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# ANALYSIS OF POST-DISASTER CITY STRUCTURE CHANGES IN INDONESIA STUDY CASE MATARAM CITY OF LOMBOK (NTB)

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**Abstract**

Research has been carried out on identifying the risk of earthquake disasters in the West Nusa Tenggara region based on 3 factors: the earthquake hazard factor, namely the maximum acceleration of ground vibrations (Peak Ground Acceleration = PGA), the vulnerability factor, namely the population density of the sub-district, and the resilience factor, namely the HDI (Human Development Index) of the sub-district. In West Nusa Tenggara Province. The PGA value was calculated using the Fukushima and Tanaka attenuation function with earthquake parameter data from 1970 – 2014 with criteria of magnitude ≥ 4.5mB, depth ≤ 60 km and epicenter in the range $7.5^{O}$ – $12.5^{O}$ LS and $115^{O}$-$120^{O}$ BT, while calculating the earthquake disaster risk index uses the AHP (Analytical Hierarchy Process) method. From the calculation results, it was found that the areas with the highest level of earthquake disaster risk were the southern part of Dompu Regency, Mataram City, Bima City, northern Bima Regency, while the lowest were West Sumbawa Regency and southern Sumbawa Regency.

**Keywords:** Peak Ground Acceleration, Population Density, Human Development Index, Hazards, Earthquakes.

## I. INTRODUCTION

The potential earthquake disaster affecting West Nusa Tenggara Island consists of 2 parts, namely the Indo-Australian subduction zone in the south of West Nusa Tenggara and the back arc thrust fault (*back arc thrust*) in the north of West Nusa Tenggara. This is what causes the frequency of earthquakes.

Every earthquake event produces ground shaking which can be identified through the acceleration value of ground vibrations at a certain location. The greater the value of the acceleration of ground vibrations that occurs in a place, the greater the danger of an earthquake that may occur.

The size of the ground vibration acceleration value is one of the factors that can indicate the level of earthquake risk. Demographically, the West Nusa Tenggara region is an area with a population of 4,773,795 people.

This condition is one of the high-risk vulnerability factors which at any time can cause large losses if a natural disaster occurs. The higher the HDI (Community Development Index) value, the higher the community's capacity to prepare oneself to face disasters (Centre for Water Resources Research and Development, 2008), based on hazard, vulnerability and capacity factors, these are used to determine the level of risk of earthquake disasters in the West Nusa Tenggara region.

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## II. LITERATURE REVIEW

### 2.1. Magnitude Body (mB)

This magnitude is defined based on the record of the largest amplitude of P waves propagating through the interior of the earth (Lay. T and Wallace.T.C. 1995).

### 2.2 Magnitude Surface (Ms)

This type of magnitude is obtained as a result of measuring the maximum amplitude of surface waves. Formulation *magnitude surface* same thing *magnitude body* However, the amplitude used is a surface wave.

By using historical earthquake data, the conversion of Ms and mB can be expressed in the equation (Ibrahim, 2005):

### 2.3. Maximum Ground Vibration Acceleration

Buildings that stand on the ground require soil stability so that the building remains stable. The acceleration of earthquake waves that reach the earth's surface is also called *Peak Ground Acceleration* (PGA). Is a disturbance that needs to be studied for every earthquake.

### 2.4. Population Density

The denser the population in an area, the more vulnerable the area is to disasters. High population density can reduce the level of social services in the area, for example the lack of community access to social services such as health and education so that this can reduce the physical readiness and understanding of the population in facing disaster events. Population density can also complicate the evacuation process.

### 2.5 Human Development Index (HDI)

HDI is a socio-economic index that depends on 3 (three) factors, namely health, education and income. HDI provides a combined measure of three main components of human development, namely the longevity index (*longevity*), Education index and standard of living index. The higher the HDI value, the higher the community's ability to prepare themselves to face disasters. (Centre for Water Resources Research and Development, 2008)

## III. RESEARCH METHODS

### 3.1 Calculation of Ground Acceleration Values and Contours

The steps taken in calculating the value and contour of maximum ground vibration acceleration are as follows:

1. Select earthquake catalogue data in the West Nusa Tenggara region (7.5° - 12.5°S and 115° - 120°E) with magnitude (M) $\geq$ 4.5mB. Then the conversion is carried out magnitude *body* the *magnitude surface* using the Gutenberg formula and C.F. Richter.
2. Calculate the distance of the epicenter from the observation point using Equation 3.1.

