Analysis Of Road Networks In Tsunami-Prone Cities

Fitriana Syahar[1], Indah Fultria Santri[2]
{fitriana.syahar@fis.unp.ac.id[1], indahfultriasantri@gmail.com[2]}

Universitas Negeri Padang, Padang, Indonesia

Abstract. The occurrence of natural disasters cannot be avoided, but what can be done is to reduce the risk of many casualties. This study intends to analyze the typology of urban road networks prone to tsunami disasters and provide development recommendations to reduce disaster risk. Through remote sensing approaches and geographic information systems, road network analysis is carried out, identifying congestion points, settlement centres, and land clearing. The study's results found a typology of the road network and recommended a road network be developed to support disaster mitigation. The typology of the Padang City road network in the city centre which is directly adjacent to the sea is 80% grid to all residential centres, but it is not evenly connected to arterial and collector roads, so it is assessed that it does not support disaster mitigation or is vulnerable to disturbances.

Keywords: tsunami disaster; road network typology; SIG

1 Introduction

A disaster is an event that cannot be missed by one corner anywhere on the face of the earth. Any natural disaster event will leave various losses for humans. The occurrence of natural disasters cannot be prevented, but what can be done is to reduce the risk of disasters. Law Number 24 of 2007 concerning Disaster Management states that a disaster is an event or series of events that threatens and disrupts people's lives and livelihoods caused, either by natural and/or non-natural factors or human factors, resulting in human casualties, environmental damage, property losses, and psychological impacts. The definition states that disasters are caused by natural, non-natural, and human factors. Philosophically in responding to disasters, four philosophies can be adopted, one of which is to live in harmony and be friendly with threats by reducing risks [1]

Seismological data shows that the west coast of the island of Sumatra, of course, including the city of Padang, is an area that often experiences earthquakes. The movement of plates in the fault along the west of Sumatra to the south of Java is arguably quite significant [2]. The release of energy from pressure resulting from plate shifts results in earthquakes [3]. Furthermore, the ITB Tsunami modelling Team [4] estimates earthquake magnitude and height from the tsunami model results and the results of the historical records of seismicity and tsunami that the team managed to collect. The results are in the form of a Table of Earthquake Magnitude and Tsunami Height Estimates. From the table, we can determine the maximum estimate for the city of Padang, which is as high as 15m. Based on data from the Indonesian Disaster Risk Index (IRBI) issued by the National Disaster Management Agency in 2013, Padang City is included in the highest disaster-prone category in West Sumatra Province compared to other regencies/cities.

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Around 50% more people in Padang City are active in the western part of the city, which is close to the beach. Therefore, the government must have urban planning and design that supports this disaster mitigation, in this case. This road network supports disaster mitigation, so the risk can be minimised if there is an earthquake disaster with the potential for a tsunami. An inventory of municipal facilities and infrastructure, including a road network that supports mitigation and the fastest road paths that can be taken, is urgently needed as input for policymaking for the development of a disaster-friendly city road network. For this to be realized, the government must develop cities that can support the implementation of disaster mitigation. No exception is the development of the road network. It is necessary to study the existing conditions and typology of the Padang City road network to analyze the road network that can support disaster mitigation and find out its location point so that it can be a development recommendation.

2 Methods

2.1 Road Network Typology

Road network configurations with high intermediate centrality have a value of being more susceptible to interference. In other words, a network with only one or a few dominant central nodes is undesirable in terms of resiliency [5]. On the contrary, this type of grid road network is excellent for urban development [6]. Here's the picture:

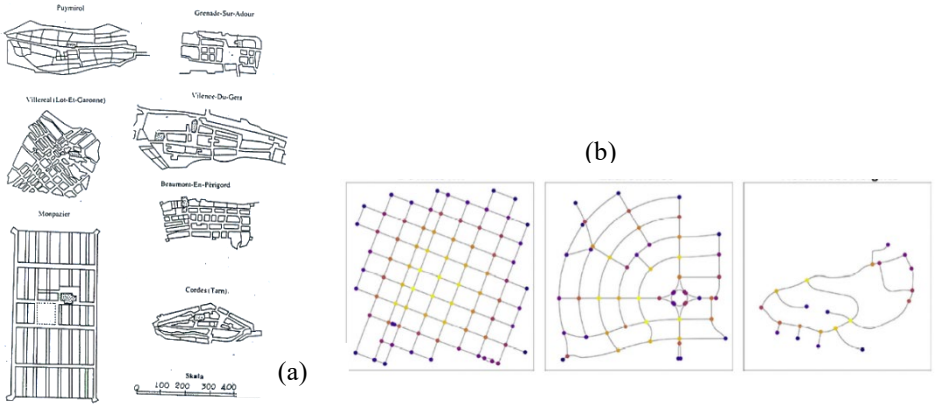

Fig. 1. Grid Road Network Typology According to Hadi Sabari Yunus (a), A Shari'a (b)

2.2 Data Processing

2.2.1 Road network typology analysis

The spatial data of the road network from the RBI 1:50,000 is adjusted to the latest conditions and validation. For this reason, the download on the shapefile of the Open Street Map of the Padang City administrative area in the newest year was issued, 2020. The shapefile data was then revalidated using high-resolution imagery, namely worldview imagery for the Padang City area and around 2020. Furthermore, classification is carried out on the road

network in Padang. The type is divided by function: arterial roads, collector roads, local roads, and neighbourhood roads.

