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Analysis of Disaster Vulnerability Level and Community Preparedness Index in the Coastal Area of Kupang City in Dealing with Tsunami Disaster

Nanda Dewi Pamungkas Siwi

Politeknik Negeri Samarinda, Indonesia

**Email: nandapam13@gmail.com*

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ABSTRACT

This study analyzes the vulnerability to disasters and the preparedness index of coastal communities in Kupang City, Indonesia, in facing tsunami risks. Employing a quantitative descriptive method, the research evaluates vulnerability across four categories: physical, social, economic, and environmental. The preparedness index was assessed using variables such as community knowledge, emergency response planning, disaster warning systems, and resource mobilization. The findings reveal that Kelurahan Fatubesi and Oesapa exhibit high vulnerability due to physical and social factors, while other areas demonstrate moderate vulnerability. The overall preparedness index of coastal communities is classified as "nearly ready," with Oesapa Barat and Oesapa showing better preparedness levels compared to other areas. The study emphasizes the need for enhancing disaster awareness, improving infrastructure, and developing community-based risk management strategies to mitigate the impact of tsunamis on coastal populations.

INTRODUCTION

Indonesia is geologically a meeting between three active tectonic plates, namely the Indo-Australian plate, the Eurasian plate, and the Pacific plate. The meeting of these plates resulted in Indonesia becoming a *ring of fire area*. *Ring of fire* is defined as an area where earthquakes and volcanic eruption disasters often occur along the basin in the Pacific Ocean. Earthquakes and volcanic eruptions are one of the factors that generate tsunami disasters. Kurniawan (2005) explained that about 70% of tectonic earthquakes occur on the seabed which has the potential to cause tsunamis.

Tsunami comes from the Japanese language, *tsu* means harbor and *nami* means wave. Literally a tsunami is a tidal wave that enters the harbor. The tidal waves at the time of the tsunami are for example in the open sea of 8 m, but once they enter the port area, the height of the tidal wave narrows to 30 m (Simamora, 2017). Tsunamis bring many losses. Areas that have a high potential for tsunami disasters are in coastal areas.

Population statistics show that almost 60% of Indonesia's population lives in coastal areas. Most of the regional growth centers in Indonesia come from coastal areas, such as Jakarta, Medan, Banda Aceh, Padang, Bengkulu, Makassar, Balikpapan, Denpasar, Bandar Lampung, Mataram, Kupang, Manado, Nabire and several other major cities. The impact produced when a tsunami disaster occurs is not only on the local community, but will also have an impact on land use, the environment, and socio-economic activities of the community (Waluyo, 2021).

