Analysis of Tsunami Disaster Risk Level Using Grid-Based Method (Case Study: Coastal South Beach Blitar)

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Abstract. Tsunamis are one of the most frequent deadly natural disasters in Indonesia. The tsunami came suddenly and destroyed everything in their path. Reporting from the BNPB website, a tsunami consists of a series of ocean waves capable of traveling at speeds reaching more than 900 kilometers per hour or more in the middle of the sea. Tsunamis are triggered by several factors, namely earthquakes and debris on the seabed, or due to volcanic eruptions at sea. No technology can predict exactly when a tsunami will occur. Therefore the mitigation process is needed as preparation to face a disaster. The geographical position of the southern coast of Blitar Regency is recorded as a tsunami-prone area due to the shift in the Indomantasia and Euroasia plates and directly adjacent to the Indian Ocean. In this study, an analysis of the risk level of a tsunami disaster in the coastal area of Blitar Regency will be carried out as the first step for disaster mitigation to minimize the occurrence of casualties using a grid-based analysis. The process is carried out using spatial data in the form of points, which are then interpolated so that the new points are obtained. Risk analysis is obtained by three parameters, namely hazard parameters, vulnerability parameters, and capacity parameters. The area affected by the tsunami hazard in the Blitar Regency spreads over 14 villages in Blitar Regency. The area affected by the tsunami in the 10m-height model is 655.76 hectares. The village with the largest inundation area is located in Sumbersih Village with an area of 97.52 hectares. In calculating the level of vulnerability, it is found that the level of vulnerability in the coastal area of Blitar Regency is in the medium class. Furthermore, the risk analysis shows that the area at risk of tsunami in the run-up model is 10 meters covering an area of 655.76 hectares, a low-risk area of 74.69 hectares, a moderate risk area of 211.44 hectares, and a high-risk area of 369.62 hectares. Hectares. In Bakung District, there are no areas with a high level of risk.

Keywords— Blitar District, Grid Based Hazard Index, Risk Index, Tsunami Vulnerability Index.

1. Introduction
Disaster is an event or series of events that threaten and disrupt people’s lives and livelihoods caused, both by natural and / or non-natural factors as well as human factors, resulting in human casualties, environmental damage, property losses, and psychological impacts [1]. Some natural disasters can be predicted when they occur by considering the pattern of disasters, but most natural disasters occur suddenly and cannot be predicted. Unpredictable natural disasters often cause many victims, both fatalities and property. To minimize casualties due to natural disasters, mitigation processes are needed in preparation for efforts to deal with disasters [2].

One of the most dangerous disasters is the tsunami. In general, there are 3 main causes of tsunami waves in Indonesia [3], namely: 1) tectonic earthquake activity 2) volcanic activity 3) underwater landslides. The southern coastal region of East Java is an area that has high potential for tsunami disasters. On July 29, it was reported that the four sub-districts in Blitar were damaged as disaster prone...
areas due to the shifting of the Indoaustralian and Euroasia plates. Namely, District Wonotirto, District Panggungrejo, District Wates, and District Bakung. It certainly requires the vigilance of the community and tourist visitors on the south coast sea [4].

Blitar Regency as one of the regions located on the south coast of East Java, the geographical position of the southern coast of Blitar Regency, which borders directly with the Indian Ocean, makes this region vulnerable to tsunami disasters [5]. The coastal area which is used as the object of research has a center for all activities of the population ranging from trade, government and education centered in the coastal area. So it is feared that if a tsunami disaster can cause many casualties [6].

Although the cause of the tsunami wave is known, the wave height and the tsunami inundation area are still unknown. This is closely related to the condition of the coastline, the profile of coastal areas and other physical factors related to the tsunami wave rate to the mainland.

Based on the explanation, it is necessary to analyze the level of tsunami risk in the coastal area of Blitar Regency as an initial step for disaster mitigation to minimize the occurrence of casualties in the area. Risk analysis is interpreted by the formula "Hazard x Vulnerability x capacity", for hazard parameters based on hloss calculations while vulnerability calculations use population parameters and capacity determination is seen defined on the local resilience component and the village preparedness component [7].

