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Spatial-Based Earthquake Disaster Risk Analysis In Parepare City, South Sulawesi

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ABSTRACt

The research objectives are to create hazard maps, vulnerability maps, spatial-based risk analysis in the form of earthquake disaster risk mapsin Parepare. The earthquake disaster riskanalysis applied Geographic Information System spatial-based overlay analysismethod. Research to identify earthquake hazard risk was based on earthquake hazard factors, the vulnerability factor of population density and capacity factor. Earthquake hazard map wasgenerated from calculatingThe Peak Ground Acceleration value, procured from the source map and hazards of earthquake in Indonesia 2017 (Team 9)the peak acceleration map in the base rock for the probability exceeded 2% in the last 50 years. Automatic terrain classification map using SRTM (250 m or mesh 1 km) was obtained from Koiwahashi and Pike (2007)and the average distribution of S-waves, shallower than 30m (AVS30),were acquired from J-SHIS for each topographical characteristic (16 classes or 24 classes). The vulnerability data were used for calculating population exposure index and loss index, and the vulnerability was obtained from Focus Group discussion. The earthquake disaster risk index calculated by useing AHP method (Analytical Hierarchy Process).The calculation results showed that the villages with a high risk of earthquake disaster were Bukit Harapan Village, Bukit Indah Village, Ujung Lare Village, WatangSoreang village, and Lapadde village, while the village having the lowest risk of earthquake wasMallusetasi village.

Keywords:*Earthquake;Capacity;Hazard;Risk;Vulnerability;*

1. INTRODUCTION

A. Background

Earth (seism) which can occur by volcanic eruptions, collisions of meteorites, undersea avalanches, atomic bomb blasts, and many other causes. However, the earthquake is generally caused by the sudden motion of the Earth's crust along the fault field[1]. The fault is a crack or reaction that restricts the two rock blocks that have shifted between the one rock block and the other. The motion was due to the rock receiving and storing the tectonical pressure earthquakes are a vibration of the transmitted by the interaction of the lithosphere plate, gradually accumulating in such a way that the stress becomes very high and able to shift the rocks in the fault field. The motion occurs suddenly and delivers a surge of shock in all directionsknown as earthquakes[2].

In the occurence of earthquake disaster in Indonesia in a regional and particularly in South Sulawesi,Parepare has experienced considerable earthquake. The incident occurred on 28

September 1997, and based on the report of the Meteorological and geophysical Agency, the earthquake was recorded at 5.9 SR, centered about 12 miles (20 km) north of the Pareparecoastal city. CNN.com reported that approximately 12 people were dead, 30 people got injured, and hundreds of houses and buildings were damaged when the incident happened. From these data showthatParepareis one of the vulnerable areas and is at risk of geological disasters of earthquake.

Parepare is a second most populous city in South Sulawesi. Based on TheParepareStatistics Bureau (BPS) data of 2020[3], Parepareis inhabitedby 145,178 people, consisting of 71,407 males, and 73,772 females, spread across in 4 sub-districts with Soreangsubdistrict recorded as the most populous sub-district. Land use shifts are also very significant there. According to [4], there are two common problems appearing in South Sulawesi that relate tolanduse namely invasion of protected forests, and the spread of urban development to rural areas. Similarly, inParepare, the land has largely been transformed into urban areas, which led to the increasingly crowded inhabitants inParepare.

Based on the historical records of earthquakes and the potential regions of Parepare arethe reason for the researcherto conduct a systematic risk analysis, in an effort to reduce the impact inflicted by the earthquake disaster in the future. The initial study conducted on this research is to conduct a spatial analysis of earthquake disaster risk. The analysis of earthquake disaster risk is based on the results of hazard, vulnerabilityand capacityanalysis.

B. Objectives and Goals

The objectives of the studyinclude: Creatinghazardmapsorearthquakedisasterthreats; Creatingearthquakedisastervulnerabilitymaps; AnalyzingearthquakedisasterCapacityindex and Creating a spatial-basedriskanalysis in the form of earthquakedisasterriskmaps.

C. Significance of Research

Basically, the study of disaster risk in relation to governmentexpected to result in disaster risk reduction (DRR) is used as basis for developing disaster management policy. This policy will be the basis for developing disaster management plans, which are mechanisms to mainstream disaster management into development plans. And for the community level, DRR results are used as a basis for developing practical acts of readiness, such as evacuation route plans, regional decision-making related to regional spatial planning, such as for housing provisions and others.

D. Research site

Parepare is geographically located between 3º57'39"-4º04'49" South latitude and 119º36'24"-119º43'40" East longitude, bordering Pinrang district to the north, Sidrap Regency in the east, Barru Regency in the south, and Makassar Strait in the west.The area of Parepare is 99.33 km^2;including 4 sub-districts (Bacukikisubdistrict, West Bacukiki, Ujung, and Soreang) and 22 villages. Bacukiki Sub-District is the widest district with an area of approximately 66.70 km^2 or 67.15 percent of Parepare[5]. For more details, the research site can be seen in Fig 1. Research site map.

