Modeling Of Tsunami Flood Maps Along The Malang Coast Using Commit 1.8.1 And Quantum Gis 2.18.28 "Las Palmas" Software

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ABSTRACT

The long coastline of Malang, located in the south of Java Island, is close to the Indian Ocean, which has a subduction zone. This makes Malang Regency a potential tsunami-prone area. Therefore, a tsunami inundation map is needed as a reference for creating a tsunami evacuation map. Tsunami inundation modeling is used to estimate the worst-case tsunami impact. The modeling was conducted using ComMIT (Community Model Interface for Tsunami) 1.8.1 based on an Mw 8.7 earthquake scenario taken from the 2017 Indonesian Earthquake Source and Hazard Center distribution of megathrusts and active faults in the South Java Sea, specifically in the East Java Megathrust zone. The inundation map was created using Quantum GIS 2.18. 28 Las Palmas The tsunami inundation modeling results showed that the inundation distance varied between 0.9 and 1.9 km inland, the tsunami height on the coast varied between 8.41 and 19.63 meters with a maximum run-up of 10 meters, and the tsunami arrival time on the coast was around 30 minutes after the earthquake occurred.

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1. INTRODUCTION

Indonesia is a disaster-prone country in terms of geography, climate, and demographics. Indonesia's geographical location between two continents and two oceans makes it prone to disasters. Geologically, Indonesia is located on three plates, namely the Eurasian Plate, the Indo-Australian Plate, and the Pacific Plate [2]. Indonesia's tectonic conditions, located at the meeting point of major world plates and several smaller plates, make the region prone to numerous earthquakes as a result of tectonic processes. One clearly identified source of earthquakes is the active subduction zone in western to eastern Indonesia.

Earthquakes with large magnitudes and shallow hypocenter depths under the sea can cause tsunamis. Figure 2 shows the distribution of megathrust segments in Indonesia and the maximum potential magnitudes that can occur. Tsunamis occur due to changes in water column height within a short period of time.

The city of Malang in East Java is listed as a disaster-prone area, both for tectonic and volcanic earthquakes. This is because the city of Malang is close to the open sea to the south, namely the Indian Ocean, where there is a plate subduction zone that can cause earthquakes that can trigger tsunamis.

Therefore, tsunami modeling is carried out to determine the travel time of the waves, the estimated height of the tsunami or run-up that will hit the affected areas, and to determine the distribution of tsunami waves from the coastline. By knowing the estimated travel time of the waves, the estimated evacuation time for the community when a tsunami occurs can be determined.

2. METHODS

The study area for research along the coast of Malang Regency, East Java. The city of Malang is located at 07°46'48" LS - 08°46'42" LS and 112°31'42" BT - 112°48'48" BT.

The software used was ComMIT and Quantum GIS version 2.18.28 Las Palmas. For tsunami modeling, prediction of height, tsunami wave arrival time, and tsunami inundation estimates using ComMIT (Community Model Interface for Tsunami) software. Quantum GIS software version 2.18.28 Las Palmas. To process raster data from ComMIT modeling into tsunami inundation maps. The earthquake source data used is based on the 2017 Indonesian Earthquake Source and Hazard Center (PuSGeN 2017) from the distribution of megathrusts and active faults in the South Java Sea, specifically in the East Java Megathrust zone, which has the potential for earthquakes with a magnitude of Mw 8.7. The data processing flow is shown in the flowchart (Figure 1).