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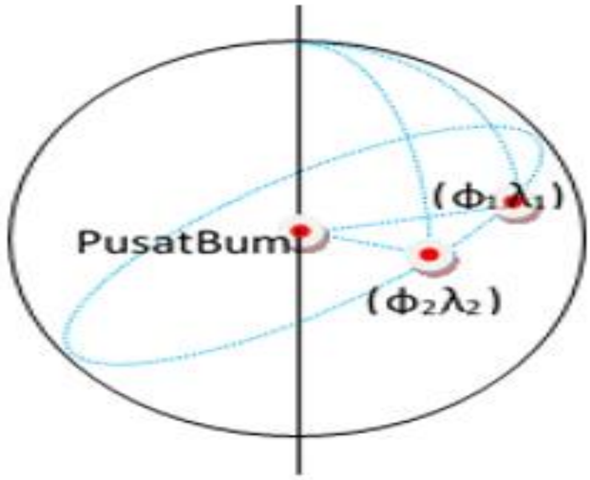


**Figure 3.1: The line connecting the center of the earth with the epicenter and observation point on the spherical plane**

### 3.2 Analysis of Earthquake Disaster Risk Levels

The steps taken in analyzing the level of earthquake disaster risk are as follows:

1. Determine factors and indicators of earthquake disaster risk levels. Identification of earthquake disaster risk in the research location, namely the West Nusa Tenggara region, is carried out based on 3 (three) factors, namely the danger factor (*hazard*), with PGA indicators, vulnerability factors (*vulnerability*) with a density indicator population, endurance/capacity factor with the Human Development Index (HDI) ratio indicator.
2. Calculating standardized indicator values to produce standard values with Equation 3.3 and Equation 3.4 (Davidson *et al*,1997).

   For an indicator of danger and vulnerability factors:
3. Weighting of factors and indicators of earthquake disaster risk levels.

   In this research, the weighting values refer to previously existing research. The weighting value of earthquake disaster risk factors (Firmansyah, 2009).
4. Count level risk of earthquake disaster from factors that influence it (danger factors, vulnerability factors and resilience factor).
5. Then divide it into several class according to the level. In this research, the determination of the number of classes is divided into 5, namely very high, high, medium, low and very low. Class division using features *data classification* in Arc GIS 9.1 with method *natural breaks*.

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**Table 1: Maximum PGA calculation at point 9.2 South Latitude 119.4 East Longitude**

| EARTHQUAKE PARAMETERS | | | | | R (km) | log *PGA* | *PGA* (gal) |
|---|---|---|---|---|---|---|---|
| DATE (GMT) | CROSS ( ° ) | LONGITUDE ( ° ) | H (km) | Ms | | | |
| 9-Jan-2014 | -9.27 | 117.25 | 58 | 5.09 | 243.11 | 0.38 | 2.38 |
| 22-Jan-2014 | -7.88 | 115.62 | 35 | 3.66 | 119.13 | 0.32 | 2.07 |
| 20-Apr-2014 | -9.91 | 119.19 | 40 | 4.78 | 420.59 | -0.80 | 0.16 |
| 22-Apr-2014 | -11.39 | 120 | 33 | 4.93 | 564.31 | -1.35 | 0.04 |
| …. | …. | …. | …. | …. | …. | …. | …. |
| 19-Dec-73 | -9.52 | 119.39 | 42.10 | 5.57 | 33.95 | 1.61 | 40.42 |
| …. | …. | …. | …. | …. | …. | …. | …. |
| 5-Dec-2018 | -9.3 | 118.75 | 10 | 3.66 | 359.40 | -0.98 | 0.11 |
| 12-Dec-2018 | -8.23 | 118.6 | 17 | 3.50 | 348.81 | -0.99 | 0.10 |
| 27-Dec-2018 | -8.94 | 118.05 | 12 | 3.66 | 280.12 | -0.60 | 0.25 |

Source; NTB Bappeda Data, 2020

## IV. RESULTS AND DISCUSSION

### 4.1 Identify Earthquake Hazard Level

To get an idea of the level of danger of earthquake disasters in the West Nusa Tenggara region, this research used historical data on earthquakes in the West Nusa Tenggara region and its surroundings from 1970 – 2014.

