Efforts to Improve Community Awareness Towards the Potential of a Great Earthquake Which Threats Jakarta Based On Geographic Information and 3D Simulation Systems in Matraman District, East Jakarta

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Abstract. Indonesia is located in an area of active tectonic plate. This area suffers from natural disasters. Recorded almost every year disasters, such as earthquakes, tsunamis, floods, and fires, occur in several regions in Indonesia. One of the major city in Indonesia is Jakarta. Jakarta as a capital city with urban area has an important position in terms of economy and government. The issue of earthquakes with the magnitude of 8 SR is one of the major disasters that threatening Jakarta. The effort to alleviate losses caused by disasters, it is necessary to inform the community regarding preparation in the face of disasters that will occur. This preparation is needed especially in densely populated areas as part of disaster mitigation measures like Matraman District in East Jakarta. The initial step in this program is to distribute questionnaires to determine the level of knowledge and information about the disaster. Furthermore, by utilising the geographical information system (GIS), evacuation routes when a disaster occurs can be made to adjust the situation of the area. The evacuation routes produced include the fastest and safest routes in evacuation by considering conditions such as road width, car parking, electricity poles, railroad crossings, and blind alley. This evacuation route will be modelled with 3D simulation in several conditions such as railroad crossings, spill markets, crossroads, and one-way lanes when a disaster occurs. This simulation will be the end result in a program to increase public awareness of potential disasters that threaten their area. This research obtains evacuation routes and 3D simulations that have been made are information media that can facilitate people to get the right knowledge about disaster mitigation. The results of the community awareness raising program on potential disasters can be used as a reference for other regions in the effort to mitigate disasters.

Keyword: Disaster mitigation, Matraman, GIS, 3D simulation

1. Introduction
Indonesia is located at the meeting of four active plates, namely Eurasia, Indo-Australia, Pacific, and Philippine Sea. Subduction zones due to collision of Indo-Australian plates with eurasian plates are located on the coast west of Sumatra, south of Java, and continue to the Nusa Tenggara. And in the
Eastern Indonesia (Papua and Maluku) collides with Pacific and Philippine Sea Plate. It was in this plate meeting area that earthquakes, tsunamis and landslides often occurred. This is caused by the accumulation of energy that cannot be held back so that it becomes a natural disaster [1]. No wonder Indonesia often experiences. At least according to Meteorological, Climatological, and Geophysical Agency (BMKG) data for 2018, there were five earthquakes with a strength of > 6.0 SR. First on January 23, 2018 an earthquake occurred with epicenter of 43 km southwest of Lebak with magnitude of 6.1 SR (felt up to Jakarta). Secondly on July 29, 2018 an earthquake centered on 28 km northwest of East Lombok with magnitude of 6.4 SR. Then one week later an earthquake which centered 18 km northwest of East Lombok with 7 SR. Then on September 28, 2018 an earthquake occurred again in 26 km North of Donggala with magnitude of 7.4 SR, and the last occurred on October 11, 2018 at 61 km northeast of Situbondo with magnitude of 6 SR. This proves that seismicity in Indonesia is still very active.

Based on seismicity data from PUSGEN (National Earthquake Study Center), in 2018 there were five megathrusts found in western South Sumatra and southern Java (figure 1). Three of them were recorded to have produced earthquakes with magnitude >7.0 SR, namely Mentawai-Pagai Megathrust, Enggano Megathrust, and West-Central Java Megathrust. While the other two, namely Sunda Strait Megathrust and East Java Megathrust, have never recorded an earthquake with magnitude >7.0 SR. This raises fears of a mega earthquake due to the seismic gap in the area. Seismic gap is a term used for tectonic active areas but earthquakes rarely occur for long periods of time. The term seismic gap was first introduced by Fedotov in 1965 and Mogi in 1969 when they mapped earthquake events in the Alaska-Aleutian subduction zone [2].

![Figure 1. Map of earthquake distribution in the southern region of Sumatra and Java indicated seismic gaps (modification from PUSGEN, 2018).](image)

2. Literature review

There are three main discussions in this paper including area of study, criteria of evacuation points, and network analysis in GIS.