This research can be done with a grid based analysis which is a technique or process involving several of calculations & logical (mathematical) evaluations, carried out to find or find relationships (patterns) between grid-based geographic elements. The grid system has one numerical data value in each cell [8]. By knowing the variables that play a role in determining the level of tsunami risks such as the type of hazard index, vulnerability index and capacity index is expected to be used as material for government consideration in improving the quality and quantity of physical and structural variables in areas that have high levels of tsunami disaster risk. In addition, the results of the analysis of the level of tsunami risk in the coastal areas of Blitar Regency can also be used as learning material for local communities to increase preparedness in the face of a tsunami disaster.

2. Data and Method

2.1. Study Area

The location of this research is located in coastal villages in Blitar District which are located in Wonotirto Subdistrict, Panggungrejo Subdistrict, Wates Subdistrict, and Bakung Subdistrict. The study area is geographically located between 8° 15'17.2" - 8° 20'56.1" L S and 112° 01'34.6" - 112° 21'32.4" East. This area study is selected because Blitar Regency is noted as a disaster-prone area due to the shift in the Indoaustralia and Euroasia plates. Namely, Wonotirto District, Panggungrejo District, Wates District, and Bakung District. This certainly requires the vigilance of the community and tourist visitors in the southern coastal sea.
2.2. Data and Equipment

Data used in this study are Sentinel 2B satellite imagery data taken on 07-13-2019 (spatial resolution of 10 meters), SRTM Digital Elevation Model (DEM) Data (30m resolution), Blitar Regency administrative boundary data issued by the Geospatial Information Agency (RBI map scale 1: 25,000 in 2015), Coastline data (1: 25,000 scale RBI map for 2015). Population demographic data published in the Central Statistics Agency publication "Blitar Regency in Figures 2018". Also 100mx100m grid population density (source www.worldpop.org).

Equipment used in this study are HP Laptops Specifications Intel® Core™ i5-3210M CPU @ 2.5 GHz (4 CPUs), ~2.40GHz. RAM 8GB, OS Windows 10 64-Bit. Number processor, Satelite Image software, and Spatial data software.

2.3. Data Processing

2.3.1. Image Cutting

Image cutting is done to focus on the area used in the study. Besides it can save memory storage so that image data processing becomes faster and more effective [9].

2.3.2. Land Cover Classification

Land cover map derived from the results of image classification Sentinel 2B previously has been corrected and be a subset then classified into 8 classes according to the instructions of BNPB ie water bodies, forests, residential, vacant lots, fields, gardens, shrubs, and ponds [10]. The number of training samples used was 50 polygons and 30 accuracy test points for each class.
2.3.3. Hazard Index
This type of land cover translates into a surface hardness coefficient which describes the appearance of land cover. Each surface hardness coefficient value varies, depending on the type of land cover. Here is a table of surface hardness coefficient values. The surface hardness coefficient values can be seen in Table I. This roughness coefficient refers to the guidelines for making tsunami hazard maps made by BNPB [11].

Table I. Roughness Coefficient Value

| No. | Land Cover          | Roughness Coefficient Value |
|-----|---------------------|----------------------------|
| 1   | Water Bodies,       | 0.007                      |
| 2   | Bush                | 0.040                      |
| 3   | Forests,           | 0.079                      |
| 4   | Plantation          | 0.035                      |
| 5   | Empty Lots,         | 0.015                      |
| 6   | Agricultural Land   | 0.025                      |
| 7   | Residential,        | 0.045                      |
| 8   | Ponds               | 0.010                      |

The distribution of tsunami affected area (hazard) is obtained from the mathematical calculation developed by Berryman [12] based on the calculation of tsunami height loss per 1 m inundation distance (inundation height).

\[
H_{\text{loss}} = \frac{167 n^2}{H_0^3} + 5 \sin s
\]  

(1)

Where \(H_{\text{loss}}\) is the height of the tsunami per 1 meter inundation distance. \(n\) is the surface roughness coefficient. \(H_0\) is the height of the tsunami wave at the coastline. \(S\) is the magnitude of the surface slope.