By selecting earthquakes with a magnitude of ≥ 4.5 Mb and a depth of less than 60 km, we obtained as many as 869 earthquake events. The earthquake distribution map can be seen in Figure 4.1.

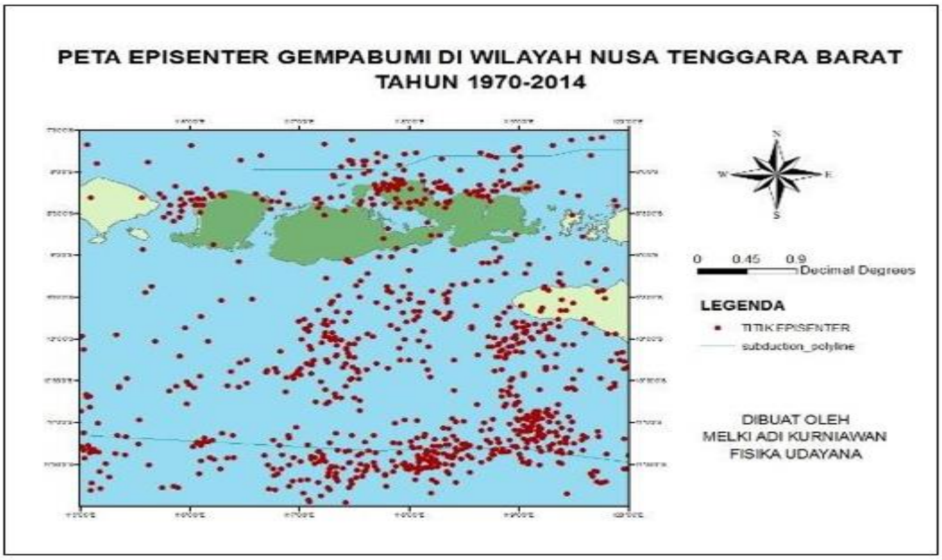


**Figure 4.1: Map of distribution of earthquake centres in West Nusa Tenggara and its surroundings (source: IRIS, 2015)**

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The selected earthquake data is then calculated *PGA* (*Peak Ground Acceleration)* maximum at the observation points. Example of calculation at one calculation point with 1 earthquake data.

For example, the calculation uses the earthquake event on 9 January 1970, epicenter: 9.27 South Latitude, 117.25 East Longitude, depth (h): 58 km, magnitude: 5.7 mB and calculation point coordinates: 9.2 South Latitude, 119.4 East Longitude to get the value *PGA* = 2.38 gal.

This calculation was continued for all data until 2014 to obtain a value *PGA* The maximum for the observation point -9.2 South Latitude, 119.4 East Longitude is 40.42 gal, in the same way as for other observation points.

Mark *PGA* the maximum obtained at each point is made into a contour map *PGA* maximum for the West Nusa Tenggara region using ArcGIS 9.1 Software with krigging interpolation. The results can be seen in Figure 4.2.

**Tabel 2: Maximum PGA Calculation at point 9.2 LS 119.4 BT**

| EARTHQUAKE PARAMETERS | | | | | R (km) | log *PGA* | *PGA* (gal) |
|---|---|---|---|---|---|---|---|
| DATE (GMT) | CROSS ( ° ) | LONGITUDE ( ° ) | H (km) | Ms | | | |
| 9-Jan-14 | -9.27 | 117.25 | 58 | 5.09 | 243.11 | 0.38 | 2.38 |
| 22-Jan-14 | -7.88 | 115.62 | 35 | 3.66 | 119.13 | 0.32 | 2.07 |
| 20-Apr-14 | -9.91 | 119.19 | 40 | 4.78 | 420.59 | -0.80 | 0.16 |
| 22-Apr-14 | -11.39 | 120 | 33 | 4.93 | 564.31 | -1.35 | 0.04 |
| …. | …. | …. | …. | …. | …. | …. | …. |
| 19-Dec-14 | -9.52 | 119.39 | 42.10 | 5.57 | 33.95 | 1.61 | 40.42 |
| …. | …. | …. | …. | …. | …. | …. | …. |
| 5-Dec-18 | -9.3 | 118.75 | 10 | 3.66 | 359.40 | -0.98 | 0.11 |
| 12-Dec-18 | -8.23 | 118.6 | 17 | 3.50 | 348.81 | -0.99 | 0.10 |
| 27-Dec-18 | -8.94 | 118.05 | 12 | 3.66 | 280.12 | -0.60 | 0.25 |