2.1. Area of study

On January 23, 2018, an earthquake with magnitude 6.1 SR shook southwest of Lebak, Banten. The earthquake shock can be felt by the people of Jakarta and surrounding areas. One of them is Matraman District, which is the smallest area in East Jakarta. With an area of 4.88 km², 82.68% of the Matraman area is a residential area, where the population of Matraman Subdistrict reaches 193,700 people and its population density is 38,482 people/km² [3]. With a very dense population and a very small area, Matraman Subdistrict has a very high potential number of disaster victims if the entire population does
not have a sense of care to disaster response. In addition, areas around Matraman often experience
disasters, such as floods and fires, so this can be a threat to Matraman Subdistrict which is the region
with the highest population density in East Jakarta. Based on the research we did by distributing
questionnaires to the community with the aim of knowing the level of community understanding about
disaster. And the results show that the level of community understanding of disaster is still quite low.
Therefore, it is very important to educate and install a disaster response attitude for all Matraman people,
one way is to conduct socialization on disaster management efforts.

![Map of Matraman Subdistrict location](image)

Figure 2. Map of Matraman Subdistrict location.

2.2. Criteria of evacuation points

Based on government regulation PU No. 20/PRT/M/2011 regarding natural disaster hazard zones, the
general criteria for determining evacuation points are: [4]
1. The absence of buildings that are at risk of being affected by a disaster is quite high (the building
is not earthquake resistant).
2. Not close to sources of disasters (high cliffs, sea, river, bank, volcano, and earthquake fault
area).

2.3. Network analysis in GIS

Generally, Network Analysis is a tool that create transportation model to find out the relationship
between elements (building, street, and tree) based on traffic situation [5]. There are five analyzes that
can be done on ArcGIS software, namely Route, Closest Facility, Service Areas, OD Cost Matrix, and
Vehicle Routing Problem Analysis [5].

Making a network analysis map begins with the creation of a basic map that will be included in
several components, including: the shp map of the area, road network data, and speed obtained
automatically from ArcGIS 10.5. As for knowing the travel time using the formula:

\[
Time (s) = \frac{Distance (m)}{Velocity (m/s)} \tag{1}
\]

By using the Network Analysis method on this GIS, we want to find out the nearest route to get some
facilities, in this case the evacuation point in the event of a disaster.

3. Research implementation phase

3.1. Research flowchart
In this paper, the first step we did was to research the knowledge of the Matraman community about disasters, by distributing questionnaires. Then we examine the best road routes that can be passed to the evacuation site, and we also make a simple simulation video about the process of self-evacuation in the event of a disaster. From this result, we conduct socialization about disaster to them as a form of community service. The stages of this research can be seen in figure 3. The next step is to determine areas that often occur in floods and fires, buildings that must be avoided when an earthquake occurs, and analysis of effective and safe evacuation routes to the holding location.

**Figure 3.** Research flowchart.

### 3.2. Research methodology

The method used in this paper is the Network Analysis using Closest Facility Analysis. This is based on the aim to find the nearest field or vacant land that is feasible to be used as a muster point. The data used are:

1. Matraman map with shp file type (downloaded from tanahair.indonesia.go.id)
2. The width of the road
3. Road situation
4. Determination of evacuation point

This Matraman map with shp file type is used in processing Network Analysis in ArcGIS 10.5. This road width data is used to estimate how many people and vehicles can pass through the road or alley. Road situation data, such as vehicles parked on the side of the road, traders who sell on the side of the road, one-way roads, and the road situation in the markets, are very important to be used to estimate how long it takes people to reach the evacuation point when a disaster occurs. Determination of evacuation point is very necessary to find out where a safe place can accommodate the community when a big earthquake really shook Jakarta. The research area is a densely populated area and has a narrow environment and many obstacles on the streets, such as there are electric poles in small alleys that are only about 1.5-2.5 m so that it can only be passed by one to two people, and there are still many vehicles parked carelessly on the road which is only about 4-5 m wide so that it often causes congestion.
4. Discussion and result

4.1. Utan Kayu Selatan Village
Utan Kayu Selatan Village has the largest area in Matraman Subdistrict, which is 1.12 km², but has the lowest population density in Matraman Subdistrict, which is 34,699.7 people/km² [3]. Traffic conditions in Utan Kayu Selatan are quite smooth and some roads are one-way roads with the aim of minimizing congestion, so that the evacuation process in this area can be carried out smoothly and easily. Based on our survey, we determined that there were four places that could be used as evacuation sites, namely SMPN 97 Jakarta, SMAN 31 Jakarta, SMAN 22 Jakarta, and UPBJJ-UT (figure 6). The time needed by citizens to reach this evacuation point varies depending on speed and distance. For example, by calculating the average pedestrian speed is 10 km/hour (this assumption used in all of sub-district in Matraman), the time needed by residents located at the farthest location with the evacuation point is around 7 minutes 10 seconds, while the fastest time needed by residents located near the evacuation point is around 60 seconds. This data is based on surveys that we have done with normal road conditions and environment.