In this study, the tsunami hazard was calculated using several scenarios, namely scenarios with wave heights of 5 meters, 10 meters, 15 meters and 20 meters. This is done with the aim of knowing the difference in danger resulting from the wave height [13]. Each tsunami wave height scenario is calculated into a set of tsunami event scenarios with their own risk impacts.

2.3.4. Formation of Inundation Classes
In this study tsunami inundation is divided into three classes based on the depth of tsunami inland. The three classes are shallow, medium and deep classes. Making the class is based on Perka BNPB which is less than 1 meter, 1-3 meters and more than 3 meters [7].

2.3.5. Vulnerability Index
There are 4 types of vulnerability, namely physical vulnerability, social vulnerability, economic vulnerability and environmental vulnerability. In this study, the vulnerability used is refers to social aspect. Given in the event of a disaster, social life factors are the factors that are most easily disturbed. The social vulnerability index has several parameters, namely: population density, sex ratio, age dependency ratio, poor population ratio and the ratio of disabled population [11]. Spatially, m foreign values are distributed within the administrative boundary per village and scoring and overlaying. This facilitates policy makers in determining the locus of disaster mitigation and adaptation efforts. Following are the weights of each social vulnerability parameter.

Table 2. Compiler parameters and social vulnerability scoring

| Parameter       | Weight (%) | Class         |
|-----------------|------------|---------------|
| Population density | 60          | Low (1)       |
|                 |            | <5 People/ha  |
|                 |            | 5-10 People/ha|
|                 |            | >10 people/ha |
2.3.6. Capacity Index
Capacity is the ability to anticipate, prevent, and recover from the effects of hazards [14]. The capacity index obtained determines the capacity based on the regional resilience and the village preparedness obtained from the results of a focused discussion by all relevant agencies. The capacity index in this study uses the data in the Blitar District Disaster Risk Assessment book, published in 2018 which includes 4 sub-districts on the coast of Blitar with the following results [15]:

| Sub-district  | Capacity Index (0-1) | Capacity class |
|---------------|----------------------|----------------|
| Bakung        | 0.28                 | Low            |
| Panggungrejo  | 0.23                 | Low            |
| Wates         | 0.22                 | Low            |
| Wonotirto     | 0.23                 | Low            |
| Kabupaten     | 0.24                 | Low            |

2.3.7. Validation of Population Estimates
Disaster risk assessment is based on 3 (three) risk components, namely hazard, vulnerability and capacity. The risk index will be directly proportional to the hazard and vulnerability index and inversely proportional to the capacity index. The hazard and vulnerability index value directly proportional to the risk because the potential hazard cannot be eliminated while the vulnerability will definitely follow. Therefore, to reduce risk, capacity building of both the government and community sectors is needed [8].

In this study, the risk index refers to the general guidelines for assessing disaster risk that have been established by BNPB in 2012:

\[
R = \left( H \times V \times (1 - C) \right)^{1/3}
\]

where:
- \( R \) : Risk Index
- \( H \) : Danger Index
- \( V \) : Vulnerability Index
- \( C \) : Capacity Index

2.3.8. Formation of Risk Classes
The results of the calculation of risk index that obtained from total hazard index calculation, indices of vulnerability and capacity indices and classified into range 3 class by using the formula [16].
\[ R = Ki = \frac{X_t - X_r}{k} \]  

\( Ki \) = Interval Class  
\( X_t \) = The highest score  
\( X_r \) = Lowest Value  
\( k \) = Number of Classes wanted

3. Result and Analysis

3.1. Land Cover

In this study, sentinel 2B images were downloaded from the website of the United States Geological Survey (USGS) (http://earthexplorer.usgs.gov/) which were further classified into 8 classes namely water bodies, forests, settlements, vacant lands, rice fields, gardens, bushes and ponds. Used to help image interpretation of RBI maps Indonesia (RBI) from Geospatial Information Agency.