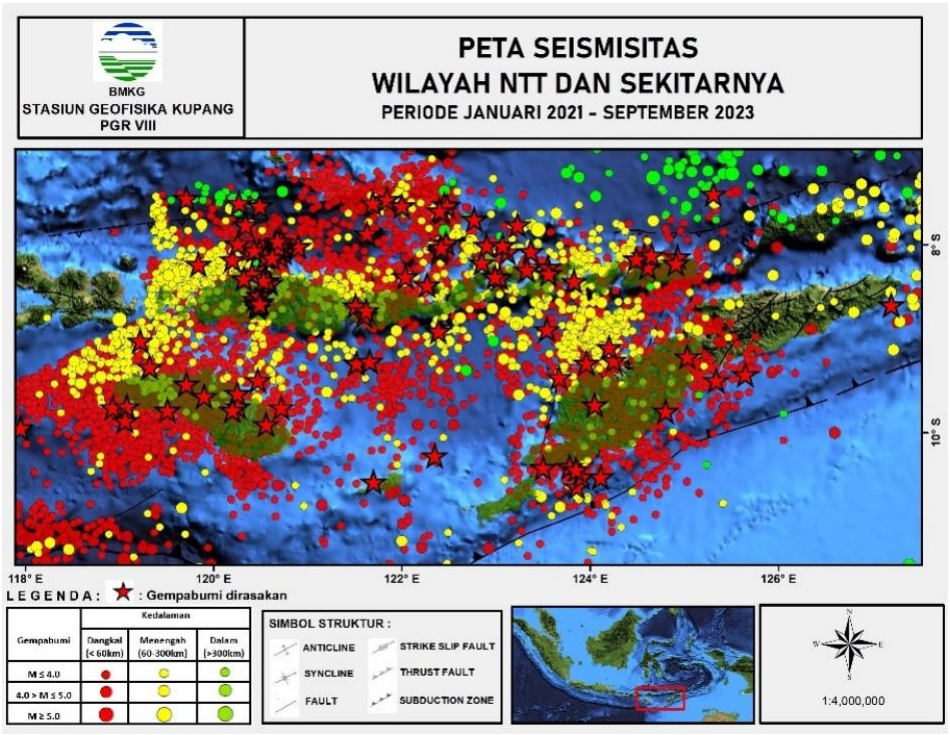

Figure 1.1 Seismicity map of NTT and its surroundings

Kupang City is the capital city of East Nusa Tenggara Province which is located in the coastal bay of Timor Island. Its position looks like it is protected by Monkey Island and Semau Island from the danger of tsunami waves, but Timor Island is located in a series of earthquake epicenters in Indonesia, so tsunami disasters need to be watched out. The Meteorology, Climatology and Geophysics Agency (BMKG) has recorded more than 8,560 earthquakes in the East Nusa Tenggara region in the period January 2021 to September 2023 and 15 earthquakes felt by the community on the island of Timor. Figure 1.1 shows the epicenter of an earthquake during the above period.

The number of earthquakes shows that the threat of tsunamis in the coastal area of Kupang City cannot be considered a mere threat. Throughout the year 416 to 2018, BMKG recorded at least 12 tsunami events in the East Nusa Tenggara region which are mapped in Figure 1.2. Tsunami disasters are inevitable, but the consequences caused by tsunamis can be minimized by taking preventive measures.

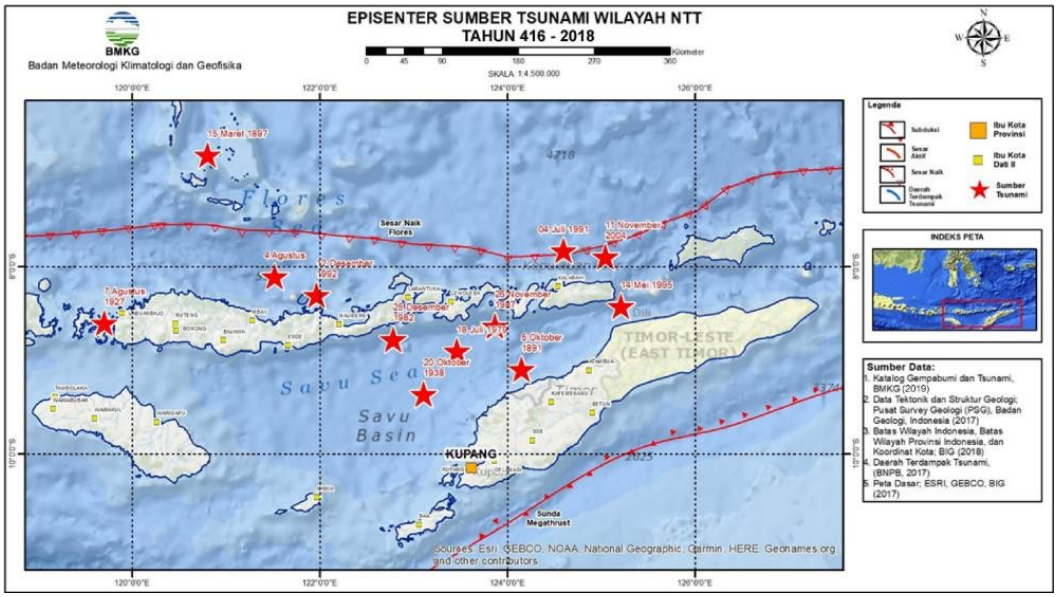

Figure 1.2 Map of the epicenter of the tsunami source in the East Nusa Tenggara region

Preventive measures begin by knowing how the level of vulnerability of an area is described in the Regulation of the Head of the National Disaster Management Agency (BNPB) No. 2 of 2012 concerning general

guidelines for disaster risk assessment which is then correlated with how the community is prepared to deal with the situation in the event of a disaster with the aim of minimizing disaster risk so that the losses caused are not too large (Apriyadi, 2021). The relationship between disaster-prone areas and their community preparedness is an important parameter in realizing regional resilience to disasters (Benazir dkk., 2022).

