An Integrated Laboratory: A Place to Bridge Scientific Approach to Community as an Effort to Prevent Disaster Risks Surrounding Pronojiwo District, Lumajang, Indonesia

Sukir Maryanto[1,3](✉), Sujarwo[2], Nurjannah[3], Didik R. Santoso[3], Kurniawan Sigit Wicaksono[2], Herman Tolle[4], Aris Subagyo[5], Hendrix Y. Setyawan[6], and Vanisa Syahra[1]

[1] Brawijaya Volcano and Geothermal Research Center, Brawijaya University, Malang, Indonesia
sukir@ub.ac.id
[2] Faculty of Agriculture, Brawijaya University, Malang, Indonesia
[3] Faculty of Mathematics & Natural Sciences, Brawijaya University, Malang, Indonesia
[4] Faculty of Computer Science, Brawijaya University, Malang, Indonesia
[5] Faculty of Engineering, Brawijaya University, Malang, Indonesia
[6] Faculty of Agriculture Technology, Brawijaya University, Malang, Indonesia

Abstract. A paradigm progressive encourages the community to implement a new approach in mitigation that integrates disaster prevention, edu-eco-tourism, economic recovery, early warning system, and community preparedness. Volcanic eruptions are disasters that occur due to natural changes in earth conditions or natural phenomena that cannot be avoided by their existence or occurrence. In dealing with volcanic eruption disasters, disaster mitigation measures are needed. One of the scientific efforts to mitigate the Mount Semeru disaster is to observe its dynamic activities with a scientific approach which is monitored directly. An integrated lab specially designed for observing the activity of Mount Semeru and developed area at Pronojiwo for multi purposes such as training center, edu-eco-tourism center, and early warning system.

Keywords: preliminary · disaster mitigation · edu-eco-tourism · volcano eruption · Semeru

1 Introduction

So far, the community considers that a disaster is an unavoidable event and the affected victims must be helped immediately. The concept of understanding like this is a conventional paradigm that focuses on relief and emergencies. This conventional paradigm aims to reduce the level of loss, damage, and fast recovery [1]. From the conventional paradigm, the view of disaster management has developed into a progressive paradigm which views disaster as part of development and is a problem that cannot be stopped. Thus, the development of this paradigm encourages the community to implement mitigation that focuses on disaster management and community preparedness in dealing

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with hazards and increasing the physical strength of infrastructure to minimise damage and losses caused by disasters [2] Furthermore, the paradigm developed into a holistic paradigm. The holistic paradigm considers that natural events can become a disaster if the vulnerability and inability of the community is large enough to face the risk.

Disaster management is an effort that aims to reduce and/avoid potential losses, losses, and victims from a disaster event, ensure fast and appropriate access to assistance, and achieve fast and effective recovery [3]. Explained about the Disaster Management Cycle in Indonesia as Fig. 1.

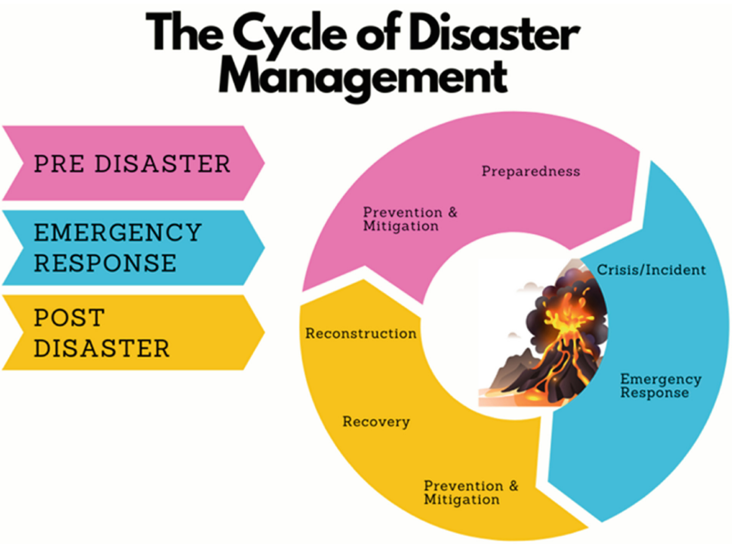

Fig. 1. Illustration of the Cycle of Disaster Management (modified from Nugroho (2016))