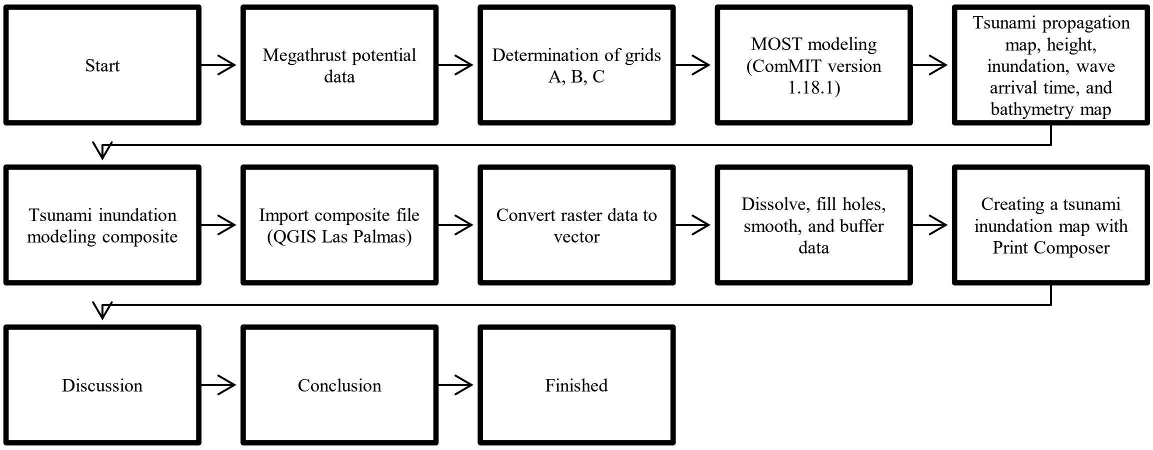
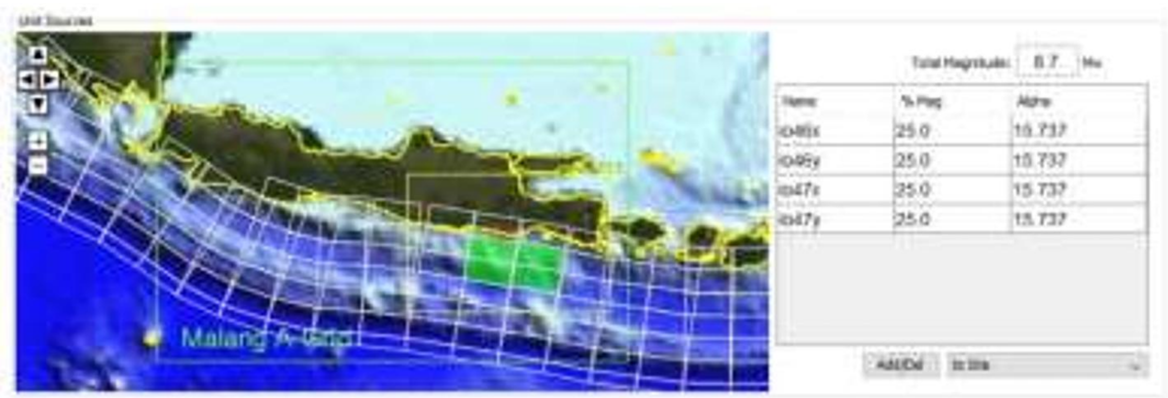


Figure 1. Flowchart of research data processing

3. RESULTS AND DISCUSSION

The earthquake fault used in determining the prediction of the height and arrival time of the tsunami wave uses three earthquake data based on the history of tsunamis in southern Java, which is the source of tectonic earthquakes that have the potential to cause tsunamis, and based on the 2017 PuSGEN catalog of the South Java Sea (Figure 2).



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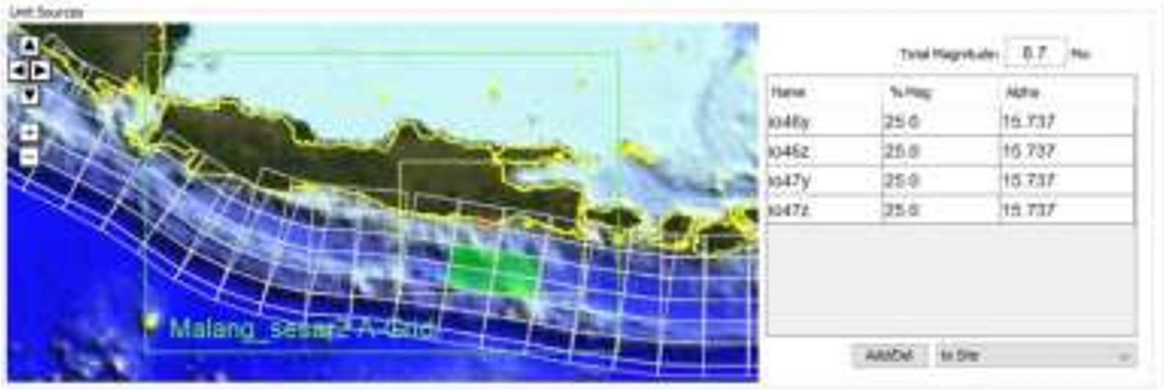