The land cover is done by supervised classification method (Supervised) using the method of maximum likelyhood. Maximum likelihood classification (MLC) was chosen for the Sentinel 2B data land cover classification. MLC is the most commonly used method in classification of remote sensing data [17].

The result of the classification of sentinel 2 images obtained by the calculation of the confusion matrix is 86.66% so that it can be said to pass the classification test. The following are the results of the drawing from the confusion matrix calculation:

Table 4. Confusion matrix resulting from land cover classification

| Class | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|-------|---|---|---|---|---|---|---|---|-------|
| 1     | 27| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30    |
| 2     | 0 | 28| 0 | 0 | 3 | 1 | 0 | 0 | 30    |
| 3     | 0 | 0 | 22| 0 | 0 | 1 | 3 | 0 | 30    |
| 4     | 0 | 0 | 0 | 27| 0 | 0 | 0 | 0 | 30    |
| 5     | 0 | 1 | 0 | 0 | 24| 0 | 1 | 0 | 30    |
| 6     | 3 | 1 | 0 | 3 | 6 | 28| 3 | 0 | 30    |
3.2. Tsunami Hazard Level

To get a tsunami hazard class it is necessary to do inundation modeling. Inundation simulations are performed with a specific wave height scenario so that an inundation estimation is obtained for an area. The approach used in estimation of inundation height is the H loss approach [8].

Mathematical operations on this inundation model are performed on the ArcGIS 10.6 platform on a pixel basis. H loss is a function of the roughness coefficient (n), the height of the water on the line (H0) and the slope (s).

H loss only shows how much water is lost and not the direction of the water. To find out the direction of water, a distance operation is performed. Cost distance analysis determines the closest distance from one pixel to another to the location of the wave source, in this case, is the coastline [18].

The results of the H loss (loss of tsunami wave height) and cost distance (direction of tsunami wave propagation) results in a tsunami hazard map [19]. For hazard classification, 3 classes are used namely; inundation <1 meter, 1-3 meters, and > 3 meters, according to the instructions for the preparation of the tsunami hazard map by BNPB [11]. The following are the results of the tsunami hazard (Hazard) on the coast of Blitar Regency with a height of 5 meters, 10 meters, 15 meters, and 200 meters.

The difference in hazard area according to the height of the run up is explained as follows.

a. From the modeling of the 5 meter run-up scenario, the tsunami inundation covers Blitar District with an area of 279.08 hectares where the majority of the flooded area was still in the form of vacant land and few settlements. Puddles widest occurs with an area of 44.30 hectares, or 15.87% of the total area flooded tsunami with a height of 5 meters. The smallest inundation area is in the Village of Kaligrenjeng, which is only 3.07 hectares or 1.03% of the total area of 5 meter tsunami inundation area.

b. In the tsunami modeling with a run-up height of 10 meters, the total area covered in this scenario is 655.76 hectares or an increase of 134.49% of the tsunami inundation area in the 5 meter run-up scenario. The village with the largest inundation area is Subetages Village with an area of 97.52 hectares or 14.87%. While the smallest inundation area is Kaligrenjeng Village with an area of 7.93 hectares with a percentage of 1.20%.

c. Tsunami modeling with a run-up height of 15 meters is classified as a very high hazard level, the area of tsunami inundation reaches 1033.13 hectares or extends 72.79% of the area of tsunami inundation at an altitude of 10 meters, the largest inundation area is Village Subetages. Spacious pool of the smallest is the village Kaligrenjeng of 14.50 hectares, modeling tsunami with a height of 15 meter run-up can be seen in Figure 3c.

d. Last tsunami modeling, namely the run-up height of 20 meters. Modeling results at a height of 20 meters indicate that tsunami inundation is increasingly widespread and pervasive. Tsunami inundation area reaches 1441.90 hectares or extends 40.14% of the area of tsunami inundation at an altitude of 15 meters. The largest inundation area is in Subetages Village and the smallest inundation area located in the village of Plandirejo with an area of 243.08 hectares and 23.06 hectares respectively. Tsunami modeling with a run-up height of 20 meters can be seen in Figure 3d.