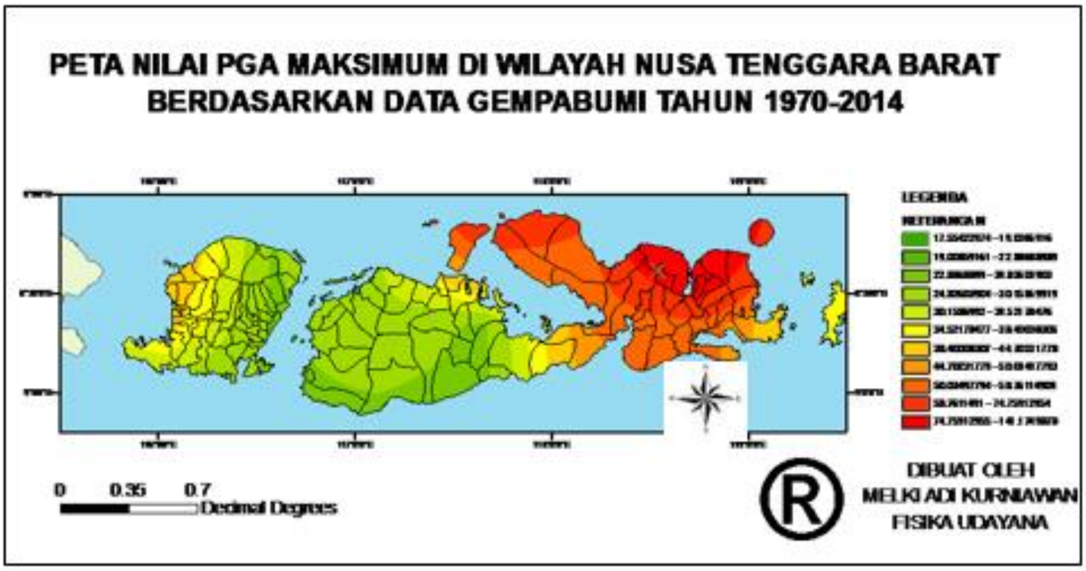


**Figure 4.2: Map *Peak Ground Acceleration* West Nusa Tenggara Region**

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From the contour map above, the maximum PGA value for the sub-district can be determined. Mark *PGA* The standard value is then calculated for sub-districts.

The standard value is then classified into 5 classes to determine the level of earthquake hazard in the West Nusa Tenggara region. Calculation of standard value.

Calculation of Standard Value *PGA* for the point (-9.2, 119.4) get a value of 2.01.

The standard PGA value per sub-district is classified into 5 classes and mapped based on the danger level category. On the earthquake hazard map (figure 4.2), it can be seen that areas with a very high level of danger are in the Dompu Regency and Bima City areas.

### 4.2 Analysis of Earthquake Disaster Risk Levels in the West Nusa Tenggara Region

The risk level for earthquake disasters is calculated based on standard values of PGA, population density and HDI with equation 3.5.

The results of the IRB calculations for Mataram City can be seen in table 4.2. In the same way, it is carried out for other districts and cities and then presented in map form, which can be seen in Figure 4.6.

Areas with a very high level of earthquake disaster risk are Dompu Regency, Bima Regency, Bima City and Mataram City. Areas with a very low level of earthquake disaster risk are in southern West Sumbawa and southern Sumbawa.