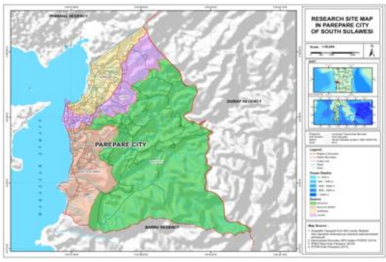


Fig. 1. Research Site Map

E. Literature Review

a. Earthquake hazard map

Vibration intensity map is the basic tool for earthquake disaster management activities. By using earthquake hazard map, quantitative damage and estimated loss can be created by combining social data areas such as the population or the number of buildings and their structures. Map of damage to buildings, number of victims, liquidated areas, damage to slopes, etc. can be made based on the earthquake hazard map. Earthquake hazard map must be processed optimally for each disaster mitigation activities [6].

Based on the physical earthquake disaster, generally, there are 2 steps needed to estimate the intensity of the vibration at the ground level–Estimation of vibration intensity without the influence of superficial shallow layers and the merging of influences from the superficial subterranean layer to the result of vibration estimation without the superficial coating effect[6].

b. Disaster Risk Reduction

Disaster Risk Reduction (DRR) studies are an approach to demonstrating the negative impact posed by disasters in the affected areas. Negative impacts are calculated based on vulnerability and capacity in the area.Based on BNPB and JICA[6], Disaster Risk Reduction (DRR) approach is shown below as:

$$\text{Risk(R)} \approx \boldsymbol{HxV} / \boldsymbol{C}$$

R= Risk

H = Hazard

V = Vulnerability

C = Capacity

Disaster risk assessment comes from index and data similar to those used to develop disaster risk maps. The difference is only in the order of use of each index. This sequence changes sincethe population cannot be judged by a number. Therefore, the threat levels that include the population index are exposed to the basis for calculating hazards and capacity levels.

F. Disaster Risk Map

Disaster risk map was created by overlaid hazard, vulnerability and capacitymap. The map is developed based on a number of indexes computed by each data and method. It is important to note that the risk map requires to be developed for each threat in one area. The methods and data used to calculate the required index will be different from each hazard.

2. METHODOLOGY

Earthquake disaster analysis was preceded by the preparation of earthquake disaster risk map. The preparation of earthquake disaster risk map consisted of three components, i.e., Earthquake hazard, vulnerability and capacity.

A. Earthquake Threat Index (Hazard)

The calculation of hazard index or earthquake hazard was based on two main components–the probability of a threat and the impact that has occurred. In other words, the threat index was based on data and historical records of the city's earthquake disaster occurence. Disaster Hazard Index was made in the form of hazard map using GIS device, using two components/indicator namely earthquake hazard map and map zoning earthquake 2010. The earthquake hazard map was a map used to determine the areas where earthquake disaster occurence with certain frequencies and intensity occurred.

By using earthquake hazard maps, quantitative damage and estimated losses can be made by combining social data areas such as the population or the number of buildings and their structures. Map of damage to buildings, victims, liquidated areas, damage to slopes, etc. can be made based on the earthquake hazard map. Earthquake hazard map must be processed optimally for each disaster mitigation activities [6].

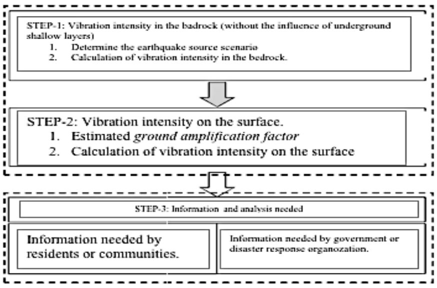


Fig. 2. Procedure of creating earthquake hazard map[6]

The flowchart of generatedvibration intensity map consisted of 3 steps (Fig. 1). The first step was to define the scenario and calculate the vibration index in the base rock. Prediction of vibration intensity in the bedrock was obtained from the source map and danger of earthquakein Indonesia,2017 revision from 2010, by the team of the source map update and danger of earthquake in Indonesiaof 2017, prepared by [7].The second step was to estimate the distribution of ground amplifcation factor and calculate vibration intensity at the ground level. The third step was to gather useful information to effectively use the map based on its purpose.

B. Vulnerability index

Vulnerability Index was created in the form of maps by using GIS device. Based on [8], vulnerability map is based on social, economic, physical and ecological/environmental components. The indicators used in vulnerability analysis are primarily exposure information. The sources of information used for vulnerability analysis are mainly derived from the BPS report of Parepare[9]; [10]; [11]; [12]; [13]; [14]) and basic map information of Bakosurtanal (land use, road network and public facilities location).

a. Social component

The exposed population index was calculated from the social culture component of Parepare. This component was derived from the population density indicator and the vulnerable group indicator of Parepare in the occurence of a disaster. The exposed population index was obtained after the earthquake hazard map had been completed. The Data obtained for the social culture component were then divided into three threat classes, namely low, medium and high. Apart from the index value in the form of a class (low, Medium or high), this component also generates the number of inhabitants of the population exposed to earthquake disaster threats.

