Rapid Response Team

Chapter 1. General Introduction

1.1. Background

Gas bursts from volcanic craters and crater lakes pose a serious threat to humans life (U.S. Geological Survey, 2010). One of the infamous events, which attracted worldwide attention, is the Lake Nyos (Cameroon) incident in 1986. It was believed that concentrated CO_2 gases from Lake Nyos resulting more than 1,700 people asphyxiated (Nasr, 2009).

Dieng Plateau, which is located in Central Java, Indonesia, also has had similar tragedy that took more than 140 lives (Allard, Dajlevic, & Delarue, 1989). Dieng has eight monitored active craters while three of them potentially have toxic gases (Center of Volcanology and Geological Disaster Mitigation, 2012). They are Sikendang Crater, Sinila Crater and Timbang Crater. However, the toxic gas is not only comes from the craters, but also from the fissures near the craters. Between Sinila Crater and Timbang Crater, there is village named Pekasiran. In 1979, earlier than Lake Nyos disaster, the Sinila Crater became active. Its phreatic eruption triggered an earthquake, which caused people in Pekasiran Village to panic and run into low-lying area (Guern, Tazieff, & Pierret, 1979). They did not know that the earthquake had triggered gases bursts from fissures near Timbang Crater, which flew into exactly where the people were (figure 1.1). From later gas collection and analysis, it was determined that the casualties were suffocated by nearly pure CO_2 gases (Allard et al., 1989).

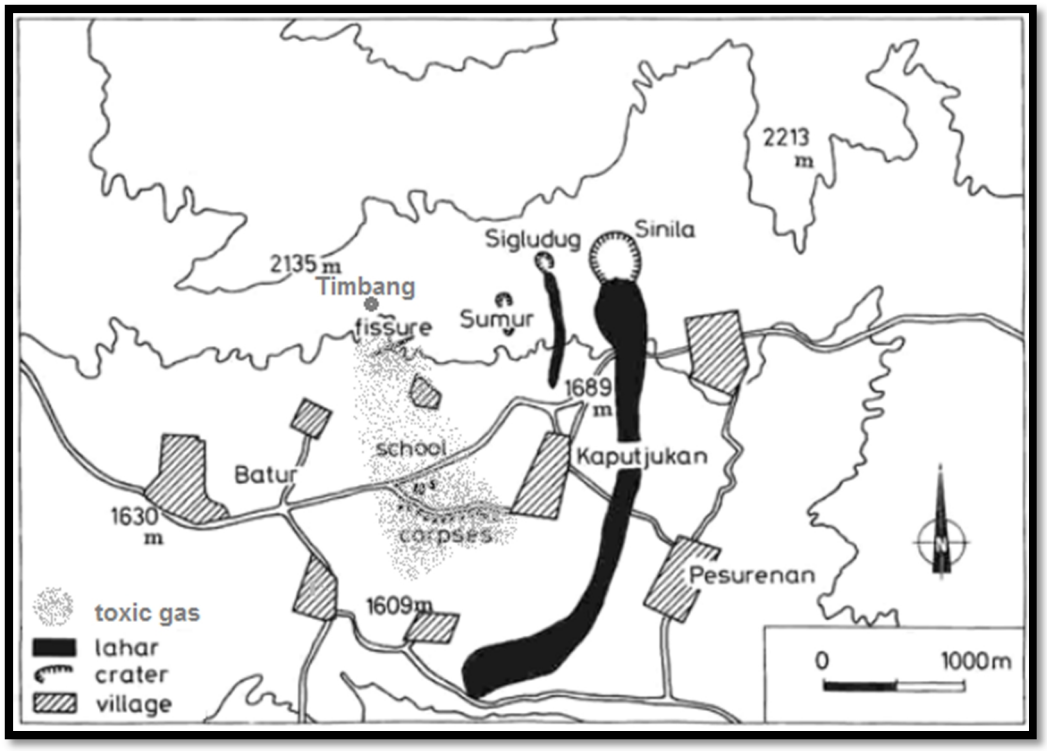


Figure 1.1. CO_2 gas flow in 1979 accident (adapted from Guern et al., 1979)

Dieng Observation Post has been monitoring concentration levels of several gases in Dieng's craters, including H_2S, CO_2, CO, SO_2, and CH_4. Since 2004, CO and CO_2 in Timbang Crater are continuously monitored through Gas Monitoring Station using Telemetry Low-Rate (TLR) Communication System. The sensor, Drager Polytron type IR, can detect the CO and CO_2 gases. TLR then sends the data from the sensor using radio signal every 5 minutes to the Dieng Observation Post (Center of Volcanology and Geological Disaster Mitigation, 2012).

The CO and CO_2 gases are not hazardous when the concentration are lower than 0.5% in the air, but when they are more than 1.5%, evacuation of people will be needed (Setyahadi & Kurniawan, 2012). These gases are very hazardous because they are colorless, odorless and poisonous. The local people cannot identify where the danger is (Giggenbach, Sano, & Schmincke, 1991; Ismail, 2011). They even named this hazard as "silent killer".

When outbursts of gases happen, the Government conducts selective evacuation according to the stages of hazard level. Usually, if Center of

Volcanology and Geological Disaster Mitigation (PVMBG) has issued the so-called High Alert level (the second highest level), the National Disaster Management Agency (BNPB) instructs full evacuation to the people who living in the villages within a radius of 1 kilometer from the burst-site (Setyahadi & Kurniawan, 2012).

The most first response function in emergencies lies to the local government (LaFeber & Lind, 2008). In the case of a volcanic toxic gas event in Dieng, the responsible institutions are the Dieng Observation Post (PGA) and Regional Disaster Management Agency (BPBD) of Banjarnegara. Both agencies sometimes need to break the complexity of bureaucracies to assure the Dieng people's safety even though stakeholder responses-chains agreement already stipulated in Contingency Plan of Banjarnegara Document (2012). For instance, in 2013, PGA closed the main road of Batur (without waiting the decision from BPBD of Banjarnegara) because there was toxic gas that crossed the road in 2 AM (figure 1.2).

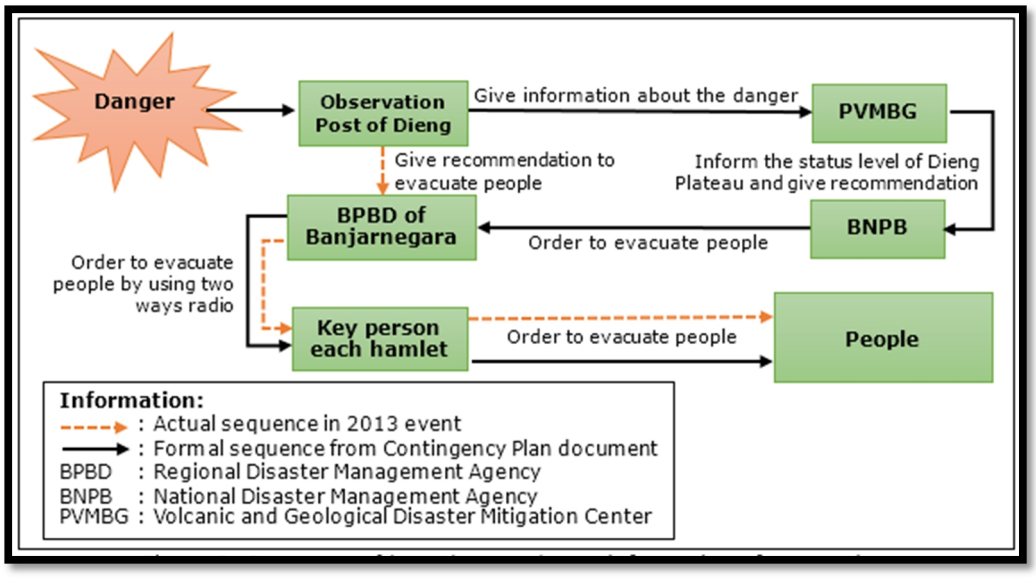


Figure 1.2. Sequence of how the people get information of evacuation (adapted from Center of Volcanology and Geological Disaster Mitigation (2012) and interview with key person of PGA (2014))

Contingency Plan Document of Banjarnegara 2012 was made by BPBD of Banjarnegara and PVMBG. It also has been approved by 40 institutions that

involved in this contingency plan. This document contains an evacuation plans, and as a part of preparedness phase to face the threat of toxic gas in Dieng Plateau.

Dieng has unique policy concerning disaster warning. BPBD of Banjarnegara applies silent warning to avoid unnecessary panic among the people. It makes sirens are strictly prohibited in Dieng. Disaster warning is given by the leader of each hamlet. Each hamlet gets the disaster warning from BPBD of Banjarnegara, which gets recommendation from PVMBG every six hours.

1.2. Research Problem

Volcanic toxic gas is a unique natural hazard. Oregon State University (2014) recorded that this type of hazard had killed people at three sites in Indonesia. They are Tangkuban Perahu Volcano, Papandayan Volcano, and Dieng Plateau. The last casualty at Tangkuban Perahu was happened in June 1923, where three boys were killed. At Papandayan, it was happened in December 1924, which killed a volcano observer. While in Dieng, the last casualty is 1992, which killed one person.

Several studies related to the preparedness and response phase are listed in many literatures. Shoemaker et al. (2011) stressed the prominence of enhancing the preparedness and resilience, and studied the steps to improve its aspect. Zhang et al. (2013) studied the evacuation of populations in a densely populated area of Beijing using population vulnerability distribution and trucks' disaster-information dissemination model as a consideration. Rifwan (2012) evaluated the effectiveness evacuation route in potential zones that affected to tsunami disaster in Padang. From disaster management perspective of Indonesia, a study has conducted by IRG & Tetra Tech Joint Venture (2007). It concluded that the current system capacity for disaster in Indonesia still lacks of development. For example in early warning category, warning dissemination system of Indonesia got only one score of maximum four. The comprehension and legitimacy of warning and the clarity of decision-making also got one score.

Previous studies that are mentioned above show that study about preparedness and response phase of volcanic toxic gas has not been discussed yet. It is maybe because the danger of volcanic toxic gas in Dieng is still underestimated comparing to another disaster such as earthquake, flood, volcanic eruption or tsunami. The location of Dieng, which is in the rural area also make the data acquisition for any research in this area more difficult.

Because of the uniqueness of the type of the hazard, the silent warning policy from government, numerous number of stakeholders involved, and the rareness of data, in-depth study of the process of preparedness and emergency response for volcanic toxic gas in Dieng Plateau is taken as a case study and is necessary to be done.

1.3. Research Objective

The main objective of this research is to analyze the past and present chain of warnings and evacuations for toxic gas events in Dieng volcanic area, Central Java and to determine the improvements using modern geo-information techniques. The specific objectives in this research are:

1. to identify the different stakeholders involved in volcanic toxic gas disaster preparedness and the evacuation process;
2. to critically assess the past volcanic toxic gas eruptions and the evacuation process in each event;
3. to determine the improvement of the individual elements of the response chain and the existing preparedness plan with emphasis on the use of modern geo-information techniques;
4. to design a disaster management scenario in which the suggestions are implemented.

1.4. Research Question

In order to achieve the objectives, several research questions are addressed as table 1.1:

Table 1.1. Research questions

No	Research Objectives	Research Questions
1.	To identify the different stakeholders involved in volcanic toxic gas disaster preparedness and the evacuation process	a. Who are involved in the preparedness and evacuation process? b. What are the role and responsibility of each stakeholder in the preparedness and evacuation process? c. How is the stakeholders' network in preparedness and evacuation process?
2.	To critically assess the past volcanic toxic gas eruptions and the evacuation process in each event	a. How are the past events of volcanic toxic gas disaster in Dieng? b. How is the evacuation process of volcanic toxic gas disaster in past events? c. Is there any issue or bottleneck related to the existing preparedness and evacuation process? d. Is the existing preparedness plan implemented properly?
3.	To determine the recommendations for improvement of the individual elements of the response chain and the existing preparedness plan with emphasis on the use of modern geo-information techniques	What are geo-information techniques that can be implemented to improve evacuation process in Dieng?
4.	To design a disaster management scenario in which the suggestions are implemented	a. On what bases the scenario is made? b. How the suggestions are implemented?

1.5. Research Limitation

This research discusses the preparedness and emergency responses for one of the hazards available in Dieng, which is volcanic toxic gas. Limitations in this research are:

1. The hazard focused in this study is volcanic toxic gas. However, there are several occurrences when the volcanic toxic gas was mixed with another hazard such as earthquake, volcanic mudflow or phreatic eruption.
2. The preparedness study in this research is derived from official preparedness plan from the local government of Banjarnegara District and in-depth interviews from institutional stakeholders related to the volcanic toxic gas disaster management.

3. The emergency responses study in this research is derived from in-depth interview from institutional stakeholders related to the volcanic toxic gas disaster management and people affected to the disaster.

1.6. Research Benefit

This research is provided with information about the local government's preparedness plan in facing the threats of volcanic toxic gas in Dieng Plateau. In addition, this research contains the detail of how volcanic toxic gas disaster was occurred from the stakeholders and people's perspective.

This study will be useful for government agencies, local communities, and other stakeholders involved in volcanic toxic gas disaster management. The several benefits of this research are explained as follows:

1. It evaluates the government's policies, especially in the preparedness phase and response phase to handle the volcanic toxic gas disaster.
2. It gives information about the occurrences of volcanic toxic gas disaster and its evacuation process from social perspective.
3. It gives understanding about the histories of volcanic toxic gas occurrences in Dieng.
4. It gives alternative improvements for preparedness policies and response policies to face the threat of volcanic toxic gas in Dieng.
5. It contributes for further research related to toxic gas especially in Dieng.

Chapter 2. Literature Review

2.1. Volcanic Hazard

Hazard is a source of potential or actual harm (Committee on Disaster Research in the Social Sciences, 2006). Since the first, volcanic hazards are known to be responsible for deaths of thousands people. Some eruptions did not cause casualties, but many others took thousands lives. One of the devastating eruption occurred in 1815 when Tambora Vocano in Indonesia erupted and caused 92,000 people were killed (Kusky, 2008).

Some of volcanic hazards are obvious, easy to be recognized such as lava flows, pyroclastic flows, tephra falls, and mudflows. However, not every volcanic hazard is easy to be seen or prevented, e.g. volcanic toxic gases. It is a one lesser-known hazard from volcanic hazards. Some gases are odorless and colorless, make them are difficult to identify. However, poisonous gases usually are released as an emission from volcanoes.

2.2. Volcanic Toxic Gas

Water (H_2O) and carbon dioxide (CO_2) are the most abundant magmatic volatiles in volcanoes. It followed by sulfur dioxide (SO_2), hydrogen sulfide (H_2S), carbon monoxide (CO), hydrogen fluoride (HF) and hydrogen chloride (HCl) (MIAVITA Team, 2012). Magma that contains those dissolved gas are freed to the atmosphere during the eruption. Gases were also released from magma below the ground and magma that rise to the surface.

Unlike volcanic eruptions, gases emission did not disturb vegetation and landscapes (Kusky, 2008). However, it can be hazardous for human. Different with Kusky, Pikiran Rakyat (2013) inform that volcanic toxic gas that burst from Timbang Crater in April 2013 resulted 20 hectares of potato fields was harmed and cannot be harvested. The gases that considered as the greatest potential hazard for human and its properties are SO_2, HF, and CO_2 (U.S. Geological Survey, 2010).

2.2.1. Sulfur Dioxide

When the volcano erupts, one of the dangerous gas emission that released to the atmosphere is sulfur dioxide. Sulfur dioxide is a colorless gas with a strong odor that causes breathing disturbance, respiratory illness, and irritated skins. Sulfur dioxide is also associated with asthma and chronic bronchitis. The effects from this gas on people are depended from three aspects (U.S. Geological Survey, 2010), which are the amount of gas that is released to the atmosphere, whether the gas slid into the troposphere or stratosphere, and the wind and the weather that may disperse the gas.

In a small amount, SO_2 leads to acid rain and air pollution. However, the increasing amount of SO_2 in the atmosphere can have a big effect to the changes of temperature. For example, in November 5, 2010, when the Mount Merapi erupted, the temperature data of earth surface from the AQUA satellite shows that Indonesian temperature reaches the lowest point with 26.4^{o} C. The SO_2 lowered the air temperature because it is blocking the sunlight in the atmosphere (Ambarsari, 2014).

2.2.2. Hydrogen Fluoride

Hydrogen fluoride is a colorless gas and has strong odor, but non-flammable (SPRI, 2014). Hydrogen fluoride gas is also highly corrosive, so it will damage metal structure. At low concentrations, hydrogen fluoride causes irritation on the eyes, nose and throat, while excess fluorine in a significant amount during ash eruptions can cause death. In 1785, eruption from Laki's fissure (Iceland) released hydrogen fluoride that causing devastating famine, resulted 10,521 people killed.

2.2.3. Carbon Dioxide

Volcanoes emit around 130 million tons of CO_2 per year (U.S. Geological Survey, 2010). Carbon dioxide is invisible, odorless and heavier than air. In low

concentrations, this gas does not threat human life because it easily dissolved with the air. However, in certain circumstance when the CO_2 accumulated in massive amount, CO_2 is become dangerous. Some of notorious emissions of CO_2 gases happened in Africa. In 1984, CO_2 were emitted from Lake Monoun in West Cameroon, caused 37 people died. Bigger incident happened in 1986 with 1,700 people were killed when a CO_2 gas from Lake Nyos in Cameroon burst into villages.

The newest accident of CO gas burst was happened in Indonesia. The burst was occurred during the phreatic eruption in February 1979, in Dieng, Central Java. At least 149 people asphyxiated (Vivanews, 2011b). Figure 2.1 shows the CO_2 gas emits from the Timbang Crater and flows to the low-lying area.

Figure 2.1. CO_2 gases mixed with water vapor from Timbang Crater (Dieng) flow into low-lying area (Vivanews, 2011a)

The CO_2 gas bursts in Dieng have been recorded in Dieng Observation Post (PGA of Dieng) from May 1928 until the latest one was happened in 2013. PGA of Dieng determines the CO_2 threshold values and its impacts to human life as shown in table 2.1.

Table 2.1. CO_2 threshold value and its impact to human life

No	CO_2 (% Volume)	Information
1	< 0.5	Safe
2	> 1.5	Need to be evacuated immediately
3	1.5 – 7.99	Out of breath, sweating, dizzy and feeling weak
4	8 – 14.99	Dizzy, nausea, unconscious
5	15 – 24.99	Unconscious
6	> 25	Unconscious and result in death

Source: PGA of Dieng

Giggenbach et al. (1991) conducted a descriptive research about CO_2 gases from Lake Nyos and Monoun (Cameroon), Laacher See (Germany), Dieng (Indonesia), and Mt. Gambier (Australia). He drawn a conclusion that by judging from the geological environment, the gas released in Dieng is stored at shallow depth. It makes the CO_2 gas emission will continues in Dieng. Some actions to prevent similar loss of life in Dieng have been done by local government. Such as intensive and sustainable observations in craters that have high potential of toxic gas, installing new and sophisticated observation equipment, and the establishment of Banjarnegara's disaster management agency in 2012 (BPBD of Banjarnegara).

2.3. Disaster Management

There are many definition of disaster management. Rao et al. (2007) defines disaster management as a process to reduce the social and physical impact of disaster. It covers mitigation, preparedness, response, and recovery effort. Another researcher, Laura et al. (2008) defines disaster risk management as the total activities which has been done before, during, and after the disaster to minimize the impact and to recover from its losses. Meanwhile, Pinkowski (2008) stated that disaster management is rooted to the fundamental belief on how people's effort to avoid disaster or reduce the impact of the disaster. It is including planning, preparedness, mitigation, response, recovery, rehabilitation, and reconstruction.

To understand the complexities of disaster management process, Pinkowski (2008) summarizes the process into cycle which comprises into five stages (figure 2.2):

1. Disaster preparedness and mitigation, related to the actions to prevent the disaster. It involves also all steps needed to make a disaster resilience structures and communities.
2. Disaster response, related to the actions when the disaster occurs, such as search and rescue operations.
3. Disaster relief, related to the actions to fulfill the emergency needs, like the needs of shelters for refugees, foods and water.

4. Disaster rehabilitation and reconstruction, related to the actions to restore the important facilities to the condition before the disaster occurs (e.g. rebuild the school that collapse because of the earthquake).
5. Disaster recovery, related to the actions that focus to the long-term recovery, either social, economy or physical recovery. The goal is also preventing the similar disaster happened again in the future or reduce the impact for future disaster.

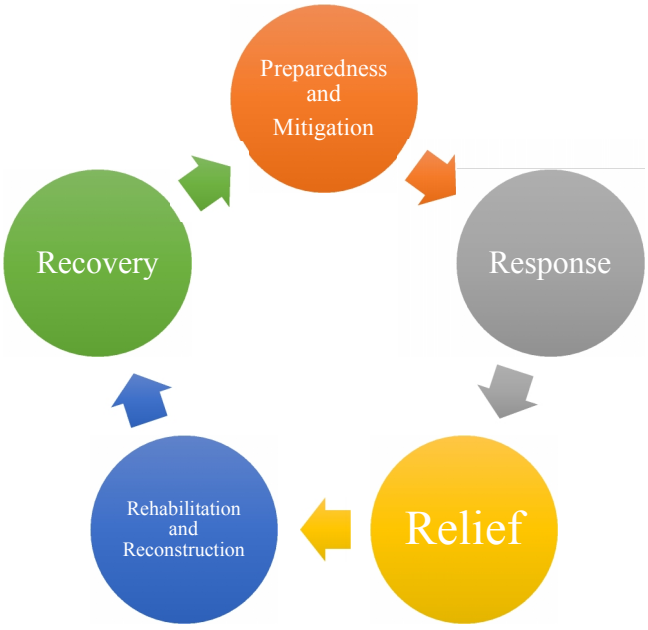


Figure 2.2. Disaster management cycle (Pinkowski, 2008)

All of these five stages are well integrated into disaster management cycle. These stages can be studied separately, but it needs to be remembered that each stage is a complement and a supplement to other stages. Therefore, each stage is inseparable from the others as an effort to resolve the disaster-related problems.

Meanwhile, Laura et al. (2008) divided the key stages in disaster management cycle into three stages, which are explained as follows:

1. Before a disaster (pre-disaster), activities in this phase are taken to minimize losses which caused by a potential hazard

2. During a disaster (disaster occurrence), is called also as emergency response activities. During this phase, activities are taken to ensure the needs of victims are fulfilled and the suffering is minimalized.
3. After a disaster (post-disaster), activities are taken to accomplish early recovery and rehabilitation to the victims. This phase also named as response and recovery activities.

2.3.1. Preparedness

Disaster preparedness is planned activities to respond and to cope the effect of disaster. According to MIAVITA (2012), there are several activities in preparedness. The activities are: (1) assessing hazard and risk; (2) defining the alert levels; (3) evaluating each possible scenario and its probability; (4) installing early warning systems; (5) designing emergency plans; (6) training people who may affected to the disaster and increasing their awareness level; (7) establishing the policies and standard operating procedure; (8) securing important resources; (9) training of experts; (10) planning and scheduling the drills and exercises.

Government's preparedness to face volcanic toxic gas in Dieng was already regulated in Contingency Plan Document of Banjarnegara 2012. That document contains risk assessment, disaster scenario based on worst-case scenario, disaster prone area map, and policies and strategy to manage the disaster scenario. At least 40 stakeholders are mentioned in contingency plan and should be involved in the preparedness and response activities.

2.3.2. Disaster Response

Disaster Response is an immediate action to provide protection of life and property, and reducing the effect of a disaster (Committee on Disaster Research in the Social Sciences, 2006). Disaster management in Dieng, especially volcanic toxic gas disaster management, the responses of stakeholders are divided into five sectors, as stated in Contingency Plan Document of Banjarnegara 2012, which are:

1. *Coordination sector*. The leading stakeholder of this sector is BPBD of Banjarnegara. It has main roles to ensure a good coordination of each sector, to ensure a good disaster response and recovery activities, to ensure that all refugees, victims, property losses, all facilities and infrastructures, logistic, and equipment that are used in the disaster management are inventoried, to record each victim's losses caused by the disaster, and to maintain the infrastructures available in disaster area.
2. *SAR sector*. This sector has main roles to minimize the victims of the disaster, to evacuate wounded victim as quick as possible and appropriately, and to record wounded victims.
3. *Social sector*. This sector has main roles to fulfill the foods for all refugees, to fulfill non-food needs for all refugees, to ensure the availability of camp-kitchen in each shelter, to fulfill the logistic for all refugees, to ensure the safety of all refugees, and to maintain the psychology condition of all refugees.
4. *Health sector*. The leading stakeholder for this sector is Health Department of Banjarnegara (Dinsosnakertrans). This sector has main roles to minimize the dead victims, to serve all of wounded victim, and to ensure a good health service for all refugees.
5. *Facilities and infrastructures sector*. This sector has main roles to ensure good evacuation routes, to ensure proper shelters for all refugees, to ensure proper facilities in the shelters, and to ensure proper transportation for all refuges during evacuation.

2.4. Stakeholders

Reed et al. (2009) defines stakeholder as individuals, groups, or institutions that affect and/or be affected by the decision that made. Associated with disaster management, the stakeholders generally are people affected to the disaster, public officials, and other institutions that concern in the disaster management. Related to the disaster management, the involved stakeholders are vary. In Indonesia, the outline of stakeholder that involved in disaster management is regulated in Law No. 24 of 2007 about disaster management.

According to Sundawati & Sanudin (2009), stakeholders can be divided into three categories, which are primary stakeholders, key stakeholders, and secondary stakeholders. Primary stakeholders are stakeholders that have direct interest and get direct impact from policies or programs of disaster management. Key stakeholders are stakeholders that have legal authorities in decision-making of disaster management. Meanwhile, secondary stakeholders are stakeholders that do not involved directly to the policies or programs of disaster management, but have concern about government decision.

2.4.1. Stakeholders' Preparedness

To deal with the volcanic threat, people who live near the volcanic area should apply a comprehensive civil protection (civil protection system) that integrated with a structured system for predicting and early warning (MIAVITA Team, 2012). There are three main components in the civil protection system:

1. National authorities

   These stakeholders are responsible for civil protection in the national level, such as PVMBG, BNPB, Ministry of Social and BASARNAS .
2. Local stakeholders

   Local stakeholders including province level, district level, and even sub-district level such as Bappeda of Banjarnegara, PMI of Banjarnegara, and Dinsosnakertrans of Banjarnegara. They need to be organized and trained to cope the emergency, because during the volcanic crisis local government stakeholders are the first stakeholders that have to response.
3. Scientific community

   It is including universities, observatories, and research institutes.

2.4.2. Stakeholder Analysis

Grimble (1998) defines stakeholder analysis as a method to obtain understanding about a system and to assess the changes impact of the system by

identifies the primer stakeholders and assess it each interests. According to Grimble (1998), there are five stages of stakeholder/network analysis (figure 2.3):

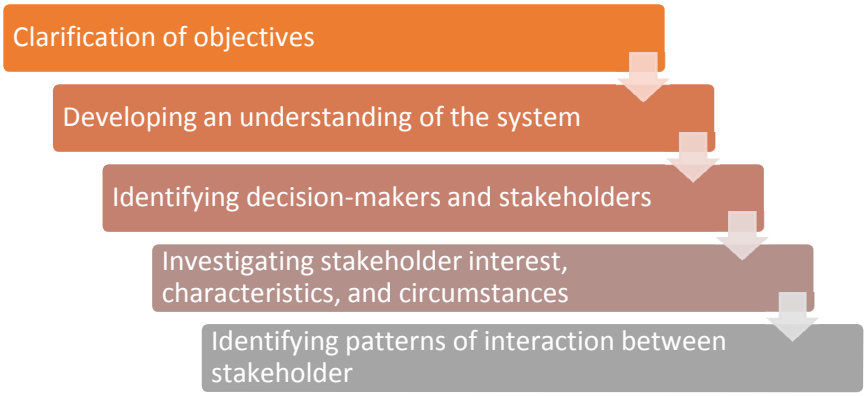


Figure 2.3. Stages of network analysis

Related to the last stage, Reed et al. (2009) explains three methods that have been developed:

- Actor-linkage matrices

  First is creating a table that has a name of stakeholders, both rows and column. Then, the relation of each stakeholder is drawn using key word. It can be used to describe the stakeholders' relationship, conflict, complementary or cooperation.