Volcanic eruptions are disasters that occur due to natural changes in earth conditions or natural phenomena that cannot be avoided by their existence or occurrence. In dealing with volcanic eruption disasters, disaster mitigation measures are needed. Volcanic disaster mitigation itself is carried out as a step to reduce the impact of disasters due to volcanic eruptions. This is because in Indonesia there are still many active volcanoes that have the potential to erupt and there are also many people who live in volcanic areas.

Mount Semeru is one of the highest mountains on the island of Java which is still active today. The eruption type of Mt. Semeru is kind of an explosive eruption that could destroy its lava dome. This explosion will lead several materials to come out from Mt. Semeru's body such as pyroclastic flows, volcanic bomb, and lava flows which move at very high speed down the slope toward the South Eastern part (Besuk Kembar, Besuk Bang dan Besuk Kobokan). On 4 December 2021, Semeru erupted violently without giving any signs. Due to its eruption, about 51 lives became victims of its violence [4]. According to BNPB data, the total number of houses damaged by hot clouds avalanches reached 1027 houses with in details of 505 damaged houses in Sumberwuluh Village, Candipuro District. About 437 units were seriously damaged and 85 units were slightly damaged in Supiturang Village, Pronojiwo District [4]. Several public facilities were also affected, such as religious facilities, health facilities, educational facilities, and infrastructure with a total of 45 public facilities. The affected livestock are 764 head cattle, 684 goats/sheep, 1578 poultries, and several domestic animals such as cats, birds, and fish [5].

Since 1953, a volcanic hazard prevention program has been conducted for Mt. Semeru. One of the scientific efforts to monitor the volcanic activity of Mt. Semeru disaster is to observe its dynamic activities with a scientific approach which is monitored directly in the Mt. Semeru Volcano Observatory Post which is coordinated by the Center for Volcanology and Geological Hazard Mitigation, traded as PVMBG [6]. This observatory post is responsible for providing the most updated information of Mt. Semeru volcanic activity via radio communication.

Although known for its violent eruptions, Mt. Semeru holds natural beauty that has great potential if it can be managed properly. At the southern part of Mt. Semeru, there is a village of Sidomulyo, located at an altitude of 700 m above sea level, which has been traded as a Tourism Village in Pronojiwo District. One of the most well-known destinations is Tumpak Sewu Waterfall, traded as the "Niagara" of Indonesia. The concept of edu-eco-tourism might match to be applied in Tumpak Sewu Waterfall as it is based on the aspects of ecotourism, geosites, history, culture, and disaster management that are able to become sustainable development for the surrounding residents.

The specific objective of this program is to integrate disaster education to the community and continuous monitoring of the activities of Mount Semeru and its surroundings with geophysical approach and instrumentation by building a research center or Integrated Laboratory. East Java has been a natural laboratory for scientists. Thus, we propose this Integrated Laboratory for being a center for research and monitoring of Mount Semeru which will provide information on subsurface conditions such as identifying magma movement, changes in ground surface, visual conditions, gas, mountain temperature, potential slip fields, and mapping of disaster risk zones. So far, this kind of integrated laboratory has been implemented in the vicinity of Mt. Merapi, known as Mt. Merapi Museum. In addition, this Integrated Laboratory can later become a forum for public education on tourism potential and disasters that may occur in the future. The concept of the Integrated Laboratory development is divided into 3 zones, namely the Public Zone, Intermediate Zone, and Research Zone. In the Research Zone, the results of geophysical data analysis and visual monitoring will be distributed using the Internet of Things (IoT) concept as information to all parties.

2 Volcanic Early Warning System

Several technologies has been developed to improve the early warning system, they are:

2.1 Temperature Measurement

The method used is based on the measurement of several physical properties of the active material which varies with temperature. The temperature measurement method can be done in two ways, namely expansion method and electric method. Examples of tools with expansion methods include: glass tube thermometer, bimetallic thermometer, filled thermal thermometer. Examples of tools with the electrical method include: thermocouples, resistance thermometers.

