The Shortest Path Finder for Tsunami Evacuation Strategy using Dijkstra Algorithm

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Abstract. Having a tsunami early warning system during the tsunami disaster is important. The tsunami early warning system that is widely applied in Indonesia using loudspeakers and information board as a medium to convey information directly to the community during the disaster. The information provided is only about the status of the disaster and what needs to be done. People who panic, tend to choose the evacuation route through the main roads without thinking that the path will become very crowded resulting in total congestion. This paper discusses a tsunami evacuation strategy by finding the shortest path of evacuation route using dijkstra algorithm. This system contains information about the shortest evacuation routes that can be taken by the community towards a safe location, either vertically or horizontally. So, people can evacuate vertically or horizontally based on the geographical location of their residence. This system will be implemented in Cilacap districts. Shortest evacuation route is determined using the dijkstra algorithm. Disaster-prone locations is the starting vertex and safe locations is finish vertex.

1. Introduction
An early warning is part of disaster risk reduction that is not only about giving accurate warning information, but also building a good understanding of risk from a warning and increasing the ability of authorities and communities to react appropriately to the early warning. The main priority for evacuation is people who live in risk areas [1]. Therefore, community preparedness in risk areas needs to be improved in order to improve understanding of evacuation routes, evacuation sites and evacuation buildings.

The tsunami early warning system that is widely applied in Indonesia based on straightforward approach using loudspeakers as a medium to convey information directly to the community during the disaster [2]. This system still has many disadvantages, which are very significant, the information delivered cannot be heard properly because of interference from the system or other external factors. To
overcome this problem an electronic information board was developed which could display information on tsunami disasters that could be seen directly by the community [3,4].

Information that is conveyed on information boards or through loudspeakers, only conveys information about the status of the disaster and what must be done. This causes the people who obtain information on the potential tsunami disaster will immediately flee away from the coast to the highlands. People who panic, tend to choose the evacuation route through the main roads without thinking that the path will become very crowded resulting in total congestion. Even though there are actually other evacuation routes that have a closer distance to the safe location. Based on this condition, a system is needed to support the early warning system so that it does not only provide tsunami information or warnings, but also provide information on the shortest evacuation routes to safe locations.

In this paper, determining the shortest path for a tsunami evacuation strategy using dijkstra algorithm is discussed. This system contains information about the shortest evacuation routes that can be taken by the community towards a safe location, either vertically or horizontally. So, people can evacuate vertically or horizontally based on the geographical location of their residence. This system will be implemented in Cilacap districts which is one of the top 3 districts with the highest disaster threat of tsunami [5].

2. Tsunami Evacuation Strategy in Cilacap District

Tsunami is difficult to predict because of the earthquake that triggered it also did not predictable. The impact of the tsunami was very severe large so that earthquake-prone areas and suspected to be very prone to tsunami disaster must be conducted structural mitigation and non-structural. Evacuation of people living in risky areas is a top priority when the system Tsunami early warning starts operating [6].

Some mitigation steps should be done for the risky area, including identification of tsunami-prone area, development of tsunami early warning system, and emergency evacuation. Identification of tsunami-prone area is needed to provide the value of risk-index from the specified location. For the early warning system, Indonesia has an INA-TEWS (Indonesia Tsunami Early Warning System) which is controlled by National Meteorology, Climatology, and Geophysics Department (Badan Meteologi, Klimatologi, dan Geofisika, BMKG). BMKG provides an earthquake information or tsunami early warning information, and sends it to related institution, such as National Disaster Relief Department (Badan Nasional Penanggulangan Bencana, BPBD), Local Government, media, etc. But the most important steps in mitigation is the proper emergency evacuation procedure. In order to reduce the material losses and casualties, a comprehensive emergency management concept must be implemented [7]. Preparedness and responses are two significant elements in emergency evacuation concept. In addition, the transmission system for information dissemination, evacuation information, evacuation route, and tsunami evacuation areas are also needed.

In Cilacap District, tsunami handling procedures follow the standard procedures performed by the Local Disaster Relief Agency (Badan Penanggulangan Bencana Daerah, BPBD) in Cilacap District. In accordance with the procedure, if a tsunami strikes, the people who are close to the coast must immediately evacuate themselves to a higher place. The high places that can be used as evacuation sites are high buildings, high land locations, or places that far from the coast. However, in disaster conditions, the simultaneous movement of refugees slows the evacuation of people to safe evacuation sites.