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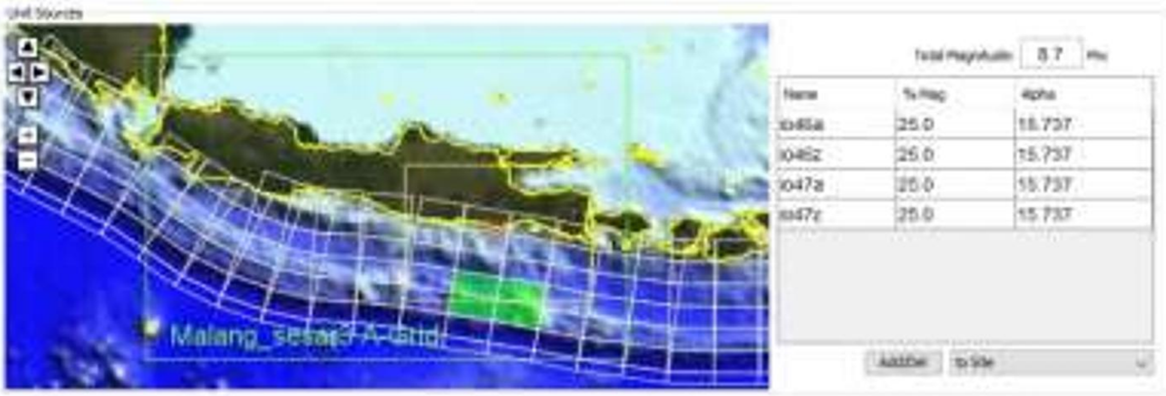

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Figure 2. Fault segments used for the Mmax 8.7 tsunami scenario. (a) Fault data 1, (b) Fault data 2, (c) Fault data 3

From the fault data used, which was then processed using ComMIT software, bathymetric data was generated to determine the depth (in meters) of the modeled area based on a predetermined grid. From the data processing, the results were obtained in the form of a tsunami animation (Figure 3). In addition to bathymetric data, information was also obtained regarding bathymetry data, initial conditions, wave arrival time, and tsunami wave height. The bathymetric data shows the depth of the sea in the Malang Coast area (Figure 4).

The initial conditions show the maximum wave amplitude from the specified source. The source (Grid) has a large amplitude, indicated by black to red contours. (Figure 5).

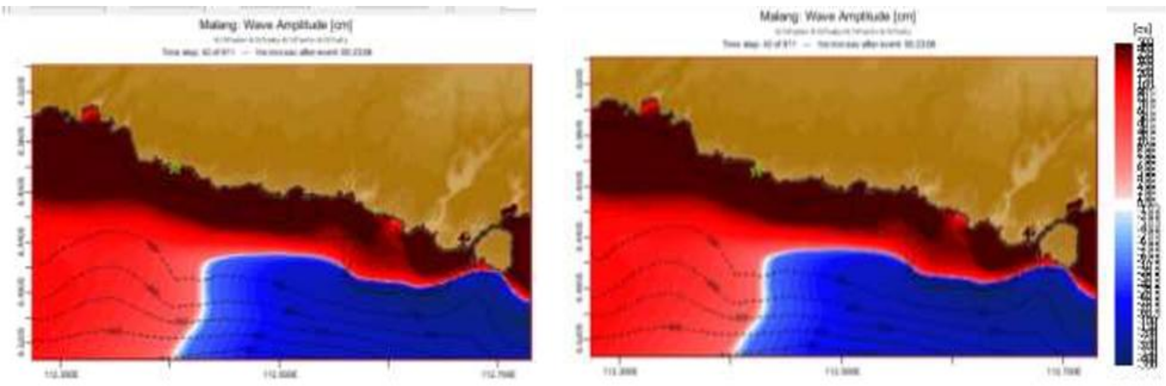


Figure 3. Animation clip of tsunami modeling for Malang Beach with an earthquake scenario of Mw 8.7

