Basic Research on Archiving and Regional Characteristics of Disasters in Indonesia

Saga University Lambung Mangkurat University Hasanuddin University Saga University Regular Member Non Member Non Member Student Member Takenori Hino Annisa Mutia Rahmah Tri Harianto Yutaka Ueno

1. Background and Purpose of This Study

Indonesia is the largest archipelago country with 17.504 islands. The five main islands are Sumatera, Java, Kalimantan, Sulawesi, and Papua. Indonesian archipelago is situated in one of the world's most active disaster hot spots, which made Indonesia highly exposed to natural disasters, where several types of disasters such as earthquakes, tsunamis, volcanic eruptions, and landslides frequently occur. This problem has become threat for Indonesian especially in Java as the world's most populated island where more than 50% of Indonesian lives, including in the capital city, Jakarta. These past few years, Jakarta has faced a range of natural hazards particularly land subsidence and flood. The objective of this study is to archive the history of geological disasters in Indonesia for past five years start from 2015 to 2019.

2. Major Disasters in Indonesia

Indonesia lies in the most active tectonic regions on Earth, with the length of tectonic plate boundary is more than two times of Japan (Cummins, 2017). Geographically located on the intersection of three major tectonic plates: Indo-Australian, Eurasian, and the Pacific plate as shown in **Figure 1**. Indo-Australian plate thrusts under the Eurasian plate, moving northward pushes into the Eurasian plate that is moving southward. It is also located at Pacific Ring of Fire, a region of high volcanic and seismic activity that surrounds the Pacific Ocean. About 47% of all disasters occurred in Indonesia are from a geophysical/geological nature (Priester, 2016). These geological disasters include internal earth processes, such as earthquakes and volcanic activity, also geophysical processes such landslides and liquefaction.

2.1 Earthquake & Tsunami

Seismic condition in Indonesia are strongly influenced by the movements of the tectonic plates. The Indo-Australian plate collides to the Eurasian plates along the offshore of Sumatera, Java, and Nusa Tenggara, then to Pasific plate in the northern Papua and Maluku. Indonesian tsunami were mostly generated

by undersea earthquakes, volcanic eruptions, and seabed landslides. Earthquake prone areas in Indonesia are distributed close to the subduction zones and nearby active faults. The subduction zones distributed along the western coasts of Sumatra, southern coast of Java, Bali and Nusa Tenggara, the northern and eastern coasts of Sulawesi, Maluku, North Maluku, and the northern coasts of Papua. Many crustal faults in Indonesia have been conclusively categorized as active. A systematic approach using geological methods was conducted to identify active faults in eastern Indonesia (Watkinson & Hall, 2016). Of the 27 faults studied, 16 show rapid and 3 show low tectonic activity. By 2016, Watkinson & Hall (2016) called particular attention to the Palu Koro Fault in Central Sulawesi, which they characterized as having a high slip rate with fault strands proximate to a large urban population in the city of Palu.

2.2 Volcano Eruption

Volcanoes are one of main concern in Indonesia, with about 100,000 lives had been lost to volcanic disasters within the past 200 years. Volcanic ash is a hazard associated to volcanic eruptions has become threat to communities living in the active volcanoes nearby area (Cummins, 2017). Indonesia has more than 500 volcanoes with 127 of those are active, distributed along the islands of Sumatra, Java, Bali, Nusa Tenggara, North Sulawesi and Maluku. **Table 1** shows the number and distribution of active volcanoes in Indonesia.

2.3 Landslide

Landslide occurred in almost all Indonesian major islands, especially the areas with rough structures of rocks and slopes are generally more prone to land mass movement. Many other cases of landslide were also generated by massive deforestation, heavy rainfall and earthquake.

2.4 Land Subsidence

Land subsidence is a common problem in lowland area, including

Jakarta, the capital city of Indonesia. Land subsidence is the downward displacement of land surface relative to certain reference surface, such as mean sea level (MSL). The land subsidence occurred in Jakarta is mainly caused by groundwater extraction, load of infrastructures and constructions, natural consolidation of alluvial sediment soil, and geotectonic subsidence. The first three are considered to be the dominant cause of land subsidence in Jakarta. (Abidin, et al., 2010).