Based on this background, the researcher is interested in conducting a study entitled "Analysis of Disaster Vulnerability Level and Community Preparedness Index in the Coastal Area of Kupang City in Facing Tsunami Disasters" with the aim of finding out the vulnerability of coastal areas in Kupang City and how the preparedness of coastal communities against the potential for tsunami disasters as the basis for the concept of community-based disaster risk management which can later be applied to reduce the risk and level of material losses and casualties when a disaster occurs.

METHOD

This study uses a descriptive quantitative research method. Sugiyono (2016) explained that the quantitative research method is a method based on the philosophy of positivism, used in researching the research sample and population. Quantitative research is research that presents data in the form of numbers as a result of the research. The descriptive research method is a method in researching the status of a human group, an object, a condition, a thought, or a current event. The descriptive method is used to create a systematic, factual and accurate description of the existing phenomenon. Quantitative descriptive research is research that describes variables as they are, supported by data in the form of numbers generated from actual conditions.

This study uses several main variables to determine the level of vulnerability to tsunami disasters and community preparedness. The level of tsunami vulnerability was analyzed based on four categories of variables: physical, social, economic, and environmental vulnerability. Physical vulnerabilities include parameters such as the number of houses, public facilities, critical facilities, road networks, and power grids, which are assessed based on their impact on the functioning of post-disaster communities. Social vulnerability considers population density, sex ratio, age group ratio, disability ratio, and poverty ratio, all of which contribute to the level of vulnerability of a society. Economic vulnerability is measured by the area of productive land and Gross Regional Domestic Income (GDP), while environmental vulnerability involves the area of protected forests, natural forests, mangrove forests, and shrubs. Each parameter is assessed by referring to the criteria of the Head of BNPB Regulation Number 02 of 2012.

To assess community preparedness, this study uses variables such as knowledge and attitudes towards disasters, emergency response plans, disaster warning systems, and mobilization of human resources and infrastructure. Public knowledge and attitudes towards disasters reflect the level of awareness and anticipation of risks, while emergency response plans include evacuation and rescue measures to minimize the impact of disasters. The disaster warning system aims to provide early information so that the community can carry out rescue actions, and mobilize resources to assess the availability of infrastructure, labor, and emergency funds. This study was conducted on the population of the coastal area of Kupang City, especially in five villages: Nunbaun Sabu, Fatubesi, Pasir Panjang, West Oesapa, and Oesapa, with a focus on families living in coastal areas and potentially directly affected by tsunami risk.

Table 1 Number of Heads of Families (KK)

No.	Neighborhoods	Number of Population Heads
1	Nunbaun Sabu	172
2	Fatubesi	399
3	Pasir Panjang	655
4	West Oesapa	84
5	Usapa	1431
Total KK		2741

Source: Kelurahan Knowledge Report, 2023

Samples and Sampling Techniques

Based on population data in the coastal area of Kupang City which includes coastal communities in Nunbaun Sabu Village, Fatubesi Village, Pasir Panjang Village, West Oesapa Village and Oesapa Village, the total

population is 2741 families. The sample technique used is *proportional stratified random sampling* or random sampling based on proportional stratification. This technique is carried out by randomly sampling stratified populations because the dispersed population is relatively large. In determining the number of samples, 5 – 15% of the total population is used (Singarimbun, 2011). Reference formula used in sampling by Taro Yamane (1973):

$$n = \frac{N}{1+N\,(d)^2}$$

$$n = \frac{2741}{1+2741\ (10\%)^2}$$

$$n = 96{,}5 \approx 97$$

Information:

$\boldsymbol{n}$ = Sample size/number of respondents

N = Population size

$\boldsymbol{d}$ = The percentage of inaccuracy is due to the withdrawal of samples that can still be tolerated, for example 10% (0.1)

Then to get the number of respondent samples per sub-district, the formula is used:

$$n_{Kelurahan\ Pesisir} = \frac{Jumlah\ penduduk\ kelurahan}{Jumlah\ keseluruhan\ populasi}\ x\ jumlah\ sample$$

