

Conference

Indonesia's Disaster Resilience Against Volcanic Eruption: Lessons from Yogyakarta

Septyanto Galan Prakoso^{1*}, Abyan Ardan Wijaya² and Ferdian Ahya Al Putra²¹Institute of Political Science, National Sun Yat-sen University, Kaohsiung, Taiwan; Lecturer at International Relations Department, Universitas Sebelas Maret Surakarta, Indonesia.² Department of International Relations, Universitas Gadjah Mada Yogyakarta, Indonesia**ORCID**

Septyanto Galan Prakoso: 0000-0002-0105-2342

Abstract. Indonesia is the largest archipelago country in the world, with more than 17,000 islands. Located on the “ring of fire”, Indonesia has many active volcanoes, and also has the threat of earthquakes as a result of constant movement of the tectonic plates between the Eurasian and Australian plates. Because of these features, Indonesia has one of the highest disaster-risk of all countries in the world. In terms of disaster resilience, the people of Indonesia have their own cultures with many local communities that have been educated about the potential disasters that might arise. After the 2004 tsunami that hit Aceh, disaster mitigation education gained more attention in Indonesia. Using the concept of disaster risk reduction uniquely fused with local wisdom and culture, this study aimed to describe the potential impact of natural disasters in Indonesia, and the prevention of the loss of life. Qualitative analyses were used, with a focus on Yogyakarta province, as one of the regions in Indonesia with the highest natural disaster risk. This study found that disaster resilience is increasing in Indonesia.

Keywords: Indonesia, natural disaster, volcanic eruption, disaster risk reduction, Yogyakarta

1. Introduction

Indonesia, as one of many big countries in the world, has a big population is according to the Central Bureau of Statistics (or *Biro Pusat Statistik* [BPS] in Indonesian) as many as 260.580.739 populations per September 2020. (1) Located in Southeast Asia, the chance of occurrence for natural disasters in Indonesia, especially volcanic-related ones, can be tracked back based on Indonesia's status which is also located in the 'Ring of Fire'. The term the *ring of fire* has meaning to the volcanic and seismic activities that frequently happen in the Pacific Plate. According to nationalgeographic.org:

The Ring of Fire is a string of volcanoes and sites of seismic activity, or earthquakes, around the edges of the Pacific Ocean (2)

It means Indonesia is one of many countries that are included in that 'ring', that vulnerable to get impacts from a natural disaster like earthquakes, volcanic eruptions, and also tsunami. The Plate movement is also various and the plate can move because

Corresponding Author:

Septyanto Galan Prakoso; email:
septyantogalan@staff.uns.ac.id

Published 15 March 2022

Publishing services provided by
Knowledge E

© Septyanto Galan Prakoso et al. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the IAPA Conference Committee.

OPEN ACCESS

it is not fixed, moving atop of mantle that means solid and molten rock. (3) The first type is convergent, the plates move closer to each other, even collide. In some cases, the colliding between plates movement creates a mountain, and the biggest collide that is known so far is the Himalayan mountain range with Mount Everest as its peak. (4)

The other type is divergent, a tectonic activity that plates pulling apart from each other. Another type is transform boundaries, which is every plate past slide horizontally, and the last is hot spots, which is about magma activity and volcanic activity. All of these situations, make the natural phenomena in Indonesia is very miscellaneous. Every year, natural phenomena routinely appear in society, from the big issues like Mt. Kelud eruption, Aceh's Tsunami 2004, Lombok earthquake in 2018, and the typical phenomena like liquefaction in Petobo, Sulawesi, and some progress like the case in Bantul.

