Disaster Mitigation: Case Study of Kelud Volcano Eruption

Adis Imam Munandar¹, Arjun Fatahilah²

¹,² School of Strategic and Global Studies, University of Indonesia, Jl Salemba Raya No. 4, Senen, Jakarta, Indonesia

Corresponding author: adis.imam@ui.ac.id

Abstract. Historical records of disasters in the world find in scriptures, history books, geography, and folklore. This study aims to analyse the mitigation of Mount Kelud eruption with ancient manuscripts. The research method is by examining the ancient script “Goenoeng Keloet,” which is in Javanese with an old spelling. The results showed the difference in height and changes in water sources, and increased temperatures around the mountain, and many indicators of small fish that died mention in ancient manuscripts as a sign of mountain eruption. Ancient manuscripts also say about mitigating volcanic eruptions by planting tamarind trees, no land clearing in the land path, and no houses building.

1. Introduction

Disasters are events that classify as catastrophe or circumstances that occur suddenly [1]. Emergencies can trigger natural, human, and social factors [2]. Historical records of catastrophe in the world find in scriptures, history books, geography, and folklore. Many great civilizations from tribes such as Maya, Norse, Minoan, and Ancient Egypt were affected by floods, earthquakes, and tsunamis [2]. Archaeological evidence shows that the risks and threats of disasters in prehistoric times are similar to those of today such as hunger, violence, disease, accidents, and scarcity [1].

One type of disaster in Indonesia related to the status of the ring of fire is a volcano eruption. Indonesia is among the countries that have the most active volcanoes in Asia, 127 volcanoes with active status [3]. The impact of the ring of fire status is showed by the extraordinary volcano eruption (super volcano-eruption). It happened in the period between the 1200s and 1900s such as; the eruption of the Samalas volcano, Lombok in 1257; the explosion of Tambora Mountain, Sumbawa in 1815; the outbreak of the Krakatau volcano, the Sunda Strait in 1883; Kelud eruption, East Java in 1919 [4]–[7]. The volcanic eruption not only has an impact on climate change in Indonesia but also affects the world’s climate. Some of them cause drought and temperature changes [5]. Also, there are 53 districts/cities in Indonesia with the high status of the volcanic disaster risk and 40 regions/cities with moderate risk [8]. There were several incidents of volcanic eruption in Indonesia from the year of 2008 to 2013, namely the eruption of Mount Merapi in 2010; Lokon Mountain in 2012; Mt. Sinabung, Merapi, and Samalas in 2013 [4], [6], [9]–[11].

The disaster event in Indonesia is also inseparable from observations and research of the National Disaster Management Agency (BNPB). The Indonesian Disaster Risk (RBI), was published by BNPB, states that Indonesia is a disaster-prone country. The geographical and geological location of Indonesia located at the confluence of three giant plates, which are Eurasia, Indo-Australia, and the Pacific, and is in the ring of fire [8]. The fact showed the necessity for efficient and effective disaster mitigation to minimize the risk of death and material losses. Disaster management or reduction is one of the four aspects of the disaster life cycle process that placed in the first rank. Four operations in the flow of a
disaster include mitigation, preparation (preparedness), response, and recovery [12]. The mitigation process is a series of activities or programs which aim to reduce the impact of disasters in a community or nation [13].

One of the mitigation strategies is the creation of a mitigation program by knowing the ancient manuscript literature that recites the catastrophic eruption events and historical sources from the community [4], [10]. Losses due to volcanic eruptions are possible to minimize when people want to learn the history of disasters in the location where they live [14]. One of the pieces of the ancient manuscript of literature that recites the impact of super volcano-eruption is the Chronicle of Lombok. It was written in the middle of the 13th century and described the catastrophic events in the form of the Samalas volcano eruption and induces the emergence of Segara Anak. The event was also destroying the center of the kingdom of Lombok in Pamatan. The estimated volcanic eruption of the text occurred between 1210 and 1260 B.C [4]. Chronicle is a traditional history writing creation that contains a collection of historical and literary stories that tell about, 1) the clearing of an area of forest to establish a royal capital or government center, 2) a certain events with specific time spans, 3) a story that has a scope spatial and temporal so that it covers several regions or a long time [15].