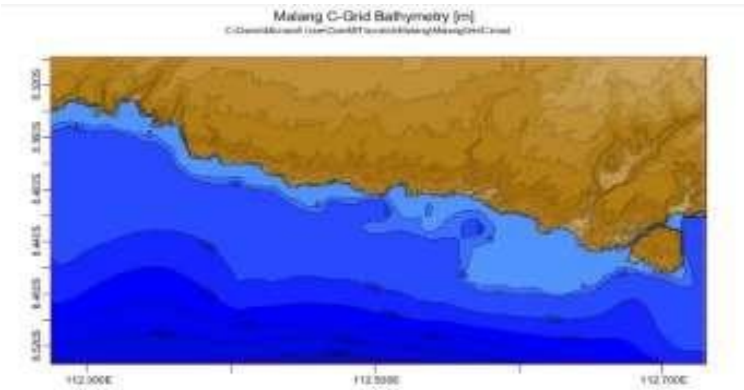


Figure 4. Bathymetry of the Malang Regency Coastline

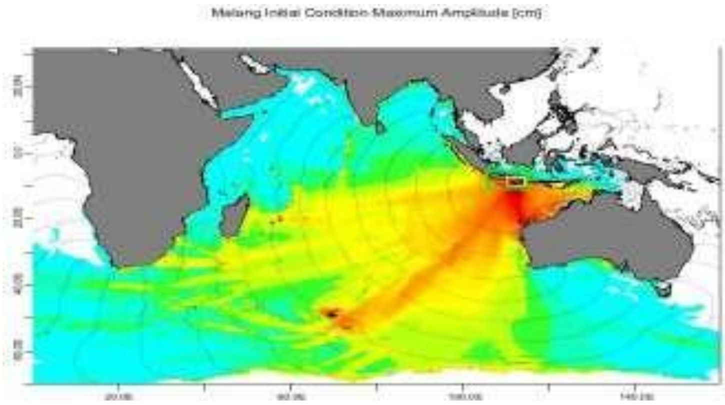
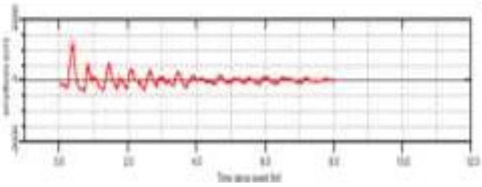


Figure 5. Initial Condition of Tsunami Modeling in Malang Regency

The recorded data focused on the animation when the highest wave reached the coast of Malang Beach (Table 1). The data is displayed in the form of a mareogram graph, where the X-axis represents the arrival time of the tsunami wave and the Y-axis represents the amplitude (height) of the wave (Figure 6, 7, 8). Based on the graphs and data, it can be seen that the highest potential tsunami height occurred at Kondang Iwak Beach to Balekambang Beach, reaching a height of 19.63 meters with a wave arrival time of 27 minutes and 14 seconds after the Mw 8.7 earthquake occurred.

Table 1. Tabulation of Tsunami Wave Height Data and Wave Arrival Times

No	Location	Wave Height (m)			Wave Arrival Time		
		Data 1	Data 2	Data 3	Data 1	Data 2	Data 3
1	Ngliyep Beach, Malang - Temu Wetan Beach	11.49	16.98	11.29	23 minutes and 6 seconds	27 minutes and 43 seconds	34 minutes and 9 seconds
2	Kondang Iwak Beach - Balekambang Beach	10.17	19.63	11.95	23 minutes and 6 seconds	27 minutes and 14 seconds	34 minutes and 9 seconds
3	Wonogoro Beach - Batu Bengkung Beach	9.58	13.34	8.22	26 minutes and 16 seconds	28 minutes and 43 seconds	36 minutes and 38 seconds
4	Watu Lepek Beach - Watu Pecah Beach	9	9.54	8.41	25 minutes and 13 seconds	30 minutes and 41 seconds	36 minutes and 8 seconds



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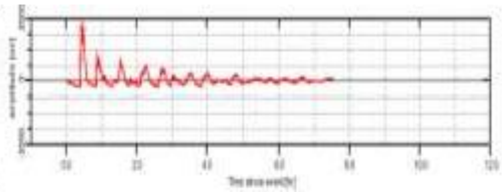

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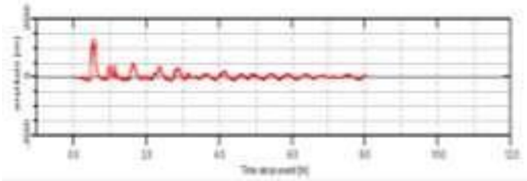

