# Analysis Of Area Affected By Tsunami Disaster Pariaman City West Sumatra Province

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**Abstract.** This study is about the analysis of the impact of the tsunami disaster which aims to, 1) Knowing the area that has the potential to be affected by the tsunami disaster at a sea level rise of 5 meters, 10 meters and 15 meters. 2) Knowing the potential of buildings affected by the tsunami disaster. 3) Knowing the extent of damage to the agricultural sector affected by the tsunami at sea level rise of 5 meters, 10 meters and 15 meters in the agricultural sector. 4) Knowing the total value of physical losses and economic losses affected by the tsunami disaster. The type of research conducted is descriptive quantitative research. The analysis used is the height of sea level rise on the coastline using the Cost-Distance analysis method, to determine the area affected by the tsunami disaster. And scoring to determine physical losses and economic losses based on the area affected by the tsunami disaster. The indicators calculated are the area of the affected area, the number of buildings affected, the area of agriculture affected and the losses affected by the tsunami. The results of the analysis of the 5 meter increase in water area affected are 1,057.63 hectares, the number of buildings is 7,023 units, the agricultural area is 221.38 hectares and the loss is IDR22,269,068,571,00. The increase in water is 10 meters, the affected area is 3,911.57 hectares, the number of buildings is 14,045 units, the agricultural area is 1,931.57 hectares and the loss is IDR219,417,793,287.00. The increase in water is 15 meters, the area affected is 5,269.18 hectares, the number of buildings is 17,968 units, the agricultural area is 3,088.57 hectares and the loss is IDR393,788,937,071.00.

**Keywords:** Analysis; Region; Affected; Disaster; Tsunami

## 1 Introduction

Indonesia is also known as Nusantara, which consists of more than 17,000 islands with an area that stretches for 3,900 miles from the Indonesian Ocean to the Pacific Ocean. This makes Indonesia has a vast ocean of about 3,273,000 km². The Indonesian seas also have boundaries according to international maritime law, namely by using a 12 nautical mile territorial sea and an exclusive economic zone of 200 nautical miles. and is also passed by three large, active tectonic plates. The three plates are the Indian-Australian Ocean Plate to the west and south, the Pacific Ocean Plate to the east and the Eurasian Plate to the north. This causes Indonesia to have a high potential for earthquake and tsunami disasters (BNPB, 2018).

A tsunami is a disaster that has the potential to cause many casualties and other losses which are affected by seabed earthquakes, underwater landslides and volcanic eruptions that affect the occurrence of a tsunami as happened in 1883 when Mount Karakatau erupted. West Sumatra itself is an area that is very vulnerable to tsunami disasters, especially in Pariaman

ICGEO 2022, November 19-20, Padang, Indonesia

DOI 10.4108/eai.19-11-2022.2332153

City, because it is located in the western coastal area of West Sumatra and is traversed by the confluence of two tectonic plates, namely, the Eurasian Plate and the Indo-Australian Plate.

Based on the population in Pariaman City according to the number of 95,294 people (BPS, 2022). The population density in the coastal area of Pariaman City is 367-1,384 people/km2. This affects changes in the total area of settlements, infrastructure, agriculture and plantations. So if a tsunami occurs, it can cause casualties and damage to buildings and other facilities. However, this can be minimized due to research and disaster mitigation against the tsunami.

Based on the background of the problem above, the author is interested in conducting research to examine the potential for tsunami impact on facilities/buildings (physical), the potential for tsunami impact on the agricultural sector and the potential total value of economic losses and physical losses from being affected by the tsunami in Pariaman City.

## 2 Method

The type of research used for this research is descriptive quantitative. This type of descriptive research is a method of examining the status of a group of people, an object, a set of conditions, a system of thought or a class of events in the present.

The research location is in Pariaman City, West Sumatra Province, Indonesia. Based on the calculation of the impact of the tsunami, physical losses and economic losses are calculated in the research area made in the analysis divided into the projected increase in water from being affected by the tsunami on the 5 meter, 10 meter and 15 meter coastlines in Pariaman City.