Table 2 Number of Respondents at the Research Location

No	Neighborhoods	Population	Number of samples
1	Nunbaun Sabu	172	6
2	Fatubesi	399	23
3	Pasir Panjang	655	14
4	West Oesapa	84	3
5	Usapa	1431	51
Total		**2741**	**97**

Source: Kelurahan Annual Report, 2023

The data collection technique in this study involves primary and secondary data collected through observation, documentation, and questionnaires. Observations were carried out on a non-participant basis to record the behavior, events, and physical and geographical conditions of the research area to strengthen the analysis of tsunami disaster vulnerability. Documentation involves the collection of secondary data such as the number of population, productive land area, GDP, number of houses, public and critical facilities from the 2023 Village Annual Report and the Kupang City BPS. The questionnaire was used to collect primary data from respondents related to community preparedness, with closed-ended questions covering indicators such as knowledge, attitudes, emergency response plans, warning systems, and resource mobilization. The validity test was carried out using the Pearson Bivariate Test to ensure the relevance of the questionnaire instrument, with r calculated compared to r table at an error rate of 5%. The test results showed that the item was valid if r calculated > 0.514, based on initial testing of 15 respondents. This validation ensures that the data generated is accurate and in accordance with the research objectives.

Table 3 Results of the Knowledge Index Validity Test

No.	Criterion	Question Number	Sum
1	Valid	A1, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13	12
2	Invalid	A2	1

Source : Analysis Results, 2024

Table 4 Results of the Emergency Response Plan Index Validity Test

No.	Criterion	Question Number	Sum
1	Valid	B1, B2, B4, B5, B6, B7, B8, B11, B12, B13	10

2	Invalid	B3, B9, B10	3

Source : Analysis Results, 2024

Table 5 Results of the Disaster Warning Index Validity Test

No.	Criterion	Question Number	Sum
1	Valid	C1, C2, C3, C4	4
2	Invalid	-	0

Source : Analysis Results, 2024

Table 6 Results of the Validity Test of the Resource Mobilization Index

No.	Criterion	Question Number	Sum
1	Valid	D1, D2, D3, D4, D6	5
2	Invalid	D5	1

Source : Analysis Results, 2024

The results of the calculation of the validity test above, there are 31 valid questions and 5 questions are considered invalid. Invalid questions will be removed from the data collection process, and only valid questions will be used.

RESULTS AND DISCUSSION

Geographical and Demographic Situation of Kupang City

Location and Area of Kupang City

Kupang City is the capital of East Nusa Tenggara Province, which is astronomically located at 123°32'14" – 123°37'01" East Longitude and 10°36'14" – 10°39'58" south latitude. Administratively, Kupang City has the following boundaries:

a. North : Teluk Kupang
b. South: West Kupang District and Nekamese District, Kupang Regency
c. East : Central Kupang District and Taebenu District, Kupang Regency
d. West Side : West Kupang and Semau Strait Districts, Kupang Regency

The area by sub-district and sub-district in Kupang City can be seen in Table 4.1.

Table 4. 1 Area by District of Kupang City

No.	District	Number of Villages	Area (km2)	Percentage of the area of Kupang City
1	Shape	12	86,91	48,21
2	Maulafa	9	54,80	30,40
3	Oebobo	7	14,22	7,89
4	City of Kings	8	6,10	3,38
5	Kelapa Lima	5	15,02	8,33
6	Old Town	10	3,22	1,79
Kupang City		**51**	**180.27**	**100**

Source : Kupang City in Figures, Year 2024

Table 4.1. shows that the widest sub-district is Alak District, followed by Maulafa District, and the narrowest is the Kota Lama District area. Alak and Maulafa Districts are the largest area, considering that the two sub-districts are new development areas and occupy the western and southern suburbs of Kupang City, including also having a larger number of villages than other areas. Kota Lama District is part of the narrowest area, but it has a relatively large number of villages (10 villages). This part of the sub-district is an old city area that initially accommodated many economic and social activities, so that in its arrangement it requires a holistic and integrative approach, so that in turn it does not cause new and sustainable problems.