| Class                  | Code | Area     | Percentage |
|------------------------|------|----------|------------|
| Residential            | 1    | 30       | 86.67%     |
| Forests                | 2    | 30       | 86.67%     |
| Water Bodies           | 3    | 30       | 86.67%     |
| Empty Lots             | 4    | 30       | 86.67%     |
| Plantation             | 5    | 25       | 75.00%     |
| Bush                   | 6    | 30       | 86.67%     |
| Agricultural Land      | 7    | 30       | 86.67%     |
| Ponds                  | 8    | 30       | 86.67%     |
3.3. Vulnerability Level

In the tsunami disaster vulnerability Spatially, each value is distributed in administrative boundary per village. This makes it easy for policy makers to determine the locus of disaster mitigation and adaptation efforts. The scoring results from the vulnerability index use a reference following with directions from BNPB [11]. Population density is a condition that said to be denser when the number of people in a certain spatial boundary is more than the area of the room [20]. Population density is the ratio between population and area of inhabited area [21] which is one aspect of vulnerability. Blitar population density originating from www.worldpop.org has an average population density of 1.80 people per hectare and has the highest value of 9.30 people per hectare and the lowest of 0.71 people per hectare. The results of the scoring index population density using a reference by the instructions of the BNPB namely as in table 2.1 obtained results that are dominated by green which represents low classes (under 5 people / ha) and some yellow colors that represent medium classes (5-10 People / ha) which only exists in 4 villages, namely Tambakrejo Village, Tulunrejo Village, Ringinrejo Village, and Tugurejo Village. Meanwhile there is no high class (above 10 people / ha).

While for other parameters such as sex ratio, ratio of vulnerable rural age groups, ratio of poor rural population, and ratio of disabled population to villages have a uniform class for all villages in the coastal area of Blitar Regency. For gender parameters are in the low class that is below 40%, the parameters of vulnerable age groups are in the middle class that is 20% -40%. While for the parameters of the poor
and disabled population are in the low class that is below 20% pervillage so that the value of vulnerability in the coastal area of Blitar Regency can be shown in Figure 8.

Figure 4. Vulnerability Index

3.4. Risk Level
Tsunami risk using references in accordance with BNPB guidelines for tsunami disasters. The more vulnerable and dangerous the area is, the risk of the area the greater. The picture can be seen that the red color indicates that the area has a high risk, yellow indicates a moderate risk and green indicates a low risk [11].

The difference in risk area according to the height of the run up is explained as follows.

a. The area of tsunami risk in Blitar District for Tsunami with a height of 5m which is 279,08 hectares. Of the total area, the majority is a medium risk area of 130,18 hectares. Based on category of low risk area, it has an area of 61.03 hectares with the largest area in Serang Village (9.40 hectares), a medium risk area of 130,19 hectares with the largest area in Ngandipuro Village (19.38 hectares), and high risk areas with an area of 87.86 hectares with the largest area in Ngandipuro Village (16,62 hectares).

b. The area of tsunami risk in Blitar District for Tsunami with a height of 10m which is 655.76 hectares. Of the total area, the majority are high risk areas, covering an area of 369,63 hectares. If broken down by category the low risk area has an area of 74,70 hectares with the largest area in the village of Sumbersih (15,02 hectares). A medium-risk area of 211,44 hectares with the largest area in the village of Bululawang (27,70 hectares), and high-risk areas of 369,63 hectares with the largest area in Tumpakrejo Village (16,62 hectares).

c. The area of the tsunami risk with a height of 15m is 1033,13 hectares. Of the total area, the majority is a high-alt region, covering an area of 697,79 hectares. the low risk area has an area of 72.17 hectares with the largest area in Sumbersih Village (15,54 hectares). Medium-risk area of 263,17 hectares covers the largest area in Tumpakepuh Village (40,17 hectares). High risk areas cover 697,79 hectares with the largest area in Sumbersih Village (129,14 hectares).

d. The area of tsunami with a height of 20m is 1441.90 hectares. Of the vast area, the majority are high risk areas, covering 1029,37 hectares. The low risk area has an area of 79.41 hectares with the largest area in Sumbersih Village (12.95 hectares). The moderate risk of all 333,122 hectares with the largest area is the Village of Tumpakilay (60,82 hectares). A high risk area in 1029,37 hectares cover an area of The Village Sumbersih (204,33 hectares).