The data used in this study are primary and secondary data. In accordance with the research objectives to be achieved. For primary data, it is in the form of seeing the location of locations such as schools and health centers based on what is in the field to make the coordinates. Meanwhile, secondary data includes DEM data, sentinel-2 imagery, coordinates of puskesmas location data, coordinates of educational facilities and land use or land cover. The primary data are direct observations in the field and interviews with surrounding residents as additional information in the study.

**Table 1.** Materials and Data Sources

| No | Materials | Data Sources |
|---|---|---|
| 1 | Administration Map | Bappeda Kota Pariaman |
| 2 | Citra Sentinel-2 | USGS |
| 3 | DEM GDAM | DEMNAS |
| 4 | Data Coordinates | Google Earth Pro dan Google Map |

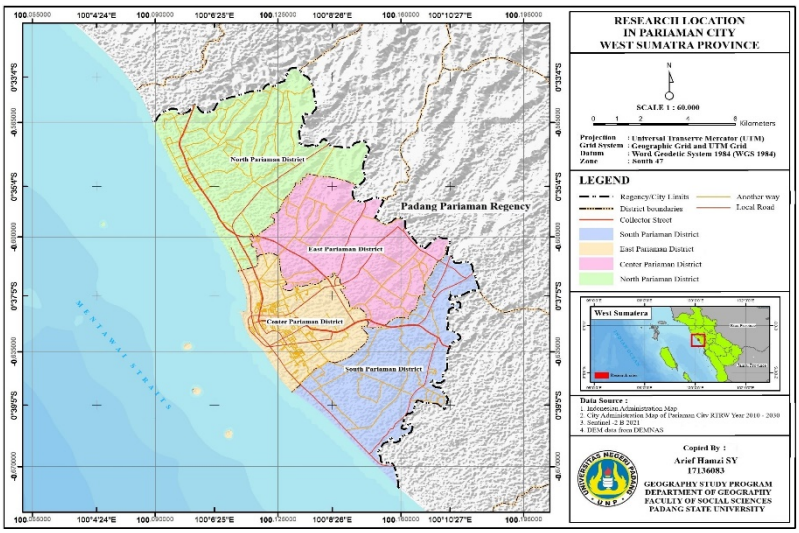


**Fig. 1.** Research Site Map

## 2.1 Research Methods

For data processing First, determine the height of sea level rise and calculate the movement of sea water decline using the Hloss formula. Second, it is continued with the cost-distance tool available in ArcGIS in order to get the area affected by the tsunami disaster. Third, combine the results of the area affected by the tsunami with each other variable data by using Overlay in ArcGIS.

Fourth, determine the result of the loss using the scoring determined based on Perka BNPB No. 2 of 2012. Fifth, present all calculation results in the form of tables or statistical data. Then a table of the total area affected, the number of buildings affected, the area in the agricultural sector affected and the losses affected by the tsunami disaster obtained from each of these analyzes in Pariaman City, West Sumatra Province.

**Table 2.** Research variable

| No | Variable | Indicator |
|---|---|---|
| 1 | Potential Tsunami Disaster | a. 5 meters sea level rise<br>b. 10 meters sea level rise<br>c. 15 meters sea level rise |
| 2 | The potential for the physical impact of the tsunami disaster | a. Residential building<br>b. School<br>c. Public health center |
| 3 | Potential impact of the tsunami on agriculture | a. Ricefield<br>b. Garden<br>c. Field |
| 4 | Potential loss of tsunami disaster | a. Physique<br>b. Economy |

## 2.2 Data Processing Techniques

The tsunami hazard is defined as the wave height reaching the shoreline and the tsunami wave propagation inland.
Where the formula used in sea level rise is:

$$Hloss = \left(\frac{167\, n^2}{H_0{}^{1/3}}\right) + 5 \sin S$$

Information :
Hloss = The value of the decrease in water when it enters the land
n = Surface roughness coefficient
$H_0$ = Tsunami wave height at the shoreline (meters)
S = Slope
To determine the coefficient of surface hardness using land use is as follows.