4.2. Pisangan Baru Village
The area of Pisangan Baru Village is not wider that the three villages above, which is 0.68 km². And the total population density in this region is the lowest in Matraman Subdistrict, which is 5,501.36 people/km² [3]. Even so, the environmental conditions in this region are very crowded and so do the road conditions because in this area there are many markets. This has caused difficulty in finding evacuation points in Pisangan Baru Village. So based on our survey, we can only find three points that can be used as evacuation points, namely SMKN 5 Jakarta, SDN Pisangan Baru 13 Pagi, and another in the open field (figure 7). With these conditions, the time needed to get to the evacuation point by people who are far from the evacuation point is around 8 minutes 10 seconds, while the fastest time that can be reached by those closest to the evacuation point is around 1 minute 35 seconds.

4.3. Palameriam Village
Palameriam Village has the second smallest area after Kayu Manis Village, which is 0.65 km², but the population density is the second highest after Kayu Manis Village, which is 35,965.74 people/km² [3]. Based on our survey, we found three points that could be used as evacuation points, namely DISLITBANG TNI AD, SDN Palameriam 02 Petang, and the Palameriam market parking lot (figure 8). Road conditions in the DISLITBANG TNI AD and SDN Palameriam 02 Petang is relatively smooth because it is on a big road, but the road conditions in the Palameriam market area are very crowded because many traders are on the side of the road and many public transportation stops at the side of the road causing congestion, it is feared that this can hamper the evacuation process. With such dense conditions, the time needed for people who are far from the evacuation point is around 12 minutes, while the fastest time to reach the nearest evacuation point with normal road and environmental conditions is around 60 seconds.
4.4. Kayu Manis Village

Kayu Manis Village is the smallest area in Matraman Subdistrict but has the highest population density, 0.58 km$^2$ and 51,902.78 people/km$^2$ [3]. Based on our survey, there are three points that can be used as evacuation points, namely SMP Al Washliyah, SMA & STMIK Muhammadiyah Jakarta, and the other is in a parking lot around Kayu Manis II Street (figure 9). Road conditions in this area are quite crowded but there are several roads which are one-way roads so that it can be reduce congestion. Usually, congestion that occurs in this area because many vehicles stop on the side of the road and many traders sell on the side of the road. Thus, the time needed to reach the evacuation point by people who are far from the evacuation point is around 5 minutes. And the fastest time that can be reached by people who are close to the evacuation point is around 60 seconds.

4.5. 3D simulation

Simulation is a way to study or predict something that has not happened by imitating or making a system model that is studied and then conducting experiments numerically using a computer [6]. So, simulation is a way to duplicate or describe the characteristics, appearance and characteristics of a real system which is then studied the nature and character of its operations, and the last create conclusions and take decisions based on the suggested simulation. The advantage of this method is that the simulation produced does not replace the real conditions of traffic and provides input if something unexpected happens such as a traffic accident, fallen tree, or other disaster. Whereas 3D visual simulation is a simulation with dimensions of space and depth on objects created [7]. So that the purpose of conveying ideas or information related to this disaster mitigation process can be conveyed well in the form of 3D visual simulations in digital format (figure 10).

![Figure 6. Evacuation route map Utan Kayu Selatan Village.](image1)

![Figure 7. Evacuation route map Pisangan Baru Village.](image2)
Figure 8. Evacuation route map Palmeriam Village.

Figure 9. Evacuation route map Kayu Manis Village.

Figure 10. 3D simulation of evacuation process to Batalyon Zeni field as evacuation point.

5. Conclusion

Based on our research, there are at least 2 evacuation points in each village in Matraman Subdistrict in the hope of accommodating the entire community when a disaster occurs. The Network Analysis method can easily choose the route that is most effective in determining the evacuation route. Each region has travel time to different evacuation points, depending on the distance between their current position and the evacuation point. The fastest time that can be reached is around 1-3 minutes and the farthest is about 4-12 minutes. Describing the state of a real system with 3D visual simulation can convey ideas or information related to this disaster mitigation process well and easily understood.
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