2.2 Measurement of Ground Movement with a Seismometer

A seismometer is an instrument for measuring ground motion, including seismic waves generated by earthquakes, volcanic eruptions, and other earthquake sources. Seismic wave recordings allow seismologists to map the interior of the earth, as well as determine the size of different earthquake sources. The recording from this device is called a seismogram (Fig. 2).

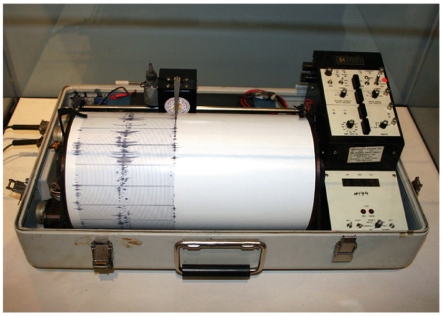

Fig. 2. Seismogram that shows the volcano's activities recorded by the seismometer deployed surrounding the volcano

At first this tool could only be used to determine from which direction an earthquake occurred. With the development of increasingly developed technology, the ability of seismometers has also been improved, which initially could only be used to determine from which direction an earthquake occurred to be able to record vibrations in a fairly wide frequency range. Such a device is called a Broadband Seismometer.

2.3 Tiltmeter

Tiltmeter is a deformation measuring device that serves to detect the swelling or deflation of the mountain body. The Tiltmeter device consists of three main components, namely the Tiltmeter Plate, Portable Tiltmeter, and Readout Unit. Structures that need to be considered for measurements using the Tiltmeter method are structures that visually have shown a change in position horizontally or vertically so that the intensity of the movement can be known. For the case of a volcano, usually scientists will install tiltmeters at many points, from the foot of the mountain to the highest plains that are thought to be the paths of lava flows. Illustration of tiltmeter's mechanism shown by Fig. 3.

2.4 CCTV Camera and Photogrammetry

Installation of CCTV cameras on the crater rim in order to visually monitor the volcanic crater and then transmit it to the BPPTKG office so that a visual picture of the crater

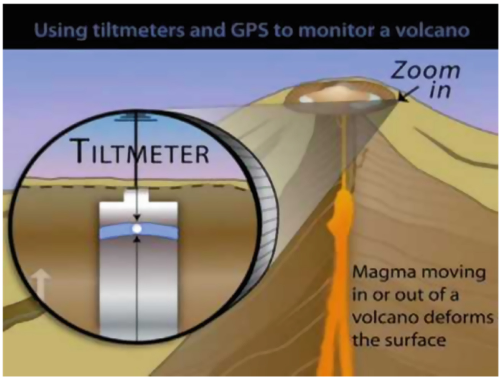

Fig. 3. Illustration of how tiltmeter works to record the volcano's deformation

Fig. 4. CCTV and Photogrammetry installed in the vicinity of Mt. Merapi, Yogyakarta as two of devices that are used in volcano visual monitoring

is obtained in real time. A detailed description of the crater is also obtained through a photogrammetry station that collects data using a DSLR camera automatically every hour and is transmitted to the receiving server at the Merapi Volcano Research Laboratory. Figure 4 illustrates how CCTV and Photogrammetry are used in volcano monitoring.

3 Methods

We implemented the ideas for the laboratory design which is depicted in Fig. 5 [7].

We first collected and analysed the problems caused by the eruption of Mt. Semeru. Kilmer & Kilmer described steps to start designing a building, in this case is a laboratory, explained below:

a. Commit. It means we have to accept the problem that we are currently facing. we noticed that Mt. Semeru is one of the most active volcanoes in East Java. While the community itself was not well educated regarding disaster prevention.
b. State means defining the problem that will be a very important step. This very initial step will definitely have a direct impact on the final solution. The problem-setting step is usually influenced by issues related to existing requirements, constraints, limitations, and assumptions.