Table 1.Indicators and results reset the classification threshold for social components [6]

Indicator		Index Classification (score)		
		Low (0,333)	Middle (0,666)	High (1,000)
Population Density (Population/Residential Area)		<500 People/Km^2	500-4000 People/Km^2	>4000 People/Km^2
Vurnerable Community Groups	Sex Ratio	>80%	(80-60)%	<60%
	Proverty Ratio	<20%	(20-40)%	>40%
	Disabled People Ratio	<20%	(24-40)%	>40%
	Age Group Ratio	<20%	(20-40)%	>40%

b. Economic component

The classification threshold for the economic component used in this study was calculated from the productive land area based on the land cover map of Parepare. For the indicator classification, the land cover was divided as follows: High Level: Area of productive land (paddy fields, dried rice fields, gardens, fish ponds); Medium Level: Area of non – productive land (forest, shrub/shrub, settlement, mangrove, swamp) and no data (not included in classification): Open land, inland water.

Table2.Indicator result reset threshold of economic component classification[6]

Componen/ Indicator	Classification Index (score)			Total weight
	Low (0,333)	Medium (0,666)	High (1,00)	
	-	Non-productive Land Area	Productive Land Area	10

c. Physical Component

Indicators of the physical component consisted of the density of buildings, the density of religious buildings, school density and the density of health facilities. Each indicator of the physical component can be calculated the amount and area of the region. Furthermore, the results of the summation and the area of existing settlements were analyzed using the following formulations:

Number of buildings/total area settlements (km^2)

The number of four types of buildings for each village were obtained from PODES[11], and the total area of settlement (or built-up) (Km^2) for each village was calculated based on a land cover map prepared by BIG and other related authorities in the province.

Table 3. Indicators and results reset threshold of physical component classification [6]

Indicator/ compoment	Classification Index (score)		
	Low (0,333)	Medium (0,666)	High (1,000)
Building density	< 150 per km2	150 - 1000 per Km2	>1000 per km2
Religious building density	< 5 per km2	5 - 15 per Km2	>15 per km2
School density	< 2 per km2	2 - 6 per Km2	> 6 per km2
Health Facilities density	< 3 per km2	3 - 9 per Km2	> 9 per km2

d. Environmental measures component

The classification threshold of environmental measures component used in this research is shown in table 4. The nature reserve area was based on a land cover map prepared by BIG and other related authorities in South Sulawesi province applied as an environmental component indicator. For the indicator classification, the land cover unit is divided as follows: High Level: natural forest, mangrove, shrub/shrub, swamp; low Level: Settlements, paddy fields, dried rice fields, gardens/plants, fish ponds and no level (not included in classification): Open Ground, inland water

Table 4. Indicator and Results reset threshold of environmental component classification [6]

Component/ indicator	Classification Index (Score)			Total Weight
	Low (0,333)	Medium (0,666)	High (1,000)	
Area of nature reserve based on land cover map	Other land cover unit (open ground and inland water are not included)	Forest, Mangrov, swamp	-	100%

C. Capacity Index calculation of regional capacity counting indicators

The capacity index was obtained by the Focus Group Discusion (FGD) among the disaster management stakeholders in Parepare. In addition, the capacity data were also determined by conducting a live interview with the stakeholders in Parepare, either in the form of seminars or field visit by conducting a questionnaire survey. The results of questionnaire survey did not show optimum result, because there were still lack of understandings of the community about disaster. The capacity data collected at the time of FGD in Parepare were incorporated into the weighted amount of one score.

Regional capacity was also obtained by knowing the regional resistance level. Assessment of the level of resilience of regions obtained based on BNPB head regulation No. 03 year of 2012 of the Regional Capacity Assessment guide in disaster management[10]. The regional resistance level consistedof 1-5 levels, where each level was assessed with the following provisions: Level 5:With the assessment that: comprehensive access has been achieved with adequate commitment and capacity at all levels of the community and government level; Level 4: With the assessment that: the commitment and comprehensive policy of disaster risk reduction in an area has gained success, but it was recognized that there were still limitations in commitment, financial resources or operational capacity in the implementation of disaster risk reduction efforts in the area; Level 3:With the assessment that: Government commitment and some communities related to disaster risk reduction; Level 2:With the assessment that: the region has carried out several disaster risk reduction measures with achievements that were still sporadic due to the absence of institutional commitments and/or systematic policies and Level 1:With the assessment that: Other areas had a small achievement in disaster risk reduction efforts, with execute some of the advanced actions in the plan – the plan or policy of an area has been achieved and supported by systematic policy, but the achievement gained with the commitments and policies is judged to be not comprehensive until it still does not mean enough to reduce the negative impact of the disaster.