3. Methods

This research consists of several stages to achieve the goal of obtaining the shortest path of tsunami disaster evacuation in Cilacap Regency as shown through the flow diagram in Figure 1. Currently, there are already many algorithms that look for the shortest path. The shortest path of the most famous Algorithm is the dijkstra algorithm. The dijkstra algorithm is applied to find the shortest path in the directed graph. But this algorithm also applies to graphs that are not directed [8]. Dijkstra algorithm is an algorithm used in this research to obtain the shortest evacuation route.
The first step is data collection. In the calculation of the Dijkstra algorithm, the points and weights from the lines connecting these points are needed. The vertexes are from tsunami prone areas, crossroads, and safe locations, while the distance between intersections is assumed to be a weighted line. The data is obtained from several ways, namely field observations, interviews with related parties, literature studies, and data acquisition. If the data has been collected, the next step is creating a simulation using Matlab. In this simulation, the calculation of the Dijkstra algorithm is applied to determine the shortest evacuation route for a tsunami disaster.

4. Results and Discussion

Based on the data that has been collected, a mapping has been obtained for the starting vertexes and the final vertexes are determined as a safe place for evacuation. The vertexes that are mapped as starting vertexes are divided into several points along the coastline as shown in Table 1, while in Table 2 are the determined end vertexes.

**Table 1. List of Starting Vertexes**

| Code | Location name                  | Vertex Coordinate          |
|------|--------------------------------|-----------------------------|
| A    | Area 70 Pertamina Cilacap      | -7.742328, 109.017578       |
| B    | Pantai Teluk Penyu Cilacap    | -7.733707, 109.019516       |
| C    | Perum Shappire Regency        | -7.728005, 109.017072       |
| D    | Rusunawa PPC                  | -7.726354, 109.022743       |
| E    | Puri Tegal Kamulyan           | -7.716056, 109.030111       |
Table 2. List of End Vertexes

| Code | Location name                  | Vertex Coordinate  |
|------|--------------------------------|--------------------|
| I    | Lapangan Terbang Tunggul Wulung | -7.640680, 109.037433 |
| J    | Lapangan Jangrana Lebeng/ lapangan desa dondong | -7.619108, 109.066165 |

In addition to collecting data for start and end vertexes, it also collects a list that is traversed on the path used from the starting vertex to the end vertex. Table 3 shows the list of intersections along the path that was passed.