- Social Network Analysis (SNA)

  According to Vance-Borland & Holley (2011) stakeholder social network analysis began in the 1930s when Moreno (1934) invented the sociogram. Sociogram is using nodes/vertex to represent individuals, group or organization, and lines/edges to represent relationship between them. The network perspective assumes that: (1) relationship between each stakeholder is important; (2) stakeholders are interdependent rather than autonomous; (3) a relationship between two stakeholders represents a flow of resources, whether material or immaterial; and (4) network structures enhance or obstruct stakeholders' ability to act (Wasserman and Faust, 1994 in Vance-Borland & Holley, 2011).

  SNA has been used in a wide variety of context, such health sector, counter-terrorism sector, business sector, and natural resources sector. Vance-Borland

& Holley (2011) describe the stakeholder social network analysis and facilitation in coastal Oregon, United States. By using snowball-sampling survey to people who work on sustainable natural resources issues, he asked the respondent a variety of network question. Then, they mapped the collaborated network as described in the figure 2.4. They found that stakeholder social network analysis make valuable contributions to conservation outcomes.

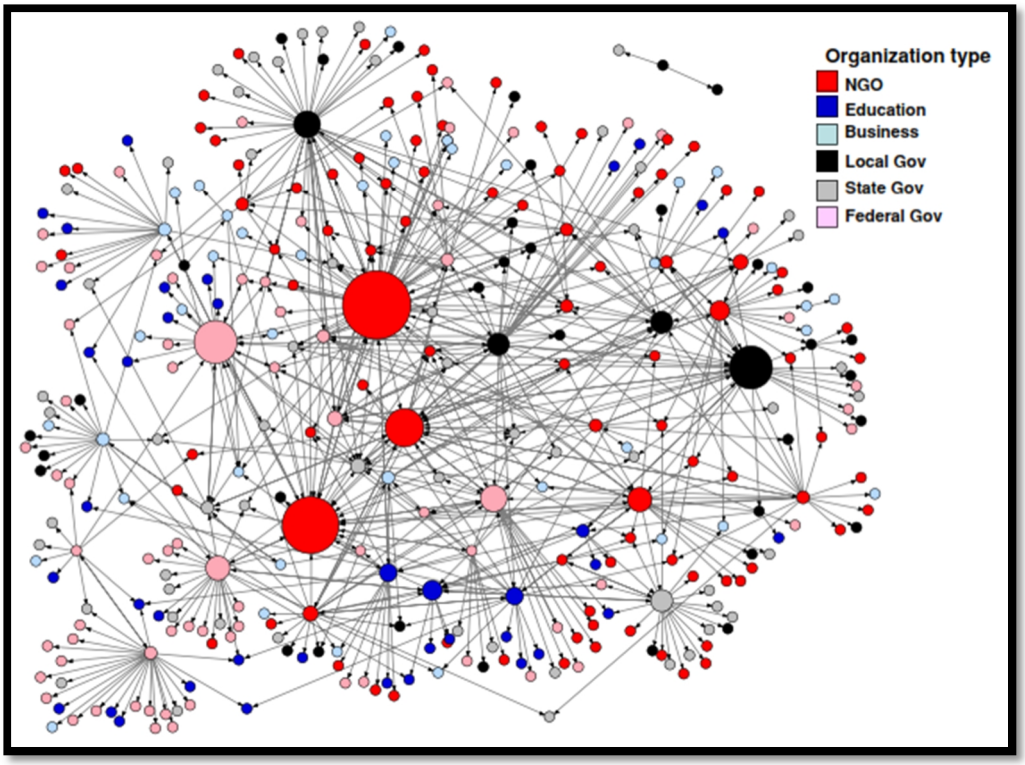


Figure 2.4. The example of collaboration network (Vance-Borland & Holley, 2011)

In disaster risk management, Yandong (2010) stressed the importance of social network in reducing the risk during and after disaster in Wenchuan earthquake 2008. His work describes and discusses the roles of social network in reducing risk of disaster with based on survey data on Wenchuan earthquake in 2008.

- Knowledge mapping

  Knowledge mapping is a tool in business and organization, but sometimes is used in conjunction with SNA and knowledge map.

2.5. NodeXL

NodeXL is a free, open-source template for Microsoft Excel that ease the network graphs exploration, including SNA (NodeXL Team, 2015). NodeXL users can collect, analyze, and visualize a variety of networks. NodeXL integrates into Microsoft Excel and opens as a workbook with specific worksheets containing the elements of a graph structure. NodeXL can also import a variety of graph formats. The graphical user interface of NodeXL is shown in figure 2.5:

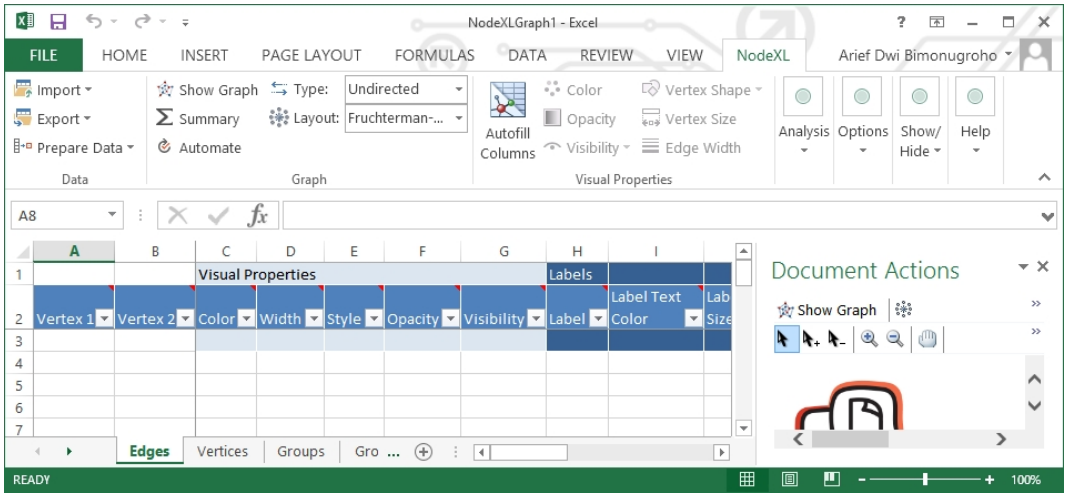


Figure 2.5. User interface in NodeXL

2.6. Sahana Eden

The word "Sahana" means "relief" in Sinhala, one of Sri Lanka languages. Sahana software was built by IT practitioners in Sri Lanka as a relief effort solution following Indian Ocean Tsunami in 2004. It then has gradually grown in order to cooperate with emergency and disaster management practitioners, university professionals, and volunteers in the software development process.

Sahana "Eden" (**E**mergency **D**evelopment **EN**vironment) is an open-source software that provides solutions for disaster management stakeholders to minimize the impact of disaster by tracking the needs of people affected to the disaster and coordinating the responding stakeholders and their resources (Tressel et al., 2014). Sahana Eden can be easily accessed through the web, or locally from a USB flash drive if the area has poor internet connection. The local version can be

synchronized with the web and vice versa, to make sure that the data/information is up to date. Sahana Eden is also highly configurable and easy to modify. It also can be adjusted with necessity in the field. With these features, Sahana Eden is expected can helps stakeholders of disaster management to manage disaster more effective and efficient.

This software has modules that can be modify or configure to provide functionality in wide range. Those modules are:

1. *Organization registry*. Sahana Eden's can tracks what stakeholders are active in what context, providing coordination on each stakeholder. This module also has abilities to record the information about each stakeholder such as name of agency, address, field site, etc. It then mapped and linked into other modules such Human Resources, Assets, and Inventory.
2. *Project tracking*. This module is a tool to help each stakeholder responds to area of disaster that the help is most needed. The stakeholders may also collaborate with other stakeholders that engaged in similar work.
3. *Human resources*. Sahana Eden also provides tool to manage people and volunteers involved in the disaster management. It tracks the location of person, in what organization the person is, and what skills he/she has.
4. *Inventory*. This module is a tool to share inventory information for each stakeholder. It will improve the efficiency of supplying basic essential to people affected to the disaster.
5. *Assets*. Assets module contain inventory of heavy equipment, vehicles, tools, and supplies needed in disaster response phase. It able to track the location of the equipment, how the condition of the equipment, and where it has been assigned.
6. *Assessment*. Sahana Eden can be used to analyze data with the assessments module. The assessment can be displayed in many customable templates. The purpose of this module is to help stakeholders build more effective plan related their activities in disaster management.

7. *Scenarios and events*. This module helps stakeholders, especially government stakeholders to have a better plan for disaster management. It can be used for many disaster scenarios, including its management scenarios.
8. *Map*. Sahana Eden is fully integrated with map functions. It allows any spatial data displayed on the map. Sahana Eden supports different formats from other sources of GIS such as topography, weather, population, or risk map.
9. *Shelter management*. Sahana Eden has a module that provides to track information on shelters called The Shelter Registry. It contains shelters locations, services provided in each shelter, organization that responsible in that shelter, contact in each shelter, demographic, and needs.
10. *Messaging*. Sahana Eden provides message communication by Email, SMS, Twitter and Google Talk. Each user can send messages to predetermined group at once. Interactive messages can also be configured so if any user replies the message, it will be stored to Sahana Eden.

Related to the study of Sahana Eden, Ngo (2013) already conducted a comparative work between Sahana Eden and Ushahidi platforms. He used a study area in Christchurch, New Zealand. New Zealand is situated on the tectonic plate boundary between the Pacific Plate and the Australia-India Plate, causing this place suffers devastating earthquakes every year. The research concludes that both platforms have its own excess value (table 2.2).

Table 2.2. Comparison between Sahana Eden and Ushahidi

	Ushahidi	Sahana Eden
Data input	Text message, email, twitter, web-forms	CSV format
Analysis	Intermediate level	Inadequate
Data Management	Intermediate level with data filter by time and incidents	Advance level with various modules
Visualization	Interactive mapping	Interactive mapping
User's Evaluation	Fairly satisfied	Satisfied

Source: Ngo, (2013)

Chapter 3. Study Area

3.1. General Information of Dieng Plateau

The study area for this research is located in Dieng Plateau, Central Java Province, Java Island, Indonesia. Administratively, there are two regencies located in Dieng Plateau, which are Wonosobo and Banjarnegara. Geographically, it is located in the Western side of Sindoro Volcanic Complex. Although a part of Dieng is situated in Wonosobo, but many danger craters are located in Banjarnegara such Sinila Crater and Timbang Crater. Because of that, the focus of the study area of this research will be in Banjarnegara District, specifically in Batur Sub-District (figure 3.1).

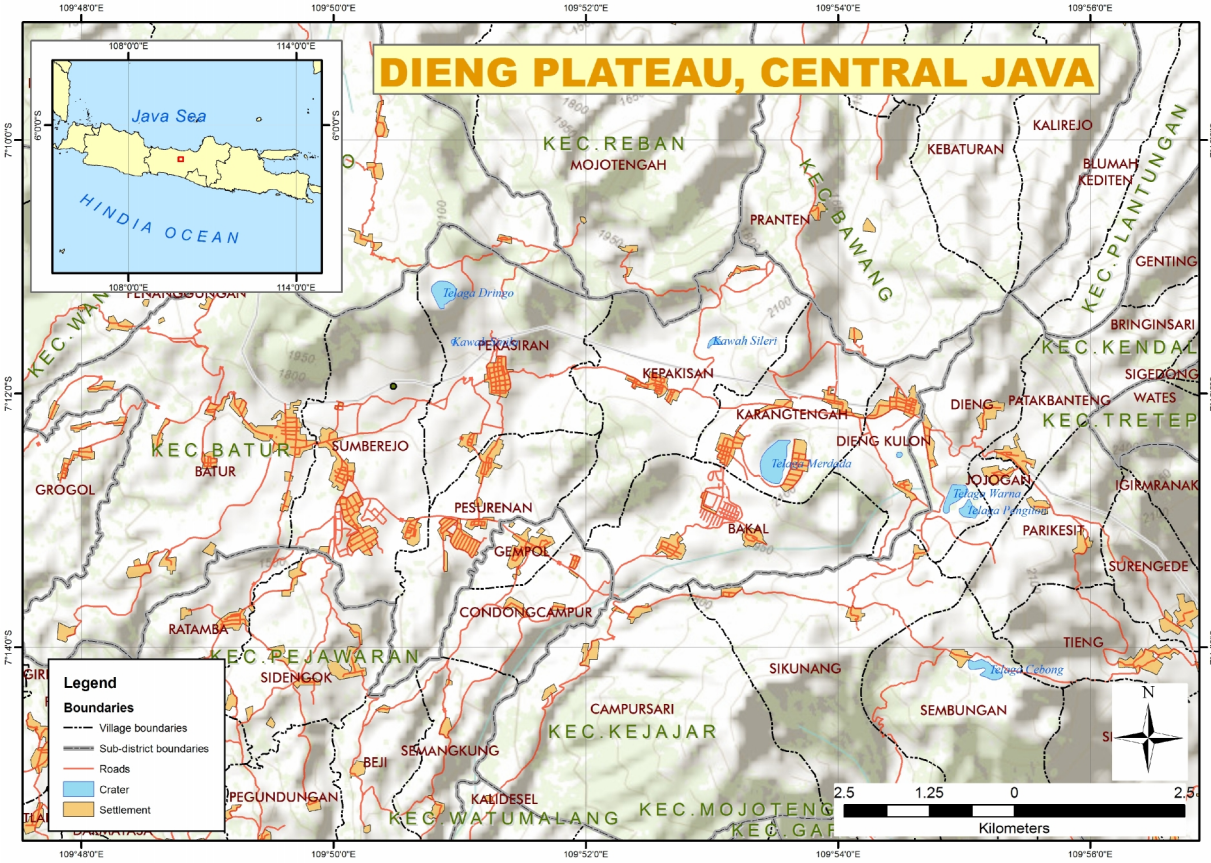


Figure 3.1. Location of Dieng Plateau (adapted from BNPB, 2011)

3.2. Geomorphology of Dieng

Geomorphology of Dieng is divided into two geomorphological units, which are mountains unit and plateau.

1. Mountains Unit

   Except for the central part of the Western area, this unit occupies the entire Dieng region. The volcanoes are composed from Mt Seroja ranges: Mt. Kunir, Mt. Prambanan, Mt. Pakuwaja, and Mt. Kendil ranges: Mt. Butak, Mt. Petarangan, Mt. Prau, Mt. Patakbanteng, Mt. Jurangrawah, Mt. Blumbang, Mt. Bisma, and Mt. Nagasari. All of those volcanoes are stratovolcanoes type.

2. Plateau

   This geomorphological unit is found among volcanic ranges and solitary cones that occupied by volcanic material. It is located in the central part of Western area of Dieng.

3.3. Geology of Dieng

The volcanic activities of Dieng Complex consists of six groups (Dan Miller, Sukhyar, Santoso, & Hamidi, 1983). Dan Miller et al. (1983) grouped Dieng Complex from its relative ages, from the oldest to the youngest:

1. Jimat, Prau and Tlerep Volcanic Complex. This volcanic complex is the oldest and already extinct. There is no original volcano morphology remains.
2. Bisma, Seroja, and Nagasari Volcanic Centers. This group is younger than Jimat, Prau and Tlerep volcanic complex. It is indicated by the less separated slopes. The original volcano morphology also remains existed.
3. The volcanic cones and explosion craters of intermediate age. This group consists of Butak-Petarangan stratovolcano, Dringo stratovolcano, Pagerkandang stratovolcano, Pangonan-Merdada stratovolcano, Igir Binem pyroclastic cone and Siterus Crater. They are distributed over the Dieng Complex and active for a long period. These centers produced a phreatic deposit that covered all older volcanic landforms in the Dieng Complex.

4. The Dieng tephra sequence. It consists of a blanket of tephra deposits that covered the Dieng Complex.
5. Lava cone, lava flow, and dome sequence in the Eastern part of Mt. Dieng. There were five vents in Eastern part of Dieng that produced lava dome and lava flow. They are Prambanan flows, Pakuwaja dome and flows, Kunir dome and flows, Kendil dome and flows, and Sikunang lava flows.
6. Postlava-complex phreatic eruption and explosion craters. The numerous eruptions have occurred during prehistoric and historic event as described in Table 3.1. The products of these eruptions are limited around the craters in the Dieng Complex. The sediments are mud and shale components. Figure 3.2 shows the geological map of Dieng.

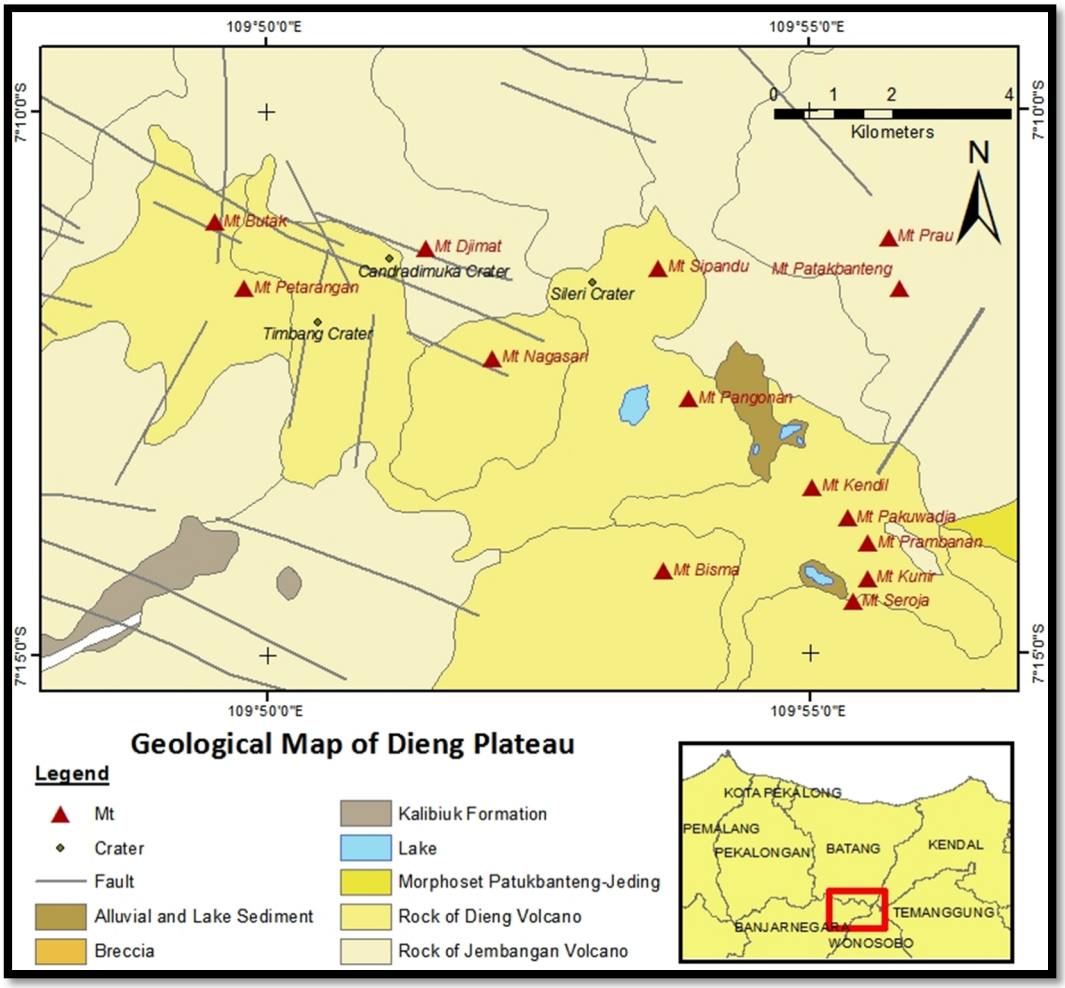


Figure 3.2. Geological map of Dieng Plateau (adapted from Puslitbang Geologi, 2008 and Dan Miller et al., 1983)

3.4. Volcanic events in Dieng Plateau

For centuries, volcanic activities at Dieng have been dominated with phreatic eruptions. Some of those eruptions did not cause casualties, but some of them are catastrophic. The occurrences of eruptions and toxic gas bursts over the last three centuries are listed in table 3.1:

Table 3.1. Volcanic activities in Dieng Plateau

Date of Event	Site	Phenomena	Aftermath
1786	Candradimuka Crater	Gas plume, block projections, ash falls, crater formation, felt seismicity, fissure opening	38 killed
1826	Mt Pakuwadja	Gas plume, block projections, ash falls, crater formation	Several fatalities
13 May 1928	Timbang Crater	Gas plume, block projections, ash falls, crater formation, mudflows, CO2 outflow, felt seismicity, fissure opening	40 killed
13 Oct 1939	Timbang Crater	Gas plume, block projections, ash falls, crater formation, mudflows, CO2 outflow, felt seismicity, fissure opening	10 killed
4 Dec 1944	Sileri Crater	Gas plume, block projections, ash falls, crater formation, fissure opening	117 killed 250 injured
12 Apr 1945	Candradimuka Crater	Gas plume, block projections	-
13 Dec 1956	Sileri Crater	Gas plume, block projections, ash falls	-
13 Dec 1964	Sileri Crater	Gas plume, block projections, ash falls, crater formation	114 killed
20 Feb 1979	Timbang Crater	Gas plume, block projections, ash falls, crater formation, mudflows, CO2 outflow, felt seismicity, fissure opening	149 killed, 17,000 evacuated
28 May 2011	Timbang Crater	Felt seismicity, CO2 outflow	1,300 evacuated
11 Mar 2013	Timbang Crater	Tectonic earthquake, CO2 outflow	5,000 evacuated

Source: adapted from Allard et al., 1989; Aryono, 2013; Center of Volcanology and Geological Disaster Mitigation, 2012; Hidayat, 2011; PVMBG, 2014; Seach, 2010; Volcano Discovery, 2014

3.5. Volcanic prone area in Dieng

In 2011, BNPB made a thematic map about volcanic disaster prone area in Dieng (figure 3.3). The 28 May 2011 disaster, which makes 1,300 people need to be evacuated, is used as a base hazard in this map. So far, this map has never been updated by either central government or local government.

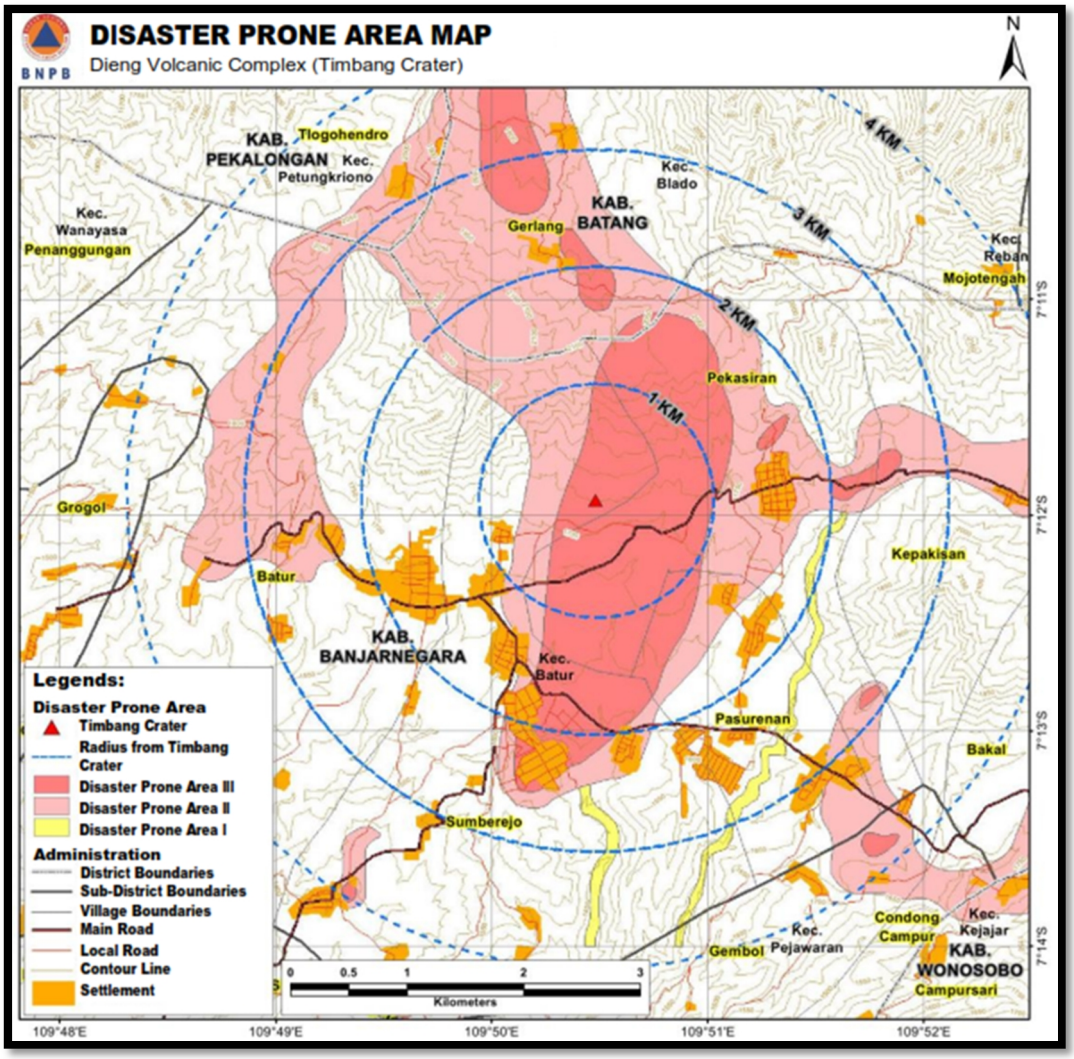


Figure 3.3. Volcanic prone area in Dieng (BNPB, 2011)

Chapter 4. Research Methodology

Method is a way to obtain the objective, while research is an effort to collect data that will be analyzed. This research is designed as a descriptive research with a qualitative approach. It is an effective method to describe existed phenomena, either natural phenomena or modified phenomena (Dasim, 2012). In descriptive research, variables in the study are not manipulated. All activities, situations, occurrences, aspect components and variables flow as it is. In qualitative approach, the methodology is not come from the research question like quantitative approach. There are no standard steps in qualitative approach that can be used as a benchmark. Maxwell (1996) in Alwasillah (2008) in Bachri (2010) stated:

> *There is no way to logically or mechanically converts research questions into methods; your methods are the means to answering your research, not a logical transformation of the latter.*

There are several types of data collection in qualitative approach. Sugiyono (2007) in Bachri (2010) specified three data collections, which are observation, interview, and documentation. Then, to assure the validity of the research, triangulation is used.

Qualitative approach is a study of describing and analyzing phenomena, events, social activities, attitudes, beliefs, perceptions, thoughts of people individually or in groups (Bachri, 2010). According to Creswell (1998), there are several common characteristics of qualitative approach, such as: the analysis of the data is inductively, recursively, and interactively; framing of human behavior and belief within a social-political/historical context or through a cultural lens; and holistic view of the social phenomena. Qualitative approach was chosen in this research because it can examines the participants' perspectives with interactive and flexible strategies (Mack, Woodsong, M.MacQueen, Guest, & Namey, 2005).

There are two types of data in this research, primary data and secondary data. Primary data were obtained by using in-depth interview, while secondary data

were collected from stakeholders related to the volcanic toxic gas in Dieng. In-depth interview was done to stakeholders related to the volcanic toxic gas disaster management in Dieng and to people who affected to the disaster. The research is divided into three phases, which are pre-fieldwork, fieldwork, and post fieldwork. The detailed activities in those phases are explained as follow sub-chapters:

4.1. Pre-Fieldwork

The main activities in the pre-fieldwork are collecting and reviewing literatures related to disaster preparedness, disaster emergency responses, law of disaster mitigation in Indonesia, and volcanic toxic gas histories in Dieng. Other activities also conducted in this phase such as determination of sampling technique, determination of study area, formulation of key questions for questionnaires, and preparation to the fieldwork phase such preparing permission letter.