2. Conceptual Framework

With the case of Indonesia's potential natural hazard, this paper will be using the UNDRR-Sendai Framework approach for *Disaster Risk Reduction* (DRR) in Indonesia, combining with local-cultural exposure. The disaster risk reduction is based on Sendai Framework on disaster risk reduction 2015. It have two levels on each implementation, national-local levels, and the global regional levels, (5) therefore its implementation must be considered by every participant in terms of their country's capacity to outcome many natural hazards that could happen potentially. There are four priorities of the action, from the most important thing, which is understanding disaster risk, and then following up with strengthening disaster risk governance. Thirdly, promoting government to invest in DRR for resilience, and the last one is to enhance the capability to recover, rehabilitate, and reconstruct post-disaster. (6)

Following the concept above is the cultural approach toward society. Wisner in 2004 says that culture could be an obstacle to the greater implementation of DRR, and it is supported by the argument that it could lead to the community's vulnerability. (7) But, in reality, cultural knowledge often saves people-group from taking damage from 'disaster'. The cultural approach can be the bridge between local groups into authorities, so the DRR chain can be easily done on both sides.

With all of the concepts from DRR and the cultural approach, the main question in this paper is, 'How did Indonesian local civilization in Yogyakarta overcome many natural hazards that could happen in their region following disaster risk reduction concept?'

3. Discussion

3.1. Potential Disaster Threat

What we learn first is the problem of the Earthquake that frequently occurs in any region of Indonesia. The same case happens in Japan, and they just more often than the case of Indonesia, which is Japan located directly on the 'Ring of Fire' position in the Pacific Ocean. What we learn is Japan is socially constructed to be ready for the earthquake if that phenomenon appears. They prepared many risks reduction like how the structure to be built, and how does to saving lives within the structure that have been built. So, the first thing that must be repaired is society's knowledge because knowledge is power. People in Indonesia are well-known about how to make a strong structure, like many professors in civil engineering explain, but sometimes corruption does make more damage. For example, in terms of high budget for building safety, they cut money for themselves and downgrade the building quality. That affect so much in the next future, if heavy earthquakes struck that area. At least, the building must have a strong choke-point for evacuation zone, for example in the corner near the stairs.

After building a strong structure, the society must be well educated to know how to use it. In the case of my home, I got an evacuation sticker to highlight evacuating road to exit. Small step to gain bigger steps, and will be great if everyone who knows about disaster transfers their knowledge and to do something for the science that they know in practically. Knowledge makes it calm if a disaster occurs, and one more thing is to choose the leader if the case of so many people in the area. The leader has to lead and manage the people to evacuate them safely and effectively. The leader must be the most well-known about disaster management and able to make momentum to escape in terms of vision. If the team has no leader, chaos will happen and the life-hope percentage will be decreased. After they got escaped from a hard situation, the leader must find the recent information.

Information is important to have, and information is power. In the coastal area, Tsunami commonly appears after a big earthquake. The information had to be used to find how big is the earthquake, is below the 6 Richter scale or above. After that, the information gives the team that escaped how big is tsunami threat will be arriving, and how to handle it. In case of a Tsunami, Indonesia and Japan are at high risk, and that phenomenon must be prepared in precautions into society. A tsunami can be 5 meters high, 10 meters, or maybe 30 meters and above. In Palu, the amateur videos show us about tsunami reached nearly the peak of a shopping mall which is had at least 4 floors. Tsunami

commonly not only in one wave, but two waves or maybe more, (8) and the next wave are stronger. In this case, Bantul has a good example, they got well-planned disaster risk reduction in BPBD, like coordinated and connected speaker via mosques speaker that spread at in line, at least 7 mosques to ready to warn if tsunami happen. Then, they have a tsunami shelter 4 floors high.

Following the name of 'Ring of Fire', we faced other problems in natural hazard, this is the danger of volcanic eruption and especially famous mountain in Yogyakarta names Mt. Merapi. This mountain had erupted many times, one of the biggest impacts from eruption recently is eruption in 2006 and 2010. According to many resources, both eruptions had different conditions of eruption. In 2006, the 'disaster' term rise following the collapse of the lava dome in Merapi, following by 171 people who passed away. (9) On the other hand, in 2010 the case is the volcanic cloud, which local people often called '*wedhus gembel*' that smashed away anything in its track. 277 people passed away, including the famous Mbah Maridjan, the local leader that called '*kuncen*' in Merapi within the Yogyakarta Sultanate mandatory. (10)