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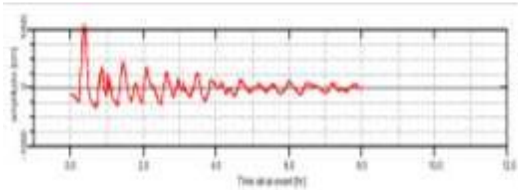
Figure 6. Mareogram graph of Ngliyep Beach, Malang – Temu Wetan Beach. (a) Fault data 1, (b) Fault data 2, (c) Fault data 3



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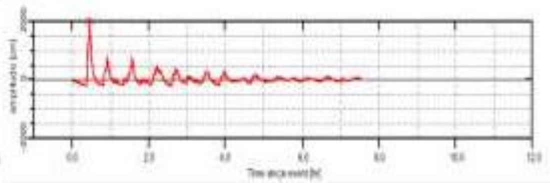

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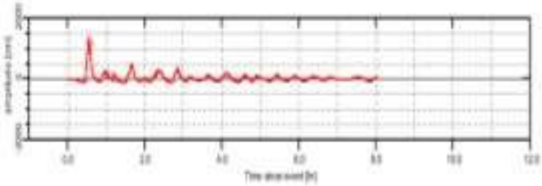

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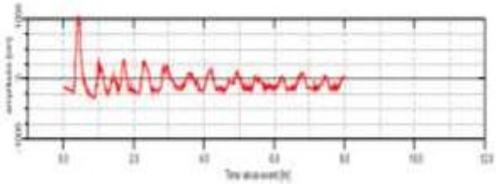
Figure 7. Mareogram graph of Kondang Iwak Beach – Balekambang Beach. (a) Fault data 1, (b) Fault data 2, (c) Fault data 3



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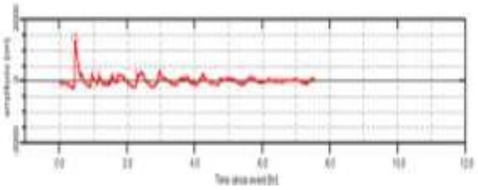

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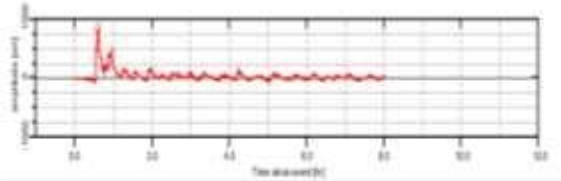

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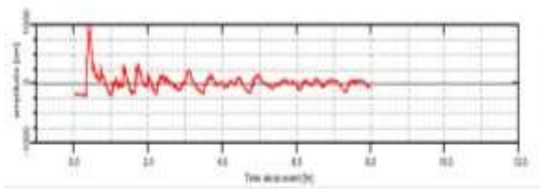
Figure 8. Mareogram graph of Wonogoro Beach – Batu Bengkung Beach. (a) Fault data 1, (b) Fault data 2, (c) Fault data 3



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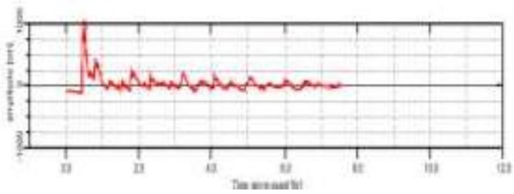

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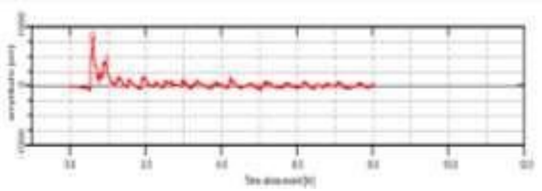

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Figure 9. Mareogram graph of Watu Lepek Beach–Watu Pecah Beach. (a) Fault data 1, (b) Fault data 2, (c) Fault data 3

Figure 10 shows a flood map produced by processing composite data using Quantum GIS version 2.18.28 Las Palmas. From Ngliyep Beach in Malang to Temu Wetan Beach, it is known that flooding on these beaches can reach 0.935 km from the shoreline (Figure 10.1). Figure 10.2 is a map of flooding that occurs from Kondang Iwak Beach to Balekambang Beach, where flooding can reach 1.5 km from the shoreline. The inundation map from Wonogoro Beach to Batu Bengkung Beach shows that inundation can reach 1.7 km from the shoreline (Figure 10.3). The tsunami inundation map from Watu Lepek Beach to Watu Pecah Beach shows inundation reaching 1.9 km from the shoreline (Figure 10.4).