D. Disaster Risk Analysis

Disaster risk analysis was conducted by reviewing and mapping hazard level, vulnerability level and capacity level based on loss index, exposed population index, hazard index and capacity index. The method for translating the index into a map and the results of the study wasexpected to generate a level of disaster risk in Parepare.

The steps involved in analyzing the risk level of earthquake disaster were as follows:

a) Determining factors and indicators of earthquake hazard risk level. Identification of earthquake disaster risk at the research site was Parepare conducted based on 3 (three) factors, namely hazard factor, with PGA indicator, vulnerability factorwith the indicator of population density, factor of durability/capacitywith indicator result FGD.
b) Calculating the standardization of the indicator value to generate the default value, by making the weighted on each parameter entered into the calculation.
c) Calculating the risk level of earthquake disaster from the factors that affected it (hazard factor, vulnerability factor and endurance factor). Then the ftors are divided into several classes according to their level. In this study the determination of the number of classes divided into 3, namely high, medium, low. Class sharing uses the data classification feature in ARC GIS 9.1.
d) Make a map of earthquake disaster risk.

E. Disaster Risk Map

Disaster risk mapping was used as a hint of zoning risk of a type of disaster hazard in an area at any given time. Disaster risk map was compiled by performing hazard/hazard map Overlay, vulnerability map and capacity map. The maps were developed based on a number of indexes computed by each data and method.

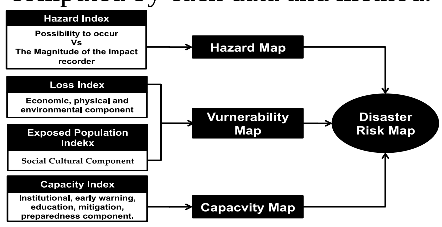


Fig. 3. The method of disaster risk [8]

The picture above illustrates the alignment between risk maps and disaster risk studies. Risk maps are generated based on hazard maps, vulnerability maps and capacity maps.

While the study was produced based on the level derived from the map – hazard map (generating hazard level), Vulnerability Map (generating vulnerability level), capacity map (generating capacity level).The resulting levels were used in disaster risk assessments to generate policies in regional disaster management plans.

F. Geographic Information System

The process of making a map of earthquake disaster Risk studies was conducted using GIS analysis, namely by following technical guidelines and using all necessary data. The GIS process consisted of the following steps:

a. Collecting required data: The Data required and used as inputs of threats, vulnerabilities and capacities, were obtained from national authorities for any related disaster and organizational mitigation in South Sulawesi and in Parepare. Furthermore, the process of collecting and putting data was done under the provisions set forth in the BNPB code. The minimum scale for maps created was 1:50.000 according to the provisions indicated in the guidelines established by the BNPB.

b. Specifying a Mesh – a grid for disaster risk analysis using spatial data: Mesh-grids are minimal spatial units used to integrate different characteristics of spatial data, not just thematic maps but statistic data for village level. The Grid-mesh size was determined by 1ha Mesh-Grid (100 m x 100 m). As for the analysis of disaster risk using various types of spatial data, further analysis was conducted using GIS (geographic information systems). This conversion method is known as the Gridded Method Mapping.

c. Quantifying hazard, vulnerability and capacity: Once all data were input into the mesh-grid system, the four types of indexes were calculated and analyzedusing a GIS tool based on the classification set by BNPB. Based on the analysis, the index of the disaster exposure, population exposed, loss and capacity would be measured at range of 0,0 to 1,0.

d. Geoprocessing Technique: The data that have been collected were then created and analyzed by geoprocessing techniques, to obtain new spatial data. Geoprocessing techniques consisted of union, merge and intersect.

e. Scoring, weighted based Analytic Hierarchy Proces (AHP) and overlay.

Scoring is the process of scoring on each class in each of the parameters [15]. Weighting is the provision of weights in each of the influential parameters [16] in [15]. The best weighted factors are obtained through consensus experts' opinion. A methodology emerged to a consensus is the Analytic Hierarchy Proces (AHP). This methodology was developed by Thomas L. satystarted in 1970[17], and was originally intended as a tool for decision making. AHP is a measurement methodology through pairing-wise comparisons and relies on expert assessments to gain a priority scale. This is the scale that measures the form relative. Comparisons are made by using an absolute scoring scale, representing how many one indicator dominates the other in connection with a particular disaster (the general guidelines for Disaster Risk Assessment [18]. While spatial analysis used in this research is overlay. Overlay is a system of information in the form of graphics formed from the merger of various individual maps (has information/database that is specific) [29];[16].