Figure 1. Active tectonics of Indonesian (Cummins, 2017)

Table. 1 Active volcanoes in Indonesia

| No. | Distribution Area | Active Volcanoes |
|-------|-------------------|------------------|
| 1 | Sumatera | 30 |
| 2 | Java | 34 |
| 3 | Lombok | 1 |
| 4 | Bali | 2 |
| 5 | Sumbawa | 2 |
| 6 | Flores | 25 |
| 7 | Laut Banda | 9 |
| 8 | Sulawesi | 13 |
| 9 | Sangir Islands | 5 |
| 10 | Halmahera | 6 |
| Total | | 127 |

3. Statistical Archiving Data and Discussion

According to the National Disaster Management Authority (BNPB, 2019), the annual number of disaster in Indonesia from 2015 to 2019 can be seen in **Figure 2**. Landslide is the most frequently geologic disaster with 846 times in 2017. The

frequency of land movements in Indonesia is increasing due to the deforestation, unsuitable land usage for environment in areas prone to land mass movement, heavy rainfall within a long duration, and also the increase frequency of earthquake.

The frequency of earthquake in Indonesia is about 6000 times in a year from the lowest to the highest level, but in this study only shown the number of disasters that caused a lot of victims and damages. The distribution area of earthquake is shown in Figure 3. Earthquake from 2015 to 2019 mainly occurred in Java with 21%, followed by 20% in Sumatera and 17% in Maluku. Rarely earthquake occurred in Kalimantan and Bali. In 2018, a deadly earthquake occured in Palu, Central Sulawesi that followed by tsunami and liquefaction as previously predicted by Watkinson & Hall (2016). Within the past five years, tsunami happened two times, both in 2018. First was in Central Sulawesi and then in Sunda straits which impacted to Banten in Java and Lampung in Sumatera.

Also in 2018, Indonesia has the most volcanoes eruption. The **Figure 4** shows the distribution area of volcanoes eruption for the past five years. Bali had the most eruptions followed by Sumatera and Java. However, Kalimantan and Papua has zero number of volcano eruption.







In case of land subsidence, there is no specific information about the zone mapping for land subsidence in Indonesia, but the most concerned area is Jakarta, especially in the northern part of Jakarta and the coastal nearby area where the land subsidence occurred about 10-15 cm/year. At certain locations and for certain time periods, the subsidence may reach up to 20-25 cm/year. The land subsidence in Jakarta is related to the excessive groundwater extraction, massive degradation of forest city areas along with the increasing loads of high building construction and infrastructures, also natural consolidation of sediment soil layers. One of the result from this case is in the early January 2020, the flood occurred in Jakarta reach up to 30-50 cm water depth. This flood is the highest flood from the past ten years in Jakarta. The worst scenario that could happen in the near future, as the result of land subsidence combined with sea level rise, Jakarta is predicted to be the fastest sinking city in the world. Therefore Indonesian government should overcome this problem as soon as possible.

4. Conclusion

- From the archiving data, within the past five years, Indonesian islands that are highly prone to the geological hazards is Java, Sumatera, Sulawesi, Nusa Tenggara, and Maluku. Kalimantan can be considered as the safest island from geological hazards in Indonesia. By this consideration, Indonesian government in 2019 has officially decided to move the capital city of Indonesia from Jakarta to East Kalimantan.
- 2) The progressive land subsidence in Jakarta urgently need recovery action and policy to prevent the worse subsidence, rapid decrease in groundwater levels and many other impacts that may occur.

5. References

- Abidin, H. Z., Andreas, H., Gamal, M., Gumilar, I., Napitupulu, M., Fukuda, Y., . . . Riawan, E. (2010). Land Subsidence Characteristics of the Jakarta Basin (Indonesia) and its Relation with Groundwater Extraction and Sea Level Rise.
- Badan Nasional Penanggulangan Bencana. (2019, December 21). *Data Informasi Bencana Inonesia*. Retrieved from Badan Nasional Penanggulangan Bencana: https://bnpb.cloud/dibi/
- Cummins, P. R. (2017). Geohazards in Indonesia: Earth science for disaster risk reduction-introduction. *Geological Society*, 441.
- Priester, L. D. (2016). An approach to the profile of disaster risk of Indonesia. Emergency and Disaster Reports.
- Watkinson, I. M., & Hall, R. (2016). Fault systems of the eastern Indonesian triple junction: evaluation of Quaternary activity and implications for seismic hazards. *Special Publication*.