Previous studies have explored much about volcanic eruption disasters and their impact and mitigation strategies [5], [7]–[9], [16]. Other researches attempt to examine the records of volcanic eruptions in ancient manuscripts [4], [10], [14]. This study provides a renewed research in the form of mapping the risk of catastrophic volcanic eruption disaster with the mitigation strategy of the ancient manuscript "Goenoeng Keloet," through a modern mitigation process.

2. Methodology

This research utilized the library research method, which is research through library materials such as books, journals, encyclopaedias, magazines, and other articles as secondary data. The study conducted in four locations in Central Jakarta. Especially at the National Library and the Office of the National Disaster Management Agency (BNPB). The research also employed the content analysis method of the ancient manuscript "Goenoeng Keloet." The content analysis consists of a manifest content description, close to the text, as well as interpretation of latent content, far from the book but still close to life experience. Hidden content is the interpretation of the underlying meaning of "common thread" between lines in the text. The epistemological assumption in quantitative content analysis is that some "truth" in a document can be expressed with as little interpretation as possible, for example, by measuring, weighing, and calculating the frequency and proportion of similar statements.

3. Result and Discussion

The ancient manuscript used in this study is titled Goenoeng Keloet by R. Kartawibawa, which uses the Javanese language with an old spelling. In the document, there are 17 chapters, of which six sections were telling about the eruption of Mount Kelut in 1543. Several episodes take which were related to the explosion of volcanoes, namely, 

- Chapter III, Meolabokane Goenoeng Keloet Djebloeg
- Chapter VIIIa, Sirnane Maesadana
- Chapter IX, Nagara Siloeman Keloet
- Chapter X, Kyai Toenggoelwoeloeng
- Chapter XVI, Kodjah chapter Goenoeng Keloet Ndjebloeg saka Blitar
- Chapter XVII, Mentas Kelaharan

All chapters contained in the manuscript held in Javanese songs (macapat) such as Sinom (chapter III), Maskoemambang (chapter VIIIa), Kinanthi (chapter IX), Megatroeh (chapter X), Doerma (chapter XVI), and Midjil (chapter XVII). Some pieces in the manuscript included along with the translation and the meaning shown in Table 1.
Table 1. Pieces of original text and ancient translation of Goenoeng Keloet.

| Chapter Nagara Siloman Keloet | Manuscript Literature | Translation |
|--------------------------------|-----------------------|-------------|
| Goenoeng Keloet saben djebloeg, poetjoek petjah lan tjoevil, bolongane aran kawah : endoete lahar kang isih mboenteti goeloening kawah : ndjemblok, akas, banjoer garing. Lah, "dasare kawah" ikoe bisa warna "tegal pasir", bisa padet dadi padas: banjoed oedan kang noempangi dasar kawah aran tlaga. Banjoed koewi sing njamari. Jen dimoerwat karu goenoeng, tlaga ikoe barang tlaga jen kataman pepanas kah nggegegiris, ngoekoes ngeget bandjoed moebal kaja lenga digeneni. Lha banjoed kang doeroeng ngoekoes kaworan endoet lan pasir, sinentor endoet blebda: dadi lahar,mbebhajani. Balik jen kawah asat, sing mboedelag moeng wedi garing. Tengere jen arep ndjebloeg: banju ing soemoer lan kali angko ndisiki mangsa, soember ngoedalake wedi; hawa ngkegesake awak; ikw tjilik akeh mato; dene ing kawah tinemoe: banjoed panas,ngoekoes, oemrik, broboesan, ganda watalang, gledoeg, gereng, lindoe, tatit..” | Mount Kelud, every time it erupts, then the peak is broken and cut, the hole is called a crater: lava that covers the neck of the cavity: slightly wet, dense, then dry. Well, the "bottom of the crater" to colored like "wet sand" can be stable into the rock: rainwater that occupies the bottom of the crater is called a lake. The water is flowing. Compared to a mountain, a lake is something small: lake water when it (erupts) becomes hot, steaming and then overflowing like heated oil. Then, water that has not boiled (in the text it says: cooking) mixed with earth and sand becomes dangerous lava. When the crater shrinks (becomes dry), only dry sand overflows. It signs when they are about to erupt: water in wells and rivers overflow ahead of the season, water sources emit sand, the air gets hot, many small fish die, then in the crater will be found hot water, boiling (steaming), smelling of sulfur. |