Furthermore, Indonesia has a greater threat, namely the threat of a megathrust earthquake and tsunami on the southern coast of Java. Various parties have researched this potential, as examples of research was carried out by Widjo Kongko (2018), Ron Harris (2017 - 2019), and finally, the Inter-Agency Team led by the Bandung Institute of Technology (ITB), and supported by the Meteorology, Climatology, and Geophysics Agency (BMKG). These various studies more or less show the same finding that there is a potential for an earthquake followed by a tsunami as high as 20 meters that can occur 20 minutes after the earthquake. (11) In a press release by BMKG, it is stated that this is not a prediction, but a potential, so when it will happen is not known for certain. BMKG also stated that based on the results of a study involving experts, the southern Java plate zone has the potential for an earthquake with a maximum magnitude of 8.7 M. (12) This potential certainly causes concern in the community given that the exact time when it occurs is not known. Therefore, the community, especially those living on the southern coast of Java, must always be vigilant, so that if an earthquake and tsunami do occur, the community will understand what to do. Thus, the potential for loss of life can be minimized.

3.2. Community Understanding regarding Disaster Mitigation

Besides being known as a city of students and culture, Yogyakarta is also known as an area with a variety of tours. One of the leading tourism in Yogyakarta is nature

tourism around Mount Merapi and on the south coast. In fact, Yogyakarta has more than 100 beaches scattered in various areas such as Gunung Kidul, Bantul, to Kulon Progo. The existence of this tourist destination can attract many tourists, both local and foreign tourists to visit. To prepare for this situation, the readiness of tourism managers at local locations needs to be well prepared. Earthquakes and tsunamis are not only caused by tectonic activities but also caused by volcanic activities, where they occur as a result of volcanic eruptions. At various points on the coast of Yogyakarta, signs are indicating the path in the event of a tsunami. However, the most important thing is socialization to tourists about mitigation when a tsunami is occurring. When an earthquake occurs, of course, the public, especially tourists, will experience panic, and therefore, establishing information about the route is the key to preventing many victims. This can be implemented by increasing the number of information boards regarding news and the steps that must be taken, in addition to using the loudspeaker of mosques around the location.

It seems that it is important to increase public understanding regarding mitigation in the event of an earthquake and tsunami. Learning from the earthquake and tsunami that occurred in Aceh, many people felt complacent after the earthquake occurred. They visited certain damaged points to help earthquake victims and some were just looking around without understanding that the water on the Aceh coast was receding which was a sign that a Tsunami would occur. There are even some of them who are busy catching fish because many fish are stranded due to the receding seawater. (13) This situation indicates that there was very little or no effort by the people of Aceh to save themselves due to the ignorance of the community regarding the signs of the Tsunami so that in the end the disaster claimed more lives. This understanding certainly needs to be disseminated as early and as widely as possible. For example, through simulations in schools, so that students are responsive to possible disasters. This can also help which parties who have been educated can socialize it to the public.

One of the problems in Yogyakarta according to the Regional Disaster Management Agency (BPBD) Bantul is that the number of signs or signs indicating evacuation routes on the coast around Bantul is still not ideal. The Head of BPBD Bantul, Dwi Daryanto stated that:

“Ideally, it takes about 1,000 signs. Currently, 5000 signs have been installed. The four evacuation routes in the Poncosari area also need increased asphalt.” (14)

This statement shows that there are still aspects that need to be addressed. This is certainly important considering that the condition of the plains in the Bantul and Gunung Kidul areas is different. The plains in the Bantul region can be said to be lower

when compared to Gunung Kidul because the texture tends to be flat. Meanwhile, in the Gunung Kidul area, the coast is blocked by high cliffs and hills, so at least this can prevent or reduce the impact of a possible tsunami. Nevertheless, both the public and tourists still have to understand the steps that must be taken. In addition, evacuation route signs are not enough, BPBD in particular, needs to assess the feasibility of evacuation points by considering the wave height with the number of people and visitors being evacuated. Nevertheless, BPDP Bantul considers that the mitigation system in the coastal area of Bantul is quite good because it is equipped with an early warning system (EWS). He further stated that his party still has 9 EWS and 12 mosque loudspeakers that are connected to the EWS. (15) Thus, this equipment can prevent or at least reduce the number of victims.