4.1.1. Determination of Sampling Technique

Purposive expert sampling technique will be implemented while choosing the sample in institutional stakeholders and the sample of people affected to the volcanic toxic gas disaster events. This type of purposive sampling technique is used to collect knowledge from individuals that have particular expertise (Lund Research Ltd, 2012). For example, when interviewing Dieng Observation Post (PGA of Dieng), the chosen sample is key persons of PGA of Dieng who directly involved in the last event of volcanic toxic gas evacuation process in Dieng. This technique was chosen to assure that the respondents are expert in volcanic toxic gas event and have experience about the preparedness and emergency response process in Dieng. Meanwhile, when interviewing people affected to the disaster, the chosen respondents are they who experienced the disaster directly.

4.1.2. Determination of Key Questions for Questionnaire

The interview will be conducted in in-depth (unstructured interview). Because of it, the list of key questions to the respondents only as global/major

questions which then followed by flexible follow-up questions that depend on the respondent's responses. The key questions are formulated in order to answer the research problems and to achieve the research objectives.

The list of key questions was made into two type of respondents. First is the list of key questions for institutional stakeholders. The questions were focused on how the disaster management stakeholders works, how each stakeholder deals with the disaster, what its roles and responsibilities, and how the collaborations with other stakeholders. Second is a list of key questions for people who affected to the disaster. The questions are mainly to dig information from the witnesses of toxic gas disaster about how the disaster happened, how the situation at the time, and how the evacuation process was.

4.2. Fieldwork

The methods that will be implemented in this research are displayed as listed in table 4.1:

Table 4.1.Method in each research question

Research Question	Method	Variables	Requirement	Expected Output
Research Objective 1: To identify the different stakeholders involved in volcanic toxic gas disaster preparedness and the evacuation process				
Who are involved in the preparedness and evacuation process?	In-depth interview with BPBD of Banjarnegara	• Law and legal basis • Task and duties	List of key questions for in-depth interview	List of stakeholders involved in the preparedness and evacuation process
What are the role and responsibility of each stakeholder in the preparedness and evacuation process?	In-depth interview with stakeholders involved	• Law and legal basis • Task and duties	List of key questions for in-depth interview	Information of stakeholders' responsibility in volcanic toxic gas disaster
How is the stakeholders' network in preparedness and evacuation process?	In-depth interview with stakeholders involved	• Law and legal basis • Task and duties	List of key questions for in-depth interview	Stakeholder's collaboration network
Research Objective 2: To critically assess the past volcanic toxic gas eruptions and the evacuation process in each event				
How are the past events of volcanic toxic gas disaster in Dieng?	• In-depth interview with stakeholders involved and people affected to the disaster	• Respondents' knowledge	List of key questions for in-depth interview	Information of the past events of volcanic toxic gas disaster in Dieng,

Research Question	Method	Variables	Requirement	Expected Output
	• Collecting secondary data from stakeholders and media	• Availability of secondary data		including its spatial distribution
How is the evacuation process of volcanic toxic gas disaster in past events?	• In-depth interview with stakeholders involved and people affected to the disaster • Collecting secondary data from stakeholders and media	• Respondents' knowledge • Availability of secondary data	List of key questions for in-depth interview	Information of the evacuation process of volcanic toxic gas disaster in Dieng, including its spatial distribution
Is there any issue or bottleneck related to the existing preparedness and evacuation process?	In-depth interview with stakeholders involved and people affected to the disaster	Respondents' knowledge	List of key questions for in-depth interview	Issues related to preparedness and evacuation process
Is the existing preparedness plan implemented properly?	• In-depth interview with stakeholders involved and people affected to the disaster • Comparing with contingency plan document of Banjarnegara	Respondents' knowledge	• List of key questions for in-depth interview • Contingency plan document of Banjarnegara	Findings about the implementation of preparedness plan of Banjarnegara
Research Objective 3: To determine the recommendations for improvement of the individual elements of the response chain and the existing preparedness plan with emphasis on the use of modern geo-information techniques				
What are geo-information techniques that can be implemented to improve evacuation process in Dieng?	In-depth interview with stakeholders involved and people affected to the disaster	Respondents' knowledge	List of key questions for in-depth interview	Geo-information techniques that can be implemented
Research Objective 4: To design a disaster management scenario in which the suggestions are implemented				
On what bases the scenario are made?	Comparing the different bases of disaster management's scenarios	Disaster management's scenarios	Preparedness plan document	The bases of disaster management scenario
How the suggestions are implemented?	Using Sahana Eden in the disaster management of Banjarnegara	Disaster management's scenarios	Preparedness plan document	Implementation of Sahana Eden in the disaster management of Banjarnegara

4.2.1. In-Depth Interview

In-depth interviews are one of the main methods of data collection in qualitative research (Legard, Keegan, & Ward, 2003). The in-depth interview often called as a conversation with a purpose. According to Cook (2008), in-depth interviews are interviews that encourage the respondent to talk in-depth about the investigated topic without the researcher's controlled, intensive, short-answer

questions. The in-depth interviews conducted in this research refer to Legard et al. (2003), who described five features of in-depth interview. First is that it is purposed to combine structure with flexibility. The structure of questions in in-depth interview is sufficiently flexible to permit subjects to be covered in the most appropriate to the respondents. The second feature is interactive in nature. The researcher can asks an initial question in such a way to encourage the respondent to speak freely in answering the questions from the researcher. Third, the researcher uses a range of probes to obtain the depth of answer. A first answer is often at a shallow level. The researcher then can use follow-up questions to achieve a deeper understanding of the respondent's meaning. In-depth interview also allows the researcher to explore all the factors that strengthen respondent's answers, including reasons, feelings, opinions and beliefs. Fourth, the interview is generative in the sense that new knowledge or thoughts to be created. Participants also can be invited to put ideas or suggestions on a particular topic and to offer solutions for problems that raised during the interview. The last, the in-depth interview are conducted face-to-face. The interview is flexible, interactive and generative, and in which meaning and language is explored in-depth.

The primary data used in this research are obtained from in-depth interview that collected in the fieldwork phase (October 2014 – January 2015). The institutional respondents are visited in their offices while the respondents affected to the disaster are visited in their home. Then, they were interviewed by using list of key questions instrument. The time needed of each interview is vary between each respondent, depends on how the interview is going. The interview process was recorded using digital voice recorder. It is to make sure that the information from each respondent is easy to be reviewed repeatedly. Experts from 20 institutional stakeholders involved in Dieng's volcanic toxic gas disaster management were interviewed. Table 4.2 shows a list of institutional respondents that have been interviewed.

Table 4.2. List of interviewed institutional respondent

No	Stakeholder	Respondent Position
1	BPBD of Banjarnegara	Head of BPBD
2	PMI of Banjarnegara	Head of Red Cross
3	SAR team of Banjarnegara	Head of SAR team
4	Satpol PP of Banjarnegara	Section Chief of Peace and Public Order
5	Dinsosnakertrans of Banjarnegara	Section Chief of Potential Development
6	Dinkes of Banjarnegara	Section Chief of Disease Control and Extraordinary Events Prevention
7	Kodim 0704 of Banjarnegara	Commissioned Officer of Intelligence Section
8	Bappeda of Banjarnegara	Chief of Infrastructure and Regional Development
9	DPSDA dan ESDM of Banjarnegara	Section Chief
10	Disbunhut of Banjarnegara	Section Head of Production and Protection
11	KLH of Banjarnegara	Section Chief
12	Kesbangpolinmas of Banjarnegara	Section Chief of public protection
13	Disbudpar of Banjarnegara	Chief of Dieng Unit
14	Polres of Banjarnegara (Polres)	Chief of Operation Unit
15	Disdikpora of Banjarnegara	Section Chief
16	PGA of Dieng	Chief of Observation Post
17	Polsek of Batur	Member of Security Post
18	Sub-District Office of Batur	Section Chief Officer of Peace and Order
19	Koramil of Batur	Non-Commissioned Officer for Village Supervisors
20	Puskesmas of Batur I	Functional Nurse

Beside institutional stakeholders, people affected to the disaster also have been interviewed. The respondents are people who witnessed the 1979, 2011 and/or 2013 incident. The respondents are listed in table 4.3:

Table 4.3. List of respondent affected to the disaster

No	Name	Witnessing	Description
1	Mr. Bugi	1979	Former settlement of Kapucukan Village, lost his all family member in 1979
2	Mr. Dion	1979, 2011, 2013	Head of Sidomulyo Hamlet
3	Mr. Suwandi	1979	Former of PGA officer in 1979
4	Mrs. Fahima	1979	Settlement of Batur Village
5	Mr. Fadhullah	1979, 2011, 2013	Head of Pekasiran Village
6	Mr. Riyanto	1979,2013	Survivor from 1979
7	Mr. Sukadir	1979	Settlement of Kepakisan Village
8	Ms. Ummu	2011	Settlement of Sumberejo Dua Village
9	Mr. Danang	2011, 2013	Head of KOKAM
10	Mrs. Prapto	1979, 2011, 2013	Former settlement of Kapucukan Village

No	Name	Witnessing	Description
11	Mr. Marjani	1979	Former settlement of Kapucukan Village
12	Mr. Marjonet	1979	Former settlement of Kapucukan Village, lost his all family member in 1979
13	Mr. Irfai	2011, 2013	Head of BAGANA

4.2.2. Secondary Data Collection

There were several secondary data needed when conducting this research. They are hazard maps from the past, information about volcanic toxic gas disaster histories, Banjarnegara's contingency plan document, and other contingency plan documents. Hazard maps from the past are needed to identify the spatial distribution of toxic gas disaster events (figure 4.1). Further, it is also be used as consideration for future disaster management scenario in objective four.

Figure 4.1. Collecting old hazard maps from PGA of Dieng

Information about volcanic toxic gas disaster also collected from media such as web pages, books, and newspapers. This secondary data are essential. It is because the data related to volcanic toxic gas in Dieng are relatively scarce. This additional data are used to complete the data that cannot be obtained from in-depth interviews or institution's documents. The last secondary data collections are contingency plan documents. Banjarnegara's Contingency Plan Document is necessary as a preparedness plan in the study area. This document also reflects the preparedness of Banjarnegara's government to face the toxic gas threat. Last, other

contingency plans are using as a consideration when creating disaster management scenario.

4.3. Post-Fieldwork

In the post-fieldwork phase, there are several things have to be done, such as digitize the old map, and transcript the recorded audio. The detailed works in post-fieldwork phase are explained as follows:

4.3.1. Transcription

Transcription is a process to change interview results, which is transform audio format into textual form (Poland, 2008). To eliminate the misinterpretations between the respondent and the researcher in the narration process, the transcripts were given to each respondent in order to obtain their approval. If they agreed with the transcript, then they must validate it with their hand signature. If they did not agree, then they need to discuss the mistaken part with the interviewer until an agreement reached, and then the respondent signed the transcript.

4.3.2. Digitation Process

Digitation process is done to all old maps that obtained from PGA (Figure 4.2). First, old map is scanned into digital map. After all of the maps are scanned, then by using GIS software (e.g. ArcGIS), the disaster prone area on the maps are digitized.

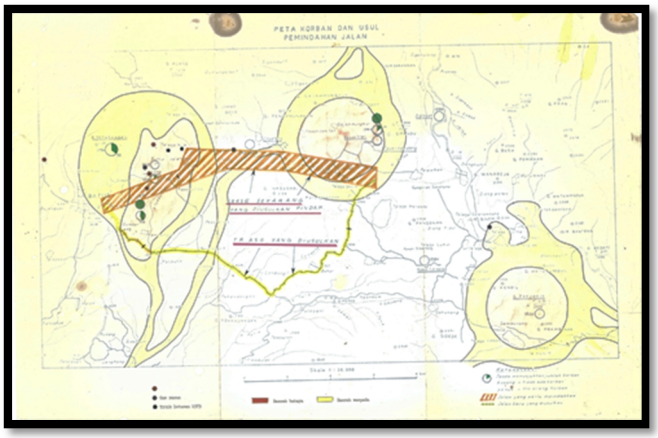


Figure 4.2. Example of disaster prone area old map (obtained from PGA, 2014)

4.3.3. Data Analysis

Data analysis is used to organize, sort, classify and categorize in order to obtain findings, either substantive or formal findings. In qualitative approach, data analysis is an activity that includes notes, organizes, categorizes, synthesizing the data, then interprets each category of data, search, and find its patterns. According to Patton (1980) in Ahmadi (2014), data analysis in qualitative approach is done in two phases: during the process of data collection, and in the end of data collection process. During the process of data collection, the data analysis is conducted by recorded field data, member check to research subject, and perfecting analysis. Then, the arisen trends are constructed according to the process and the type of data that available to obtain the explicit meaning (Dasim, 2012).

Miles and Huberman (1984) in Emzir (2010) explain the analysis steps of qualitative data as shown in figure 4.3:

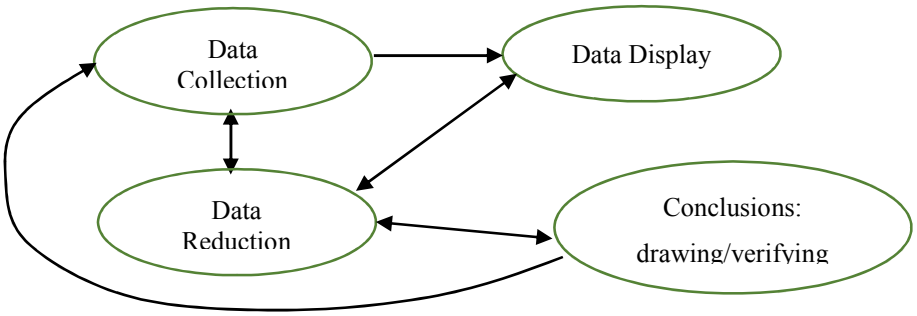


Figure 4.3. Qualitative data analysis steps (Miles and Huberman, 1984) in Emzir (2010)

Those steps are not done separately but continuously. It is expected that the intended theme is actually to what is suggested by the field data (Dasim, 2012).

- Data collection

  Consist of interview results and literature reviews of secondary data documents such as articles, journals, textbooks, newspapers and digital data.

- Data reduction

  Data reduction is referring to selecting, focusing, simplifying, abstracting, and transforming raw data from the field, for example the data reduction in transcription process. Not every word from respondents is included in the transcription process. The statements in the transcription process are the result of data reduction. The raw data are described, reduced, arranged systematically, and highlighted for the important subjects.

- Data display

  The general form of qualitative display is narrative text, and then features with matrix, graphs, flowcharts, networks, and maps. For example, the display of stakeholders' network chains will be a diagram. It is designed to gather a lot of information in the simpler form.

- Conclusions

  Conclusions and verifications are performed since the data are collected. Initially, it is still vague and bias, but when the data is growing it can be concluded more grounded. Along with these activities, the verification can be done by looking for new data. Conclusion is taken by maintain the fairness and skepticism. In this research, the example of verification is in the transcription process.

The collected data is a valuable initial capital in the research. However, the validity of the data must be confirmed in order to produce good quality research. Understanding the importance of research validity is an important thing, especially in qualitative approach that has the post-positivism characteristics, that truth is not absolute. To obtain the research validity, triangulation of data sources is implemented. In-depth interviews to stakeholders of toxic gas disaster management,

in-depth interviews to people affected to the disaster, contingency plan of Banjarnegara, written document from governmental stakeholder, and data collected from media are used together to support each other (triangulation). Triangulation is an approach that synthesis the data collection and data analysis from various sources. The purpose of triangulation is not to find the truth, but to increase the researcher understanding based on to his/her data and fact. In this research, each type of data sources will result difference evidence that provides different insight regarding the phenomena of toxic gas disaster and its management.

4.3.4. Social Network Analysis (SNA)

Based on Contingency Plan Document of Banjarnegara 2012, the number of stakeholders involved in disaster management of volcanic toxic gas in Dieng is 40 stakeholders. In interview session with the key person of BPBD of Banjarnegara, it is known that only 29 stakeholders involved. Then, in interview session with the key person of PGA of Dieng, one stakeholder is crossed out because it is irrelevant. From 28 stakeholders, 20 have been interviewed (Table 4.2).

The stakeholders can be grouped into three categories (Sundawati & Sanudin, 2009) which are primary stakeholders, secondary stakeholders and key stakeholders. The categorization of stakeholders in this study is based on in-depth interview and legal basis in Indonesia. In-depth interview is used to analyze the interest and impact of each stakeholder, while legal basis are to understand the involvement of stakeholders in legal regulation.

For collaboration network, the researcher analyzes the relation between each stakeholder by using in-depth interviews. The list of key questions that has been used to analyze the collaboration network is available in appendix.

4.3.5. Volcanic Toxic Gas Disaster Histories and Its Evacuation Process

In order to obtain the narrative result of volcanic toxic gas disaster histories and its evacuation process, descriptive analysis is used. The data is from the in-depth interviews results of institutional stakeholders and people affected to the toxic

gas disaster in 1979, 2011 and 2013, and from the literatures. Things that will be discussed such as:

- disaster prone area map after each disaster,
- chronology of each disaster,
- how the evacuation process run from people affected to the disaster's viewpoint and institutional stakeholder's viewpoint,
- comparison of disaster response in each disaster.

4.3.6. Problems and Suggestions

The problems and suggestions are come from interviewed respondent. The problems and suggestions will be discussed to understand the issues from institutional perspective. The suggestion also related to the suggestion of contingency plan of Banjarnegara as a handbook of toxic gas disaster management (especially preparedness and response phase) in Dieng.

4.3.7. Disaster Management Scenario Using Sahana Eden Software

As described in the literature review, Sahana Eden has several abilities that can help disaster management such as organization registry, project tracking, human resource, inventory, asset, assessment map and shelter management. In the making of disaster scenario, Sahana Eden will be used as a tool to simulate the disaster response when the toxic gas disaster occurred in Dieng. Disaster management scenario that has been used is a disaster management scenario that based on Contingency Plan Document of Banjarnegara 2012.

4.4. Research Instrument and Software

Table 4.4 explains the research instruments used in this research to support the achievement of the objectives in this research.

Table 4.4. List of material used in the fieldwork

Material	Function
List of key questions	Contain key questions to guide interviewer in interview process
Digital Voice Recorder	To record the voice of interview process
Stationary	To make notes
Notebook	To collect the secondary data from internet
Digital Camera	To collect digital images from field

Four software were used to analyze and present the data in this research as shown in table 4.5:

Table 4.5. List of software used in analysis

Software	Function
ArcGIS 10.2	Spatial data analysis
Sahana Eden	Disaster management web-based
Microsoft Office 2013	Data display
NodeXL	Stakeholder network analysis

4.5. Research Flowchart

The flowchart of this research is explained in figure 4.4:

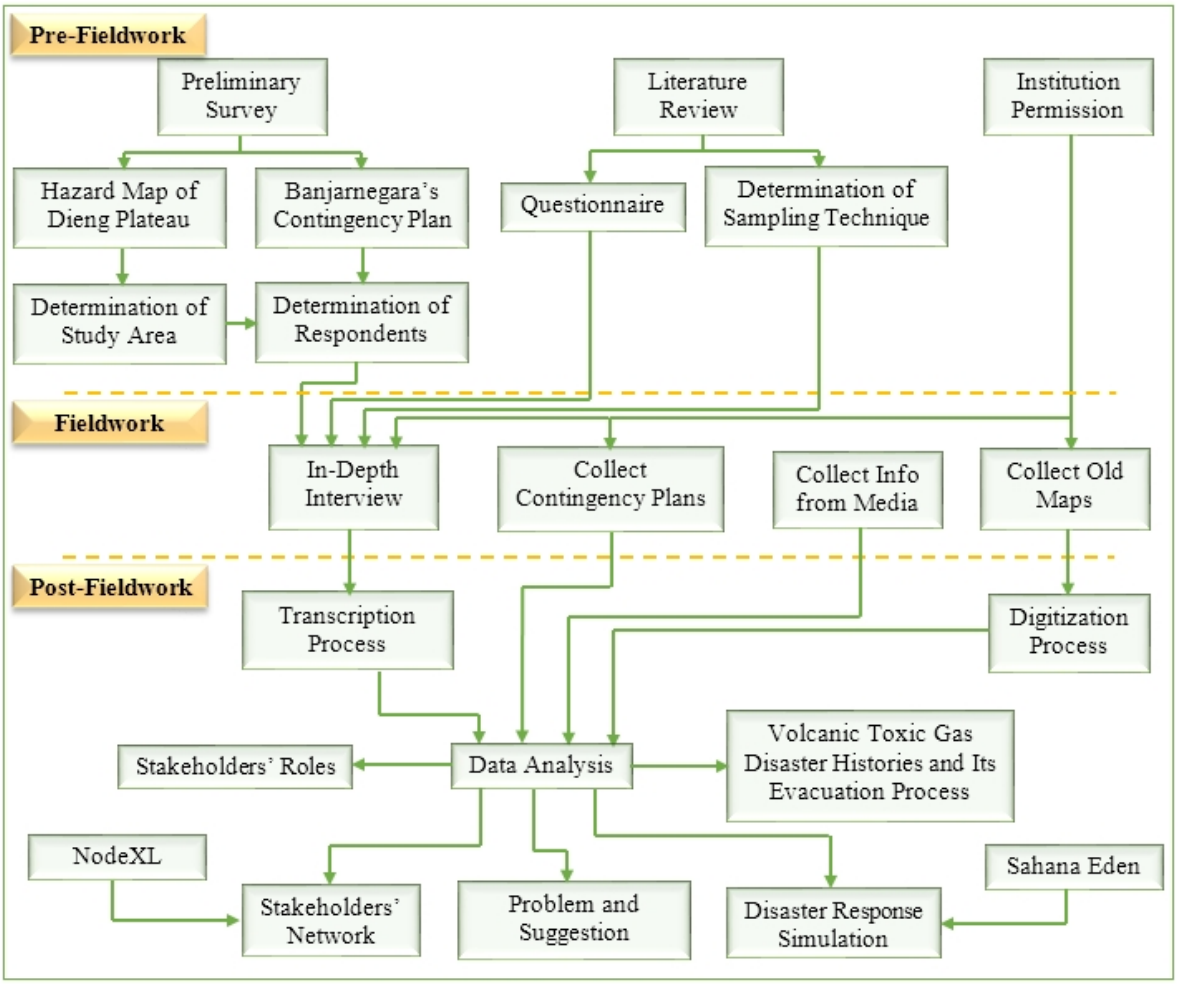


Figure 4.4. Research flowchart

This flowchart can be separated into four flowcharts that represent each research objective. They are shown in appendix.

Chapter 5. Result and Discussion

5.1. Identification of Stakeholders' Responsibility in Dieng Plateau

From in-depth interviews of 20 stakeholders that listed in Banjarnegara's contingency plan, it is known that there are 44 stakeholders involved in the volcanic toxic gas disaster management in Dieng. The stakeholders' identification is obtained in the next sub-chapter as follows:

5.1.1. Legal Basis of Disaster Management in Dieng Plateau

Disaster management in Indonesia is based on a mandate of Preamble of 1945 Constitution of the Republic of Indonesia in paragraph IV that stated:

> *"Pursuant to which, in order to form a Government of the State of Indonesia that shall protect the whole people of Indonesia and the entire homeland of Indonesia, …"*

Although it has been stated in the Preamble of the 1945 Constitution of the Republic of Indonesia, but the Law of disaster management was not formed until 2007. Lessons learned from Aceh tsunami disaster in 2004 is the need of formal legal basis to set the functions and roles of the stakeholders involved in disaster management. Legal basis is expected to reduce uncertainty, encourage clearer coordination and resulting a more effective emergency response. Law is one of the solutions that can be taken to address issues such as lack of coordination, miscommunication, and ineffective management. Therefore, Law No. 24 of 2007 about disaster management was established three years after the devastation caused by tsunami in Aceh.

Law No. 24 of 2007 regulates about the responsibility of government to organize disaster risk reduction, public protection, standard service for refugees, refugees' right, disaster recovery, and disaster budgeting. It is also stated that the disaster management in Indonesia is coordinated by BNPB (National Disaster Management Agency) while the establishment of BPBD (Regional Disaster

Management Agency) is an authority of Local Government (in province and district level).

Further, legal basis of disaster management in Central Java is regulated in Central Java Provincial Regulation No. 11 of 2009 about Disaster Management in Central Java. It is generally similar with the Law No. 24 of 2007 but it is conditioned in the province level. In this regulation, it is mentioned that the areas around Dieng Volcanic Complex is a disaster-prone area.

Banjarnegara in a district level completed the regulations of disaster management by established the Banjarnegara District Regulation No. 3 of 2011 about Organizations and Procedures of Disaster Management in Banjarnegara District. The regulation explained about the roles of BPBD of Banjarnegara, which have three functions: coordination, commando, and executive.

Specific to toxic gas disaster management, Banjarnegara undertake preparedness effort by establishing Contingency Plan of Banjarnegara (2012). The contingency plan shows the stakeholders which involved in the disaster response, and their roles. It is also provided with a disaster management scenario (which based on worst-case disaster scenario), and the estimation of funds and logistics needed.

5.1.2. Stakeholder Involved in Preparedness and Emergency Response in Dieng Plateau

As explained in Sundawati & Sanudin (2009), stakeholder can be divided into three categories, which are primary stakeholder, secondary stakeholder, and key stakeholder. Primary stakeholder is stakeholder that has direct interest and gets direct impact from policies or programs of disaster management. Secondary stakeholder is stakeholder that does not involved directly to the policies or programs of disaster management, but has concern about every government legal decision. Key stakeholder is stakeholder that has legal authority in decision-making of disaster management.

The 44 stakeholders that involved in volcanic toxic gas disaster in Dieng as identified in the interviews are listed in table 5.1 as follow:

Table 5.1. Stakeholder involved in toxic gas disaster management and its roles

No	Institution	Roles
Primary Stakeholder		
1	People affected to disaster	As refugees
2	PGA of Dieng	Responsible to observe and report volcanic activities in Dieng Plateau to every stakeholder involved in disaster management
3	BAGANA	Supporting SAR Team of Banjarnegara as skilled volunteers
Secondary Stakeholder		
4	Ministry of Health	Supporting Dinkes of Banjarnegara in medical aspects and human resources if needed
5	BMKG	Supporting in meteorology, climatology, and geophysics data
6	BPPTK	Conducting researches about volcanic toxic gas
7	Millitary Regional Command IV/Diponegoro	Supporting Kodim 0704 of Banjarnegara in coordination and human resources if needed
8	Police Regional Command	Supporting Polres of Banjarnegara in coordination and human resources if needed
9	Satpol PP of Banjarnegara	Supporting in safeguarding people's assets and human resources if needed
10	Dinkes of Banjarnegara	Supplying medicine and medical equipment, and support Puskesmas of Batur I in human resources if needed
11	Kodim 0704 of Banjarnegara	Supporting Koramil of Batur in coordination and human resources if needed
12	Bappeda of Banjarnegara	Connecting every stakeholder which need coordination with another stakeholder in district level
13	DPSDA dan ESDM of Banjarnegara	Supporting PVMBG in observe volcanic activities in Dieng Plateau
14	Disbunhut of Banjarnegara	Supporting in human resources if needed
15	DPU of Banjarnegara	Supplying heavy equipment such as dozer, excavator, loader, and truck
16	Dinhubkominfo of Banjarnegara	Responsible for good and accessible evacuation routes (rarely involved)
17	KLH of Banjarnegara	Supporting in human resources if needed
18	Kesbangpolinmas of Banjarnegara	Supporting in human resources
19	Disbudpar of Banjarnegara	Dispel misleading issues regarding to Dieng tourism if needed
20	BPS of Banjarnegara	Supplying statistics to stakeholders if needed
21	Polres of Banjarnegara	Supporting Polsek of Batur in coordination and human resources if needed

No	Institution	Roles
22	Disdikpora of Banjarnegara	Responsible related to education unit, including student learning, teachers' welfare in the time of disaster and book supplies if needed
23	Polsek of Batur	Supporting in safeguarding people's assets
24	Sub-district office of Batur	As a host of central shelter and coordinate the village officials
25	Koramil of Batur	Supporting in safeguarding people's assets
26	Puskesmas of Batur I	Responsible in refugees' health
27	Puskesmas of Batur II	Supporting Puskesmas of Batur I in medicine and health workers if needed
28	PMI of Banjarnegara	Supporting Dinsosnakertrans of Banjarnegara in logistic and human resources
29	SAR Team of Banjarnegara	Responsible for SAR activities
30	TAGANA	Supporting Dinsosnakertrans of Banjarnegara as skilled volunteers in soup kitchen
31	ORARI of Banjarnegara	Supporting every stakeholder to communicate updated information related to the disaster
32	PDAM of Banjarnegara	Supplying drinking water if needed
33	PT. Telkom of Banjarnegara	Responsible for telephone network (rarely needed)
34	PT. PLN of Banjarnegara	Responsible for electricity
35	PT. Geodipa Energi	Contributing heavy equipment and safety equipment if needed
36	PT. Java Agritech	Contributing heavy equipment and safety equipment
Key Stakeholder		
37	BNPB	Supporting BPBD of Central Java in coordination
38	BASARNAS	Supporting BASARNAS of Central Java in SAR activities and human resources if needed
39	Ministry of Social	Supporting Dinsosnakertrans of Banjarnegara in logistic
40	PVMBG	Determining the level of danger and supporting PGA in human resources and technical assistance
41	BPBD of Central Java	Supporting the local government in coordination
42	BASARNAS of Central Java	Supporting SAR Team of Banjarnegara in SAR activities and human resources if needed
43	Dinsosnakertrans of Banjarnegara	Responsible in refugees' logistic
44	BPBD of Banjarnegara	Coordinating and directing stakeholders involved in disaster management,

Source: in-depth interview analysis

The stakeholder categories in the table are illustrated in figure 5.1.