**Table 3.** Materials and Data Sources

| No | Type of Land Use | Surface Roughness Coefficient Value |
|---|---|---|
| 1 | Water body | 0,007 |
| 2 | Shrubs | 0,040 |
| 3 | Forest | 0,070 |
| 4 | Plantation | 0,035 |
| 5 | Agricultural land | 0,025 |
| 6 | Empty land | 0,015 |
| 7 | Settlement | 0,045 |
| 8 | Mangroves | 0,025 |
| 9 | Pond | 0,010 |

Source: Berryman, 2006

The total number of existing residential buildings in Pariaman City is 21,623 units, puskesmas buildings are 7 units and educational facility buildings are 128 units. This can affect the calculation of the impact of the tsunami disaster. In calculating the affected area in the agricultural sector, it is as follows.

$$T = n1 + n2 + n3 \ldots$$

Information :
T = Water rise height
n = Area of agricultural sector per polygon

In calculating losses, it is classified into two, namely economic losses and physical losses. Economic losses are obtained from economic vulnerability which consists of parameters for the contribution of GRDP and productive land. The rupiah value of productive land is calculated based on the value of the GRDP contribution in sectors related to productive land (such as the agricultural sector) which can be classified based on land use data (BNPB, 2018). The rupiah value for economic parameters is calculated based on the following equation:

a. GDP Contribution
   The GRDP parameter in the study of economic vulnerability is analyzed as the value of the GRDP contribution of sectors related to productive land that can be directly impacted

by disaster events. The GRDP of the productive land sector, especially the agricultural sector, can be measured and analyzed spatially with an approach to land use in an area.

$$e_{ij} = \frac{B_i}{L_i}$$

Information :

$e_{ij}$ = Land value (Rp/Ha) on land type (i) and village (j)
$B_i$ = GRDP value (Rp) in each sector based on land type (i) in district/city
$L_i$ = Area of land type (i) at district/city level

b. Productive Land

The parameters of productive land in the study of economic vulnerability are analyzed as the amount of losses that can arise (potential) due to productive land which is generally agricultural land (food land, plantations, and inland fisheries) located in areas that are potentially affected (hazards) by disasters. The reference for the economic value of productive land uses data from the analysis of the contribution of GRDP by adjusting the conditions for the hazard class obtained from the calculation of the existing hazard analysis, assuming:

1) Low hazard, no loss;
2) Moderate Hazard, 50% total loss of productive land;
3) High Hazard, 100% total loss of productive land.

Meanwhile, physical losses are obtained from physical vulnerability consisting of parameters of houses, public facilities and critical facilities. The total rupiah value of houses, public facilities, and critical facilities is calculated based on the hazard class in the affected area. The spatial distribution of the rupiah value for the parameters of houses and public facilities was analyzed based on the distribution of settlement areas. Each parameter was analyzed using the scoring method according to Perka BNPB No. 2 of 2012 (BNPB, 2018). The unit values for houses and public facilities based on the affected tsunami hazard class are as follows.

**Table 4.** House Unit Value Based on Hazard Class

| No | Danger Class | Unit Value (Rp) |
|---|---|---|
| 1 | Low | 5 million |
| 2 | Medium | 10 million |
| 3 | High | 15 million |

Source: BNPB, 2018

**Table 5.** Value of Public Facilities Unit

| No | Kelas Bahaya | Nilai Unit (Rp) |
|---|---|---|
| 1 | SD | 300 million |
| 2 | SMP/SMA/SMK | 800 million |
| 3 | Public health center | 500 million |

Source: BNPB, 2018

To calculate the value of each parameter (except the house) is carried out based on:

1) Low Hazard ~ no damage;
2) Moderate Hazard ~ 50% of the unit price for minor damage;
3) High Hazard ~ 50% of the regional unit price for moderate damage and 50% of the regional unit price for heavily damaged.