3.3. Utilization of Technology in Disaster Mitigation

Considering that the Indonesian region, especially Yogyakarta, which is vulnerable to natural disasters such as volcanic eruptions, earthquakes, and tsunamis, the Earthquake Early Warning System Research team from Gadjah Mada University (UGM) Yogyakarta, under the coordination of Professor Sunarno, developed an earthquake detector. As mentioned earlier, this tool is namely the Early Warning System (EWS). EWS is considered to be able to detect earthquakes and tsunamis 3 -7 days before the earthquake. Previously, this system was proven to be able to predict an earthquake that occurred in West Bengkulu M 5.2 on August 28, 2020, Southwest Sumur-Banten M 5.3 on August 26, 2020, Southwest Bengkulu M5.1 on August 29, 2020, and Southwest Sinabang Aceh M5.0 on September 1, 2020. (16) This is important to reduce the disaster risk since this system is an early warning so that evacuations can be carried out before a disaster occurs. When the evacuation has been carried out as early as possible, the potential for casualties becomes smaller. Connecting this system with loudspeakers at the mosque is the right step since it can be informed directly to certain areas so that people can immediately evacuate themselves when the earthquake and tsunami are detected.

The Early Warning System is not only intended to detect earthquakes and tsunamis but there is one that is specially made for detecting volcanic eruptions. The Sleman BPBD, for example, has more than 30 EWS. The EWS installed by the Sleman BPBD can detect hot clouds and lava floods in the Mount Merapi area. (17) Just like EWS in coastal areas, the presence of this detector can help anticipate early in the event of an eruption of Mount Merapi. In the previous discussion, it was stated that the Merapi eruption caused many casualties, so the presence of the EWS is expected to reduce the impact

caused by the eruption. However, the problem that arises with this EWS is whether this tool works properly. Damage was found to one of the EWS, which is located in Kali Krasak due to a falling tree. Head of Sleman BPBD Disaster Mitigation Section, Joko Lelono also mentioned that his party had constraints on budget constraints due to the COVID-19 pandemic with the following argument: "This (EWS) wants to be installed in Watu Purbo, Tempel, this was proposed first because of COVID the budget was limited so we asked BTT (unexpected cost), the budget was Rp. 50 million to be able to move the EWS which was previously in Dusun Kembang to Merdikorejo, we will move it". (18)

This situation reminds us of the importance of regular monitoring and maintenance to ensure that the installed equipment can function properly. The availability of a budget is also important to make sure that every region has enough facilities and instruments to detect the possibility of disasters happen.

Related to reducing the impact of disasters, currently, various parties are starting to use digital media to facilitate the flow of information. BPBD Yogyakarta currently has a disaster reporting mechanism, one of which is through its official website. The official website provides a disaster reporting mechanism by identifying the occurrence of disasters starting from the type of disaster, the damage that occurred, the number of victims, to those related to the evacuation. (19) This reporting mechanism is certainly important for mapping the impacts caused by the eruption so that it can help determine the right response regarding the mitigation that occurs. This reporting mechanism is also a synergy between the local government and the community, especially regarding the management of information on the ongoing disaster. In addition, through the website, BPBD Yogyakarta routinely reports information related to disasters, both natural and non-natural disasters through its social media, especially through Instagram. The results of monitoring carried out by the Yogyakarta BPBD team are often reported via Instagram, so that information can be spread more quickly to the public. The use of social media is certainly important to implement considering that currently, access to information is circulating rapidly through social media, both from the official accounts of the relevant institutions and from non-government accounts. Nevertheless, information management is an important thing to pay attention to. The goal is to prevent the spread of hoaxes and prevent panic in the public. Therefore, related parties, such as BPBD, should be careful in releasing any information so that people do not panic easily.