Figure 5.1. Stakeholder involved in toxic gas disaster management grouped by its category

Primary stakeholders in the toxic gas disaster management are PGA of Dieng, people affected to the disaster and BAGANA. People affected to the disaster are clearly a main actor in the toxic gas disaster management, because they are dependent to the toxic gas disaster management. Every decision made by the government related to the disaster management will has effect to them.

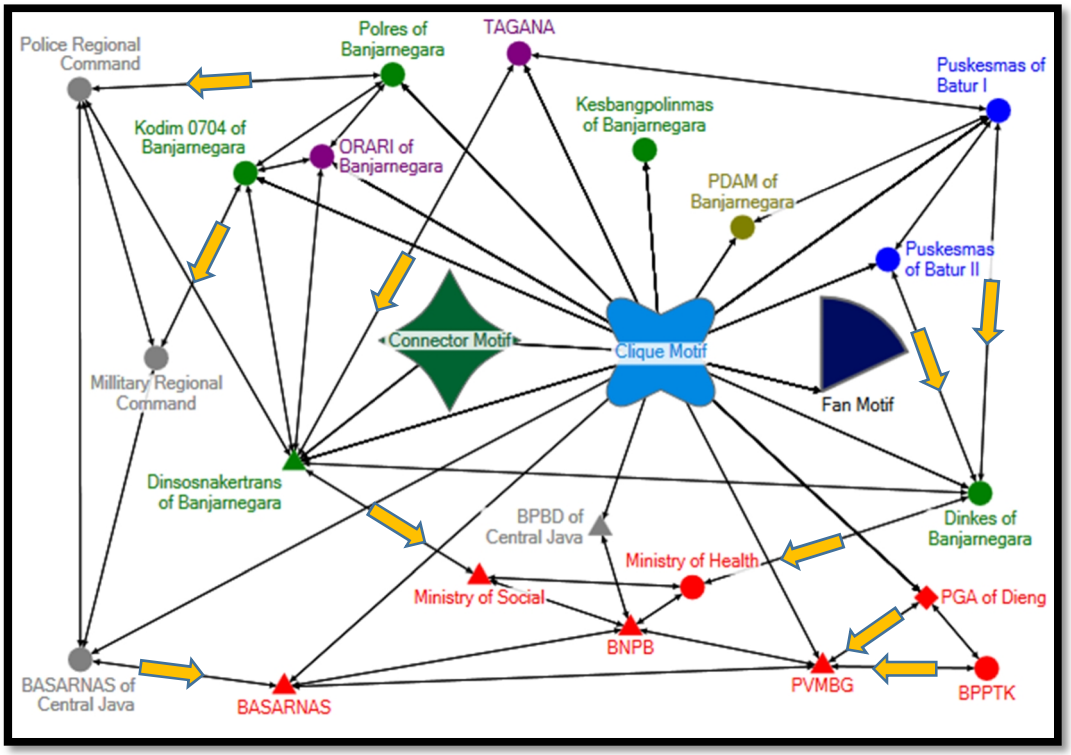
PGA of Dieng and BAGANA are primary stakeholders that the main purpose of its establishment is to prevent and manage disaster. PGA of Dieng is a national level institution that has main duty to observe Dieng Volcanic Complex. PGA of Dieng also as a frontline to disseminate the latest information related to the volcanic activity in Dieng Plateau. When the volcanic activity is increasing, PGA of Dieng immediately spreads the information to every involved stakeholder via Short Messaging System (SMS). Meanwhile, BAGANA is a main volunteer organization in the toxic gas disaster management in Dieng. It was formed after 2011 incident. BAGANA is a volunteer organization that consists of youngsters in Dieng. Until now, the total members of BAGANA reach 246 people.

The key stakeholders in the toxic gas disaster management consist of eight government institutions. Four stakeholders from national level that categorized as a key stakeholder are BNPB, BASARNAS, Ministry of Social, and PVMBG. Stakeholders from national level have strong authority in decision-making. BNPB has strong authority to make regulations in the national level of disaster management, BASARNAS in national level of search and rescue, Ministry of Social in logistic supplies, and PVMBG in the decision-making of volcanoes' danger zones. From Province level, there are BPBD of Central Java and BASARNAS of Central Java. BPBD of Central Java is responsible in disaster management in Central Java level, while BASARNAS is responsible in Central Java's search and rescue. In district level, the key stakeholders BPBD of Banjarnegara and Dinsosnakertrans of Banjarnegara. BPBD of Banjarnegara has full authorities in the toxic gas disaster management, while Dinsosnakertrans of Banjarnegara is responsible to the logistic supplies for refugees and volunteers.

The last category is secondary stakeholder. The secondary stakeholders consist of mostly Banjarnegara's district level institutions with 14 stakeholders from 33 in total. The secondary stakeholders also are filled by State Owner Enterprises (SOE) and private companies. It is because SOE and private companies only have little concern and interest regarding to the disaster management in Dieng. Their tasks and duties also are unrelated with the disaster management.

5.1.3. Stakeholders' Collaboration Network

Based on the analysis of in-depth interview result to stakeholders related in the toxic gas disaster management in Dieng, the stakeholders' collaboration network is shown in figure 5.2:



Information:

Shapes:

○	:	Indicates secondary stakeholder
△	:	Indicates key stakeholder

Colors:

	:	Indicates national level governmental stakeholder
	:	Indicates sub-district level governmental stakeholder

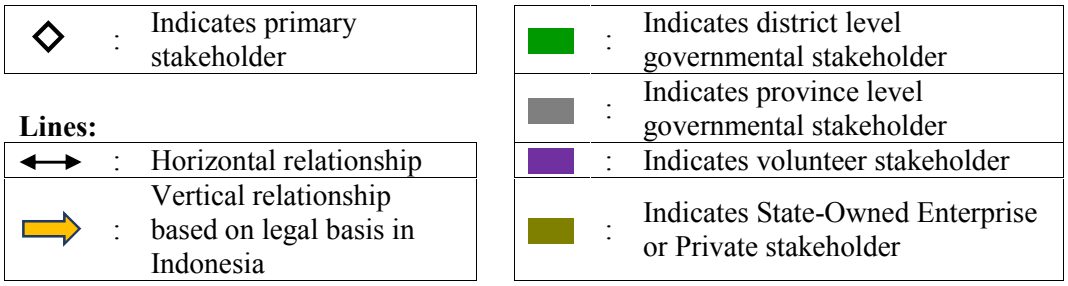
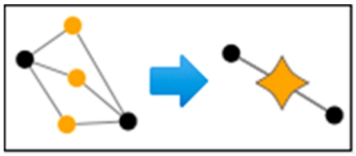


Figure 5.2. Stakeholders' collaboration network

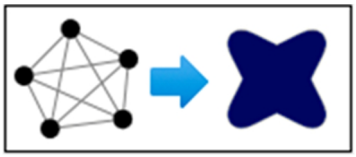
Each connector line in the diagram shows the collaboration of the connected stakeholder. The collaboration can be a vertical collaboration and horizontal collaboration. Vertical collaboration is collaboration between stakeholders that have vertical bureaucracy in legal basis. For example, PGA of Dieng has vertical collaboration with PVMBG according to Ministerial Regulation No. 18 of 2010 about Organization and Function of the Ministry of Energy and Mineral Resources. Meanwhile, horizontal coordination is a coordination between peer stakeholders in the activities of toxic gas disaster management. For example, in the toxic gas disaster response, BPBD of Banjarnegara is coordinating horizontally with Dinsosnakertrans of Banjarnegara to make sure the logistic supplies to the refugees are under control. All stakeholder's coordination in figure 5.2 is shown in appendix, with the total reach 133 coordination.

In order to reduce the complexity of the diagram, and to make the diagram more readable, figure 5.2 is simplified by using group of three motifs. The explanation of each motif is displayed as follows:

: This group is called Fan Motif. Fan Motif is used to simplify the stakeholders that only have one relation to the stakeholder in the middle.



: This group is called D-Connector Motif. It is used to simplify stakeholders that flanked by anchor stakeholders (black).



: This group is called Clique Motif. Clique Motif is used to simplify stakeholders that connect to each other.

Each motif is not only to make a simpler diagram, but it also can be used as an indicator that a stakeholder has more interest than others do. The figure 5.3 shows that BPBD of Banjarnegara, as a center stakeholder, is an important stakeholder in the collaboration network. BPBD of Banjarnegara is coordinating with 33 stakeholders, with 12 of them are only connected to BPBD of Banjarnegara. Those 12 stakeholders are secondary stakeholder, which do not have high interest in the toxic gas disaster management. Their existence is because BPBD of Banjarnegara needs to manage something that has become the main tasks and duties of secondary stakeholders, or they have ability on it. For example, the O_2 gas of breathing apparatus that belong to BPBD has out of stock. PT. Geodipa Energy has breathing air compressor to fill oxygen into breathing apparatus. BPBD then asked PT. Geodipa Energy to fill the breathing apparatus.

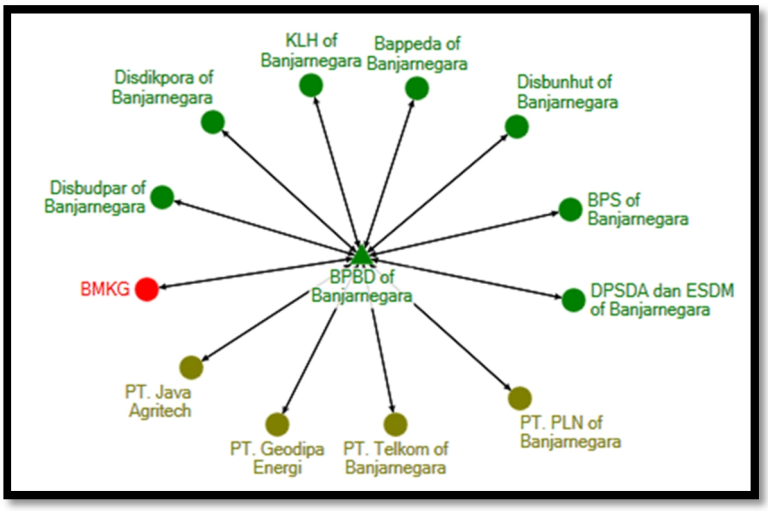


Figure 5.3. Fan Motif in stakeholders' collaboration network

The D-Connector in this stakeholders' collaboration network center is involving two anchor stakeholders, which are BPBD of Banjarnegara and Dinsosnakertrans of Banjarnegara (figure 5.4). Both are categorized as key stakeholders. Meanwhile, the stakeholders between the anchors are Dinhubkominfo of Banjarnegara and DPU of Banjarnegara, which are secondary stakeholders. In toxic gas disaster management, Dinhubkominfo has a main role to make sure that the evacuation routes are good, while DPU supplies heavy equipment. Both stakeholders coordinate with BPBD of Banjarnegara as a leading sector. They also

coordinate with Dinsosnakertrans in logistic supplies matters. Dinhubkominfo and DPU help Dinsosnakertrans to carry the logistic supplies from warehouse of Dinsosnakertrans to refugees' camps.

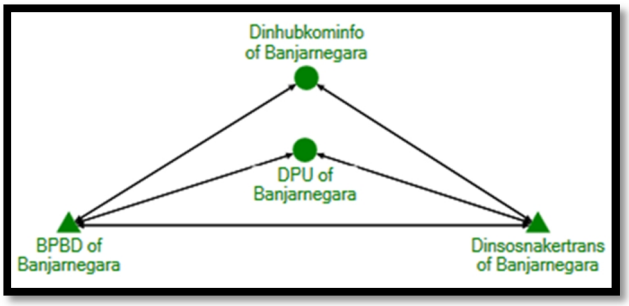


Figure 5.4. D-Connector Motif in stakeholders' collaboration network

The last group is Clique Motif (figure 5.5). There are nine stakeholders involved in this group, which are BPBD of Banjarnegara, Sub-district office of Batur, Polsek of Batur, Koramil of Batur, PMI of Banjarnegara, BAGANA, People affected to the disaster, SAR Team of Banjarnegara, and Satpol PP of Banjarnegara. Each of those stakeholders is connected to other stakeholders. This motif indicates a solid group collaboration between each stakeholder in toxic gas disaster management.

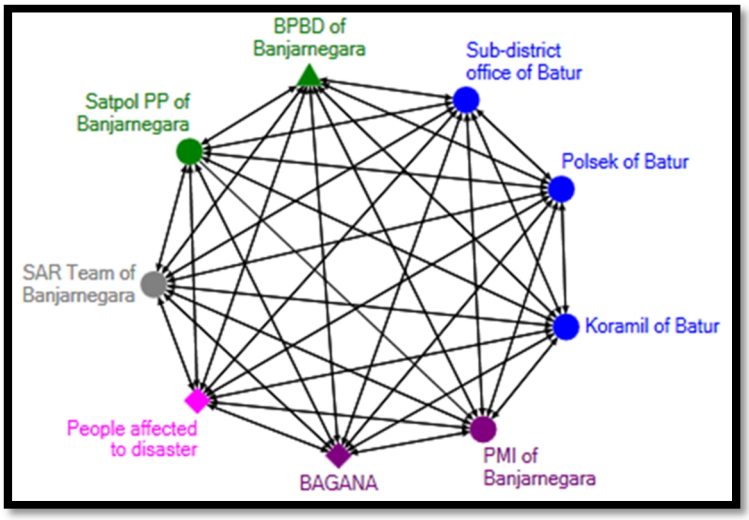


Figure 5.5. Clique Motif in stakeholders' collaboration network

The example of relation in the Clique Motif is coordination in the evacuation process. In evacuation process, SAR Team together with Satpol PP,

Koramil of Batur, Polsek of Batur, and BAGANA evacuate people affected to the disaster from their home to refugees' camps. They were commanded by BPBD of Banjarnegara and coordinate with Sub-district office of Batur that knows the exact condition in the field. They also coordinate with PMI if there is wounded victim.

If we see figure 5.2, there are many connected lines (edges) between other stakeholders to the Clique Motif. One edge from one stakeholder to Clique Motif does not mean that it only has one coordination. Because of it, the next three diagrams are shown to go in detail about the relations between Clique Motif and other stakeholders. First diagram is the relations between Clique Motif and district level governmental stakeholders (figure 5.6).

District level governmental stakeholder that has the most coordination with the Clique Motif is Dinsosnakertrans of Banjarnegara with five edges. It makes Dinsosnakertrans has total 13 edges with other stakeholders. Dinsosnakertrans has many coordination for its big role in the response phase as a leading stakeholder in logistic sector.

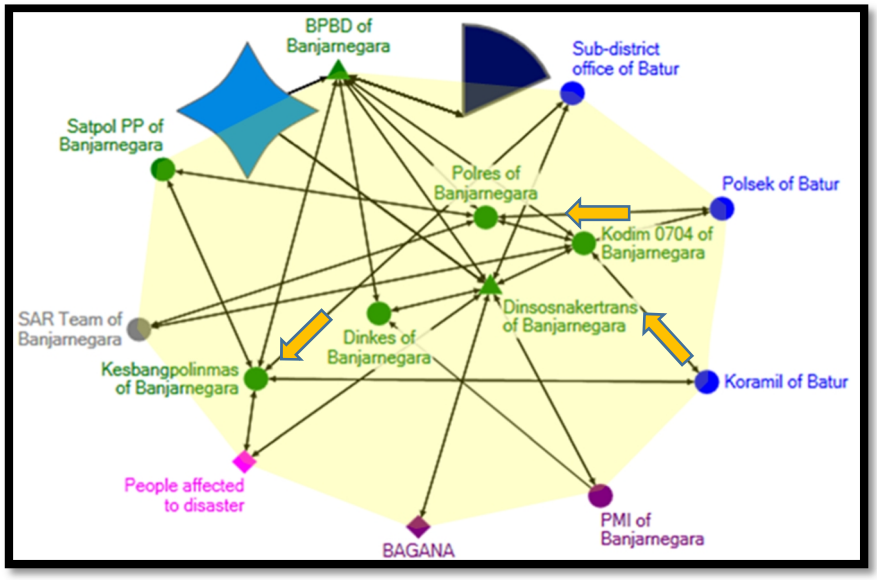


Figure 5.6. Relations between Clique Motif and district level governmental stakeholders in stakeholders' collaboration network

The next diagram explains the relation between Clique Motif and stakeholder from national and sub-district level governmental stakeholders (figure

5.7). PGA of Dieng and Puskesmas of Batur 1 have seven relations to the Clique Motif, which are stakeholder that has the most coordination with the Clique Motif comparing to other stakeholders. PGA of Dieng and Puskesmas of Batur has many relations because they have big roles in toxic gas disaster management. PGA of Dieng, as a national level governmental institution that located in Batur, has responsible to every activity of volcanoes in the Dieng complex. Meanwhile, Puskesmas of Batur 1 is the nearest medical center to the Timbang Crater. This medical center is responsible for the refugees' health, which located near the Timbang Crater.

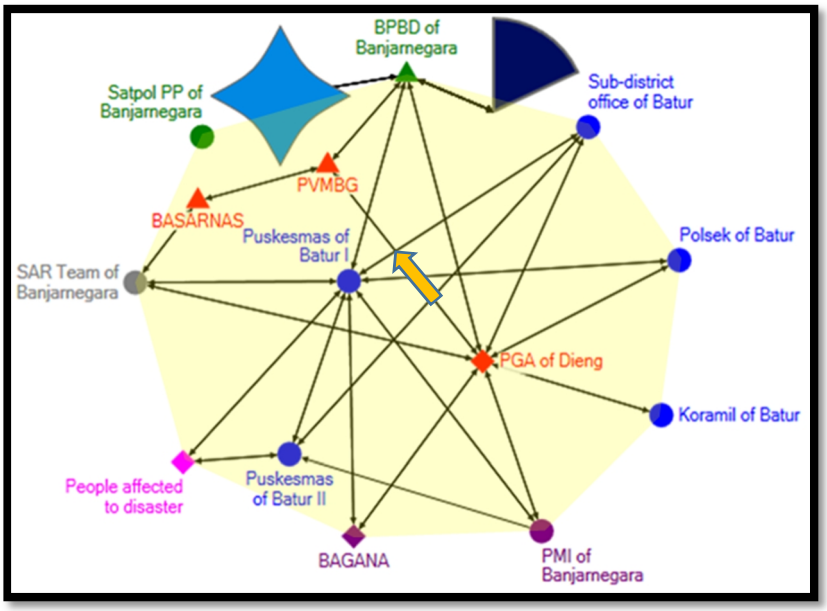


Figure 5.7. Relations between Clique Motif and national and sub-district level governmental stakeholders, in stakeholders' collaboration network

The last diagram explains the relation between Clique Motif and province level governmental, state-owned enterprise, and volunteer stakeholders (figure 5.8). ORARI of Banjarnegara has most relation with six edges to the Clique Motif. ORARI of Banjarnegara has role to communicate updated information related to the disaster to every stakeholder involved in toxic gas disaster management. Although it does not has an office building, but ORARI's existence is important in the communication, especially the communication between staffs and volunteers whom in-charge in the toxic gas disaster management.

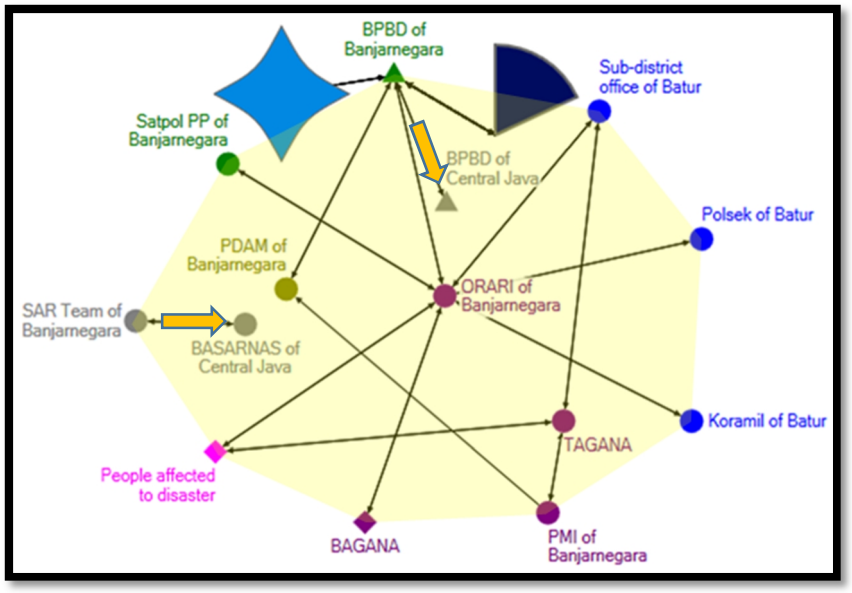


Figure 5.8. Relations between Clique Motif and province level governmental, state-owned enterprise, and volunteer stakeholders in stakeholders' collaboration network

5.1.4. Discussion of Stakeholder Analysis

Disaster management in Indonesia

BPBD of Banjarnegara is a leader stakeholder in disaster management in Banjarnegara. It is listed in contingency plan of Banjarnegara 2012 and District Regulation No. 3 of 2011 about Organizations and Procedures of Disaster Management in Banjarnegara District. In performing its duty, BPBD of Banjarnegara is supported by BPBD of Central Java and BNPB. Mr. Tursiman, head of BPBD of Banjarnegara stated:

> *"BNPB, BPBD of Central Java, and BNPB are collaborated between each other in the disaster management. Although for toxic gas disaster management in Dieng BPBD of Banjarnegara is the responsible one, but BPBD of Central Java also helped in logistics, infrastructures, finances, and human resources. If it is still not enough, then BNPB will come to intervene."*

This underlines that the disaster management in Indonesia is flexible. From national level, the disaster management agency is BNPB. BNPB is a national

disaster management agency. Its main role in the toxic gas disaster management is support BPBD of Central Java if needed. According to Law No. 24 of 2007, BNPB is responsible to the disaster management in national disaster level while BPBD is responsible to handle the regional disaster. However, there is no regulation that can be used as a legal basis to determine the level of a disaster. Until now, the determination of a disaster level only based on regional government's ability to manage the disaster. For example, if district government cannot handle the disaster, then they will asking for help to province level. If province government still cannot handle the disaster, then it will be undertaken by national government level (Astuti, 2014; Tempo, 2014).

Mr. Tursiman said:

> *"For 2013, the disaster still managed by BPBD of Banjarnegara although BPBD Province and BNPB helped. Although it was not a national disaster, but the refugees are so many, so the aids from them were needed."*

It is stipulated in Law No. 24 of 2007 that BNPB only manage national disasters. In 2013, the action by BNPB is categorized as a help or support. The responsible stakeholder was still on BPBD of Banjarnegara, but helped by BPBD of Central Java and BNPB.

The condition can be justified by several reason:

- The 2013 disaster in Dieng was considered big. More than 5,000 people were evacuated. Comparing with the disaster scenario in contingency plan of Banjarnegara 2012 that only assumed 3,305 people evacuated.
- The emergency response phase in 2013 was determined from March 14, 2013 – April 10, 2013, or almost one month, while the disaster scenario from contingency plan is only 14 days.
- In 2013, the disaster not only came from the toxic gas, but also from earthquake that causing more material loss than what is on contingency plan.

Contingency Plan of Banjarnegara 2012

As stated in the literature review, there are five management sectors in the contingency plan of Banjarnegara 2012 as shown in table 5.2:

Table 5.2. Management sectors in toxic gas disaster management

No	Sector	Leading Stakeholder
1	Coordination management	BPBD of Banjarnegara
2	Search and Rescue (SAR)	SAR Team of Banjarnegara
3	Social	Dinsosnakertrans of Banjarnegara
4	Health	Dinkes of Banjarnegara
5	Facilities and infrastructures	DPU of Banjarnegara

Source: contingency plan of Banjarnegara 2012

However, in March 2013, the TRC (Rapid Response Team), which is consist of BPBD of Banjarnegara, PVMBG, volunteer, and element of society formed organizational structure of the command post. The structure is shown in figure 5.9:

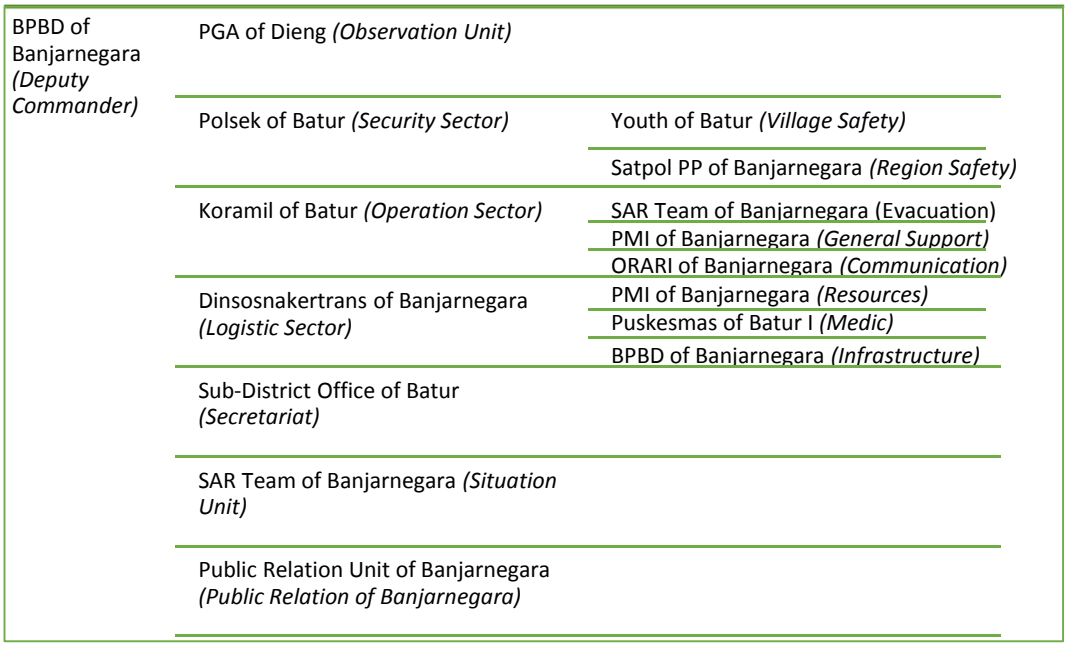


Figure 5.9. Organizational structure of the Command Post (BPBD of Banjarnegara, 2013)

This structure is different with the management sectors that listed in the contingency plan. It also seems to be focused in the sub-district level management. It is parallel with the statement of Mr. Tursiman:

> *"If it is possible, the level of disaster management is made as small as possible (sub-district level rather than district level) to avoid people be in panicked."*

It means that the contingency plan of Banjarnegara 2012 was not implemented in the toxic gas disaster 2013. The making of contingency plan of Banjarnegara 2012 seems to be a formal procedure at the time, because Banjarnegara had just experienced toxic gas disaster (in 2011). Last time Banjarnegara experienced toxic gas disaster was in 1979. Contingency plan is supposed to be updated by BPBD of Banjarnegara every year if possible. If it cannot be fulfilled, then it is compulsory to be evaluated. Mr. Edi Purwanto, Head of PMI of Banjarnegara, who also has direct involvement in the making of contingency plan Banjarnegara 2012 said:

> *"The need of contingency plan document was not high, so the making/evaluation of contingency plan has not been carried annually."*

> *"This contingency plan was not properly implemented yet. Sometimes when the disaster was occurred, the contingency plan is not a document that used as a reference in the disaster management."*

Gaps and Overlaps

There are gaps and overlaps between what stipulated on contingency plan of Banjarnegara with the real condition on the field. Related to the logistic sector, there is different perception between BPBD of Banjarnegara and Dinsosnakertrans of Banjarnegara. BPBD stated that Dinsosnakertrans is a leading stakeholder for social sector, including logistic, refugees' safety, and refugees' physiology. Meanwhile, Dinsosnakertrans stated that they only dealing with the logistic sector. BPBD referred on contingency plan 2012, while Dinsosnakertrans is based on command post 2013, where Dinsosnakertrans is a leading stakeholder for logistic sector. However, when to be confirmed about the command post 2013 if the

Dinsosnakertrans supervises PMI of Banjarnegara, Puskesmas of Batur I and BPBD of Banjarnegara, Mrs. Yuliati declined. Mrs. Yuliati is an official in Dinsosnakertrans of Banjarnegara, and has direct involvement in the toxic gas disaster management 2013 in Dieng.