The Kupang City area has a topography dominated by lowlands with an altitude of 0-350 meters above sea level (masl) and an average slope of 0-15%. Areas with an altitude of 100-400 meters above sea level are located in the southern part, while an altitude of 0-100 meters above sea level is located on the north and west coasts. Areas with slopes of 0-5% are spread along the west and north coasts, 5-10% in the central part, and >10% in the southern part. Geologically, the soil is formed from karst and non-volcanic materials, with structures such as burly, folds, and microfaults. Some areas, such as the Matahitu and Nunkurus rivers, are in the depression zone due to active faults that have the potential to trigger earthquakes and erosion.

The distribution of rocks in Kupang City includes the Bobonaro, Noele, coral limestone, and alluvial deposits. The Bobonaro Formation, which is located in the Manutapen and Kolhua areas, is prone to landslides due to its complex nature. The Noele Formation has a narrow spread but is prone to erosion, such as in Oebufu which experiences creep and fall-type avalanches. Coral limestone covers almost 90% of the city's territory, while alluvial deposits dominate the Oesapa floodplain. Relief in this area allows some areas to be used for plantations, while land with moderate to steep slopes is recommended for conservation using a terraced system.

Demographically, Kupang City has experienced significant population growth, averaging 2.64% per year over the last five years (2019-2023), with an increase from 463,340 people in 2019 to 466,630 people in 2023. The highest growth occurred in Alak District (4.42%/year) and the lowest in Kota Lama District (1.46%/year). The high flow of inward migration, especially to find jobs and education, is a major factor in population growth in Kupang City, given its role as the center of government of NTT Province.

Table 4. 2 Number and Population Density of Kupang City in 2019-2023

No.	***District***	***Year***					***Average Population Growth (%/Year)***
		2019	***2020***	***2021***	***2022***	***2023***	
1	*Shape*	*76.290*	*76.910*	*80.250*	*83.440*	*84.110*	*4,42*
2	*Maulafa*	*98.720*	*97.980*	*102.150*	*106.130*	*106.880*	*3,89*
3	*Oebobo*	*106.340*	*100.560*	*102.820*	*105.080*	*103.800*	*1,84*
4	*City of Kings*	*64.390*	*57.120*	*58.070*	*59.690*	*58.960*	*1,6325*
5	*Kelapa Lima*	*76.570*	*75.470*	*77.250*	*78.470*	*77.310*	*1,685*
6	*Old Town*	*41.030*	*34.730*	*35.310*	*36.110*	*35.570*	*1,46*
Sum		***463.340***	***442.770***	***455.850***	***468.920***	***466.630***	***2,64***

Source : Kupang City in Figures, Year 2024

The high population growth in the Kelapa Lima District area is suspected to be due to being a new development district, so that it is an attractive location for residential areas.

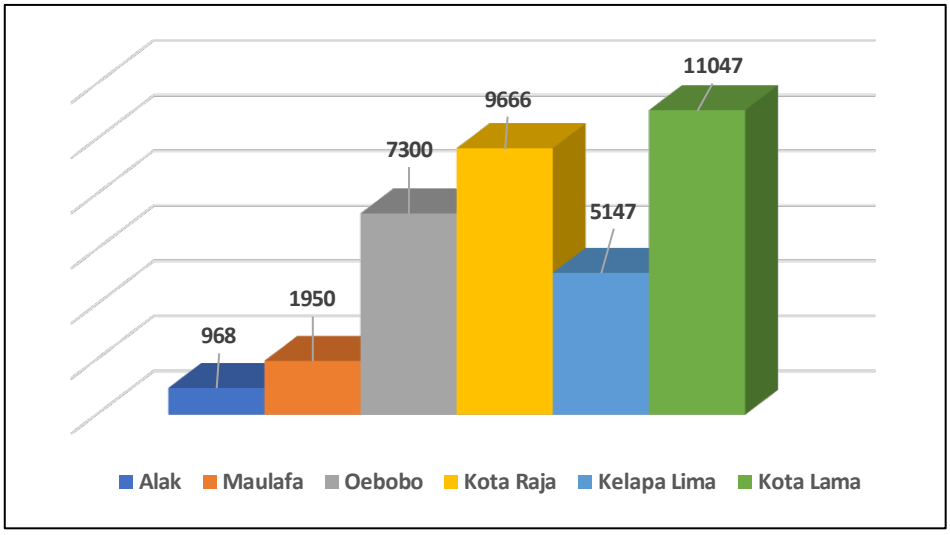

Figure 4. 1 Geographical Density of Population (souls/km²Kupang City by District in 2023 (BPS Kupang City in Figures, 2024)

Comparing the area of Kupang City with the distribution of the population according to the existing sub-districts, the level of geographical density as presented in Figure 4.1 shows that the most is in Kota Lama District (11,047 people/km^2) while the lowest is in Alak District of 968 people/km^2. With the distribution of geographical density, it is important information for local governments in planning and implementing more targeted regional development policies, while still considering the regional spatial plans that have been made previously. This is important so as not to cause various new problems related to the spatial irregularity of urban areas that have generally hit various medium-sized cities in Indonesia.