The calculation of the house parameter values is carried out based on:

1) Low Hazard ~ no damage;
2) Moderate Hazard ~ 50% of the number of houses affected by minor damage times the unit price of the area;
3) High Danger ~ 50% of the number of houses affected by moderate damage multiplied by the unit price of the area, and 50% of the number of houses affected by heavy damage multiplied by the unit price of the area.

The rupiah value of the resulting house based on the adjustment to each hazard class is defined as the loss value of the house. The figure of 50% is the value of the assumption that not all houses are damaged in the potential hazard area.

## 2.3 Data analysis technique

The data analysis techniques used in this study are as follows.

1. Cost – Distance Analysis
   Distance analysis is an analysis of raster data that is used to perform analysis related to distance. One of the analysis related to distance that can be used in ArcGIS is Cost-Distance. Cost-Distance analysis is used to calculate the cumulative cost in each cell by considering the distance to the source location. In this study, Cost-Distance analysis is used to make calculations based on the formula or formula for the decrease in the value of water entering the land. For research, this analysis is used to determine the area that has the potential to be affected by a tsunami at a sea level rise of 5 meters. 10 meters and 15 meters.
2. Overlay Analysis
   Overlay analysis is the merging of data from different layers in order to generate new information, in ArcGis there are several tools that can perform Overlays. In this analysis, the research aims to determine the potential of buildings and agriculture affected by the tsunami.
3. Scoring Analysis
   Scoring analysis is in the form of giving a score to the secondary and primary data that are coded, then assigning a value and weight to the data. This scoring is done on data related to measurement variables in the BSC. For this analysis, the research function is to determine physical losses and economic losses in tsunami-affected areas.