| Chapter Kyai Toenggoelwoeloeng | Jen wis genah Keloet moeroeb arep ndjebloeg, wong wong lawasan sing ngreti bandjoer enggal akekoetoeq, lawang-lawang didjeb lagi, wonge bandjoer menek ranggon. Lahar mono banjoed-wedi-endoet-watoe, mili santer kaja bandjir ngantjar saka poetjoek goenoeng, sawarnane aling-aling kang keterak masti djebol. Dadi lawang diboekaki ikoe maoe menehi dalan si bandjir oetawa angin kang nempoeh” | It becomes certain when Kelud will erupt, people who understand immediately leave, the doors are opened wide, the people then climb onto the tree. Lava fille with watersand-soil-stone, water flows like a flood coming from the top of a mountain, whatever it passed must be broken. The doors that opened are intended to make way for flooding water or the coming wind. |

| Chapter Goenoeng Keloet Njebloeg Saka Blitar | “Let sadela kroengoe swara ping pat: “derr,” goemeter ing langit. Bijang bajek ngoetjap: “gleger saka lor wetan, mengko gek Keloet: sing muni” ndajal ndelenga prenahe Keloet disik” Pakne bajek metoe ngoengak ngalar wetan: “langit resak resik” O, lha kae apa ndoeowoere Keloet padang, ana kaja kembang api”. Oewong saomah metoe toemenga nglangit. | A moment later came the sound of "derr," vibrate in the sky. Father says: "loud sound like lightning or explosion from the northeast, maybe Kelud: which speaks "try to see the truth to Kelud first" then father tried to get out and looked to the east:" the sky is clean "Oh, it turns out above Kelud very bright, like there are fireworks. "Everyone in the house
Ndoweor Keloet ana mendoenge ngrempajak, liveran kilat tattit, tjeremomong koeningbang satjowek tjowek mlesat, sing tjilik pating peletik, tjoemlorot moenggah, mlengkoeng tiba ing iring" "Ing esoke padange wiwit djam sanga, langite warna koening, bandjoer malih abang, watara djam sewelas oedan avoe wis tipis; avoe roemarab saka godonging oewit"
came out and looked towards the sky. The top of Kelud has clouds that are piled up, lightning flashes, and the light is highlighted in yellow, red, streaking, small parts such as spraying, highlighting up, curving, and falling together". "Then, the next morning it looks bright from 9 o'clock, the sky is yellow, then it turns red, between 11 o'clock thin rain of ash: ash falling from the leaves of the trees."

Chapter Mentas Kelaharan

"Teka ing palaharan manoni endoet klawoe anoeteopi palemahan kabei, tegal sawah tanpa djeprik-djeprik, pakarangan kari wit-wite kang doewoer. Randoe, waroe roeboeh ting ndjempalik, barongan pring esol, pating sladang pring malang ing kalen, wit kang ngadeg boendas sing saisih kasentor ing wedi lan katempoeh watoe. Empyk kaja mentas digantoli, gedeg-gedeg djebol, ing pok tjagak keomaloeng sangkrake; tembok bobol, batoer toegel nggoling kaja didjegoli, oesoek ereng moembroek. Desa redja regeng temah dadi alas arang, nrontong, ilang omah, pager lan dalane. Moela preloe dalan ditandoeri wit-wit ing pinggir, minangka panoedoeh oepamane ana lahar, bandjir kang ngadeg boendas sing wesig sahroeng ingkono; asem ikoe wit kang tegoe dewe, pange woeled, woh-godonge tjilik,ora nguwatiri marang oewong mlakoe."
When in a place where lava has passed, there is ash which covers all the land, rice fields, and fields without remains, the yard is only tall trees. Leaves, Waru fell, bamboo fell apart, all scattered in the river, the remaining trees were exposed to sand and crushed by rocks. Many houses have broken walls, many items wasted: walls broken, lots of things violated, poles have collapsed. The village of Redja Regeng flattened into charcoal, dried up, houses, fences, and roads disappeared. Therefore, it is necessary to plant trees on the verges, when at any time there is lava, floods that drown somewhere: acid trees are vigorous trees, small fruit and leaves, do not worry about people who walk.