Tsunami Vulnerability Analysis

Physical Vulnerability

The indicators used for physical vulnerability are house density (permanent, semi-permanent and non-permanent), availability of public facility buildings and availability of critical facilities, house density is obtained by dividing them over the built-up area or village area divided by the area of HA and multiplied by the unit price of each parameter. The number of availability of house buildings, public facilities and critical facilities in Nunbaun Sabu, Fatubesi, Pasir Panjang, West Oesapa and Oesapa Villages can be seen in Table 4.3, Table 4.4, and Table 4.5.

Table 4. 3 Number of Availability of House Buildings at the Research Site

No.	Neighborhoods	Number of House Buildings (units)
1	Nunbaun Sabu	1317
2	Fatubesi	844
3	Pasir Panjang	2029
4	West Oesapa	3778
5	Usapa	6441

Source : Kelurahan Annual Report, 2024

Table 4. 4 Number of Availability of Public Facilities at the Research Site

No.	Neighborhoods	Public Facilities		
		Number of School Buildings	Number of Buildings of Worship	Number of Other Public Facilities
1	Nunbaun Sabu	6	7	1
2	Fatubesi	8	6	9
3	Pasir Panjang	9	2	25
4	West Oesapa	8	5	6
5	Usapa	15	11	10

Source : Kelurahan Annual Report, 2024

Table 4. 5 Number of Availability of Critical Facilities at Research Sites

No	Neighborhoods	Number of Critical Facilities
1	Nunbaun Sabu	11
2	Fatubesi	7
3	Pasir Panjang	10
4	West Oesapa	1
5	Usapa	15

Source : Kelurahan Annual Report, 2024

Physical vulnerability describes the condition of the level of physical fragility in tsunami-prone areas. If a disaster occurs in a vulnerable physical state, the impact of the losses caused will be even greater, in this case it is damage to buildings, be it house buildings, public facilities, critical facilities, road networks and electricity

networks in an area. The larger the number of buildings along with all infrastructure and facilities, the higher the level of vulnerability to tsunamis, because the number of objects affected by tsunami hazards is larger. Figure 4.2 shows a visualization of the distribution of settlements, public facilities, critical facilities, and road networks at the research site.