Table 3. List of Intersections along The Path

| No  | Name of Intersection                      |
|-----|------------------------------------------|
| 1   | Jl. Dayung dan Jl. Kelapa Lima           |
| 2   | Jl. Kelapa Lima dan Jl. Veteran          |
| 3   | Area 70 Pertamina Cilacap                |
| 4   | Jl. Kelapa Lima dan Jl. Karang           |
| 5   | Jl. Karang dan Jl. Kol. Sugiono          |
| 6   | Jl. Kol. Sugiono dan Jl. Brug Sentul     |
| 7   | Jl. Brug Sentul dan Jl. Dr. Wahidin      |
| 8   | Jl. Kolonel Sugiono dan Jl. Laut         |
| 9   | Pantai Teluk Penyu Cilacap              |
| 10  | Kantor Basarnas Cilacap                 |
| 11  | Jl. Lingkar Selatan dan Jl. Budi Utomo   |
| 12  | Perum Shappire Regency                  |
| 13  | Jl. Dr. Wahidin dan Jl. Dr. Sutomo       |
| 14  | Dafam Hotel                             |
| 15  | Jl. Jend. Sudirman dan Jl. S. Parman     |
| 16  | Jl. Jend Sudirman dan Jl. Katamso        |
| 17  | Alun-alun Cilacap                       |
| 18  | Jl. A. Yani dan Jl. Jend Sudirman       |
| 19  | Pasar Gede                              |
| 20  | RS Santa Maria                          |
| 21  | Puskesmas Cilacap Selatan               |
| 22  | Stasiun Cilacap                         |
| 23  | Jl. Veteran dan Jl. A. Yani             |
| 24  | Pelabuhan Batu bara Wijayapura          |
| 25  | Jl. Laut Jawa dan Jl. Syah Bandur       |
| 26  | Pangkalan TNI AL Cilacap                |
| 27  | Jl. Yos Sudarso dan Jl. Kluwih          |
| 28  | Jl. Laut Jawa dan Jl. Selat Bali        |
| 29  | Pelabuhan Tanjung Intan                 |
| 30  | PT. Pelindo III Persero                 |
| 31  | Kantor BEA Cukai                        |
| No. | Location |
|-----|----------|
| 32  | Pelabuhan Penyebrangan Seleko |
| 33  | Jl. Di. Panjaitan dan Jl. Jend. Sudirman |
| 34  | Jl. Di. Panjaitan dan Jl. Let Jend. Supripto |
| 35  | Jl. Katamso dan Jl. Tidar |
| 36  | Jl. S. Parman dan Jl. Gatot Subroto |
| 37  | Fave Hotel |
| 38  | Rusunawa PPC |
| 39  | Kantor kelurahan Tegal Kamulyan |
| 40  | TPI Pelabuhan Perikanan Samudra |
| 41  | Puri Tegal Kamulyan |
| 42  | Jl. Dr Sutomo dan Jl. Lingkar Selatan |
| 43  | PNC |
| 44  | Kantor kelurahan Sidakaya |
| 45  | Jl. Cerme dan Jl. Dr. sutomo |
| 46  | Yayasan Al Irasyad |
| 47  | Jl. Cerme dan Jl. Gatot Subroto |
| 48  | RSUD Cilacap |
| 49  | Jl. Kawi dan Jl. Gatot Subroto |
| 50  | AMN |
| 51  | Jl. Kendeng dan Jl. Flores |
| 52  | Jl. Flores dan Jl. Rinjani |
| 53  | Jl. Tidar dan Jl. Rinjani |
| 54  | Jl. Rinjani dan Jl. Ir. Juanda |
| 55  | Jl. Ir. Juanda dan Jl. Nusantara |
| 56  | RS Fatimah |
| 57  | Jl. Ir. Juanda dan Jl. Laban |
| 58  | Jl. Gatot Subroto dan Jl. Perintis Kemerdekaan |
| 59  | Terminal cilacap |
| 60  | Jl. Kalimantan dan Jl. Gatot Subroto |
| 61  | Pasar Tanjung |
| 62  | Jl. Dr. Sutomo dan Jl. Dr. Rajiman |
| 63  | Kantor kelurahan Gunung Simping |
| 64  | Kantor kecamatan Cilacap Tengah |
| 65  | Perum GSP |
| 66  | SMA N 3 |
| 67  | Perum Taman Gading |
| 68  | Jl. Kalimantan dan Jl. Lingkar Selatan |
| 69  | TPI Kemiren |
| 70  | RSPC |
| 71  | Perum setia budi |
| 72  | Jl. Dr. Rajiman dan Jl. Setia Budi |
| 73  | Kantor kelurahan Kebon Manis |
| 74  | Jl. Setia Budi dan Jl. Perintis Kemerdekaan |
| 75  | Puskesmas Cilacap Utara 1 |
| 76  | Jl. Perintis Kemerdekaan dan Jl. Tentara Pelajar |
Then, the data is processed using the dijkstra algorithm in the Matlab software. The simulation produced in Matlab can be seen in Figure 2. In this simulation, there are two input variables, namely the starting vertex and the desired destination / end vertex. Furthermore, the simulation will produce the shortest path displayed in graph and distance values.

Figure 2. Simulation Results of The Shortest Path Using Dijkstra Algorithm
Based on the simulation results, the shortest distance from each starting vertex to the end vertex is obtained. The simulation has succeeded in determining the shortest path from the specified starting vertexes and end vertexes. Overall, the shortest distance from each point can be seen in Table 4.

### Table 4. Simulation Results of the Shortest Path

| Code | Starting Vertex                  | Distance (Km) |
|------|----------------------------------|---------------|
|      |                                  | Tunggul Wulung | Jangrana     |
| A    | Area 70 Pertamina Cilacap       | 14,539        | 19,359       |
| B    | Pantai Teluk Penyu Cilacap      | 13,479        | 18,299       |
| C    | Perum Shappire Regency          | 12,439        | 17,259       |
| D    | Rusunawa PPC                    | 12.9          | 17.6         |
| E    | Puri Tegal Kamulyan             | 11            | 15.7         |
| F    | Perum Taman Gading              | 9,898         | 14,718       |
| G    | RSPC                            | 8.95          | 13.65        |
| H    | Perum Griya Tegal Asri          | 6.9           | 11.6         |

### 5. Conclusion

The shortest path finder using dijkstra algorithm has been successfully implemented in Matlab simulation. Based on the results of the test are obtained the shortest path from the starting vertex to destination/end vertex of 6.9 km to Tunggul Wulung and 11.6 km to Jangrana. This result is obtained because the location of these vertexes can directly access the vertical path for evacuation.

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