3 Results and Discussion

3.1 Padang City Road Network Typology

Cities are dynamic with all their complexity. The influence of political, economic, and population growth puts the city at the centre of innovation. However, geographical conditions and factors prone to natural disasters result in cities having to think about the existing threats. Given this, the city must think about its resilience. The focus so far has been a lot in terms of structural patterns, urban development, and urban environment. However, some aspects may still be few that discuss it is about the role of the physical and the contribution of infrastructure, especially the road network, in supporting the resilience of cities to the threat of natural disasters.

Roads and road networks are the backbones of the city. They are fundamental to the emergence of an artificial component of the city that is dominant in shaping the city's structure and tends to lock the urban system will lead or form into a negative or positive path. The road network is also a component that binds various elements of the city structure so that it has implications for the function of the city [7]. It is, therefore, necessary to review the type of city road network and whether it supports disaster mitigation. The following are the results of the typology analysis of the Padang City road network:

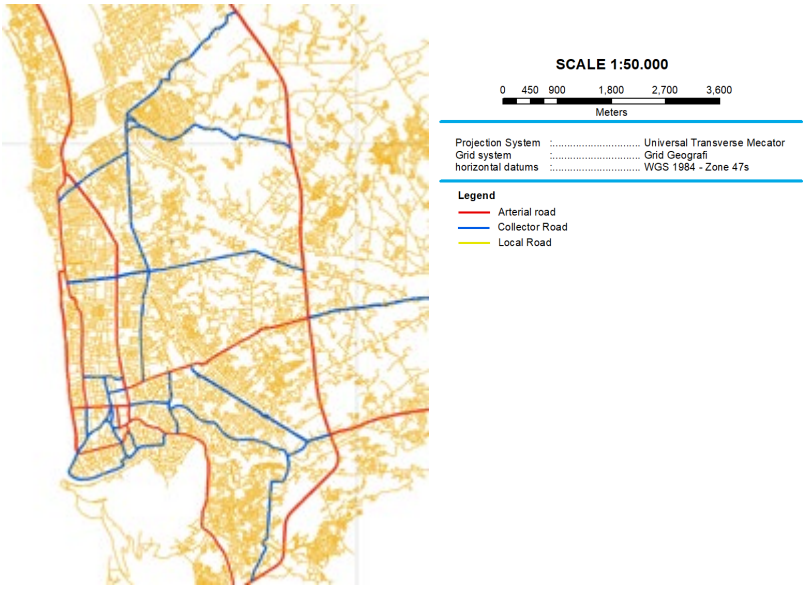

Fig. 2. Padang City Road Network Map
Source: Data processing results, 2021

In figure 2, it can be said that the dominant arterial road has a linear type against the local highway. So it is with collector's roads. The results of a study on the Beijing City road

network by Wang [8] stated that the road network tends to have ring roads and arterial roads that provide better connectivity to minor roads and collectors evenly in all directions because it has more resistance in decomposing vehicles. Thus facilitating better distribution of traffic throughout the city. It can be said that for the City of Padang, the typology of the road network if observed on a small scale, is not conducive or does not support disaster mitigation because the arterial and collector road networks have not been able to evenly connect with local roads, so they do not have high resilience.

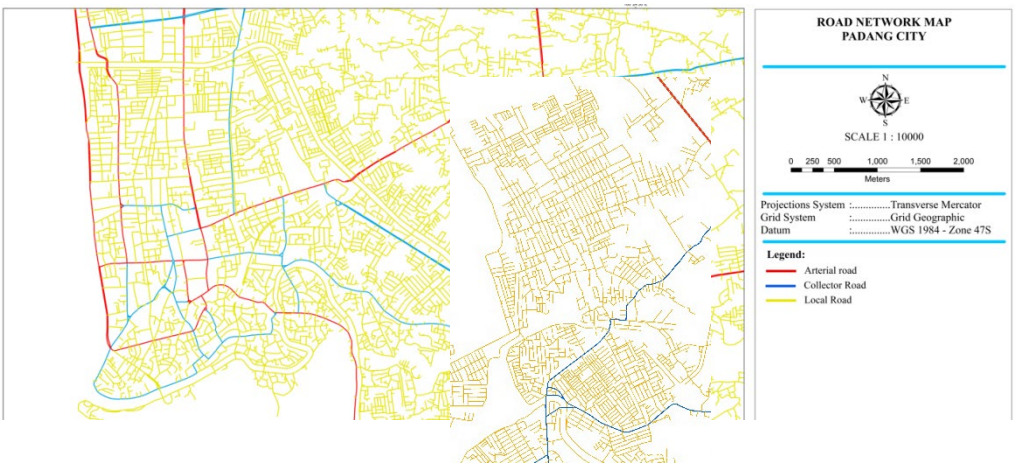

Fig. 3. Typology Map of Padang City Road network
Source: Data processing results, 2021.

The results of the interpretation show that the typology of the Padang City road network on a large scale is a grid. According to [5], the grid road type is to have a considerable number of nodes or intersections. If this is in the centre of the city, then it is likely that this node will be closed, caused of congestion caused by a disaster. So the nodes in the centre of this city are not recommended [9]. In other cases, if the road network is of continuous and comprehensive grid type, it can reduce the risk of being close to the nodes (road intersections) and support evacuation and serve as a road network that accommodates emergency response [10][11][12].

4 Conclusion

The typology of the Padang City road network in the city centre which is directly adjacent to the sea is 80% grid to all residential centres, but it is not evenly connected to arterial and collector roads, so it is assessed that it does not support disaster mitigation or is vulnerable to disturbances. In other conditions, the typology of a continuous grid and width in all directions of the city supports disaster mitigation because it is easier to navigate.

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