The area of tsunami risk obtained from the hazard index, vulnerability index, and capacity index calculations are described in Table 5-8.
### Table 5. The area of the village is at risk of a Tsunami 5m

| Sub District | Desa         | Area Affected (Hectares) |     |     |
|--------------|--------------|--------------------------|-----|-----|
| Bakung       | Tumpakepuh   | 1,691                    | 10,631 |     |
|              | Plandirejo   | 1,427                    | 4,351  |     |
| Panggunrejo  | Tumpakoyot   | 1,779                    | 6,024  |     |
|              | Sidomulyo    | 1,503                    | 5,694  |     |
|              | Bululawang   | 3,454                    | 11,876 |     |
| Wates        | Serang       | 9,395                    | 14,825 | 8,809 |
|              | Sumbersih    | 7,820                    | 18,370 | 14,385 |
|              | Tugurejo     | 3,225                    | 4,027  | 6,621 |
|              | Tulunrejo    | 1,971                    | 2,191  | 6,142 |
|              | Ringinrejo   | 3,519                    | 7,288  | 6,810 |
|              | Gununggade   | 6,865                    | 14,028 | 11,105 |
|              | Kaligrenjeng | 0,659                    | 0,874  | 1,539 |
| Wonotirto    | Ngadipuro    | 8,298                    | 19,376 | 16,621 |
|              | Tambakrejo   | 9,421                    | 10,631 | 15,833 |
|              | **Total**    | **61,0280**              | **130,1862** | **87,8644** |

### Table 6. The area of the village is at risk of a Tsunami 10m

| Sub District | Desa         | Area Affected (Hectares) |     |     |
|--------------|--------------|--------------------------|-----|-----|
| Bakung       | Tumpakepuh   | 3,329                    | 23,864 |     |
|              | Plandirejo   | 1,502                    | 10,370 |     |
| Panggunrejo  | Tumpakoyot   | 2,175                    | 17,951 |     |
|              | Sidomulyo    | 1,849                    | 13,927 |     |
|              | Bululawang   | 1,515                    | 27,704 |     |
| Wates        | Serang       | 9,188                    | 20,840 | 56,881 |
|              | Sumbersih    | 15,020                   | 23,710 | 58,790 |
|              | Tugurejo     | 6,165                    | 11,770 | 23,387 |
|              | Tulunrejo    | 1,947                    | 4,162  | 16,591 |
|              | Ringinrejo   | 5,859                    | 11,133 | 29,948 |
|              | Gununggade   | 8,405                    | 15,397 | 49,167 |
|              | Kaligrenjeng | 0,981                    | 1,915  | 5,031 |
| Wonotirto    | Ngadipuro    | 8,123                    | 18,591 | 62,695 |
|              | Tambakrejo   | 8,636                    | 10,102 | 67,136 |
|              | **Total**    | **74,6943**              | **211,4386** | **369,6256** |
### Table 7. The area of the village is at risk of a Tsunami 15m

| Sub District | Desa       | Area Affected (Hectares) |
|--------------|------------|--------------------------|
| Bakung       | Tumpakepuh | 3,844 40,165             |
|              | Plandirejo | 0,657 16,481             |
| Panggunrejo  | Tumpakoyot | 1,399 29,441             |
|              | Sidomulyo  | 1,314 22,765             |
|              | Bululawang | 1,136 35,668             |
| Wates        | Serang     | 6,620 12,866 101,955     |
|              | Sumbersih  | 15,543 30,088 129,014    |
|              | Tugurejo   | 5,606 11,015 52,305      |
|              | Tulungrejo | 2,435 4,808 28,950       |
|              | Ringinrejo | 3,687 10,662 61,175      |
|              | Gununggede | 7,801 16,281 90,099      |
|              | Kaligrenjeng | 1,220 2,788 10,485     |
| Wonotirto    | Ngadipuro  | 9,277 19,112 107,311     |
|              | Tambakrejo | 11,635 11,029 116,492    |
| Total        |            | 72,1745 263,1679 697     |