> *"Organizational structure in command post 2013 is incorrect because in the command post Dinsosnakertrans supervises PMI, Puskesmas, and BPBD. Meanwhile in the real condition, BPBD of Banjarnegara was the one who supervises PMI and Dinsosnakertrans, without Puskesmas."*

Related to SAR sector, in the command post 2013, the roles of BAGANA in SAR activities cannot be seen. However, BAGANA has high level of interest as a volunteer institution, as shown in table 5.4. BAGANA even considered has higher roles in SAR activity comparing to SAR Team of Banjarnegara. It is stated in decree of disaster management in Banjarnegara, where it is stated that institution which responsible of SAR activity in disaster site is BAGANA, not SAR Team of Banjarnegara.

Related to the roles of stakeholder, there are differences between what are stated in contingency plan and from the result of in-depth interview. Firstly, from all interviewed respondent, there is no stakeholder stated that PT. Java Agritech has roles in the toxic gas disaster management. Most of them only confirmed that PT. Geodipa Energy helped as a stakeholder that has compressor to fill the breathing apparatus. Secondly, KOKAM as an influenced Moslem organization in Batur has a big role in the logistic distribution, as stated by Mr. Dion, head of Sidomulyo hamlet:

> *"Organization from Batur that help in logistic distribution only KOKAM, there is no other."*

Although has a big role for Batur Sub-District, but this stakeholder is not mentioned anywhere. Either in contingency plan of Banjarnegara 2012 or commando post 2013.

5.2. Toxic Gas Disaster Histories and Its Evacuation Process

Since 17th century, Dieng Volcanic Complex has been experienced several eruptions. Most of the eruptions are phreatic and has small to moderate explosive level. Some of the eruptions are involving the CO_2 outflow, such as in 1928, 1939, 1979, 2011, and 2013. The toxic gas disaster histories that will be discussed in this sub-chapter are disaster in 1979, 2011 and 2013 incident. Each discussion will be equipped with chronology map that summaries the disaster spatially. For the maps of disaster prone area in each disaster are digitized from old maps that collected from PGA. Each map was already confirmed by the PGA officer to ensure its genuineness.

5.2.1. 1979 Disaster

Chronology of 1979 Disaster and Its Evacuation Process

- February 19, 1979, afternoon, Mr. Suwandi, a PGA of Dieng officer conducted a routine visual observation in Sinila Crater, Sikidang Crater, and Candradimuka Crater and measured the craters' temperature by using thermometer. Everything was went normal, as he recalled:

  "There is no sign of tremors or anything. It (Sinila) suddenly explodes."

  There was no sign of volcanic activities, although gas detectors have not available at the time. In 1979, people already aware that Timbang Crater is dangerous from 1928 and 1939 gas flow incident.
- February 20, 1979, at 01.55 AM, there was an explosion from Sinila followed by an earthquake. The resident of Simbar Hamlet, Sumberejo Village, Mr. Riyanto described the earthquake as a continuous vibration.

  "There was an earthquake. The interval was like 15 minutes. When we take a look to the outside, we saw a black cloud soar to the sky from Sinila Crater, but we did not hear the explosion."

  Sinila ejected a dark gray cloud and hot lahar. In the same time, a fissure near Timbang Crater opened and released toxic gas to the South. At 02.40 AM and

04.00 AM, other earthquakes make people in Kapucukan Village fled to escape. At 4.30 AM, Mr. Riyanto and his friends approach the Sinila Craters. In the way to the crater, he found many people lying on the ground. He and his friends are the first team who evacuate the victims. At 5.04 Sinila ejected a second dark gray cloud and hot lahar that flowed down a gully, cutting a road in Sumberejo. At 6.00 AM, PMI, Polsek of Batur, Koramil of Batur, Sub-District of Batur officers and volunteer began to evacuate the corpses (figure 5.10). The evacuation process was lasted for three days. The bodies' condition was damaged because their blood vessels burst. More than 15,000 people were evacuated in the School located in Batur. At 06.50 new crater was formed (Sigluduk Crater, 25 m in diameter and 10 m deep) in the Western of Sinila. The crater was emit white smoke. At 11.00 AM, Sigluduk Crater ejected a dark gray cloud, while the volcanic activities in Sinila and Timbang Crater were declined. At the evening, the gray cloud from Sinila was completely stopped.

Figure 5.10. Evacuation process (Harsaja, 1979)

- February 22, 1979, in the morning, PVMBG Team visited Sinila Crater. At the bottom of the crater, 60-70 m across and 40 m deep, was filled with bubbling mud.
- After a few days, the President of Indonesia came to the mass graves to give a prayer (the condition of the mass graves now is shown in figure 5.11). He declared this disaster as a national disaster. In total, 149 people died (another version said it was 151, the difference come from two people who were died in the hospital), 145 are Kapucukan people, four of them are people who try to

rescue the victims. The remaining Kepucukan's villagers then were moved into Baturaja, South Sulawesi through transmigration program.

Figure 5.11. Mass graves of 1979 incident in Batur Sub-District

Map of 1979 Disaster

The map of 1979-disaster chronology is shown in figure 5.12:

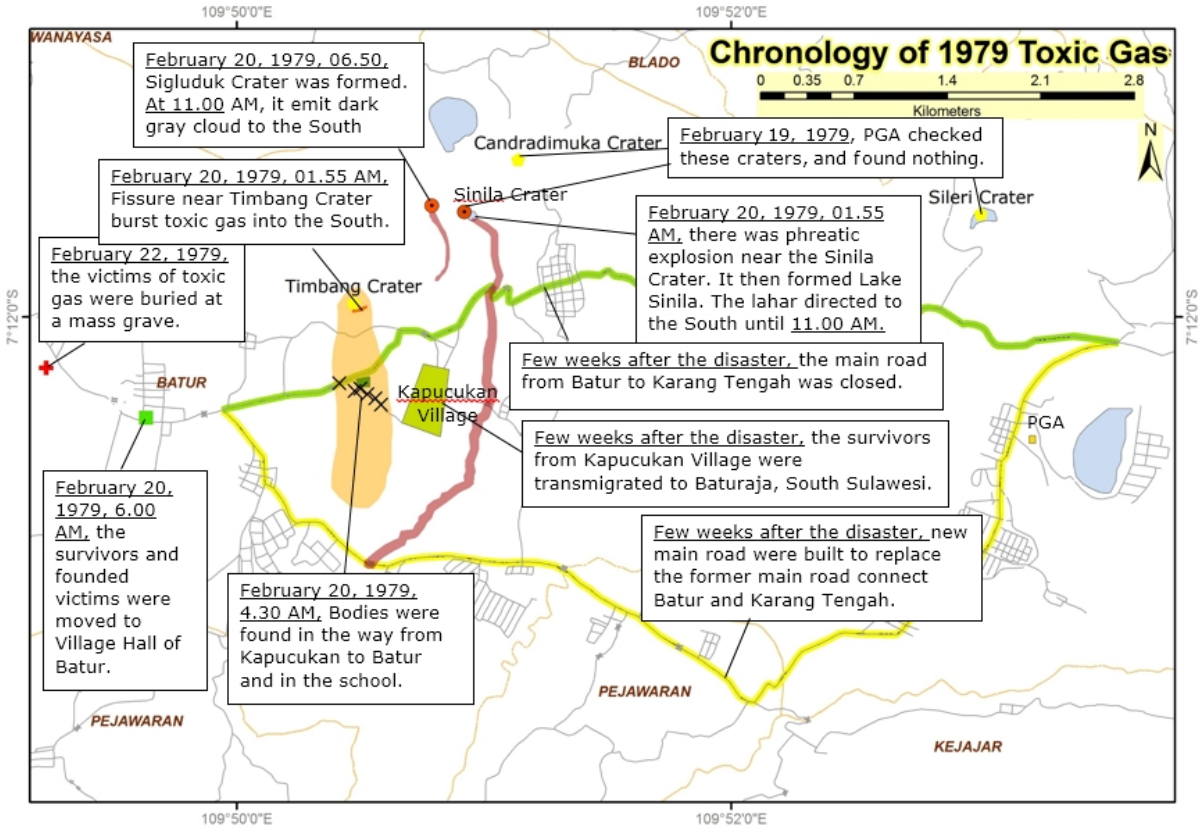


Figure 5.12. Map of Chronology in 1979

Before 1979 disaster, the attention was given to Mt Pakuwaja and Sileri Crater. It was considering that Mt Pakuwaja is the youngest mountain in the Dieng, while Sileri eruption in 1944 makes 144 people dead. After 1979, the attentions were more in Timbang Crater, Sileri Crater and Mt Pakuwaja. The Disaster Prone Area (DPA) map in 1979 is displayed in figure 5.13:

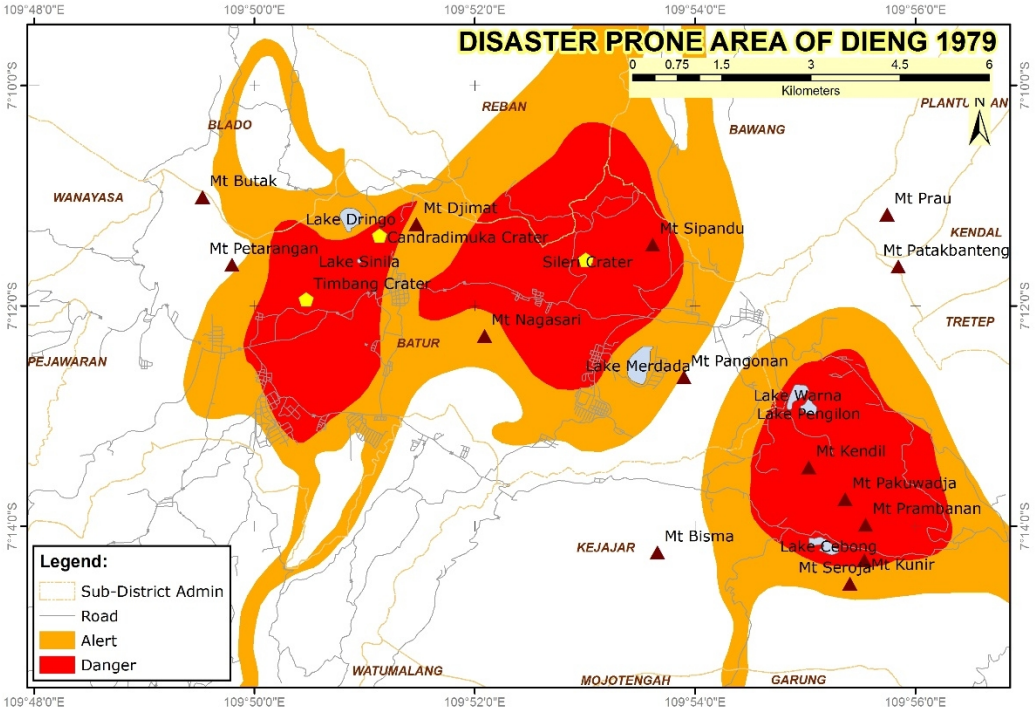


Figure 5.13. Map of Disaster Prone Area of Dieng 1979 (Adapted from PGA of Dieng, 1979)

The map of DPA in 1979 consists of two zone, which are danger and alert. The danger zone encircles Timbang Crater, Sileri Crater, and Mt Pakuwaja. For the threat of toxic gas in Timbang Crater, the danger zone is more to the South. It is because the land contour in Timbang Crater is decreasing to the South. As experienced in 1979 incident, the CO_2 gas flew following the topography, like water. Based on this reason also, the main road from Batur to Karang Tengah is closed, replaced with the new main road in the South part of Kapucukan Village. Until now, the former main road is still exist, but unmaintained and unpaved (figure 5.14). While for alert zone in 1979 buffered in the outside area of the danger zone and the rivers which may affected to the mudflows or lahars.

Figure 5.14. Former main road that connected Batur and Karang Tengah (private documentation)

In 1997, PVMBG released a DPA map for Timbang Crater (figure 5.15). The map consists of three zones. Zone 3 is zones that potentially get affected by toxic gas, stones burst, base surges, mudflows and lahars. Zone 2 is a distribution zones from zone 3 that potentially get affected by stones burst, base surges, mudflows and lahars. Zone 1 is a distribution zones from zone 2 that potentially get affected by base surges, mudflows and lahars.

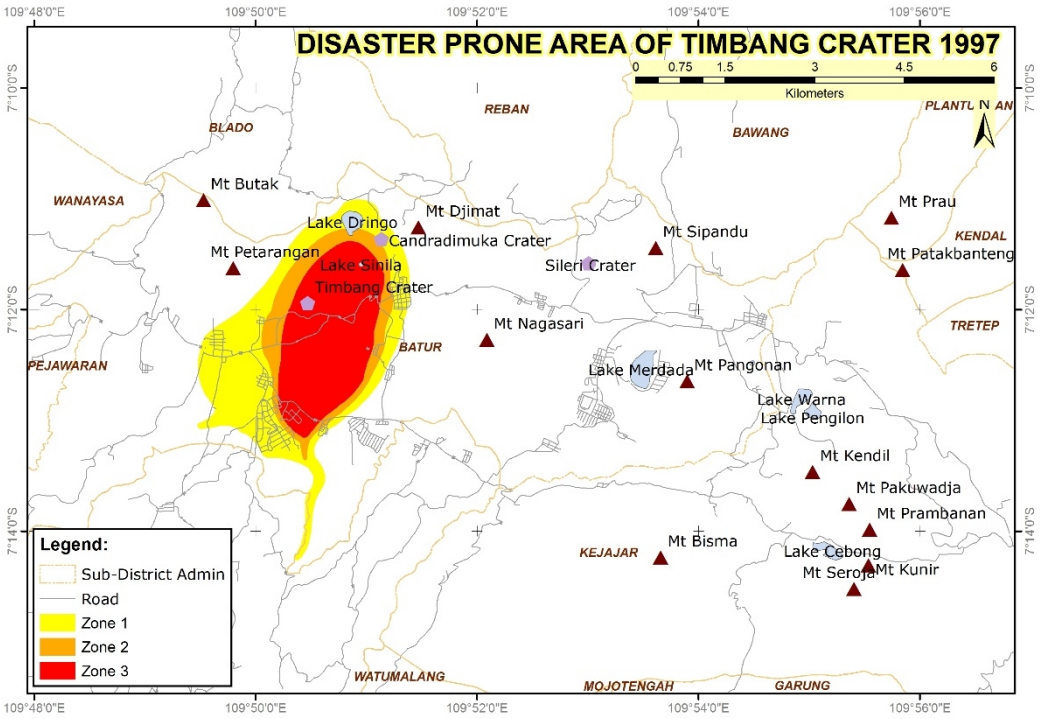


Figure 5.15. Map of Disaster Prone Area of Timbang Crater 1997 (Adapted from PGA of Dieng, 1997)

In 2006, PVMBG renewed the DPA map of Timbang Crater into a disaster prone area of Dieng. This map is similar with the 1997 one, but it was added a danger points in Sileri and Mt Pakuwaja. Zone 3 covers the Timbang Crater areas and Lake Sinila, same with the 1997 map. Zone 2 covers the distributions of zone 3 in Timbang Crater, radius 2 – 2.5 km from Sileri Crater, and radius 1 – 3 km from Mt Pakuwaja. Zone 1 covers the distributions of zone 2. The DPA map of Dieng 2006 is shown in the figure 5.16.

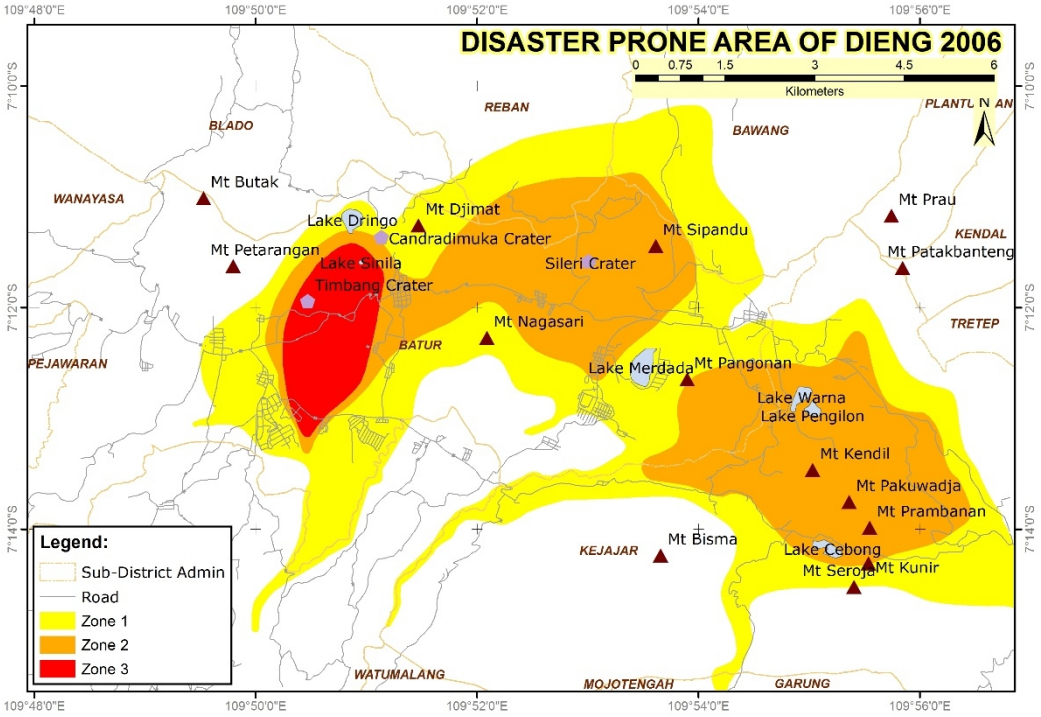


Figure 5.16. Map of Disaster Prone Area of Dieng 2006 (Adapted from PGA of Dieng, 2006)

5.2.2. 2011 Disaster

In 2011, the integrated disaster management in Banjarnegara has not been formed. There was no contingency plan, and BPBD has not been established. Different with 2013, Banjarnegara seems not ready to manage the disaster. Mr. Ngalim, Non-Commissioned Officer for Village Supervisors of Koramil of Batur stated:

> *"The toxic gas disaster management in 2011 seems not very good because the lack of preparedness of Banjarnegara's stakeholders to handle the disaster. This is because since 1979, there was no other toxic gas disaster. It leads to a shock or impediment of disaster management."*

At the time, the stakeholder that was chosen by the Regent to manage the disaster response was PMI of Banjarnegara and Dinsosnakertrans of Banjarnegara. PMI of Banjarnegara was assigned to coordinate the aid that come from many organizations, while Dinsosnakertrans coordinated the logistic that come from Province level and private.

Chronology of 2011 Disaster and Its Evacuation Process

- May 22, 2011, observer from PGA of Dieng conducted a routine observation and found the presence of CO_2 gas with the period between 15 – 20 minutes and the height reached 20 m.
- May 23, 2011, 02.00 PM, PVMBG set the status level of Timbang Crater from **NORMAL** (level 1) into **ALERT** (level 2), with the safe radius from Timbang Crater was 500 meters.
- May 28, 2011, the CO_2 concentration level was increasing into 1.3% volume. At 5.30 PM, there was a report from Puskesmas of Batur 1 to Dinkes of Banjarnegara. They said that there were many people came to Village Hall of Batur because an issue that the mountain had erupted. After soothed by the PGA of Dieng officers, they back to their home.
- May 29, 2011, 6.00 AM, the CO_2 gas was seen flew into the South (50 m). At 8.45 PM, PVMBG with the Statement Letter No. 997/45/BGL.V/2011 set the status level of Timbang Crater from **ALERT** (level 2) into **HIGH ALERT** (level 3), with the safe radius from Timbang Crater was 1 kilometers. Medical services from Puskesmas of Batur 1 were moved to SMA 1 Batur because Puskesmas of Batur 1 was located near enough with Timbang Crater.

- May 30, 2011, Regent of Banjarnegara with the Statement Letter No. 360/1506/V/2011 stated the emergency response period between May 30 and June 12 2011.
- May 31, 2011, the CO_2 gas concentration at the highest. It reached 2.3 % volume. Mr. Surono, the Head of PVMBG prohibited all activities in the radius 1 kilometer from Timbang Crater. Based on the Statement Letter from the Regent, at 6.00 AM, evacuation was done by BNPB, BASARNAS, PMI of Banjarnegara, Koramil of Batur, Polsek of Batur, and volunteers in Simbar and Serang Hamlet. These two hamlets were emptied. The refugees' camps were established in SMA 1 Batur and the Village Hall of Batur. The total refugees at the time were 1.179 people with 69 refugees got low stages of respiratory disease. Further, there were total 17 refugees' camps available in four sub-district, which are Batur, Wanayasa, Pejawaran and Karangkobar.
- June 2, 2011, Dinkes of Banjarnegara launched mobile medical services.
- June 7, 2011, the CO_2 concentration was still recorded high with maximum 1.07% volume.
- June 8 – June 10, 2011, the Village Hall of Batur was crowded of refugees (figure 5.17).

Figure 5.17. The condition of Village Hall of Batur and trauma healing by volunteer in June 8 – June 10, 2011 (PKPU, 2011)

- June 10, 2011, at 6.45 PM, PVMBG with its report No. 45/BGL.V/2011, set the status level of Timbang Crater from **HIGH ALERT** (level 3) into **ALERT**

(level 2). The safe radius from Timbang Crater was changed form 1 kilometer became 500 meters.

- June 11, 2011, a meeting was held in Banjarnegara to evaluate the disaster. The meeting was attended by PVMBG, BNPB, PGA of Dieng, Muspida of Banjarnegara, Muspika of Batur, SAR Team of Banjarnegara, Head of Villages, Medical Team, and other related stakeholder. They concluded that the refugees were allowed to go back to their home. The recapitulation of refugees is shown in table 5.3:

Table 5.3. Number of refugees between June 2 and June 11, 2011

	June 2011									
Date	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Number of refugees	708	910	1,091	902	979	979	979	853	853	853

Source: Dinkes of Banjarnegara (2011)

- September 9, 2011, PVMBG set the status level of Timbang Crater from **ALERT** (level 2) into **NORMAL** (level 1).

Map of 2011 Disaster

The chronology map of 2011 disaster is shown in the figure 5.18:

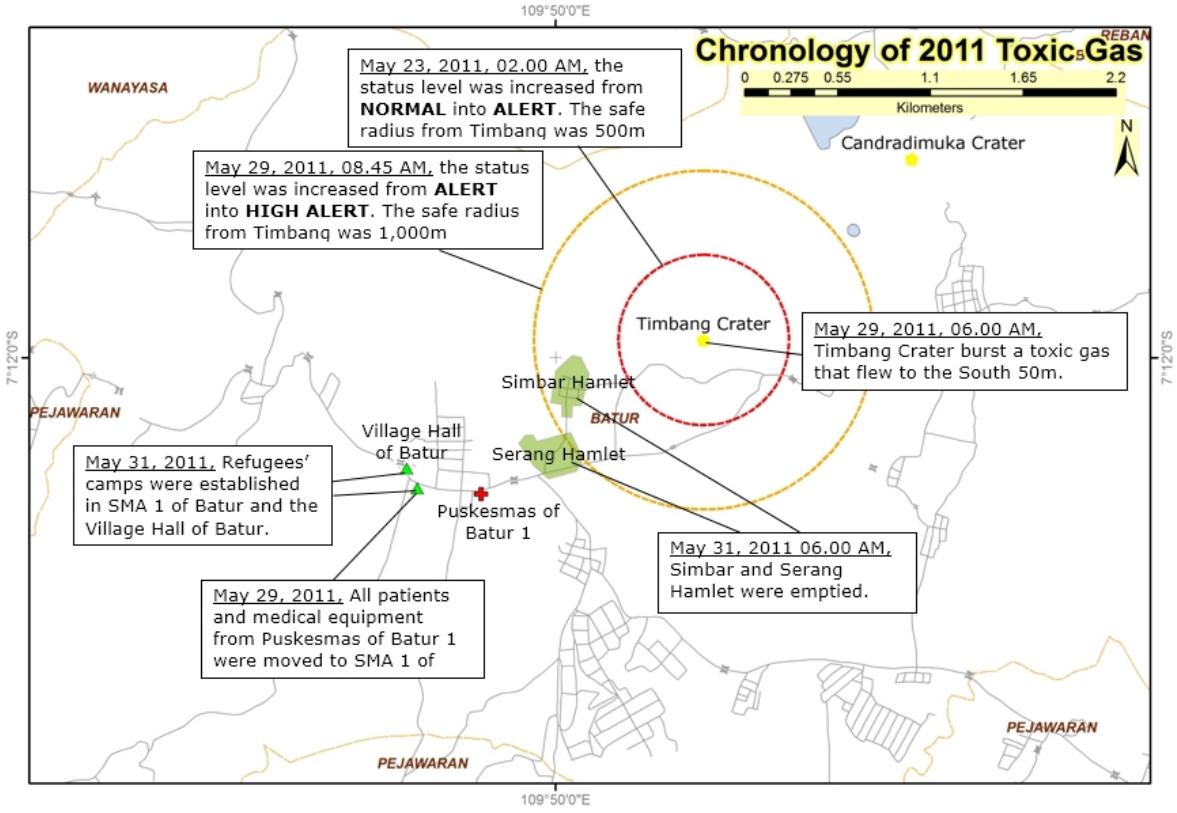


Figure 5.18. Map of Chronology in 2011

After 2011 disaster, PVMBG released a new DPA map of Dieng. The concentration of danger area is still of Timbang Crater, and added with areas in Dieng that are categorized as a danger (zone 3). Comparing to previous DPA maps, this map categorized the threats from Sileri and Mt Pakuwaja as a small threat. Instead, zone 3 was filled by small areas surround the craters/lakes that considered as dangerous. Those areas even including tourism objects, like Warna Lake, Sileri Crater, Candradimuka Crater, and Balekambang Lake. The DPA map 2011 is the latest map that issued by PVMBG as an official government institution that handle the volcanology and geological disaster mitigation (figure 5.19).