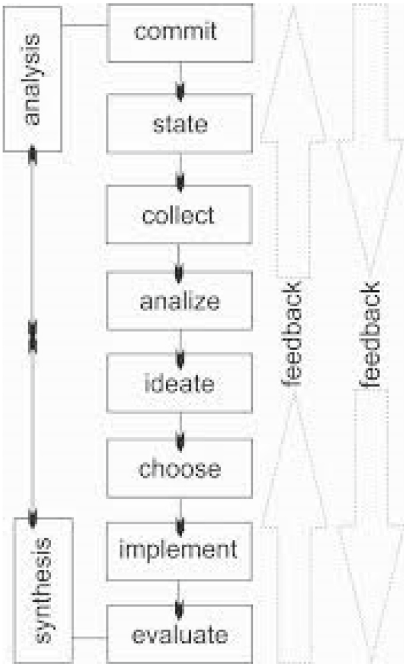

Fig. 5. A schematic diagram of designing a building [7]

c. Collect. After the problem can be understood, we found information related to the problem. This stage involves a lot of research, data and surveys. Steps that can be taken to obtain information can be done by interviewing room users (managers and visitors), looking for references from similar projects.
d. Analyze. The designer must analyze the information obtained about the problem and group it into related categories. Data and information must be filtered, only those that affect the final solution and are related to the problem. The steps that can be taken to analyze the problem are conceptual sketches, matrix, categorization.

Secondly, we tried to find and develop our design ideas. Following are the steps for this stage.

a. Ideate. The most creative stage in the design process where ideas or alternatives to achieve design goals emerge. The idea search process has 2 stages, namely the drawing phase, which includes diagrams, plans, sketches that support the needs and functions of space. Can be in the form of a bubble diagram that generally describes the proportion of area size, circulation, and existing boundaries. The step taken is to use the spatial planning method used by Mark Karlen. Concept statement, the stage where inspiration and ideas are expressed in sentences. The sentence must describe the main ideas by considering functional and aesthetic aspects. The steps taken are to make sketches of ideas and form experiments in the form of simple prototypes that have been adapted to references.

b. Choose or select the best option. The stage where the designer must choose the best option seen from the concept that fits the client's budget, needs, objectives, and desires. Steps that can be taken to select and determine the best alternative with personal judgement, the method most used by designers by comparing each of the available options and deciding which option best meets the objectives of the problem. Comparative analysis, comparing how one solution is better than another.
c. Implement (take action). The stage where the selected ideas are put into physical form such as final drawings, floor plans, renderings, and presentations. The steps taken to translate ideas into physical form are final design drawings, budgets, and construction drawings.

Third stage was design selection evaluation. Following are the steps:

a. Evaluate. The process of reviewing and making a critical assessment of what has been achieved has succeeded in solving the problem. Seeing what is learned/gained from experience and what is the influence/result of the design. As a guide for designers to solve the next problems that will be faced.
b. Feedback is the term used to evaluate each design stage. Steps to compare the results of the design with the process of project work in the field.

4 Results and Discussion

An integrated laboratory is specially designed to integrate disaster education to the community and monitoring of Mt. Semeru's activities and its surroundings continuously using geophysical approach and instrumentation by building a research center for observing the activity of Mount Semeru with the following design.

This Integrated Laboratory carries the main theme "The Power of Knowledge" as a symbol of human efforts to adapt to the natural conditions of the surrounding environment. This Integrated Laboratory will become a research and monitoring center for Mt. Semeru which will depict the subsurface condition such as identifying magma movement, changes in ground surface, visual conditions, gases, mountain temperatures, potential slip fields, and disaster risk zone mapping. In addition, this Integrated Laboratory can later become a forum for public education on tourism potential and disasters that may occur in the near future.

The integrated laboratory will be divided into 3 (three) zones, namely the Public Zone, Intermediate Zone, and Research Zone (Fig. 6). Each zone is defined as follows:

a. The PUBLIK Zone represents the THREAT symbol having a design with volcanic characteristics. This zone will be a zone that can be visited by visitors as an educational zone in the form of museums and dioramas
b. The ANTARA Zone will be a gallery that bridging the Public Zone with the Research Zone which represents the KNOWLEDGE symbol. This zone serves as an information center for the real-time activities of Mount Semeru.
c. The PENELITIAN Zone represents the blessing symbol with natural design characteristics that take natural elements. This zone will be used as the observatory and research zone for Mt. Semeru.