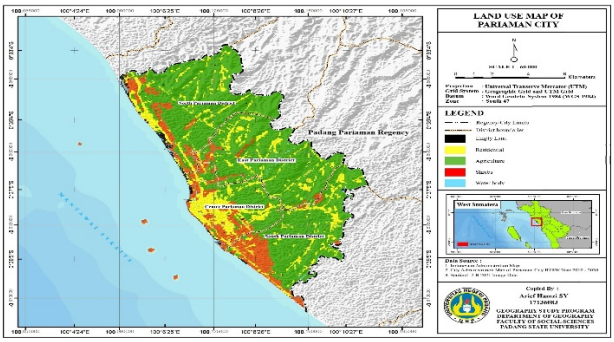


**Fig. 2.** Pariaman City Land Use Map

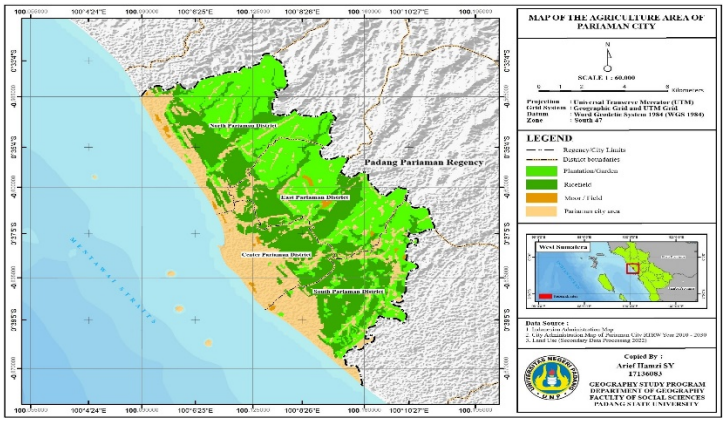


**Fig. 3.** Pariaman City Agricultural Area Map

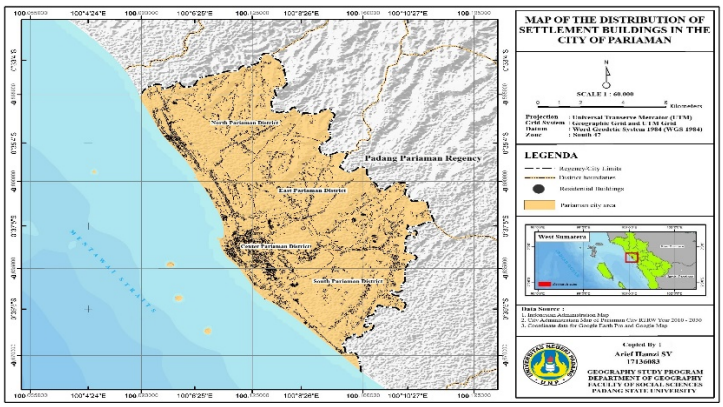


**Fig. 4.** Pariaman City Building Distribution Map

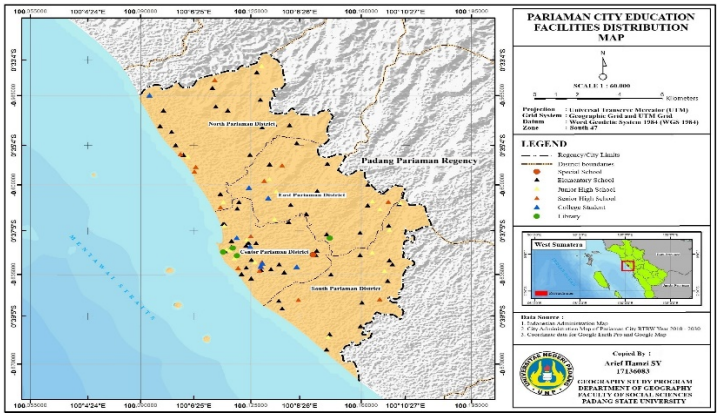


**Fig. 5.** Map of the Distribution of Pariaman City Education Facilities

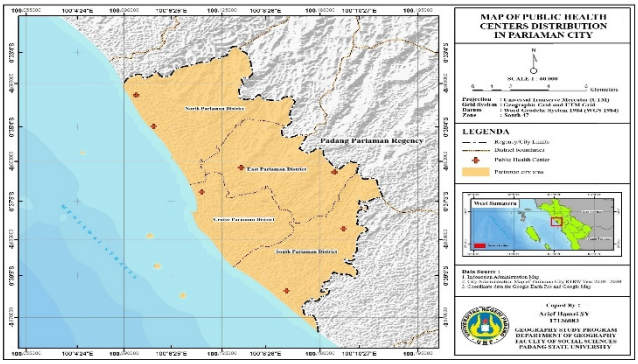


**Fig. 6.** Pariaman City Health Center Distribution Map

# 3 Results and Discussion

## 3.1 Sea level rise 5 meters

Affected by the tsunami, the water increased by 5 meters, affecting an area of 1,057.63 Ha with an area of 334.63 Ha of low hazard class, 276.06 Ha of medium hazard class and 446.94 Ha of high hazard class. The affected agricultural sector is 221.38 ha, based on agricultural classification, namely rice fields with an area of 119.28 ha, gardens with an area of 75.39 ha and fields with an area of 26.71 ha. The affected houses were 7,023 units, 41 units for affected education facilities and 4 units for puskesmas. The affected losses amounted to IDR 22,269,068,571,00.

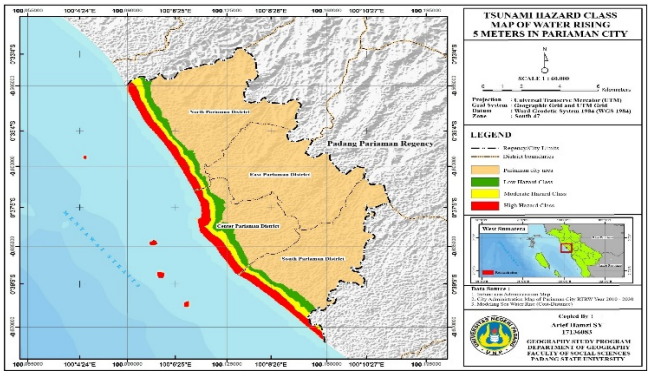


**Fig. 7.** Affected by a 5 meter rise in water

## 3.2 Sea level rise 10 meters

When affected by the tsunami, the water rose 10 meters, the impact was 3,911.57 Ha with a low hazard class area of 448.06 Ha, a medium hazard class 651.29 Ha and a high hazard class 2,811.56 Ha. The affected agricultural sector is 1,931.57 Ha, based on the agricultural classification, namely rice fields with an area of 1,509.09 Ha, gardens with an area of 391.12

Ha and fields with an area of 31.36 Ha. The affected houses were 14,045 units, for education facilities affected were 70 units and puskesmas were 5 units. The affected losses amounted to IDR219,417,793,287.00.