3.4. The local-National Levels on Information and Linking Aspects

One of the keys in DRR is the bridging in local communities within the government and international assistance. Following Kulatunga's argument:

Community-based DRR activities are a form of participant empowerment and a mechanism that transfers ideas from the community to the authorities who take decisions at the top level of the governance system. (20)

Following those sentences, the cultural values in Indonesia, which are very sociable, humble with the spirit of *gotong-royong*, could make a greater impact in tackling the problem in its region when disaster hits. For example, NATO civil-military cooperation, or CIMIC type, was developed by the Indonesian army (TNI) long before its concept grows up with the name of *ABRI Masuk Desa* (AMD).

Other examples of how linking and bridging aspects in Indonesia could work is the BPBD and BNPB as national officials for disaster mitigation is work well with many layers of society. When I was studied at UGM, I join a program named Disaster Response Unit (DERU) in collaboration with BPBD Bantul. Shared knowledge is one of the most important things to do in the cultural approach, so education into society is the primary thing in the DRR approach in collaboration with the cultural approach.

What we can do is to relink what we know and transfer it into our community. The government frequently makes socialization the disaster plan into society, our duty is to extend the knowledge transfer into our very local community. We can divide it into three-step :

1. First step: educating ourselves to get to know what is a potential threat and what is happening in disaster; including technical and practical knowledge, because theory without practice will not go in the right ways.
2. Second step: After we had enough information, we share it and start it with the smallest and closest community, family. Start with family is the easiest step to wider the scale and to share the knowledge power. We can tell our information, and also we can make an evacuating plan for our family.
3. Third Step: Relink, with many students with inter-discipline, practitioner, specialist, professor, government, and many more as much as we can. Then use the advantages of this country, in fact of the largest Muslim population in the world, Indonesia got potential advantages in the spread of information. Like we explained before, the mosques got important roles because they have speakers out (they use it for calling for prayers), and are located in almost every village in Indonesia.

These three steps may just be simple but are realistic to do. Indonesia has a social culture that is not individualistic, but they have relations with each other. If we used that point, connecting and knowledge transfer will be easier than we think. Social media is mastered in the youth of Indonesia. Like the case of Merapi voluntary, they are good at it, because they have strong media to communicate with each other. Social media have an important role in this era because it spread very fast and is easy to access for everyone. The Merapi Volunteer use it to accommodates incoming volunteer from many areas. Social media keep people contacting and sounding position. We will use it as our power to inform one and another, to spread the information fast, and to connect each aspect of our society in this country.

Social media, youth movement, and also many local ways of using mosque speaker itself is part of the implementation of the disaster risk reduction concept. Sendai Framework for disaster risk reduction for 2015-2030 states that:

(d) Establish community centers for the promotion of public awareness and the stockpiling of necessary materials to implement rescue and relief activities;

(e) Adopt public policies and actions that support the role of public service workers to establish or strengthen coordination and funding mechanisms and procedures for relief assistance and to plan and prepare for post-disaster recovery and reconstruction;
(21)

With this base, we can say that the action from the local having various kind of action within the social-media approach, community, and also mosque linking with their loudspeaker, but in terms of government way, we have BNPB and BPBD for tackle this issue. There are also many tsunami shelters that we met, in the Disaster Response Unit (DERU) UGM program. In another way, there is a system called '*Kampung Siaga Bencana/KSB*' at the locals level. One place that we visited called KSB Tegal Tirto, also having great preparations and stockpiles in their camp, so it can handle internally displaced person (IDPs) very well. That system implements DRR in Indonesia has a great way in the future.