### Table 8. The area of the village is at risk of a Tsunami 20m

| Sub District | Desa       | Area Affected (Hectares) |
|--------------|------------|--------------------------|
| Bakung       | Tumpakepuh | 5,173 60,819             |
|              | Plandirejo | 1,314 21,742             |
| Panggunrejo  | Tumpakoyot | 1,624 38,392             |
|              | Sidomulyo  | 2,406 33,212             |
|              | Bululawang | 1,132 41,834             |
| Wates        | Serang     | 8,926 17,005 137,017     |
|              | Sumbersih  | 12,951 25,797 204,329    |
|              | Tugurejo   | 4,839 10,740 80,414      |
|              | Tulungrejo | 2,637 5,257 42,081       |
|              | Ringinrejo | 3,973 8,142 84,887       |
|              | Gununggede | 8,812 20,145 132,130     |
|              | Kaligrenjeng | 2,560 3,981 18,418     |
| Wonotirto    | Ngadipuro  | 8,790 19,161 154,718     |
|              | Tambakrejo | 14,323 26,895 175,372    |
| Total        |            | 79,4065 333,1228 1029,3660 |
The analysis of the difference in the risk index in Biltar district 2018 uses data such as data, land cover maps, tsunami run-up height, and the vulnerability components. The DEM data used is the SRTM DEM which has a resolution of 30m and land cover data comes from land cover maps derived from the land cover map issued by the Ministry of Environment and Forestry in 2017. For run-up height data, only one data is derived from altitude. The vulnerability components use include social, cultural, economic, physical and environmental aspects so that the resulting risk index is shown in table 9.

| Kecamatan | Luas Risiko (Hektar) | Total Luas |
|-----------|----------------------|------------|
| Bakung    | 2,21                 | 58,26      |
| Panggungrejo | 1,91               | 85,90      |
| Wates     | 3,76                 | 70,40      |
| Wonotirto | 3,09                 | 113,91     |
| Kab. Blitar | 10,98              | 328,48     |

From the total area of tsunami risk generated by the BNPB data, the closest is the 5m data in table 9 where the total risk area in the 5m model is 279.08 hectares.
4. Conclusion

Based on the results of the study, it was concluded that:

a. The results of the 5 meters inundating tsunami obtained Blitar region cover 279.0 8 hectares with an area of inundation by high grade of 132,12 hectares. In the 10 meter run-up model, the lace of the tsunami inundated an area of 655.76 hectares with a welding height of 433.65 hectares. From the run-up model 15 meters of tsunami an area of 1033,13 hectares presents a high class area of 814.54 hectares. From the 20 meter run-up, it was found that a tsunami inundation area of 1441.90 hectares reaches a height of 11 98 , 30 hectares.

b. In the population density parameter, the population density of Blitar Regency is dominated by low kels and some the moderate classes. For gender parameters are in the low class, parameters of the vulnerable age group are in the middle class, 20% -40% of villages, while for parameters of the poor and disabled population are in the low class which is below 20%.

c. The results of the analysis of the level of risk in the 5 meter model has an area of 279.08 hectares, and a high risk area of 87.86 hectares. For the 10 meter run-up model, the area of tsunami risk area is 655.76 hectares with a low risk area, a medium risk area of 211.44 hectares, and a high risk area of 369.62 hectares. The run-up model of 15 meters of low risk area has 72.17 hectares, medium risk area is 263.16 hectares, and high risk area is 697.79 hectares. While the run-up model of 20 meters of tsunami risk area covering 1441.90 hectares with low risk area has 79.41 hectares, medium risk area is 333.12 hectares, and high risk area is 1029.37 hectares.

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