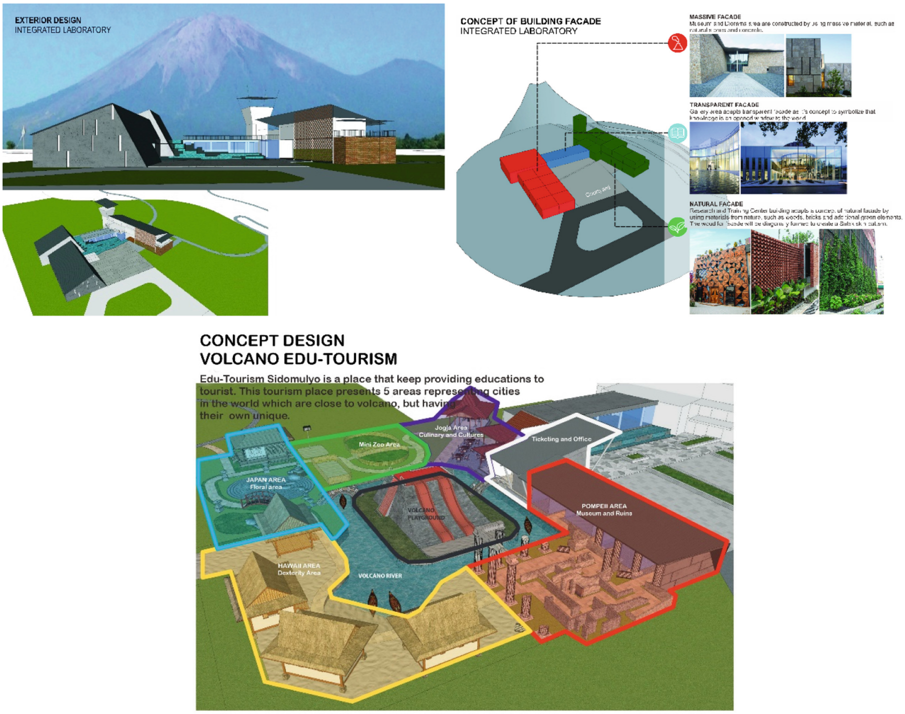

Fig. 6. Integrated laboratory design to observe the activity of Mount Semeru

The Research Zone is the right zone for geophysical and geological research.. In this case the research will be applied to various integrated geophysical methods used for, such as, identification slip fields and groundwater in supporting clean water for MCK and prayer rooms in the area edu-tourism Tumpak Sewu Waterfall using the GPR method, Seismic Refraction, and Geoelectricity, visual monitoring around Mt. Semeru, and subsurface structures around Mount Semeru using gravity and magnetism methods (temporarily) and seismology (for real time). Currently the reliable one is the visual monitoring around Mount Semeru.

Based on the Semeru Volcano Base Data [8], visual observations were carried out continuously to observe the eruption column height, eruption colour, pressure, and direction of ash distribution. This visual observation was carried out at PPGA G. Sawur and Argosuko. In addition, thermal cameras will also be installed around Besuk Kobokan to observe potential pyroclastic flows. This thermal camera works to detect heat from objects. If there is a pyroclastic flow, the temperature will be known [9].

Another observation is in the form of seismic monitoring. A total of 5 (five) seismic stations are installed around Mount Semeru (Fig. 7). This station recorded the earthquake which then used a radio telemetry system to PPGA Semeru. Output data in the form of analog and digital data. Digital data is sent to the PVMBG Bandung office via the VSAT satellite. The locations of the five seismic stations are shown in Table 1 (Fig. 8).