Moreover, as mentioned before that there's a social capital concept in Indonesia known as the spirit of *gotong-royong*. It can have an impact on progress in disaster mitigation. The concept of *gotong-royong* itself is interpreted as working together or helping each other (KBBI). In other words, cooperation can be optimized in disaster management. The cooperation here is not only aimed at those who are directly involved in the field, but also at a wider scope, especially in this digital era. Indonesia itself in the 10th edition of the World Giving Index (WGI) is included in the 10 most generous countries in the world. According to Sebelas Maret University's Anthropology Sociology

Education Lecturer, Nurhadi, Indonesian people have good social capital, namely a high level of concern for the fate of others. (22)

In today's digital era, many people use digital platforms, both social media and other platforms such as *Kitabisa*, to collect donations in various ways, including aid for disasters. Natural disasters are not something that can be avoided, but can be anticipated or minimized. Donations from various parties can at least help the burden on the government and society as a result of the disaster. This can also more or less reduce dependence on foreign aid, related to disaster management. With this social capital, disaster recovery can be carried out more quickly, thereby reducing the suffering of disaster victims. This step is also a manifestation of the concept of *gotong-royong* of the Indonesian people, namely working together in tackling disasters. The concept of *gotong-royong* also applies to preventive measures, namely by understanding as well as possible the steps that must be taken when a disaster occurs, whether an earthquake, tsunami, or eruption, so that when an early warning appears from the relevant institution, the community already understands what steps to take; as this is also part of the disaster risk reduction (DRR).

4. Conclusion

Indonesia has its unique styles to handle and control its potential disaster. Its cultural identity brings the majority concept into the society. One of the most important things is the value of their leader that could lead the ground people, and make them slipstreaming their leader. This leader concept here can be a cleric, or influencer in the regional community that could drive group, or-community to move. Indonesia had many things to explore, following by its local wisdom that was widespread across the country. Indonesian society system also taking great part to overcome the disaster, for example is the group of *Kampung Siaga Bencana (KSB)* that spread out through this country. The KSB will provide great warehouse and preparation for disaster to cover the internally displaced person (IDPs).

Still, several aspects need to be considered. The application of technology in disaster risk reduction is important to be maintained and developed. By combining the use of technology with the concept of *gotong-royong* and social capital owned by the Indonesian people, the impact caused by disasters can be reduced to a minimum. These factors certainly have contributed to the specific practices of DRR in Indonesia, which also underlined the role of local civilization in learning and adapting to the risky environment and landscape of the country. The use of early warning system (EWS) that

developed by multi-sectoral aspect is one of the key to improving Indonesian's DRR, which are also supported by simple system like the mosque speaker that spread-out in every village. At the end of the day, Indonesia has more potential to be reached in the sector of disaster mitigation and disaster resilience.

References

- [1] Badan Pusat Statistik. Hasil sensus penduduk 2020. BPS 2021 Jan 21. Available from: <https://www.bps.go.id/pressrelease/2021/01/21/1854/hasil-sensus-penduduk-2020.html>
- [2] Ring of fire. National Geographic, Retrieved on 2021 June 17. Available from: [nationalgeographic.org](https://www.nationalgeographic.org/encyclopedia/ring-fire/), <https://www.nationalgeographic.org/encyclopedia/ring-fire/>
- [3] Ring of fire. National Geographic, Retrieved on 2021 June 17. Available from: [nationalgeographic.org](https://www.nationalgeographic.org/encyclopedia/ring-fire/), <https://www.nationalgeographic.org/encyclopedia/ring-fire/>
- [4] Geolsoc.org. Plate tectonic convergent. The Geological Society, 2021 February 18. Available from: <https://www.geolsoc.org.uk/Plate-Tectonics/Chap3-Plate-Margins/Convergent/Continental-Collision>
- [5] United Nations Office for Disaster Risk Reduction. Sendai framework for disaster risk reduction 2015-2030. Sendai: UNDRR; 2015.
- [6] United Nations Office for Disaster Risk Reduction. Sendai framework for disaster risk reduction 2015-2030. Sendai: UNDRR; 2015.
- [7] Kulatunga, Udayangani. Impact of culture on disaster risk reduction. Manchester: University of Salford; 2010.
- [8] Sukamoto S. 'Management in Disaster Risk Reduction' lecture. UGM-Osaka University joint program; 2019 Feb 21.
- [9] Anjani, Zena Rena. Perbedaan erupsi 2006 dan 2010. Tirto.id, 2020 November 6. Available from: <https://tirto.id/sejarah-letusan-merapi-perbedaan-erupsi-pada-2006-dan-2010-f6ED>
- [10] Anjani, Zena Rena. Perbedaan erupsi 2006 dan 2010. Tirto.id, 2020 November 6. Available from: <https://tirto.id/sejarah-letusan-merapi-perbedaan-erupsi-pada-2006-dan-2010-f6ED>
- [11] Oktari, Rosi. Potensi Tsunami Pantai Selatan Jawa, Jangan Panik ya Sohib!. [indonesiabaik.id](https://indonesiabaik.id/infografis/potensi-tsunami-pantai-selatan-jawa-jangan-panik-ya-sohib). Available from <https://indonesiabaik.id/infografis/potensi-tsunami-pantai-selatan-jawa-jangan-panik-ya-sohib>
- [12] Thirafi, Hatif. Gempa magnitudo 8,7 dan tsunami 29 meter di pantai selatan jawa timur adalah potensi bukan prediksi. BMKG, 5 June 2021. Available from:

<https://www.bmkg.go.id/press-release/?p=bmkg-gempa-magnitudo-87-dan-tsunami-29-meter-di-pantai-selatan-jawa-timur-adalah-potensi-bukan-prediksi&tag=press-release&lang=ID>

- [13] Fajri, Rihal. Tsunami aceh, 13 tahun kemudian dan kesadaran melawan lupa. BBC.com. Bbc.com, 2017 Desember 26. Available from: <https://www.bbc.com/indonesia/majalah-42482538>
- [14] Cahyana, Budi. Rambu jalur evakuasi dari tsunami di bantu belum ideal. Harianjogja.com; 2020 Oct 5. Available from: <https://jogjapolitan.harianjogja.com/read/2020/10/05/511/1051709/rambu-jalur-evakuasi-dari-tsunami-di-bantul-belum-ideal>
- [15] Cahyana, Budi. Rambu jalur evakuasi dari tsunami di bantu belum ideal. Harianjogja.com; 2020 Oct 5. Available from: <https://jogjapolitan.harianjogja.com/read/2020/10/05/511/1051709/rambu-jalur-evakuasi-dari-tsunami-di-bantul-belum-ideal>
- [16] Indonesia.go.id. Peramal gempa dari Yogyakarta. Indonesia.go.id. 2021 Juni 25 Available from: <https://www.indonesia.go.id/kategori/komoditas/2927/peramal-gempa-dari-yogyakarta>
- [17] BPBD Sleman. Pemeliharaan early warning system BPBD Sleman. BPBD Sleman, 2020 January 31. Available from: <https://bpbd.slemankab.go.id/pemeliharaan-early-warning-system-bpbd-sleman/>
- [18] Wawan SJH. BPBD: EWS lahar hujan gunung merapi di kali krasak rusak. Detik news, 2021 February 17. Available from: <https://news.detik.com/berita-jawa-tengah/d-5377142/bpbd-ews-lahar-hujan-gunung-merapi-di-kali-krasak-rusak>
- [19] BPBD. Laporan bencana. BPBD, retrieved on 2021 June 17 Available from: <http://bpbd.jogjaprovo.go.id/lapor-bencana>
- [20] Kulatunga, Udayangani. Impact of culture on disaster risk reduction. Manchester: University of Salford; 2010.
- [21] United Nations Office for Disaster Risk Reduction. Sendai framework for disaster risk reduction 2015-2030. Sendai: UNDRR; 2015.
- [22] Rizal JG. Indonesia masuk negara paling dermawan sedunia, ternyata ini alasannya. Kompas.com; 2021 Mar 9. Available from: <https://www.kompas.com/tren/read/2021/03/09/190000165/indonesia-masuk-negara-paling-dermawan-sedunia-ternyata-ini-alasannya?page=all>