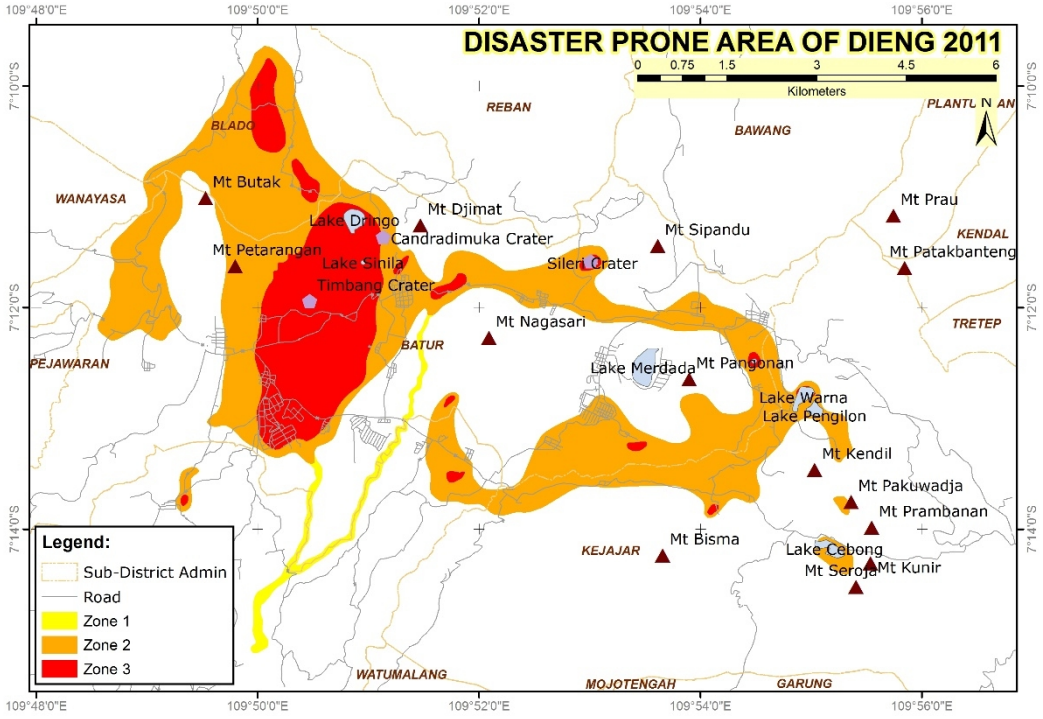


Figure 5.19. Map of Disaster Prone Area of Dieng 2011 (Adapted from PGA of Dieng, 2011)

5.2.3. 2013 Disaster

In 2013, the danger was not only came from CO_2 gases flow, but also H_2S gas and an earthquake in April 19, 2013. All of interviewed stakeholder agreed that the disaster management at the time is better than 2011. This is because the establishment of BPBD of Banjarnegara in 2012, which focus in the disaster management in Banjanegara.

> Mr. Tursiman, Head of BPBD of Banjarnegara: *"The integrated disaster management are newly implemented in 2013. Previously, it was the responsibility of Secretariat of Welfare Section of Banjarnegara."*

> Mr. Ngalim Non-Commissioned Officer for Village Supervisors of Koramil: *"The disaster management in 2013 is better than 2011."*

Mr. Feri, Functional Nurse of Puskesmas of Batur I: *"The disaster management in 2013 is better, because each stakeholder already knows its roles."*

Chronology of 2013 Disaster and Its Evacuation Process

- March 7, 2013, when the observer from PGA of Dieng conducted a routine observation around Timbang Crater (+50 m), he saw the presence of CO_2 gas flew from the Timbang Crater. He also found a dead animal (figure 5.20).

Figure 5.20. A dead wildcat was found in Timbang Crater area (Mr. Surip, PGA of Dieng, 2013)

- March 9, 2013, a monitoring team that was led by Mr. Tunut (Head of PGA of Dieng), released a guinea pig near the Timbang Crater (20 m). The result was the guinea pig was dead. At the time, the CO_2 concentration was 0.73 – 1.24 % volume
- Start from March 10, 2013, BPBD of Banjarnegara conduct observations and socialization to settlement near Timbang Crater. Those actions were based on the phone report from PGA of Dieng since March 7, 2013.
- March 11, 2013, at 6.00 AM, there was a drastic increase of CO_2 concentration. The detector got error. It is expected because the concentration level exceeds the limit of that instrument. At 4.00 PM, the concentration level of CO and CO_2 was still high, which reach 4.7 % volume.

- March 11, 2013, at 10.00 PM, PVMBG set the status level of Timbang Crater from **NORMAL** (level 1) into **ALERT** (level 2), with the safe radius from Timbang Crater was 500 meters.
- March 12, 2013, at 4.20 PM, the visual of Timbang Crater was shown in figure 5.21.

Figure 5.21. Visual of Timbang Crater in March 12, 2013 (PGA of Dieng)

- With the changes of status level of Timbang Crater, BPBD of Banjarnegara together with Muspika (Head of Sub-District of Batur, Commander of Koramil of Batur, and Head of Polsek of Batur) and other related stakeholders prepared needed activities when the situation was getting worse. Farther, March 14, 2013, with the Banjarnegara Regent Statement Letter No. 360/846/III/2013 about the emergency disaster statement of Timbang Crater, the main post of emergency disaster of Timbang Crater, Sumberejo Village, Batur Sub-District was officially opened for 14 days ahead. This main post was located in the pavilion of sub-district office of Batur, and supported by observation post of Timbang Crater in Simbar Hamlet, Sumberejo Village and volcano observation post in PGA of Dieng in Karang Tengah Village, Batur Sub-District.
- March 15, 2013, a coordination meeting was held (figure 5.22).

Figure 5.22. March 15, 2013 meeting in main post of Batur, led by Vice-Regent of Banjarnegara (Dinkes of Banjarnegara)

- The main post of emergency disaster of Timbang Crater was maintained by several stakeholders. They are BPBD of Banjarnegara, Sub-District Office of Batur, Sumberejo and Batur Village, Koramil of Batur, Polsek of Batur, SAR Team of Banjarnegara, PMI of Banjarnegara, Puskesmas of Batur I, BAGANA, TAGANA, SAR Team of Cilacap, Sekber PAB (Joint Secretariat of Banjarnegara's Nature Lovers), Banyuwong Rescue and other volunteers. Every day they worked 40-50 people in 12 hours shift.
- Since March 18, 2013, BPBD of Banjarnegara distributed mask in Sumberejo Village, Batur Village, and school in the Batur Sub-District to avoid Acute Respiratory Infections (ARI).
- During the emergency period of 14 days, the danger variables of Timbang Crater, which is seismic activity, gas burst, concentration level of H_2S, CO_2, and CO was increasing. The biggest was a gas burst in March 24, 2013 at 6.30 AM that reached 700 meters to the South. From this occurrence, since March 24, 2013, the road of Kepucukan, Sumberejo Village was closed from any people activities.
- March 27, 2013, at 11.30 AM, the status level of Timbang Crater was increased from **ALERT** (level 2) into **HIGH ALERT** (level 3) based on the letter of Head of PVMBG No. 7612/45/BGL/III/2013. The safe radius in Timbang Crater was changes into 1 kilometers. Internal coordination was held in the main post of Batur to anticipate the shelters for refugees.

- March 28, 2013, at 2.00 AM, PGA of Dieng identified the CO_2 and H_2S flow to the South as far as 2 kilometers, and reached Dieng – Batur main road. At 2.30 AM, PGA of Dieng measured the concentration level of CO_2 gas in Kaliputih Bridge, which is located 2 kilometers to the South from Timbang Crater. It was resulted that the concentration level of CO_2 gas was 0.6 % volume and H_2S was 57 ppm. These concentrations were already exceed the safe level (0.5% volume for CO_2 and 10 ppm for H_2S), so the officer from PGA of Dieng took an initiative to close the roads (Dieng – Batur main road from Kaliputih Village – Sumberejo Village along 4 kilometers) for three hours. In the evening, the statement letter of Banjarnegara Regent was renewed with No. 360/963/III/2013 on March 28, 2013 about renewal status of disaster emergency in Timbang Crater between March 28 and April 10, 2013 or to the level status of Timbang Crater is normal.
- The CO_2 gas concentration was lower than H_2S concentration. H_2S has lower density that the air. It made the Timbang Crater gases soar vertically, not flow follow the valley (figure 5.23).

Figure 5.23. March 17, 2013 at Timbang Crater (PGA of Dieng)

- April 19, 2013, at 7.05 PM, there was a 4.8 SR tectonic earthquake (figure 5.24). This earthquake was felt in all Dieng area with scale of MMI III – IV.

Figure 5.24. The impact of earthquake in April 2013, from small crack to collapsed house (antaranews.com, detik.com, and private documentation)

After the earthquake, BPBD immediately took steps as follows:

1. All lanes/roads to the Timbang Crater and Sileri Crater were closed until PGA of Dieng stated that there are no flows of toxic gas.
2. Opened posts and refugee camps in Batur Sub-District (Village Hall of Batur, Kaliputih, Dieng Kulon, and Dieng Wetan) and in three villages (Gembol, Ratamba, and Bintoro) to accommodate the refugees that reach 5,511 people in that day.
3. Deployment of volunteers in every available post, and medical team had been docked to the refugees' camps.

- April 20, 2013, BPBD of Banjarnegara stated the earthquake emergency disaster and Timbang Crater disaster for 14 days (April 20, 2013 – May 4, 2013). The command post status also increased from standby into response. BPBD of Banjarnegara immediately conducted evacuation to the people affected to the earthquake and people in the radius 1 kilometer from Timbang Crater. The refugees' camps are located in Village Hall of Batur, Kaliputih Hamlet, Ratamba Village, Village Hall of Dieng Kulon, Village Hall of

Gembol, Bintaro Village, Pasurenan Village, Village Square of Kepakisan, and several points in Batur Sub-District, Pejawaran Sub-District, Wanayasa Sub-District, and Kejajar Sub-Distrit. The evacuation process was done by joint team from BPBD of Banjarnegara, BASARNAS, Satpol PP, Dinhub of Banjarnegara, Kodim of Banjarnegara, Polres of Banjarnegara, SAR Team of Banjarnegara, and volunteers. The operational vehicles were using 2 BPBD of Banjarnegara's trucks, 2 BASARNAS's trucks, 1 truck and 1 SUV from Satpol PP of Banjarnegara, 1 Kodim of Banjarnegara's truck, 3 ambulances from PMI of Banjarnegara's and Puskesmas of Batur, and many vehicles from volunteers. The number of refugees that day reaches 3,539 people.

- Between April 20 – May 2, 2013, the refugees' camps received many refugees that their house had severe damage because the earthquake. Refugees' camps also occupied by people who were afraid if the craters explode or burst toxic gas. Refugees' camps were coordinated by the Main Post. They were helped by volunteers that had been placed to guard or help people in the refugees' camps. The detail number of the refugees are displayed in table 5.4:

Table 5.4. Number of refugees between April 19 and April 29, 2013

No	Camp Location	April 2013									
		19	20	21	23	24	25	26	27	28	29
1	Sidareja							34	34	34	
2	Karang Tengah, Pejawaran						18	18			
3	Gembol	2,000	1,000	1,000	500	500	250	70			
4	Karang Tengah, Batur							125		45	40
5	Bakal						15	15			20
6	Ratamba	25	25	25	25	25	25	17	17	17	17
7	Kepakisan Field		27	25			30	20	189	189	
8	Panusupan						18	18			
9	Pasurenan		160	160	160	120			70	70	
10	Pawuhan								79	79	20
11	Bitingan								359	359	
12	Wadas Putih Hamlet										52
13	Village Hall of Batur	551	185								
14	Kaliputih Post	55	55	55							
15	Dieng Kulon Post	2,000	1,800	2,250	1,515	676					
16	Dieng Wetan Post	500	287	373							
17	Bintoro	380									
Total		**5,511**	**3,539**	**3,888**	**2,200**	**1,321**	**356**	**317**	**748**	**793**	**149**

Source: BPBD of Banjarnegara (2013)

In the disaster response, the Main Post opened kitchen soup in several location that helped by TAGANA, PMI, and volunteers. The post buys groceries and logistic then gave it to the kitchen soups. The kitchen soups were managed by different stakeholders. Kitchen soup in the Main Post and Kepakisan field were managed by PMI. Kitchen soup in the Village Hall of Dieng Kulon was managed by Koramil, while in the Village Hall of Gembol was managed by TAGANA and volunteers.

Meanwhile, health services were done by Puskesmas and Dinkes of Banjarnegara. They opened health center in the Main Post and launched mobile services in several villages. Most patients in the response phase were stressed. Acute Respiratory Infection (ARI) also often found because they sleep in the open area. To manage patients who got stress, Dinkes of Banjarnegara and volunteer were conducting trauma healing. Only two patients were struck down by the ruins. They are Mrs Sri Haryati (37 years old) and a kid named Hibban Abiyyu Prabowo. They immediately were brought to Margono Hospital in Purwokerto and Islamic Hospital in Wonosobo. In the treatment period, they were accompanied by Dinkes of Banjarnegara and BPBD of Banjarnegara.

- May 2, 2013, the last refugees left the main post in Batur.
- May 8, 2013, the status level of Timbang Crater was decreased from **HIGH ALERT** (level 3) into **ALERT** (level 2)
- August 11, 2014 the status level of Timbang Crater was decreased from **ALERT** (level 2) into **NORMAL** (level 1)

Map of 2013 Disaster

The chronology map of 2013 toxic gas disaster is shown in the figure 5.25:

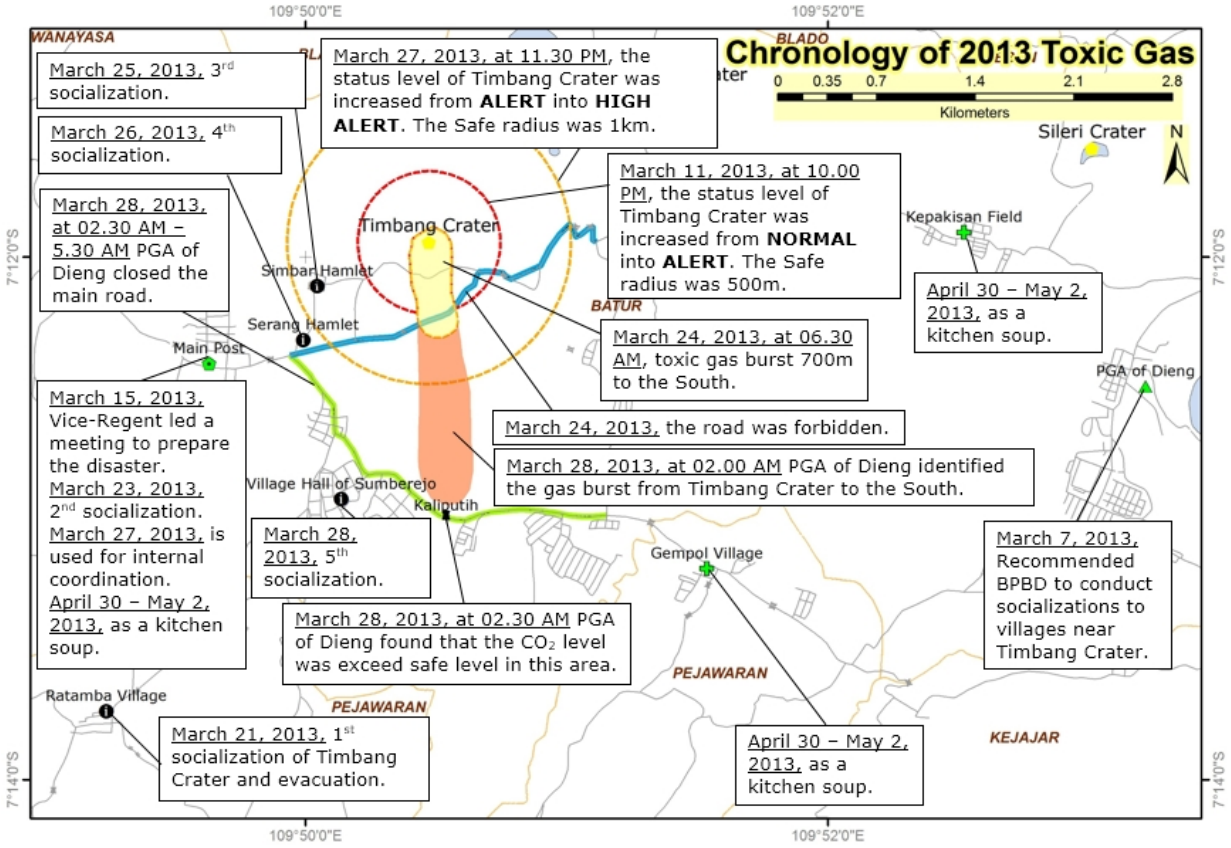


Figure 5.25. Map of Chronology in 2013

5.3. Problems and Suggestion

Problems

There are several problems expressed about the toxic gas disaster management by the institutional stakeholders in while interview process. The list of problems is shown in the table 5.5:

Table 5.5. List of problem expressed by stakeholders

Problem	Stakeholder
The needs of contingency plan is not high	• PMI of Banjarnegara • Dinkes of Banjarnegara • Polres of Banjarnegara

Problem	Stakeholder
Contingency plan document has not been implemented properly yet	PMI of Banjarnegara
Local wisdom from people affected by the disaster sometimes make them become more disobedient to government warning	• PMI of Banjarnegara • SAR Team of Banjarnegara • Dinkes of Banjarnegara • Polres of Banjarnegara • Polsek of Batur
There are a strong ego sector between each stakeholder	PMI of Banjarnegara
Overlap between each stakeholder	Dinkes of Banjarnegara
The spatial plans is not applied properly	KLH of Banjarnegara
The roles of the private sector are not much	Polres of Banjarnegara
The discrepancy of organizational structure with the real field condition	Sub-District Office of Batur
The funding disbursement is not flexible even though in emergency condition	• Dinkes of Banjarnegara • Disdikpora of Banjarnegara
The lack of medical staff in the beginning of crisis	Puskesmas of Batur 1

Source: in-depth interview analysis

Many stakeholders stated that the main problem in the toxic gas disaster management in Dieng is the people's local wisdom. Sometimes it makes people become more disobedient to government warning. Local wisdom is values that considered good and right that lasts for generations and implemented by the people in their community. The example of local wisdom in Dieng is their belief that when the sun shines, it is okay to cultivate in the near Timbang Crater. Indeed, it is true that sunlight can decomposes the CO_2, but it does not mean that areas near Timbang Crater are always safe when the sun shines. If the CO_2 gas is highly concentrated, even sunlight cannot decomposed all the CO_2 gas. This local wisdom caused the people sometimes does not want to be evacuated when the sun shines although government already stated that Timbang Crater's status is Alert or even High Alert. Their disobedient was not without reason. For some farmers, their livelihood is located near to Timbang Crater. They need to cultivate their potato fields or they can be suffered from crop failure.

The second problem is the need in contingency plan. Three stakeholders (PMI, Dinkes and Polres) contend that the stakeholder's need to contingency plan is low. The contingency plan is only as a document that compulsory need to be made because PVMBG said so. The document has never been implemented and

hardly implemented because the plan in the document is unrealistic. Mr. Edi, the head of PMI of Banjarnegara stated:

> *"Contingency plan document will be useful when it has been made with a realistic scenario, as real as possible. For example, the document needs more gap analysis and resources analysis."*

Suggestion

There are several suggestions expressed by the institutional stakeholders related to the toxic gas disaster management while interview process. The list of suggestions is shown in the table 5.6:

Table 5.6. List of suggestions expressed by stakeholders

Suggestion	Stakeholder
Contingency document need to be updated every year	• BPBD of Banjarnegara • PMI of Banjarnegara • SAR Team of Banjarnegara • Satpol PP of Banjarnegara • Dinkes of Banjarnegara • Kodim of Banjarnegara • KLH of Banjarnegara • Polres of Banjarnegara
The technical abilities of staff and volunteer are need to be elevated, including the training and simulation.	• BPBD of Banjarnegara • SAR Team of Banjarnegara • Dinkes of Banjarnegara • Kodim of Banjarnegara
Facilities and Infrastructures to handle the disaster management are need to be enhanced	• SAR Team of Banjarnegara • Satpol PP of Banjarnegara • KLH of Banjarnegara • Polres of Banjarnegara • Kesbangpolinmas of Banjarnegara • Polsek of Banjarnegara • Sub-District Office of Batur • Puskesmas of Batur 1
Contingency Plan Document is need to be socialized to involved stakeholders	• PMI of Banjarnegara • SAR Team of Banjarnegara • Dinkes of Banjarnegara
Enhance technology is needed in Banjarnegara disaster management, such as using Sahana Eden	PMI of Banjarnegara
Special curriculum to Dieng students is needed to increase the people awareness	Disdikpora of Banjarnegara

Suggestion	Stakeholder
Socialization about the Dieng danger is need to be conducted regularly	• Disdikpora of Banjarnegara • Polsek of Banjarnegara
The establishment of BPBD of Wonosobo and BPBD of Batang is important	PGA of Dieng

Source: in-depth interview analysis

The suggestion expressed most by stakeholders is that the contingency plan is need to be updated every year. Updated contingency plan is important. It is because in a year, the assets, the equipment, the ability, and person in charge in each stakeholder can be changed. It also ensures that the document is relevant as a guidebook in toxic gas disaster management. Mr. Permadi, Section Chief Officer of Disease Control and Extraordinary Events Prevention of Dinkes of Banjarnegara stated:

> *"The contingency plan document 2012 is need to be updated, because the number of health workers, the amount of equipment and the number of ambulances has been different."*

Another suggestion that also stated most by the stakeholders is related to the improvement of facilities and infrastructure. The improvements are including to the evacuation road, search and rescue equipment, and vehicles for evacuation.

Meanwhile, a suggestion that has relation to geo-information technique is come from PMI of Banjarnegara. Mr. Edi suggests that the local government of Banjarnegara should enhances the disaster management by implementing Sahana Eden.

5.4. Disaster Management Scenario by Using Sahana Eden

This disaster management scenario is based on contingency plan of Banjarnegara 2012 with modification. The Contingency Plan Document of Banjarnegara 2012 was chosen because the hazard and the location on the Contingency Plan Document of Banjarnegara 2012 is the same, which is toxic gas in Dieng. The disaster management scenario in the contingency document itself is

using real disaster approach (from 2011 disaster). Then, it was modified into disaster scenario that used as a simulation in Contingency Plan Document 2012.

Sahana Eden is used in this disaster management scenario as a simulation tool. It is also to make sure that Sahana Eden's solutions can be applied in disaster management to face the threat of toxic gas disaster in Banjarnegara. In the making of the disaster management scenario, some bases are followed/made as shown in table 5.7

Table 5.7. Bases in disaster management scenario

Item	Base
Disaster scenario's time and date	Fictive with consideration from actual 2011 and 2013 incidents
Disaster response actions	Contingency Plan Document 2012 and actual actions from 2011 and 2013 incidents
Person's identity	Contingency Plan Document 2012 (for volunteers using fictive identity)
Assets and facilities	Contingency Plan Document 2012 and fieldwork
Spatial information	Fieldwork
Shelters information	Actual shelters from 2011 and 2013 incidents
Number of threatened people	Contingency Plan Document 2012
Hospital information	Fictive data
Number of injured people	Contingency Plan Document 2012

The disaster management scenario to mitigate toxic gas hazard in Dieng, Banjarnegara is described as follows:

- March 6, 2015 at 12.27, PGA of Dieng received warning from gas detector in Timbang Crater that the CO_2 gas was exceeded the normal level. PGA of Dieng immediately checked and measured Timbang Crater directly. When it is confirmed, PGA of Dieng contacted all stakeholder that related to the disaster, including Sumberejo and Batur's village officials. PGA also makes official report to PVMBG.

Table | Report | Map

Link to this result | Export as:

Show 25 entries

Showing 1 to 25 of 42 entries

	Person	Job Title	Organization	Department / Unit	Facility	Email
Open Delete Send Message	Andy	-	Dinas Pendidikan, Pemuda dan Olahraga Banjarnegara (Disdikpora)	-	Office of Disdikpora (Office)	andy@andi.com
Open Delete Send Message	Aris	-	SAR Team of Banjarnegara (SARKAB)	-	-	arisman@gmail.com
Open Delete Send Message	Aulia	-	Komando Distrik Militer of Banjarnegara 0704 (KODIM)	-	Office of KODIM (Office)	aulia29@yahoo.com
Open Delete Send Message	Aziz	-	Volcano Post Observation of Dieng (PGA of Dieng)	-	Office of PGA of Dieng (Office)	azisvolcano@gmail.com
Open Delete Send Message	Budi	-	Badan Perencanaan Daerah Banjarnegara (Bappeda)	-	Office of Bappeda (Office)	budiw@gmail.com

Above is a list of staff and volunteers that were recorded manually in Sahana Eden. It is consist of detail information such as phone number, e-mail address, work address, blood type, his/her experiences and even skills he/she has. PGA can used all of this information to contact others stakeholders. Sahana Eden provides several types of communication such as e-mail, SMS, and Twitter.

- March 8, 2015, at 10.00 PM, PVMBG set the status level of Timbang Crater from **NORMAL** (level 1) into **ALERT** (level 2), with the safe radius from Timbang Crater was 500 meters. BPBD prepared the preparedness of each stakeholder to manage the disaster by recorded their assets and equipment that can be used, and identified its exact location.

Table | Report | Map

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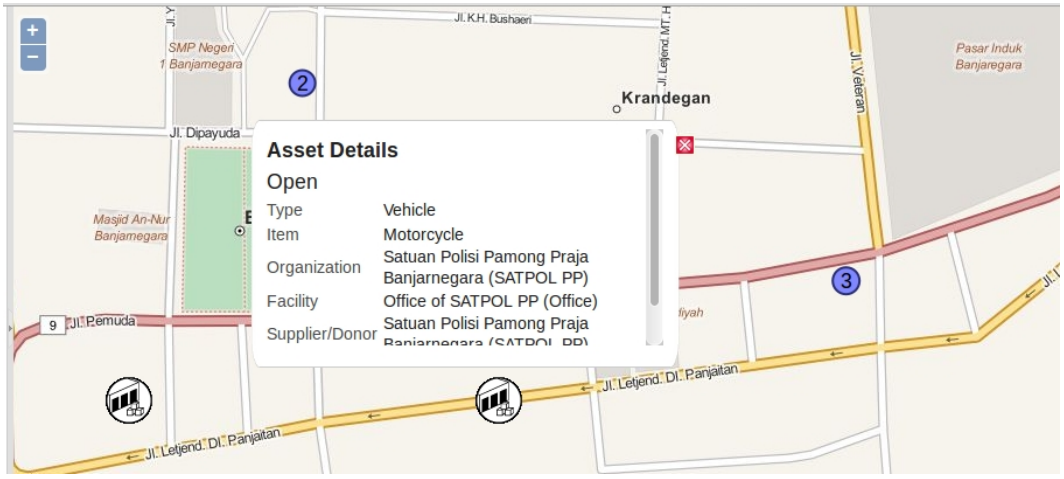
	Category	Item	Asset Number	Assigned To	Organization	Facility	Country	State / Province	County / District	City / Town / Village
Open	Standard > CLOTHING	Household appliance		-	Dinas Sosial, Tenaga Kerja, dan Transmigrasi Kabupaten Banjarnegara (Dinsosnakertrans)	Logistic Warehouse (Warehouse)	Indonesia	-	-	-
Open	Default > -Other	Bicycle		-	Dinas Kesehatan Banjarnegara (Dinkes)	Office of Dinkes (Office)	Indonesia	-	-	-
Open	Standard > MATERIALS	Toilet		-	Regional Disaster Management Agency of Banjarnegara (BPBD)	Logistic Warehouse (Warehouse)	Indonesia	-	-	-
Open	Standard > EQUIP	Vehicles		-	Dinas Kebudayaan dan Pariwisata	Office of Dinbudpar	Indonesia	-	-	-



The list of assets of each stakeholders can be added in Sahana Eden. It then can be displayed spatially on the map, complete with the detail information about the assets owned by stakeholder such as the assets condition, the price, and the buy date. It can also mapped the location of suppliers and its information if added.