3.RESULTS AND DISCUSSION

A. Earthquake Hazard levelsIdentifying

To get an overview of hazard or earthquake hazard levels in Parepare, then in this study used several stepsdetermining the intensity of vibration n the base rocks and determining vibration on the surface. Prediction of vibration intensity in bedrock was obtained from the source and hazardmap of Indonesia earthquake year 2017 revision from year 2010 [7].

Surface wave speed Estimation (VS30) on Sulawesi Island based on geomorphological classification obtained[20]. The automatic Terrain classification map using SRTM (250 m or 1 km mesh was obtained [21]; [22].

Table5. Data drafted in the preparation of hazard maps or earthquake threats.

No.	Data Name	Type	Source
1.	The intensity of the shock in the bedrock	Raster	Team 9: SNI Revision-03-17 26-2002, Peak Ground Acceleration (PGA) Indonesia 2% probability exceeded in 50 years, 1 second Indonesian spectral acceleration 2% probability exceeded in 50 years.
2.	Automatic terrain classification map using SRTM (250m or mesh 1km)	Raster	Jun koiwashi and Richard J. pike (2007) http://gisstar.gsi.go.jp/terrain/front_page.htm
3.	AVS distribution (mesh 250m)	Raster	J-SHIS: http://www.j-shis.bosai.go.jp/en/

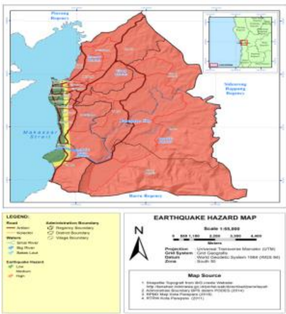


Fig. 4. Earthquake Hazard Map in Parepare

B. Identifying vulnerability Level

Identifying vulnerability level used population density data, while for identification of resistanc levels facing earthquake disaster used the quarantine/FGD data obtained further calculated its value to determine vulnerability index and resilience of the region in case of earthquake occurrence. It was then determined that the class of vulnerability and resilience levels were in each sub-district to find out which areas had very low levels of vulnerability and resistance to very high.

a. Exposed Population Index

Exposed Population indexwas calculated based on social cmponents as population density and vulnerable community groups, divided into three classes (high, medium and low). Basically, the disaster exposure index refers to the BNPB code as a standard procedure. The preparation ofParepare disaster risk assessment, utilizing data on the village level statistic as a minimum requirement for detailed analysis based on BNPB guidelines.

In the disaster risk assessment of Parepare City, village statistic level was prepared by each district BPS and land cover information was obtained from BIG and other related authorities in the province used as the source of social component. Indicators of the social component consist of population density and vulnerable community groups, and vulnerable community groups consist of gender ratio, poverty ratio, disability ratio and age group ratio as sub-indicators based on BNPB guidelines. Each indicator has been calculated in the following activities:

- ✓ Population Density (soul/km^2) for each village was calculated with the following formula:

Total population/total area (or Build-up) (km^2)

The total population of each village was obtained from PODES[11] and the total area of housing (built-up) of each municipality was calculated based on the land cover map prepared by BIG and other relevant authorities in South Sulawesi.

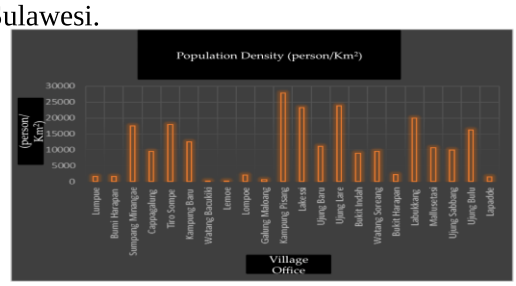


Fig.5. Population density of Parepare city according to District Record in 2016

- Gender Ratio (%) for each village was calculated with the following formula:

Total male population (soul)/Total population of women (soul)

The total number of male and female residents for each village was obtained [11]

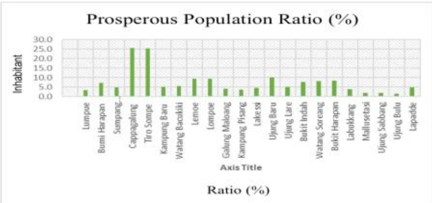


Fig. 6. Gender ratio (%) of Parepare According to Sub-districtof year 2016, (Source: BPS Parepare2017)

- The ratio of poverty in (%) was calculated using the number of HOUSEHOLDS belonging to the Pre-prosperity group based on existing data, with the following formula:*Number of HOUSEHOLDS (Soul)/Total KK (Soul)*

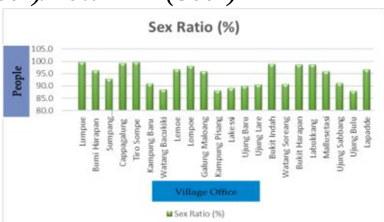
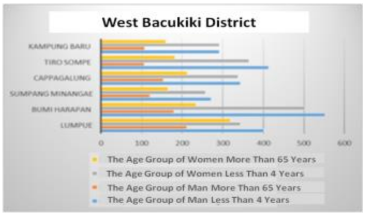