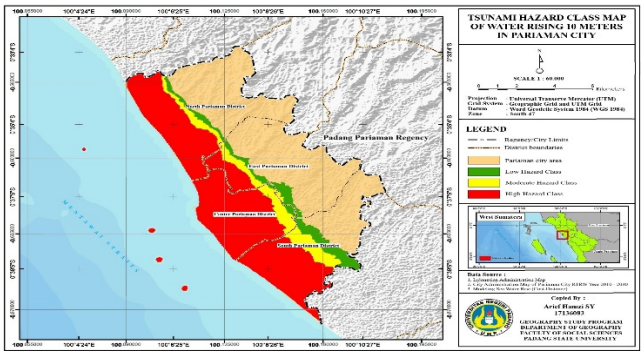


**Fig. 8.** Affected by a 10 meter rise in water

### 3.3 Sea level rise 15 meters

Affected by the tsunami, the water increased by 15 meters, affecting an area of 5,269.18 Ha with a low hazard class area of 356.63 Ha, a medium hazard class of 533.32 Ha and a high hazard class of 4,379.40 Ha. The affected agricultural sector is 3,088.57 Ha, based on agricultural classification, namely rice fields with an area of 1,946.62 Ha, gardens with an area of 1,090.23 Ha and fields with an area of 51.72 Ha. The affected houses were 17,968 units, for education facilities affected were 83 units and the puskesmas was 6 units. Then for the affected losses, it reached IDR393,788,937,071.00.

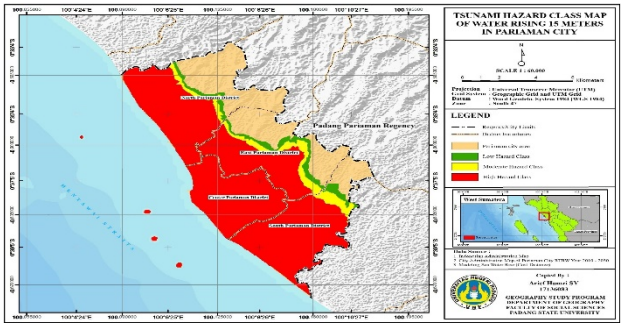


**Fig. 9.** Affected by a 15 meter rise in water

## 4 Conclusion

In the research that has been done, the following conclusions can be drawn:

a. The area affected by the tsunami disaster in Pariaman City based on a 5 meter increase in water is 1,057.63 Ha, an increase in 10 meters of water is 3,911.57 Ha and a 15 meter increase in water is 5,269.18 Ha.

b. The potential number of buildings affected by the tsunami disaster based on a 5 meter water increase is 7,023 housing units, 41 educational facilities units and 4 puskesmas units, a 10 meter water increase is 14,045 housing units, 70 educational facilities units and 5 puskesmas units, then the increase 15 meters of water is 17,968 housing units, 83 educational facilities and 6 puskesmas.
c. The area of agricultural agriculture affected by the tsunami disaster based on a 5 meter water increase is 221.38 Ha, a 10 meter water increase is 1,931.57 Ha and a 15 meter water increase is 3,088.57 Ha.
d. Total losses from being affected by the tsunami based on a 5 meter increase in water are around IDR22,269,068,571,00., a 10 meter increase in water is around IDR219,417,793,287.00. And the increase in water is 15 meters totaling around IDR393,788,937,071.00.

## Acknowledgements

Pariaman city administrative data provided by the government from the Pariaman City Bappeda, DEM data from DEMNAS and the tsunami disaster data processing module from BNPB 2018

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