- March 10, 2015, the main post of emergency disaster of Timbang Crater, Sumberejo Village, Batur Sub-District was officially opened for 14 days ahead. This main post was located in the pavilion of sub-district office of Batur.

Show 25 entries — Showing 1 to 1 of 1 entries

	Project Name	Lead Implementer	Sectors	Themes	Start Date	End Date	Location
Open Delete	Main Post of Timbang Disaster	Regional Disaster Management Agency of Banjarnegara (BPBD)	-	-	2015-03-10	2015-03-24	Main Post of Timbang Disaster

Showing 1 to 1 of 1 entries

Projects can be added to handle the disaster that occurred. In this case, a project called "Main Post of Timbang Crater" was created. This project started in March 10, 2015 and will end in March 24, 2015. The project is located in the Pavilion of Batur Sub-District and can be shown in a map.

Search: Show 25 entries — Showing 1 to 6 of 6 entries

	Person	Team Leader	Email	Mobile Phone	Organization	Facility
Open Delete	Edi		epurwanto@pmi.org	-	Red Cross of Banjarnegara (PMI)	Office of PMI (Office)
Open Delete	Hermawan		cutesmile@yahoo.com	-	Polres of Banjarnegara (Polres)	Office of Polres (Office)
Open Delete	Khalim		ngalimbangets@yahoo.co.id	-	Koramil of Batur (Koramil)	Office of Koramil (Office)
Open Delete	Nasrudin		nasrudin@gmail.com	-	Sub-District Office of Batur	Office of Sub-District Office of Batur (Office)
Open Delete	Tunut		tunut@vsi.go.id	-	Volcano Post Observation of Dieng (PGA of Dieng)	Office of PGA of Dieng (Office)
Open Delete	Tursiman	yes	tursiman@gmail.com	-	Regional Disaster Management Agency of Banjarnegara (BPBD)	Office of BPBD (Office)

The project were consisted of member from different stakeholders. Team leader also can be specified. In this case, the team leader was BPBD of Banjarnegara (Mr. Tursiman).

Search: Show 25 entries Showing 1 to 4 of 4 entries

	Staff	Status	Budget	Start Date	End Date	Daily Cost
Open Delete	Hermawan	Assigned	Day Shift of Timbang Crater	2015-03-10	2015-03-18	0.0
Open Delete	Wahyu Feri	Assigned	Day Shift of Timbang Crater	2015-03-07	2015-03-11	0.0
Open Delete	Khalim	Assigned	Night Shift of Timbang Crater	2015-03-11	2015-03-24	0.0
Open Delete	Sarman	Assigned	Day Shift of Timbang Crater	2015-03-18	2015-03-24	0.0

It also can be used to assign staff or volunteers and also define the work dates for each assigned person.

- March 11, 2015, at 8.00 PM, PVMBG set the status level of Timbang Crater from **ALERT** (level 2) into **HIGH ALERT** (level 3), with the safe radius from Timbang Crater was 1,000 meters.

Search: Show 25 entries Showing 1 to 1 of 1 entries

	Name	Incident Type	Exercise?	Closed	Comments
Open Delete	Timbang Toxic Gas	Volcanic Event	None	No	Safe Radius was 1,000 m

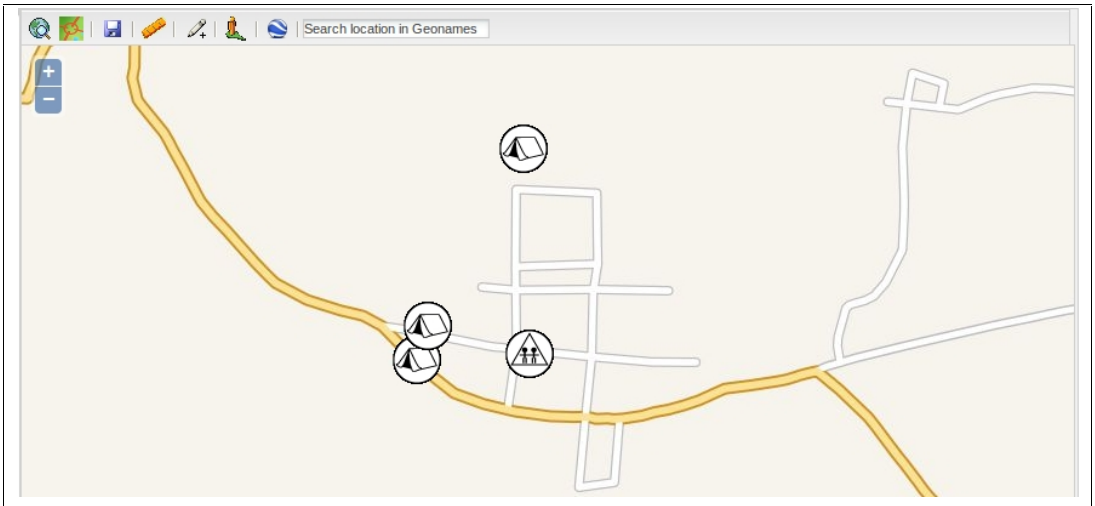
The incident can be created in Sahana Eden, including the detail information about the incident such as, the type of the incident, the situation reports and the location that displayed on the map. Then, to follow up the incident, tasks also can be made. Complete with the list of assigned staff.

At 11.00, Timbang Rapid Response Team coordinated all stakeholders to evacuate people in Sumberejo Villages. The refugees' camps were established in SMA 1 Batur, SMP 1 Batur, and Field of Batur, which are located in safe areas (3.5 kilometers from Western side of Timbang Crater)

Show 25 entries Showing 1 to 3 of 3 entries

	Shelter Name	Status	Shelter Type	Estimated Population	Street Address	Country	State / Province	County / District	City / Town / Village	Village / Suburb
Open Delete	Field of Batur	Open	Temporary Camp	1 000	-	Indonesia	-	-	-	-
Open Delete	SMA 1 Batur	Open	Temporary Camp	550	-	Indonesia	-	-	-	-
Open Delete	SMP 1 Batur	Open	Temporary Camp	550	-	Indonesia	-	-	-	-

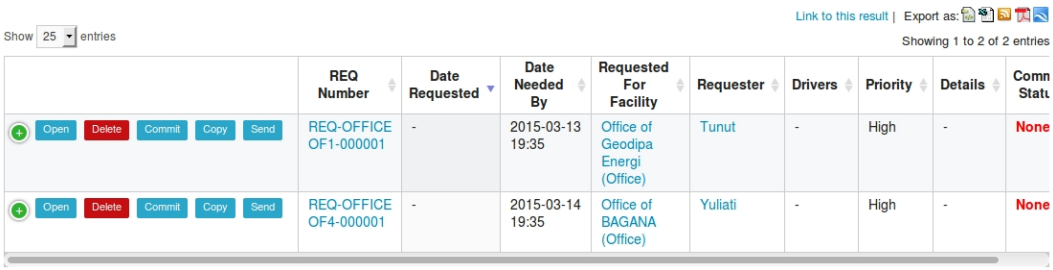
Showing 1 to 3 of 3 entries



The making of shelters in Sahana Eden. Each of shelter were equiped by information of shelter's capacity, status reports, the person who in charge, and the exact location of the shelters.

- Statistical data from Central Statistical Agency and Sub-District Office of Batur showed that there were two villages with 6,650 people threatened from the CO_2 gas flow. There were in Batur Village (2,190 people) and in Sumberejo Village (4,460 people).
- Between March 11 and March 20, 2013, the refugees' camps received many refugees. All evacuated people were recorded by Dinsosnakertrans. It was known that the evacuated people were 3,305. The 1,578 people evacuated to their relatives, while the rest were evacuated into those three shelters.

To organize the shelter, each refugee was recorded in Sahana Eden. It also can be used to record groups of people who need shelters. This data collection was to make sure that the capacity of each shelter is not overload, and to make it easier in the handle of refugees' logistics.



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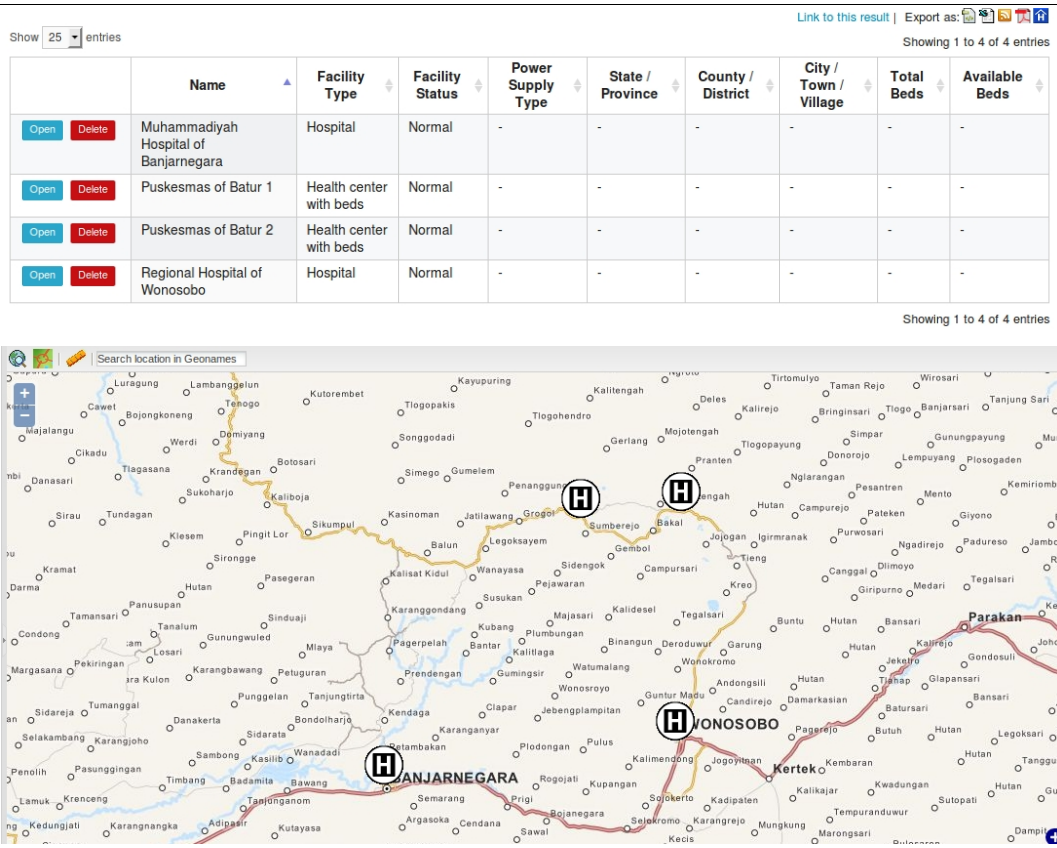
	REQ Number	Date Requested	Date Needed By	Requested For Facility	Requester	Drivers	Priority	Details	Comm Statu
Open Delete Commit Copy Send	REQ-OFFICEOF1-000001	-	2015-03-13 19:35	Office of Geodipa Energi (Office)	Tunut	-	High	-	None
Open Delete Commit Copy Send	REQ-OFFICEOF4-000001	-	2015-03-14 19:35	Office of BAGANA (Office)	Yuliati	-	High	-	None

Sahana Eden also allowed person/stakeholder to make requests to other stakeholders. The request can be a human resource, volunteers/staff with specific skills, facilities, equipments, or logistic.

- There were 10 people who were injured in the evacuation process, they then immediately be brought to the Puskesmas of Batur 1, which is the nearest health center in Batur Sub-District.



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	Name	Facility Type	Facility Status	Power Supply Type	State / Province	County / District	City / Town / Village	Total Beds	Available Beds
Open Delete	Muhammadiyah Hospital of Banjarnegara	Hospital	Normal	-	-	-	-	-	-
Open Delete	Puskesmas of Batur 1	Health center with beds	Normal	-	-	-	-	-	-
Open Delete	Puskesmas of Batur 2	Health center with beds	Normal	-	-	-	-	-	-
Open Delete	Regional Hospital of Wonosobo	Hospital	Normal	-	-	-	-	-	-

Showing 1 to 4 of 4 entries

A list of hospital can be inputted, including its status (normal or impacted by disaster), number of beds, number of available beds, and the location in map.

- March 19, 2015, the toxic gas level from Timbang crater has decreased.
- March 21, 2015, the last refugees left the main post in Batur.

- March 22, 2015, the status level of Timbang Crater was decreased from **HIGH ALERT** (level 3) into **ALERT** (level 2).
- March 24, 2015, the main Post of Batur was closed by BPBD of Banjarnegara.
- April 11, 2015 the status level of Timbang Crater was decreased from **ALERT** (level 2) into **NORMAL** (level 1).

Group of stakeholders' zones in toxic gas disaster management are divided into two groups (figure 5.26). First is located in Banjarnegara Sub-District (group A), the other is located in Batur Sub-District (group B). Banjarnegara Sub-District's group is consist of Banjarnegara's district stakeholders, which is located in the center of development of Banjarnegara District. Meanwhile, Batur Sub-District's group is consist of stakeholders in Batur that involved in the toxic gas disaster management. The map that describes the groups is shown in figure 5.26.

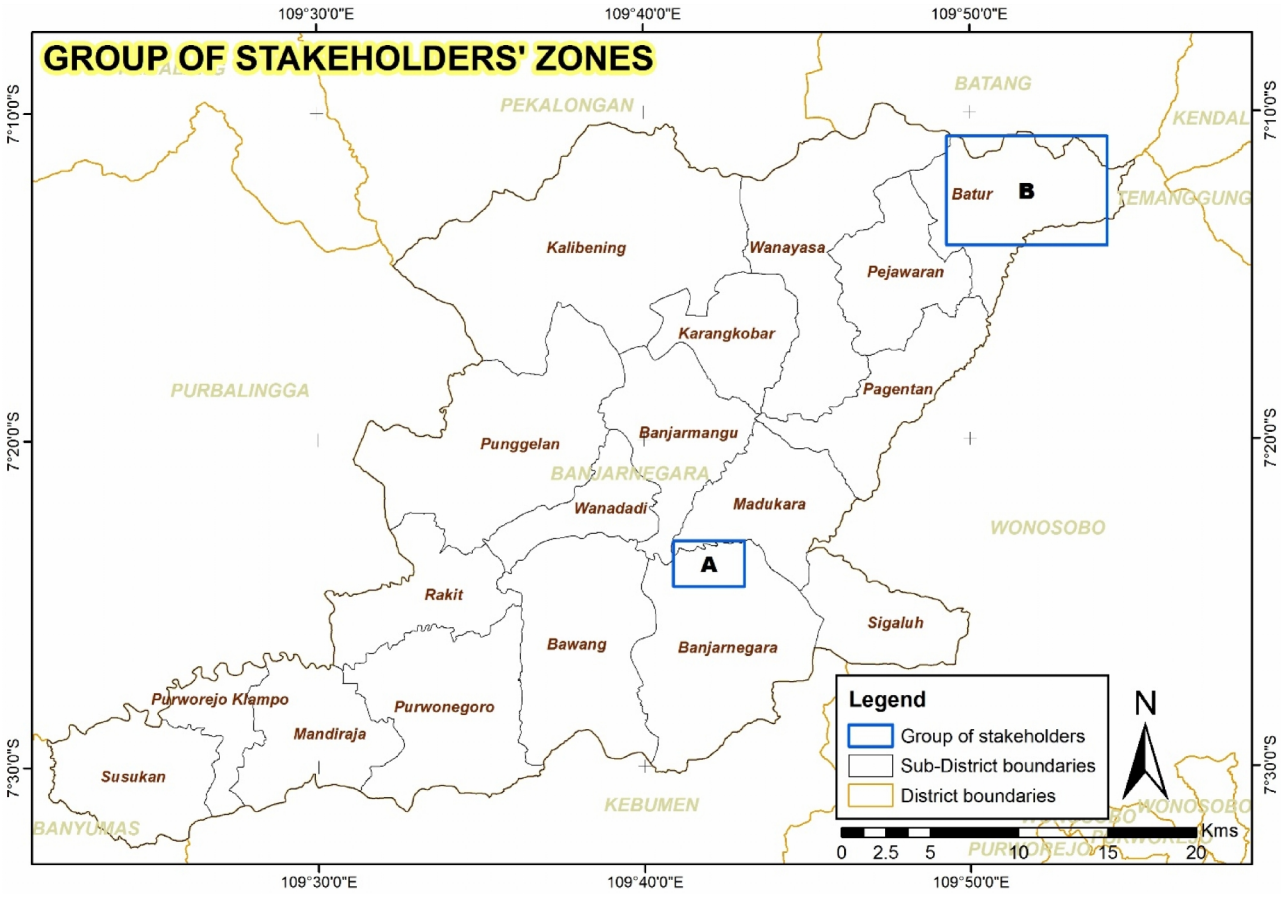

Figure 5.26. Group of stakeholders' zones' map

Those groups are separated within 40 kilometers accessed with closest road (Banjarnegara – Pagentan). Although only 40 kilometers in distance, but the traveling time usually reaches two hours an even more (using car). The accessed roads are relatively narrow and many potholes.

The spatial distribution of stakeholder office in Banjarnegara Sub-District (group A) is shown in figure 5.27. The office of stakeholders in Banjarnegara District is gathered in the Banjarnegara Sub-District. This eases the coordination between stakeholders in toxic gas disaster management. A big hospital with complete facilities (Regional Hospital of Banjarnegara) is also available in this area. The serious injured victims of toxic gas disaster that need specific treatment can be referenced here. Another regional hospital also available in Wonosobo District, which is located 38 kilometers from Batur Sub-District.

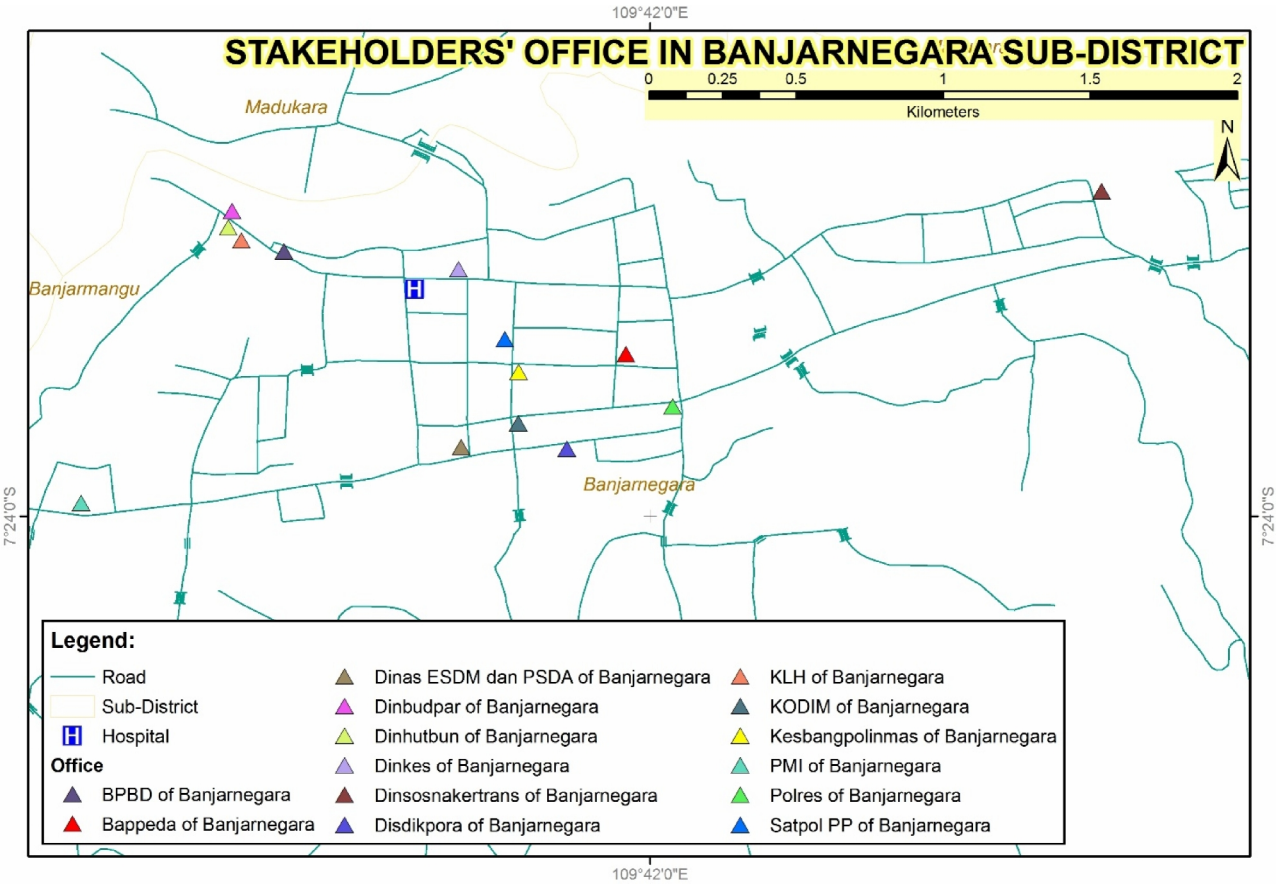

Figure 5.27. Stakeholder' office in Banjarnegara Sub-District

The group B, which is the stakeholders in Batur Sub-District, is shown in figure 5.28. Eight stakeholders involved in the toxic gas disaster management. Six stakeholders are from governmental institution, which is Koramil of Batur, PGA of Dieng, Polsek of Batur, Puskesmas of Batur 1 and 2, and Sub-District Office of Batur. Two others stakeholders are BAGANA and PT. Geodipa Energy.

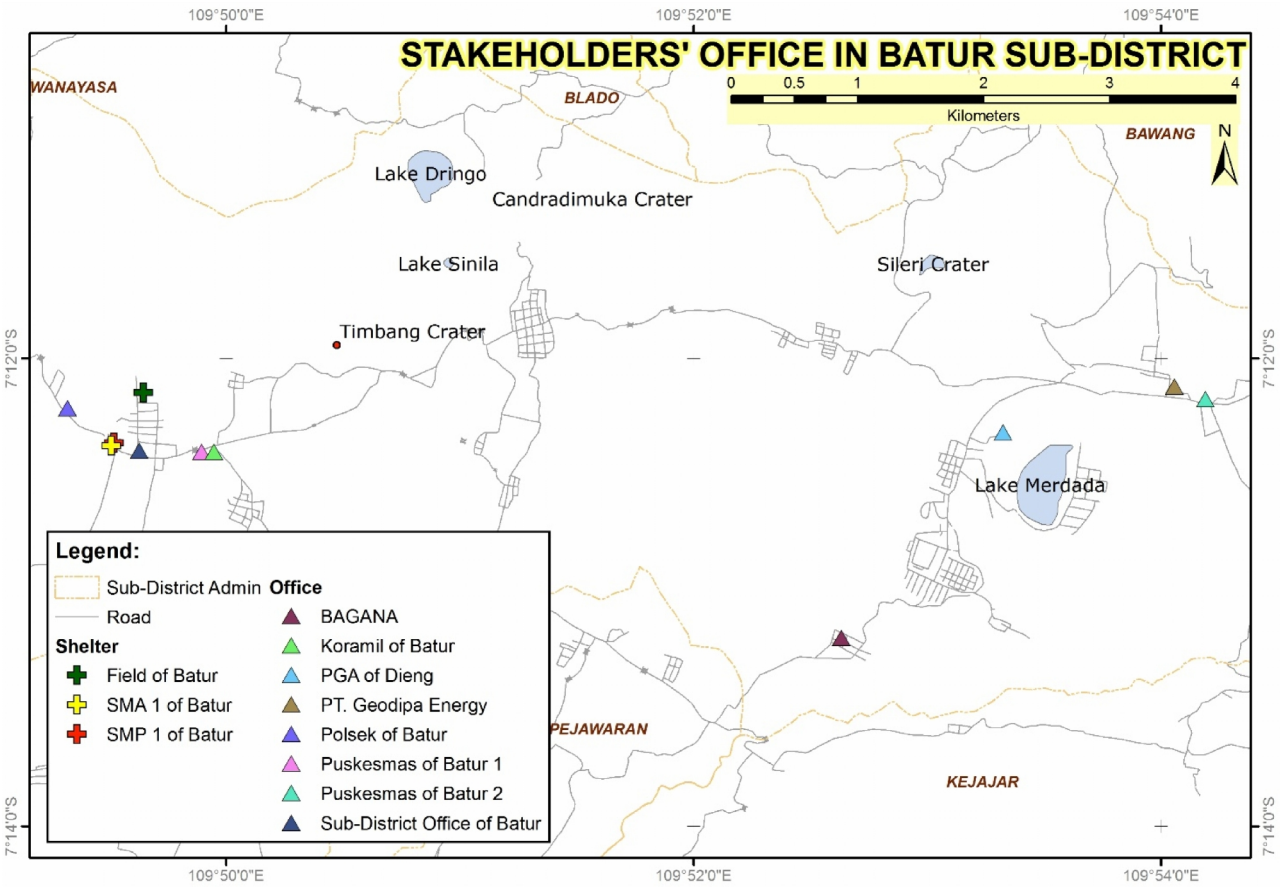

Figure 5.28. Stakeholder' office in Batur Sub-District

Chapter 6. Conclusion and Recommendation

6.1. Conclusions

The main objective of this research is to analyze the past and present chain of warnings and evacuations for toxic gas events in the Dieng volcanic area, Central Java and to determine the improvements using modern geo-information techniques. Based on the previous chapters, the research found several findings:

1. Forty-four stakeholders were involved in the toxic gas disaster management in Dieng. Three stakeholders (PGA of Dieng, BAGANA, and people affected to the disaster) were categorized as primary stakeholders. Eight stakeholders (BNPB, BASARNAS, Ministry of Social, PVMBG, BPBD of Central Java, SAR of Central Java, Dinsosnakertrans of Banjarnegara and BPBD of Banjarnegara) were categorized as key stakeholders. The rest of the stakeholders (33 stakeholders) were categorized as secondary stakeholders.
2. Stakeholders' Collaboration Network revealed the importance of BPBD of Banjarnegara as the institution that is responsible for Banjarnegara's disaster management. Compared to the other stakeholders, BPBD of Banjanegara conducted the most collaborations (33 collaborations). Even, twelve stakeholders collaborated merely with BPBD of Banjarnegara. Overall, 133 collaborations were discovered in the Stakeholders' Collaboration Network.
3. The preparedness document of Banjarnegara (Contingency Plan 2012) was not implemented in 2013 disaster. Although the Contingency Plan 2012 has already regulated policies and strategies to cope the toxic gases from Timbang Crater, policies and strategies applied in the field during the 2013 disaster were different from what was stipulated in the Contingency Plan. The example was the establishing of the Command Post of 2013 that overlapped the structure of organizations in the Contingency Plan Document.
4. The purpose of the making of the Contingency Plan was only due to the occurrence of toxic gases disaster in 2011 not caused by awareness to make a good preparedness document from the Banjarnegara's government. The

initiative came from the PVMBG (institution at national level) and the same time also the organizer of the Contingency Plan, not from the local government (Banjarnegara). Up to now, the Contingency Plan 2012 document has never been updated by Banjarnegara's Government.