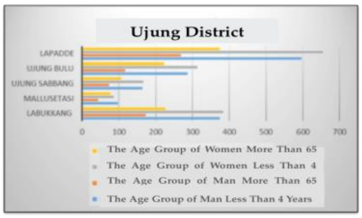
Fig.7. The ratio of population to underprivileged (%)ofParepare According to Sub-district of year 2016, (Source: BPS Parepare 2017)

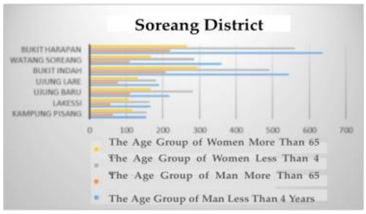
The ratio of disabled people (%):Calculated based on the statistical data of BP which includes the total population of vision disabilities, hearing, walking, memory impairment and NATTCT for each village.

The ratio of disabled people was not included in the weighted, due to the absence of data owned, because it is still a symptom of a defect determination parameter entered in the city of Parepare by BPS. Therefore, the value of the weighted values of the disabled person ratio was inserted into the other parameters.Age group ratio (%): Calculated with the following formula for each village;

The number of age was less than 4 years and more than 65 years (people)/Total population (people).







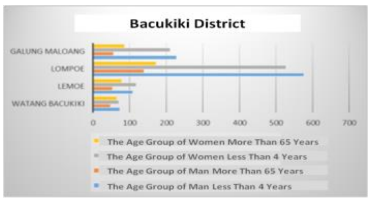


Fig.8. Age group was less than 4 years old and over 65 years based on gender

Table 6. Earthquake Exposure Indicator value

Village Office	Social Component	Social Component	Earthquake Weight	Index of Earthquake Exposure
Lemoe	33,30	33,30	1,00	0,89328
Lompoe	53,28	53,28	1,00	0,89328
Galung Maloang	53,28	53,28	1,00	0,89328
Watang Bacukiki	33,30	33,30	1,00	0,89328
Kampung Baru	73,32	73,32	1,00	0,89328
Lumpue	53,28	53,28	1,00	0,89328
Tiro Sompe	76,65	76,65	1,00	0,89328
Sumpang Minangae	73,32	73,32	1,00	0,89328
Bumi Harapan	53,28	53,28	1,00	0,89328
Cappagalung	76,65	76,65	1,00	0,89328
Bukit Harapan	53,28	53,28	0,00	0,29328
Kampung Pisang	73,32	73,32	0,00	0,29328
Ujung Baru	73,32	73,32	1,00	0,89328
Watang Soreang			1,00	0,89328
Lakessi	73,32	73,32	0,00	0,29328
Bukit Indah	73,32	73,32	0,00	0,29328
Ujung Lare	73,32	73,32	1.00	0,89328
Ujung Bulu			1,00	0,89328
Labukkang	73,32	73,32	0,00	0,29328
Unung Sabbang	73,32	73,32	0,00	0,29328
Mallusetasi	73,32	73,32	1,00	0,89328
Lapadde	53,28	53,28	1,00	0,89328

Fig.9. Social Culture Component of Vulnerability Map

b. Loss Index

The loss index, calculated based on the economic, physical and environmental components, was divided into three classes (high, medium and low) with the threshold to be set. Basically, to prepare for the loss index, BNPB guidelines should be referred to as standard.

The statistic Data of sub-district levels were prepared by each district BPS and land cover information was prepared by BIG and other related authorities in the pilot province were used as indicators of economic, physical and environmental components.

The detailed procedure for classifying each indicator component was as follows;

a) Economic Component

The classification threshold for economic component was productive land area based on the land cover map prepared by BIG and other related authorities in the province applied as an indicator of the economic component.