Table 2. Tabulation of Tsunami Flooding Data from the Coastline

No	Location	Flooding (km)
1	Ngliyep Beach, Malang - Temu Wetan Beach	0.935
2	Kondang Iwak Beach - Balekambang Beach	1.5
3	Wonogoro Beach - Batu Bengkung Beach	1.7
4	Watu Lepek Beach - Watu Pecah Beach	1.9

Figure 10.1 Map of Ngliyep Beach Flooding in Malang-Temu Wetan Beach

Figure 10.2 Flood Map of Kondang Iwak Beach – Balekambang Beach

Figure 10.3 Map of Wonogoro Beach – Balekambang Beach Flooding

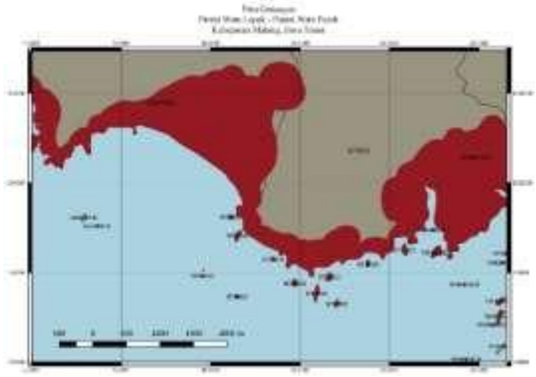

Figure 10.4 Flood Map of Watu Lepek Beach – Watu Pecah Beach

The extent of flooding varied, with the length of flooding increasing as the tsunami reached its maximum height. The slope of the coast, vegetation, and topography also influenced the flooding that occurred.

4. CONCLUSION

1. The height of the tsunami waves along the Malang coast, triggered by an earthquake measuring Mw 8.7, ranged from 8.2 meters to 19.63 meters, with the fastest arrival time being 23 minutes and 6 seconds.
2. The tsunami inundation along the Malang coast ranged from 0.935 kilometers to 1.948 kilometers.
3. The highest tsunami wave height reached 19.63 meters from Kondang Iwak Beach to Balekambang Beach, with a wave arrival time of 27 minutes and 14 seconds.
4. The longest tsunami inundation occurred from Watu Lepek Beach to Watu Pecah Beach, reaching 1.948 kilometers.

DECLARATION

Author Contribution

R. Annur, processed the experimental data, performed the analysis, drafted the manuscript and designed the figure. WA. Sungkowo was involved in planning and supervised the work. All authors discussed the results and commented on the manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

REFERENCES

[1] BMKG, *Pedoman Pelayanan Peringatan Dini Tsunami,* Jakarta, 2012.
[2] BNPB, *Peraturan Kepala Badan Nasional Penanggulangan Bencana No 2 Tahun 2012 Tentang Pedoman Umum Pengkajian Resiko Bencana,* Jakarta: BNBP, 2012.
[3] Latief, H., & dkk, *Review Masterplan Pengurangan Resiko Bencana Tsunami,* BNPB, 2014.
[4] Pemerintah Kota Malang, *Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kota Malang Tahun 2018-2023,* Malang: Pemerintah Kota Malang, 2019.
[5] Pratama, P. D., Pemodelan dan Pembuatan Peta Evakuasi Tsunami Pesisir Sanur. *Jurnal Pendidikan Geografi Undiksha*, vol. 8, pp. 65-75, Agustus 2020.

[6] Pusat Studi Gempa Nasional, *Peta Sumber dan Bahaya Gempa Indonesia Tahun 2017,* Bandung: Pusat Peneliti dan Pengembangan Perumahan dan Pemukiman, Badan Peneliti dan Pengembangan, Kementrian Pekerjaab Umum dan Perumahan Rakyat, 2017.
[7] Rusli, A. F, Peran Pemerintah Kota Malang Dalam Meningkatkan Kesiapsiagaan Masyarakat Menghadapi Bencana (Studi Manajemen Bencana). *JPIPS : Jurnal Pendidikan Ilmu Pengetahuan Sosial.* vol. 5, pp. 1-13, 2018.