5. Before the 1979 disaster, the attentions were given to Mt Pakuwaja and Sileri Crater because Mt Pakuwaja is the youngest mountain in the Dieng Plateau and Sileri erupted in 1944 that killed 144 people. After 1979, Timbang Crater was added to be the focus of monitoring.
6. The last map of toxic gas prone area in Dieng was made in 2011. Since then, the map has never been updated by the local government of Banjarnegara.
7. The 2013 toxic gases disaster management was better than 2011's. It cannot be separated from the involvement of BPBD of Banjarnegara. All interviewed respondents (either institutional stakeholders or people affected by the disaster) agreed that the establishment of BPBD of Banjarnegara made disaster management in 2013 more organized than that in 2011.
8. According to most stakeholders, main problems in the toxic gas disaster management in Banjarnegara were people's disobedience to government's warning and in addition, the government institution thought that Contingency Plan was not necessary.
9. Most stakeholders believed that the contingency plan document is necessary to be updated every year.
10. The Sahana Eden can be implemented in the toxic gas disaster management in Banjarnegara.

6.2. Recommendation for Governments

There are several recommendations to the Local Government and National Government related to this research. The recommendations shown as follows:

1. Considering that toxic gas disaster is a rare disaster in Indonesia (and in the world), and influencing more than 36,000 people who lived in Batur Sub-District, Contingency Plan of Toxic Gas in Banjarnegara need to be made every

year, or at least updated every year. It is because in a year, the assets, the equipment, the ability, and person in charge in each stakeholder can be changed.

2. Contingency plan document should be made as a real need of Banjarnegara's government, not a compulsory that stipulated in a legal basis. This will assure that the making of contingency plan document is made with earnest, not perfunctory. Furthermore, when the disaster occurs, contingency plan document can be used as a guidebook to conduct a good disaster response.
3. Socialization of the contingency plan document to each stakeholder that involved/mentioned in the document is crucial. It is to make sure that stakeholders know what their roles and their responsibilities in the disaster management. From interviews to institution stakeholders, it is known that they all even do not have the contingency plan document.
4. Disaster prone area map of Dieng is need to be updated. The last map (2011), of course does not included 2013 disaster for the prone area consideration. Therefore, PVMBG or BNPB should update the map to make sure that the disaster prone area map of Dieng is relevant and accurate to be used.

6.3. Recommendation for Further Research

The toxic gas disaster management in Dieng sometimes is constrained by several problems. One of the main problems is the local wisdom of Dieng's people that conflicted with government decision, which is based on knowledge and technology. The value, ethic, perception, belief, customary law and rules in Dieng are need to be explored, so in the future there is synchronization between people's local wisdom and government decisions in the toxic gas disaster management.

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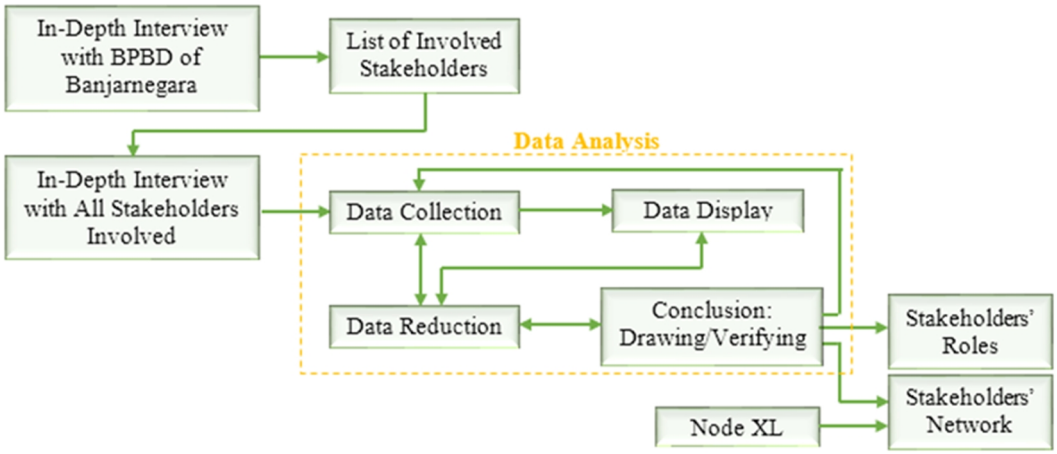
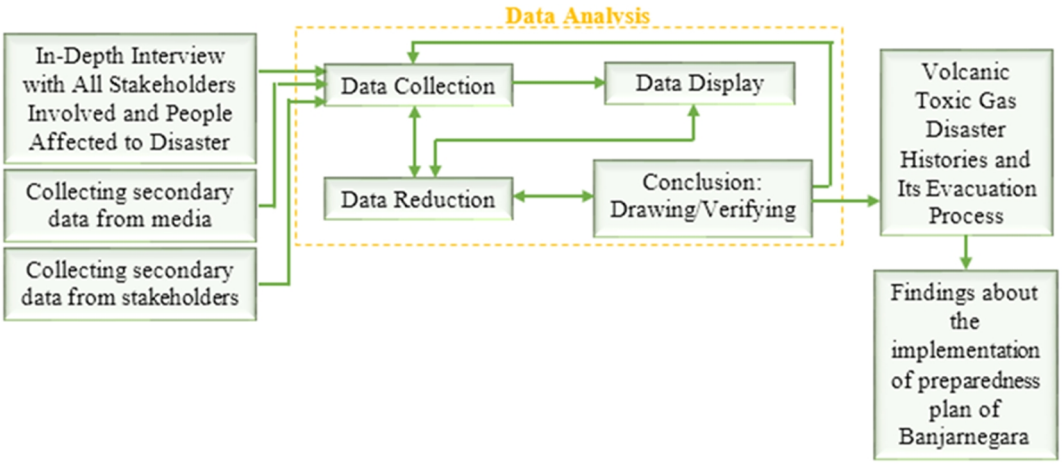
APPENDIX

Appendix 1: Flowchart in each objective

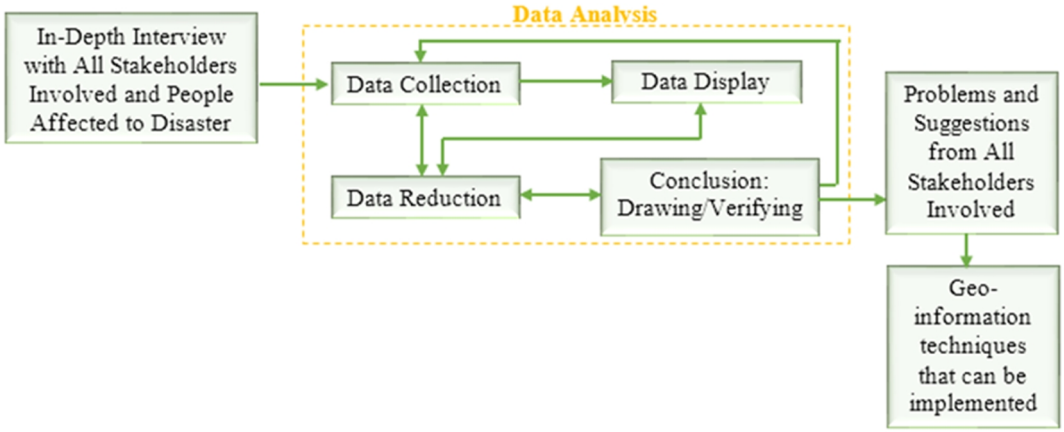
Research objective 1: To identify the different stakeholders involved in volcanic toxic gas disaster preparedness and the evacuation process



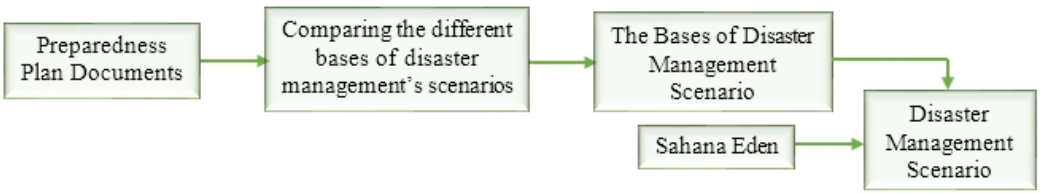
Research objective 2: To critically assess the past volcanic toxic gas eruptions and the evacuation process in each event



Research objective 3: To determine the recommendations for improvement of the individual elements of the response chain and the existing preparedness plan with emphasis on the use of modern geo-information techniques



Research objective 4: To design a disaster management scenario in which the suggestions are implemented



Appendix 2: List of key questions

List of key questions to institutional stakeholders

Institution's name	:
Respondent's name	:
Position	:
Cellphone	:
Date of interview	:
Signature	:

1. Could you please explain the events of disaster you were involved?
2. Could you please explain how the response phase was?
3. Could you please explain how your institution's roles in the making of preparedness document and in the response phase when the disaster occurs?
4. Is there any issue/bottleneck in the response phase?
5. Do you have any suggestion to the improvement of preparedness and response phases?
6. Could you please explain the stakeholders you were coordinating with in the preparedness phase and response phase?
7. What do you think about the existing preparedness plan?
8. Do you have any suggestion to improve existing preparedness plan?

List of key questions to people affected to the disaster

Respondent's name	:
Position	:
Cellphone	:
Date of interview	:

1. Could you please explain the events of disaster you were involved?
2. Could you please explain the chronology of the disaster event?
3. Do you know any stakeholder involved in the response phase?
4. Is there any socialization or drill from government related to toxic gas disaster?
5. What do you think about the disaster response from the government?
6. Could you explain the situation in the refugee's camp?
7. Is there any issue/problem in the evacuation or in the refugee's camp?
8. Do you have any suggestion to the improvement of preparedness and response phases?

Appendix 3: Relationship between stakeholders

Stakeholder 1	Stakeholder 2	Relationship
BNPB	Ministry of Social	Coordination of national logistic supplies for refugees
BNPB	BPBD of Central Java	• BPBD reports the situation of disaster management to BNPB • BNBP is a vertical institution to BPBD of Central Java • BNPB supports BPBD if necessary
BNPB	Ministry of Health	Coordination of national medical kits and medicines supplies for refugees
BNPB	PVMBG	Coordination of recent situation in Dieng area
BASARNAS	BNPB	Coordination of national SAR team if needed
BASARNAS	SAR Team of Banjarnegara	BASARNAS supports SAR Team of Banjarnegara in SAR equipment and trained personals
BASARNAS	BASARNAS of Central Java	• BASARNAS of Central Java reports the situation to BASARNAS • BASARNAS is a vertical institution to BASARNAS of Central Java • BASARNAS supports BASARNAS of Central Java in SAR equipment and trained personals if necessary
BASARNAS	PVMBG	Coordination of recent situation in Dieng area
BPPTK	PGA of Dieng	• BPPTK supplies required data to PGA • BPPTK supports observation equipment to PGA
BPPTK	PVMBG	PVMBG is a vertical institution to BPPTK
PGA of Dieng	Polsek of Batur	Coordination about information of safe areas and dangerous areas
PGA of Dieng	Sub-district office of Batur	Coordination about information of safe areas and dangerous areas
PGA of Dieng	PMI of Banjarnegara	Coordination about information of safe areas and dangerous areas
PGA of Dieng	SAR Team of Banjarnegara	Coordination about information of safe areas and dangerous areas
PGA of Dieng	PVMBG	• PVMBG is a vertical institution to PGA of Dieng • PVMBG supports observation equipment to PGA • PVMBG determines the policy from PGA of Dieng's recommendations
Dinsosnakertrans of Banjarnegara	Ministry of Social	• Ministry of Social is a vertical institution to Dinsosnakertrans • Ministry of Social supports Dinsosnakertrans of Banjarnegara in logistic supply if needed through Dinsosnakertrans of Central Java
Dinsosnakertrans of Banjarnegara	Sub-district office of Batur	Coordination in logistic distribution and management of kitchen soup

Stakeholder 1	Stakeholder 2	Relationship
Dinsosnakertrans of Banjarnegara	PMI of Banjarnegara	Coordination in logistic distribution and human resources
Dinsosnakertrans of Banjarnegara	People affected to disaster	Coordination in logistic distribution and management of kitchen soup
Dinsosnakertrans of Banjarnegara	Police Regional Command	Coordination in logistic security and distribution
Dinsosnakertrans of Banjarnegara	Kodim 0704 of Banjarnegara	Coordination in logistic security and distribution
Dinsosnakertrans of Banjarnegara	DPU of Banjarnegara	Coordination in logistic delivery
Dinsosnakertrans of Banjarnegara	TAGANA	• Dinsosnakertrans is a vertical institution to TAGANA • Coordination in management of kitchen soup
Dinsosnakertrans of Banjarnegara	ORARI of Banjarnegara	Coordination in updated disaster information
Polsek of Batur	Sub-district office of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
Polsek of Batur	Puskesmas of Batur I	Coordination in the security of medical post
Polsek of Batur	SAR Team of Banjarnegara	Coordination in the SAR activities
Polsek of Batur	Satpol PP of Banjarnegara	Coordination in the security of people's assets
Sub-district office of Batur	TAGANA	Coordination in kitchen soups management
Koramil of Batur	PGA of Dieng	Coordination about information of safe areas and dangerous areas
Koramil of Batur	Polsek of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
Koramil of Batur	Sub-district office of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
Koramil of Batur	PMI of Banjarnegara	Coordination in human resources
Koramil of Batur	SAR Team of Banjarnegara	Coordination in SAR activities
Koramil of Batur	People affected to disaster	Coordination in the security of people's assets, evacuation, and SAR activities
Koramil of Batur	Satpol PP of Banjarnegara	Coordination in the security of people's assets
Koramil of Batur	ORARI of Banjarnegara	Coordination in updated disaster information
Puskesmas of Batur I	Sub-district office of Batur	Coordination in medical posts
Puskesmas of Batur I	SAR Team of Banjarnegara	Coordination in first aid
Puskesmas of Batur I	Puskesmas of Batur II	Coordination in medical kits, medicines and refugees' health
Puskesmas of Batur I	TAGANA	Coordination in refugees' health
PMI of Banjarnegara	Polsek of Batur	Coordination in human resources
PMI of Banjarnegara	Sub-district office of Batur	Coordination in logistic and human resources
PMI of Banjarnegara	Puskesmas of Batur I	Coordination in medical staff and medical kits

Stakeholder 1	Stakeholder 2	Relationship
PMI of Banjarnegara	SAR Team of Banjarnegara	Coordination in human resources and SAR activities
PMI of Banjarnegara	Puskesmas of Batur II	Coordination in medical staff and medical kits
PMI of Banjarnegara	TAGANA	Coordination in management of kitchen soup
BAGANA	PGA of Dieng	Coordination in craters observation and about information of safe areas and dangerous areas
BAGANA	Dinsosnakertrans of Banjarnegara	Coordination in human resources and management of kitchen soup
BAGANA	Polsek of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
BAGANA	Sub-district office of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
BAGANA	Koramil of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
BAGANA	Puskesmas of Batur I	Coordination in human resources
BAGANA	PMI of Banjarnegara	Coordination in human resources and logistic distribution
BAGANA	SAR Team of Banjarnegara	Coordination in SAR activities
BAGANA	People affected to disaster	Coordination in the security of people's assets, evacuation, and SAR activities
BAGANA	Satpol PP of Banjarnegara	Coordination in the security of people's assets
BAGANA	ORARI of Banjarnegara	Coordination in updated disaster information
BAGANA	BPBD of Banjarnegara	Coordination in the security of people's assets, evacuation, and SAR activities
SAR Team of Banjarnegara	Sub-district office of Batur	Coordination in SAR activities
SAR Team of Banjarnegara	Satpol PP of Banjarnegara	Coordination in the human resource
People affected to disaster	Polsek of Batur	Coordination in the security of people's assets, evacuation, and SAR activities
People affected to disaster	Sub-district office of Batur	Coordination related refugees' camps and logistic distribution
People affected to disaster	Puskesmas of Batur I	Coordination in refugees' health and first aid
People affected to disaster	PMI of Banjarnegara	Coordination related logistic distribution, first aid and refugees' health
People affected to disaster	SAR Team of Banjarnegara	Coordination in SAR activities
People affected to disaster	Satpol PP of Banjarnegara	Coordination in the security of people's assets
People affected to disaster	Puskesmas of Batur II	Coordination in refugees' health and first aid
People affected to disaster	TAGANA	Coordination in management of kitchen soup
Ministry of Health	Ministry of Social	Coordination of national medical kits, medicines supplies for refugees, and logistic supplies
BMKG	BPBD of Banjarnegara	BMKG supplies meteorological, climatological and geophysical data to BPBD of Banjarnegara

Stakeholder 1	Stakeholder 2	Relationship
BASARNAS of Central Java	SAR Team of Banjarnegara	• SAR Team of Banjarnegara reports the situation to BASARNAS • BASARNAS of Central Java is a vertical institution to SAR Team of Banjarnegara • BASARNAS of Central Java supports SAR Team of Banjarnegara in SAR equipment and trained personals if necessary
BASARNAS of Central Java	Millitary Regional Command IV/Diponegoro	Coordination of province SAR and overall disaster command
BASARNAS of Central Java	Police Regional Command	Coordination of province SAR and overall disaster command
Millitary Regional Command IV/Diponegoro	Police Regional Command	Coordination of overall disaster command
Police Regional Command	Polres of Banjarnegara	• Polres of Banjarnegara reports the situation to Police Regional Command • Police Regional Command is a vertical institution to Polres of Banjarnegara • Police Regional Command supports Polres of Banjarnegara in evacuation equipment and personals if necessary
Satpol PP of Banjarnegara	Sub-district office of Batur	Coordination in the security of people's assets
Dinkes of Banjarnegara	Dinsosnakertrans of Banjarnegara	Coordination in human resources and refugees' camps
Dinkes of Banjarnegara	Puskesmas of Batur I	• Puskesmas of Batur 1 reports the situation to Dinkes of Banjarnegara • Dinkes of Banjarnegara is a vertical institution to Puskesmas of Batur 1 • Dinkes of Banjarnegara supports Puskesmas of Batur 1 in medical kits, medicine and trained personals if necessary
Dinkes of Banjarnegara	Ministry of Health	• Dinkes of Banjarnegara reports the situation to Ministry of Health through Dinkes of Central Java • Ministry of Health is a vertical institution to Dinkes of Banjarnegara • Ministry of Health supports Dinkes of Banjarnegara in medical kits, medicine and trained personals if necessary through Dinkes of Central Java
Dinkes of Banjarnegara	Puskesmas of Batur II	• Puskesmas of Batur 2 reports the situation to Dinkes of Banjarnegara • Dinkes of Banjarnegara is a vertical institution to Puskesmas of Batur 2 • Dinkes of Banjarnegara supports Puskesmas of Batur 2 in medical kits, medicine and trained personals if necessary
Kodim 0704 of Banjarnegara	Polsek of Batur	Coordination of overall disaster command
Kodim 0704 of Banjarnegara	Koramil of Batur	• Koramil of Batur reports the situation to Kodim 0704 of Banjarnegara

Stakeholder 1	Stakeholder 2	Relationship
		• Kodim 0704 of Banjarnegara is a vertical institution to Koramil of Batur • Kodim 0704 of Banjarnegara supports Koramil of Batur in personals and evacuation equipment if necessary
Kodim 0704 of Banjarnegara	SAR Team of Banjarnegara	Coordination in SAR activities and human resources
Kodim 0704 of Banjarnegara	Military Regional Command IV/Diponegoro	• Kodim 0704 of Banjarnegara reports the situation to Military Regional Command IV • Military Regional Command IV is a vertical institution to Kodim 0704 of Banjarnegara • Military Regional Command IV supports Kodim 0704 of Banjarnegara in personals and evacuation equipment if necessary
Kodim 0704 of Banjarnegara	Polres of Banjarnegara	Coordination in overall disaster command and human resources in district level
Kodim 0704 of Banjarnegara	ORARI of Banjarnegara	Coordination in updated disaster information
Bappeda of Banjarnegara	BPBD of Banjarnegara	Coordination in spatial planning of Dieng
Dinhubkominfo of Banjarnegara	Dinsosnakertrans of Banjarnegara	Coordination in logistic delivery
Kesbangpolinmas of Banjarnegara	Sub-district office of Batur	Coordination in human resources
Kesbangpolinmas of Banjarnegara	Koramil of Batur	Coordination in human resources and safety of people's assets
Kesbangpolinmas of Banjarnegara	People affected to disaster	Coordination in safety of people's assets
Kesbangpolinmas of Banjarnegara	Satpol PP of Banjarnegara	Coordination in safety of people's assets
Polres of Banjarnegara	Polsek of Batur	• Polsek of Batur reports the situation to Polres of Banjarnegara • Polres of Banjarnegara is a vertical institution to Polsek of Batur • Polres of Banjarnegara supports Polsek of Batur in personals and evacuation equipment if necessary
Polres of Banjarnegara	SAR Team of Banjarnegara	Coordination in SAR activities and human resources
Polres of Banjarnegara	Satpol PP of Banjarnegara	Coordination in safety of people's assets and human resources
Puskesmas of Batur II	Sub-district office of Batur	Coordination in medical posts as a backup of Puskesmas of Batur 1 if necessary
ORARI of Banjarnegara	Polsek of Batur	Coordination in updated disaster information
ORARI of Banjarnegara	Sub-district office of Batur	Coordination in updated disaster information
ORARI of Banjarnegara	People affected to disaster	Coordination in updated disaster information

Stakeholder 1	Stakeholder 2	Relationship
ORARI of Banjarnegara	Satpol PP of Banjarnegara	Coordination in updated disaster information
ORARI of Banjarnegara	Polres of Banjarnegara	Coordination in updated disaster information
PDAM of Banjarnegara	Puskesmas of Batur I	Coordination in sanitary of refugees' camps
BPBD of Banjarnegara	PGA of Dieng	Coordination about information of safe areas and dangerous areas
BPBD of Banjarnegara	BPBD of Central Java	• BPBD of Banjarnegara reports the situation to BPBD of Central Java • BPBD of Central Java is a vertical institution to BPBD of Banjarnegara • BPBD of Central Java supports BPBD of Banjarnegara in personals, logistic, and evacuation equipment if necessary
BPBD of Banjarnegara	Dinsosnakertrans of Banjarnegara	Coordination in logistic sector
BPBD of Banjarnegara	Polsek of Batur	Coordination in safety sector, including safety of people's assets and evacuation
BPBD of Banjarnegara	Sub-district office of Batur	Coordination in refugees' camps, main posts, and general problem in response phase
BPBD of Banjarnegara	Koramil of Batur	Coordination in safety sector, including safety of people's assets and evacuation
BPBD of Banjarnegara	Puskesmas of Batur I	Coordination in refugees' health sector
BPBD of Banjarnegara	PMI of Banjarnegara	Coordination in logistic sector
BPBD of Banjarnegara	SAR Team of Banjarnegara	Coordination in SAR sector
BPBD of Banjarnegara	People affected to disaster	Coordination in disaster management sector
BPBD of Banjarnegara	Satpol PP of Banjarnegara	Coordination in safety sector, including safety of people's assets and evacuation
BPBD of Banjarnegara	Dinkes of Banjarnegara	Coordination in refugees' health sector
BPBD of Banjarnegara	Kodim 0704 of Banjarnegara	Coordination in safety sector, including safety of people's assets and evacuation
BPBD of Banjarnegara	DPSDA dan ESDM of Banjarnegara	Coordination in disaster observation
BPBD of Banjarnegara	Disbunhut of Banjarnegara	Coordination in forest preservation
BPBD of Banjarnegara	DPU of Banjarnegara	Coordination in heavy equipment for disaster management
BPBD of Banjarnegara	Dinhubkominfo of Banjarnegara	Coordination in evacuation routes
BPBD of Banjarnegara	KLH of Banjarnegara	Coordination in air quality of disaster area
BPBD of Banjarnegara	Kesbangpolinmas of Banjarnegara	Coordination in safety of people's assets
BPBD of Banjarnegara	Disbudpar of Banjarnegara	Coordination in tourism activities
BPBD of Banjarnegara	BPS of Banjarnegara	Coordination in statistic sector
BPBD of Banjarnegara	Polres of Banjarnegara	Coordination in safety sector, including safety of people's assets and evacuation
BPBD of Banjarnegara	Disdikpora of Banjarnegara	Coordination in the matter of study for student who also as a refugee
BPBD of Banjarnegara	ORARI of Banjarnegara	Coordination in updated disaster information

Stakeholder 1	Stakeholder 2	Relationship
BPBD of Banjarnegara	PDAM of Banjarnegara	Coordination in sanitary and fresh water in refugees' camps
BPBD of Banjarnegara	PT. Telkom of Banjarnegara	Coordination in phone line connection if needed
BPBD of Banjarnegara	PT. PLN of Banjarnegara	Coordination in electricity if needed
BPBD of Banjarnegara	PT. Geodipa Energi	Coordination in safety equipment for volcanic observation
BPBD of Banjarnegara	PT. Java Agritech	Coordination in safety equipment for volcanic observation
BPBD of Banjarnegara	PVMBG	Coordination in status level of disaster

Appendix 4: Resources ability of stakeholders in the Contingency Plan Document of Banjarnegara 2012 and fieldwork observation

Institution	Resources		
	Personal	Infrastructures	Equipment
PGA of Dieng	3 people	Office in Batur Sub-District	A motorcycle, volcano's monitoring equipment
BAGANA	226 people	Secretariat office in Batur Sub-District	-
Satpol PP of Banjarnegara	15 people	Office in Banjarnegara Sub-District	4 cars, 4 motorcycles
Dinkes of Banjarnegara	8 people	Office in Banjarnegara Sub-District, 4 hospitals	37 ambulance, 171 motorcycles
Kodim 0704 of Banjarnegara	150 people	Office in Banjarnegara Sub-District	A truck, a patrol car, 2 tents, 10 vests
Bappeda of Banjarnegara	40 people	Office in Banjarnegara Sub-District	10 motorcycles, 2 cars
DPSDA dan ESDM of Banjarnegara	100 people	Office in Banjarnegara Sub-District	3 cars
Disbunhut of Banjarnegara	4 people	Office in Banjarnegara Sub-District	4 cars, 50 motorcycle, GPS, compass
DPU of Banjarnegara	200 people	Office in Banjarnegara Sub-District	Office stationary
KLH of Banjarnegara	19 people	Office in Banjarnegara Sub-District, laboratory	A laboratory car, handy talky, GPS, air testing tool, water testing tool
Kesbangpolinmas of Banjarnegara	16 people	Office in Banjarnegara Sub-District	2 cars, 3 motorcycles
Disbudpar of Banjarnegara	2 people	Office in Banjarnegara Sub-District	A car
Polres of Banjarnegara	100 people	Office in Banjarnegara Sub-District, policlinic	2 trucks, 4 cars, 4 motorcycles
Disdikpora of Banjarnegara	50 people	Office in Banjarnegara Sub-District, school buildings	2 cars
Polsek of Batur	3 people	Office in Batur Sub-District	Unknown
Sub-district office of Batur	14 people	Office in Batur Sub-District	A car, 3 motorcycles
Koramil of Batur	3 people	Office in Batur Sub-District	Unknown
Puskesmas of Batur I	32 people	Health center building in Batur Sub-District	Health center mobile, an ambulance, a motorcycle
Puskesmas of Batur II	15 people	Health center building in Batur Sub-District	An ambulance, 2 motorcycles
PMI of Banjarnegara	60 people	Office in Batur Sub-District, warehouse	An ambulance, a hearse, tents
SAR Team of Banjarnegara	50 people	Secretariat office in Banjarnegara Sub-District	Carmantel rope, carabiner, figure eight, float, seat harness

Institution	Resources		
	Personal	Infrastructures	Equipment
PT. Geodipa Energi	2 people	Office in Batur Sub-District	30 minutes self-contained breathing apparatus, air compressor, cars
Dinsosnakertrans of Banjarnegara	20 people	Office in Banjarnegara Sub-District and logistic warehouse	A rescue car, tent equipment, kitchen soup equipment
BPBD of Banjarnegara	24 people	Office in Banjarnegara Sub-District	25 knock down closet, 2 post tents, 21 family tents, 2 rescue cars, 6 kitchen cars, 6 breathing apparatus, 6 trolleys, 2 trail motorcycles, 3 power generators, 28 motorcycles