Table 7. Economic Component Loss Index indicator value

Village Office	Non Productive Land (Km^2)	Productive Land (Km^2)	Open Field (Km^2)	Large per Village (Km^2)	Weight
Galung Maloang	0,45	10,34	0,26	11,05	1,00
Lemoe	6,76	12,09	0,12	18,97	1,00
Lompoe	0,14	5,54	0,10	5,78	1,00
Watang Bacukiki	13,33	7,78	0,00	21,11	1,00
Bumi Harapan	0,12	5,76	0,16	6,04	0,33
Cappagalung	0,40	0,47	0,00	0,88	0,33
Kampung baru	0,24	0,22	0,00	0,46	1,00
Lumpue	0,55	4,16	0,08	4,79	0,33
Sumpang Minangae	0,27	0,20	0,11	0,57	1,00
Tro Sompe	0,21	0,29	0,00	0,49	1,00
Bukit Harapan	0,26	4,83	0,00	5,09	1,00
Bukit Indah	0,44	0,71	0,00	1,15	0,67
Kampung Pisang	0,14	0,00	0,00	0,14	1,00
Lakessi	0,17	0,00	0,00	0,17	1,00
Ujung Baru	0,29	0,15	0,00	0,44	0,67
Ujung Lare	0,26	0,00	0,00	0,24	1,00
Watang Soreang	0,41	0,35	0,00	0,76	0,33
Labukkang	0,27	0,07	0,00	0,34	0,67
Lapadde	1,09	7,18	0,00	8,27	0,33
Mallusetasi	0,25	0,00	0,00	0,25	0,67
Ujung Baru	0,29	0,05	0,00	0,34	0,33
Ujung Sabbang	0,31	0,00	0,00	0,31	1,00

The loss index of the city's economic component of Pareparewas generally included in the low category.

Fig. 10. Economic Components VulnerabilityMap

b) Physical Component

Indicators of the physical component consisted of the density of buildings, the density of religious buildings, school density and the density of health facilities.These densitieswere calculated for each village with the following formula:

Number of buildings (total)/Total area of settlement (or built-up) (km^2)

The number of four types of buildings for each village were obtained from PODES, and the total area of settlement (or built-up) (Km^2) for each village was calculated based on a land cover map prepared by BIG and other related authorities in the province.

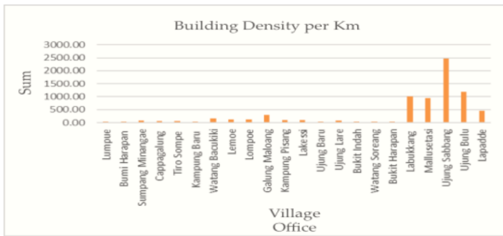


Fig. 11. Building density per km Parepare city

Table8. Number of density buildings of Parepare municipality

Fig. 12. Physical Component Vulnerability Map

c) Environmental Component

The classification threshold of environmental components used in pilot activities is shown in table 11 area of nature reserve based on land cover maps prepared by BIG and other related authorities in the province. The pilot was applied as an environmental component indicator. For the indicator classification, the land cover unit was divided as follows; Moderate: natural forest, mangrove, shrub/shrub and swamp; low-level: settlements, paddy fields, dried rice fields, gardens/plants, fish ponds and there are no levels; (Not included in classification): Open Land, inland water

Table 9. The value of the index map indicator of environmental losses

Low Sub-Village (Km^2)	Medium Sub-Village (Km^2)	High Sub-Village (Km^2)	Large per Village (Km^2)	Weight	Village Office	Hihg Sub-Village (Km^2)	Medium Sub-Village (Km^2)	Low Sub-Village (Km^2)	Large per Village (Km^2)	Weight
10,38	0,40	0,26	11,05	0,33	Bukit Indah	1,15	0,00	0,00	1,15	0,33
12,09	6.76	0,12	18,97	0,33	Kampung Pisang	0,14	0,00	0,00	0,14	0,33
5,68	0,00	0,10	5,78	0,33	Lakessi	0,17	0,00	0,00	0,17	0,33
7,78	13,33	0,00	21,11	0,33	Ujung Baru	0,44	0,00	0,00	0,44	0,33
5,88	0,00	0,16	6,04	0,00	Ujung Lare	0,26	0,00	0,00	0,26	0,33
0,88	0,00	0,00	0,88	0,00	Watang Soreang	0,76	0,00	0,00	0,76	0,00
0,46	0,00	0,00	0,46	0,33	Labukkang	0,34	0,00	0,00	0,34	0,33
0,49	0,00	0,08	4,79	0,00	Lapadde	7,65	0,62	0,00	8,27	0,00
0,46	0,00	0,11	0,57	0,33	Mallusetasi	0,25	0,00	0,00	0,25	0,33
0,49	0,00	0,00	0,49	0,33	Ujung Bulu	0,34	0,00	0,00	0,34	0,00
5,09	0,00	0,00	5,09	0,33	Ujung Sabbang	0,31	0,00	0,00	0,31	0,33

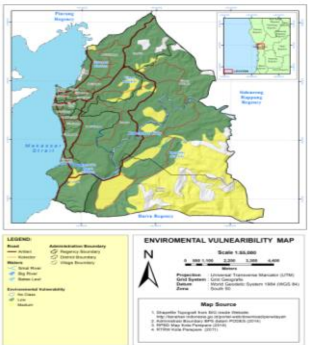


Fig. 13. Environmental Components Vulnerability Map

3.1City Capacity Index in Parepare

The capacity index was determined by the level of resilience of areas acquired through the questionnaire of stakeholders at ParepareCitylevel. The assessment of capacity based on the regulation of BNPB head No. 03. Year 2012 of the Regional Capacity Assessment guide in disaster management. Institutions involved in the filling of the questionnaire consisted of BPBD City Parepare, Indonesian Army (TNI), Indonesian National Police (POLRI), Village Chief, District Head, Department of Food Security, Department of Agriculture, private companies, Office of Communication and Information, TRC,TangguhBencana village, Office of Transportation, Office of Health, etc. The results of the resilience review inParepare can be seen in the following table:

Table 10. Results of the resilience study of Parepare city

No.	Indicator Description	Total Priority Value	Level
1.	Ensuring that disaster risk reduction becomes a national and local priority with a strong institutional basis for implementation	40,63	3
2.	Identify, assess and monitor disaster risks and improve early warning systems to reduce disaster risks	25,57	2
3.	Realization of The uase of Knowledge, Innovation and Education to Build Capacity and a Culture of Safety From disasters at All Levels.	17,05	1
4.	Reduce Basic Risk Factors	27,27	2
5.	Strengthen Disaster Preparednes for Effective Responses at All Levels	41,19	3
	Total Priority Value	30,34	
	Regional Resilience Level	2	

The table above shows that the overall resilience in Parepare in facing the potential disaster is at level 2 with a total priority value of 30.34. The achievement of the level means that the city of Parepare has carried out several disaster risk reduction measures with the achievements of which still are sporadic because of the beluma of institutional commitments or systematic policies.

Parepare City level achievements that belong to the low category require improvement. The resilience in Parepare should be minimal to be improved to achieve the next level of regional disaster management. Government commitments and some communities related to disaster risk reduction have been achieved and supported by systematic policy, requiring a commitment and a policy that is thoroughly assessed to mean enough to reduce the negative impact of disasters.

C. Earthquake hazard analysis of Parepare Area

Earthquake disaster risk was a result obtained by overlay analysis of hazard map, vulnerability and capacity. The map was developed based on several indexes calculated according to each data and method.

Table 11.Parepare Earthquake Risk Index Value

Sub-disctrict	Village Office	Broad High Risk (%)	Broad Low Risk (%)
Bacukiki	Galung Maloang	83,34	16,66
	Lemoe	76,46	23,54
	Lompoe	75,83	24,17
	Watang bacukiki	94,06	5,94
Bacukiki Total		82,49	17,51
Bacukiki Barat	Bumi Harapan	63,66	36,34
	Cappagalung	66,74	33,26
	Kampung Baru	81,62	18,38
	Lumpue	43,06	56,94
	Sumpang Minangae	56,07	43,93
	Tiro Sompe	82,97	17,03
Bacukiki Barat Total		59,56	40,44
Soreang	Bukit Harapan	100,00	0,00
	Bukit Indah	100,00	0,00
	Kampung Pisang	69,52	30,48
	Lakessi	86,29	13,71
	Ujung Baru	92,40	7,60
	Ujung Lare	100,00	0,00
	Watang Soreang	100,00	0,00
Soreang Total		96,04	3,96
Ujung	Labukkang	71,75	28,25
	Lapadde	100,00	0,00
	Mallusetasi	0,00	100,00
	Ujung Bulu	92,04	7,96
	Ujung Sabbang	32,04	67,96
Ujung Total		84,70	15,30
Grand Total		75,59	24,41

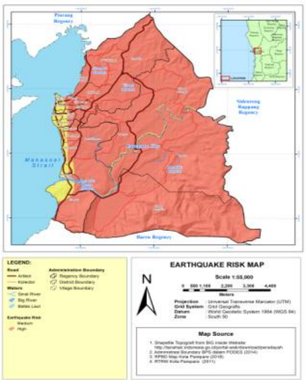


Fig. 14. Earthquake Risk Map in Parepare

From the results of the calculations and analyses that can be seen on the value of the risk index of the earthquake Parepare in table 10, then obtained the result that the village with high earthquake disaster risk is in 5 Districts–Bukit Harapan district, Bukit Indah district, Ujung Lare district, WatangSoreang district, and Lapadde. While the Kelurahan having the lowest risk of earthquake is the village Mallusetasi.

The value of the earthquake risk index is transfered into spatial data in the form of the city of Parepare earthquake disaster risk map (Figure 12). Based on the map it can be explained that almost all areas of the city Perepare is an area with a high risk of earthquake, or about 95% of the area in Parepare. These conditions occured due to the topographical conditions of the city of Parepare which are largely hilly areas with complex geological structures, especially those associated with the earthquake. Only about 5% with a low risk of earthquake disaster, namely along the coast in the terrain.

4. CONCLUSIONS

This research concluded that a high level of disaster risk of earthquake covering about 95% of Parepare city area, with highrisk indexare Bukit Harapan village, Bukit Indah Village, Ujung Lare village, WatangSoreang village, andLapadde village. Meanwhile, the lowest earthquake risk index is in Mallusetasi village.

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