Chapter Mentas Kelaharan

Distrik Srengat roesake ngoengkoeli lija-lija enggon. Sawah wajah panen dadi leseh, sawah oedan-awoe kebak wedi, dasar kono koewi dalan lahar Keloet. Masti bae ing saoewat koewi tanah Blitar bobrok; Wong kang tiwas limang ewoe kehe; desa boebrah, tetandoeran goesis, nagara ngingoni Wong mawoe-ewoe. Lahar ikoe ngoeroegake wedi ing papan kang ledok. Jen wedine tipis-tipis bae, tegal sawah ija bakal noeli kena ditandoeri, djandji oleh banjoe. Jen lahare kandele ngoengkoeli djeroning waloekeon, boemi kono maeo “anjar” maneh, satin waled saka ndjeron boemi, doeroeng ngoentoer sari
Srengat District has more damage than any other places. Rice fields didn't harvest, and many areas exposed to ash and full of sand because down there is the Kelud lava road. Inevitably the Blitar land around there has become damaged; more than 5,000 people died; the village is a chaos, the plants die, the country raises thousands of people. Lava is hoarding sand in a low place. When the sand is thin, rice fields can plant, as long as there is water. When the thickness of the lava exceeds the depth of the place, the land becomes "new" again, and there is a new change from the ground, the essence
The scientific features of the volcano that will erupt have been seen in some literature [3]. The summary of clear signs are associated with ancient manuscript literature found, as shown in Table 2.

Table 2. Mitigation Signs from Pieces of original text and translations of ancient Goenoeng Keloet.

| The Scientific Sign of Volcano Eruption | Manuscript Literature                                                                 | Translation                                                                                         |
|----------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| Drastic increase in temperature due to heat emitted by the mountain | "Tengere jen arep ndjebloeg: banju ing soemoer lan kali angoke ndisiki mangsa, soember ngoedalake wedi; hawa ngekesake awak; ivak tjilik akeh mati; dene ing kawah tinemoe: banjoe panas, ngoekoes, oemrik, broboesan, ganda waltirang, gledoeg, gereng, lindoel, tatt..." | Signs when they are about to erupt: water in wells and rivers overflow ahead of the season, water sources emit sand; the air gets hot; many small fish die; then, in the crater will be found hot water, boiling (steaming), smelling of sulfur. |
| Sources of springs dry up or overflow due to magma activity, which causes the groundwater reserve to evaporate or could also create flood due to the impact of the lava discharge from the eruption | "Jen wis genah Keloet moeroeb arep ndjebloeg, wong-wong lawasan sing ngegeit bandjoer engsal akekoetoeg, lawang-lawang didjeblagi, wonge bandjoer menek ranggon. Lahar mono banjoe-wedi-endoe watoe, mili sante kaja bandjir ngantjar saka poetojoe goenoeng, sawarnane ailing ailing kang keterak masti djebol" | When Kelud was about to erupt, the people who understood immediately left, the doors were opened wide, the people then climbed onto the tree. Lava filled with water-sand-rock ground, and water flows like a flood coming from the top of a mountain, whatever is passed must be broken. |
| Earthquakes often occur, and there are loud explosions from the mountains [3] | "Let sadela kroengoe swara ping pat:A moment later came the sound of "derr,,", goemeter ing langit" | "derr" vibrates in the sky. |

Based on the chronicle of the ancient manuscript "Goenoeng Keloet", several mitigations were produced as follows:
- to see the difference in height and change in water sources;
- there will be an increase in temperature around the mountain;
- one mentioned indicator is in the form of many small animals such as fish (there are local species of fish such as vests, crabs, mahseers, etc.) die;
- the condition of lake water in the mountains that has sulfur odor;
- to open the doors and windows of the house and run to the field in the event of an earthquake;
- to avoid unveiling of agricultural land and homes within the lava lane; and
- to plant many trees along the lava lane, especially tamarind trees (can grow up to 30m in height, 1-2m in diameter, are very leafy and have small leaves, and the fruit can be useful as food/drink).

4. Conclusion and Recommendations
Mitigation processes before and after volcanic eruptions are recorded in ancient manuscript literature. Disaster mitigation can be made by using existing local wisdom or written or verbal knowledge in the
community. In the future, local intelligence can be used as a reinforcement in national security, especially in the field of disaster management. In the future research, this study could be developed specifically to discuss how local wisdom can be used as an asset to building a better country with a cultural perspective.

5. References

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