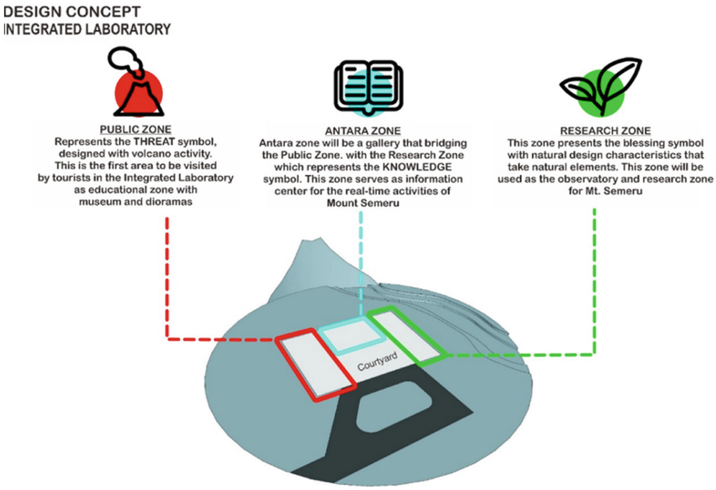

Fig. 7. Illustration of Zone Division in the Integrated Laboratory

Table 1. List of seismic stations that are used and installed in the vicinity of Mt. Semeru as the earthquakes recorder

No.	Station Name	Latitude	Longitude	Elevation (msl)	Remarks
1.	Leker (LEK)	8°8′14,8″	112°59′9,4″	1060	Permanent
2.	Tretes (TRS)	8°8′54,5″	112°57′50,3″	1208	Permanent
3.	Bsk. Bang (BAN)	8°10′50″	112°57′9,2″	917	Permanent
4.	Puncak (PCK)	8°6′26,3″	112°55′26,7″	3657	Permanent
5.	Kepolo (KPL)	8°5′2,7″	112°55′13″	2764	Permanent

Another monitoring is deformation monitoring. This monitoring is carried out to observe changes in the ground surface in the body of the mountain. Monitoring of deformation on Mount Semeru using a tiltmeter. This tiltmeter has been installed at a distance of 500 m to the north of the peak of Semeru since 2005. From observations using a tiltmeter, it was successful in detecting an increase in Semeru activity in the form of inflation (development) of the mountain body as a precursor and prediction of the eruption of Semeru [6, 10–12].

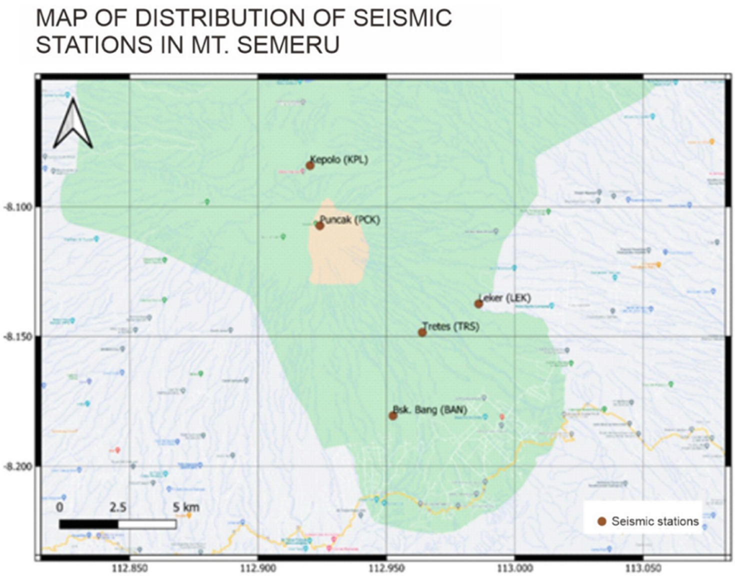

Fig. 8. Map of the distribution of the Mt. Semeru seismic stations. Brown circles represent the seismic station belonging to the PVMBG

5 Conclusion

A new approach of development of an integrated early warning system in the Mount Semeru, especially in Pronojiwo District is currently being carried out. The efforts to establish cooperation between Brawijaya University and Pronojiwo Village-Owned Enterprises continue to be carried out in order to develop science disaster management in order to create a disaster-independent community and develop its potential tourism in it. This development will later require a container permanently so that disaster education and tourism programs could be continued. Therefore, this research intends to develop the concept of an Integrated Laboratory as a center for development of scientific studies of volcanoes as well as education and tourism centers both for the community locals and tourists.

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