**Table 3: Table of calculation results for the Disaster Risk Index in one of the cities in the research area**

| CITY | SUBDISTRICT | POPULATION DENSITY | IPM | PGA | POPULATION STANDARD VALUE | HDI RAW VALUE | PGA RAW VALUE | IRB | LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| Mataram City | Ampenan | 9096.00 | 75.93 | 47.79 | 6.92 | 1.45 | 2.04 | 3.52 | Very High |
| Mataram City | Cakranegara | 6879.00 | 75.93 | 43.62 | 5.58 | 1.45 | 1.85 | 2.99 | Very High |
| Mataram City | mataram | 7570.00 | 75.93 | 42.31 | 5.99 | 1.45 | 1.79 | 3.11 | Very High |
| Mataram City | Sandubaya | 6785.00 | 75.93 | 42.09 | 5.52 | 1.45 | 1.78 | 2.95 | Very High |
| Mataram City | Sekarbela | 6057.00 | 75.93 | 44.46 | 5.08 | 1.45 | 1.89 | 2.84 | Very High |
| Mataram City | Selaparang | 6919.00 | 75.93 | 42.06 | 5.60 | 1.45 | 1.78 | 2.98 | Very High |

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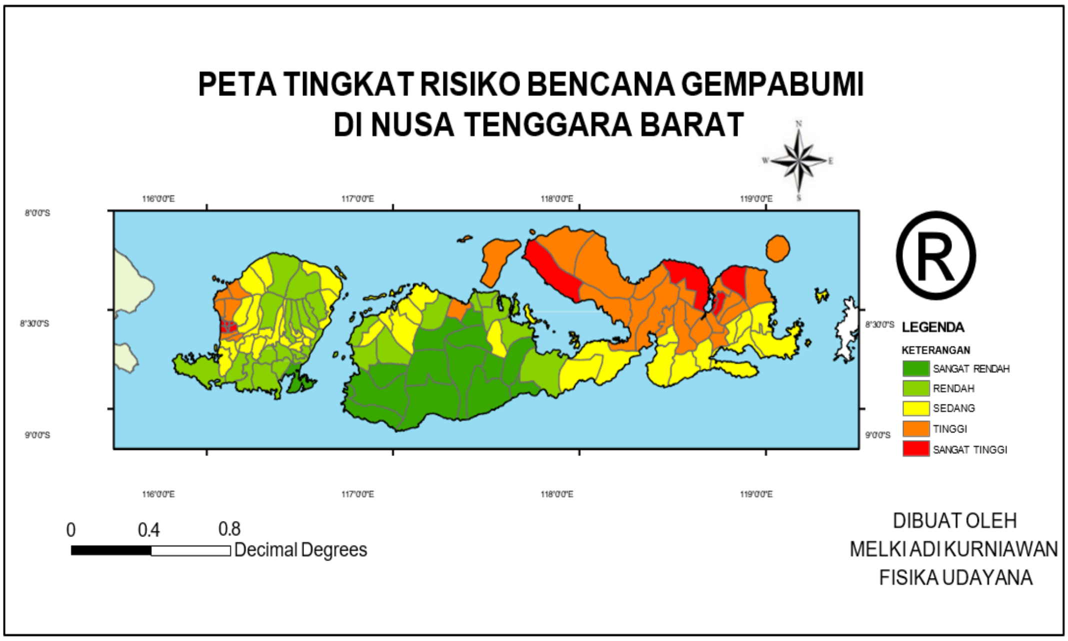


**Figure 4.3: Map of the risk level for earthquake disasters in the West Nusa Tenggara region**

## V. CONCLUSIONS DAN RECOMMENDATIONS

### 5.1 Conclusion

From the description above, it can be concluded that the areas with the highest level of earthquake disaster risk are the southern part of Dompu Regency, Mataram City, Bima City, northern Bima Regency, while the lowest are West Sumbawa Regency and southern Sumbawa Regency.

### 5.2 Suggestion

This research can be continued by adding other factors that influence the level of earthquake disaster risk in the West Nusa Tenggara region. The results of calcination in a mortar with pastel for 4 hours to obtain a very smooth mixture. The samples were then molded into pellets with a diameter of 1.5 cm using a hydraulic press of ~ 400 kPa. Pellets disintering in the furnace at 910$^0$C for 30 hours in an air atmosphere in the furnace. Cooling is carried out according to cooling in the furnace.

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