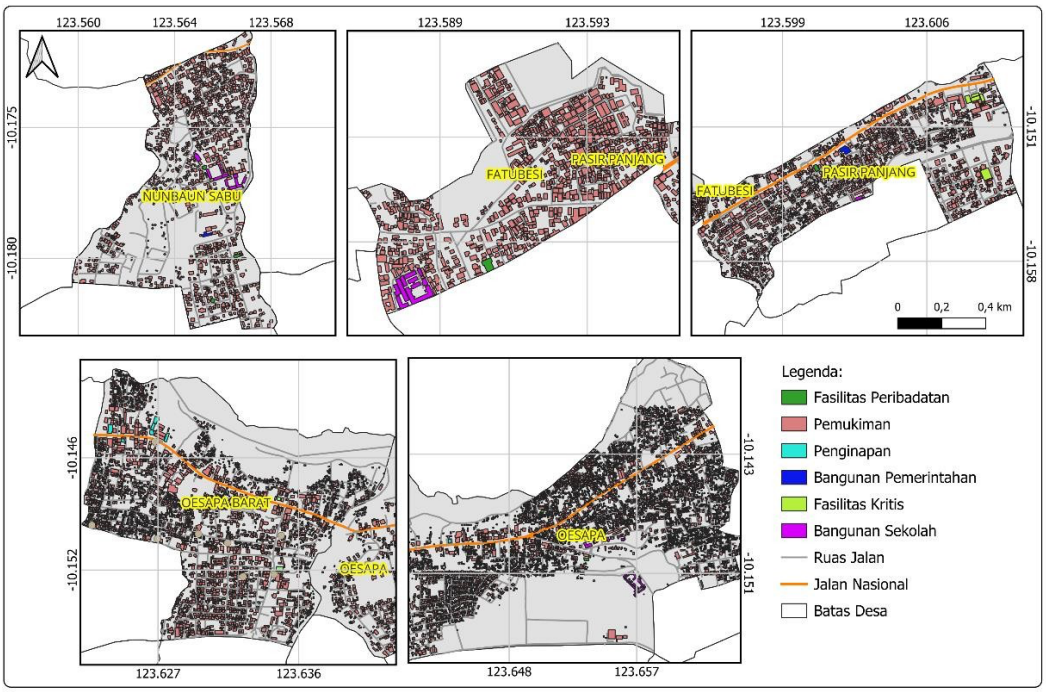

Figure 4. 2 Distribution Map of Settlements, Public Facilities, Critical Facilities, and Road Networks (Analysis Results, 2024)

Oesapa Village has the highest number of housing units, public facilities, and critical facilities, namely 6,441 housing units, 36 public facilities, and 15 critical facilities, which are shown in Table 4.3, Table 4.4 and Table 4.5, respectively. This number is positively correlated with the high population (30,900 people) and the area in Oesapa Village (377,358 ha). The smallest number of house buildings is in Fatubesi Village, which is 844 house buildings, the smallest number of public facilities is in Nunbaun Sabu Village, and the smallest number of critical facilities is in West Oesapa. The data was then scored and weighted in accordance with the 2012 Disaster Management Agency Regulation in Table 3.12. The scoring and weighting results are shown in Table 4.6, Table 4.7, Table 4.8, Table 3.9 and Table 4.10 below.

Table 4. 6 Results of Scoring and Weighting of House Buildings

It	Neighborhoods	House Building			
		Total Estimated Price (Rupiah)	Vulnerability Classes	Shoes	Weight
1	Nunbaun Sabu	> IDR 1 billion	Tall	3	0,9
2	Fatubesi	> IDR 1 billion	Tall	3	0,9
3	Pasir Panjang	> IDR 1 billion	Tall	3	0,9
4	West Oesapa	> IDR 1 billion	Tall	3	0,9
5	Oesapa	> IDR 1 billion	Tall	3	0,9

Source : Analysis Results, 2024

Table 4. 7 Results of Scoring and Weighting of Public Facilities

It	Neighborhoods	Public Facilities			
		Total Estimated Price (Rupiah)	Vulnerability Classes	Score	Weight
1	Nunbaun Sabu	> IDR 1 billion	Tall	3	0,75
2	Fatubesi	> IDR 1 billion	Tall	3	0,75
3	Pasir Panjang	> IDR 1 billion	Tall	3	0,75
4	West Oesapa	> IDR 1 billion	Tall	3	0,75
5	Oesapa	> IDR 1 billion	Tall	3	0,75

Source : Analysis Results, 2024

Table 4. 8 Results of Scoring and Weighting of Critical Facilities

It	Neighborhoods	Critical Facilities			
		Total Estimated Price (Rupiah)	Vulnerability Classes	Score	Weight
1	Nunbaun Sabu	> IDR 1 billion	Tall	3	0,75
2	Fatubesi	> IDR 1 billion	Tall	3	0,75
3	Pasir Panjang	> IDR 1 billion	Tall	3	0,75
4	West Oesapa	Rp 500 million - 1 billion	Keep	2	0,5
5	Oesapa	> IDR 1 billion	Tall	3	0,75

Source: Analysis Results, 2024

Table 4. 9 Results of Scoring and Weighting of the Road Network

No	Neighborhoods	Road Network					
		Total Road Length (m)	Tsunami-Affected Roads (m)	Percentage of Affected Roads (%)	Vulnerability Classes	Shoes	Weight
1	Nunbaun Sabu	11111.7	2940.4	26.5	Low	1	0.1
2	Fatubesi	6449.5	4245.2	65.8	Tall	3	0.3
3	Pasir Panjang	16580.9	8148.4	49.1	Keep	2	0.2
4	West Oesapa	30935.5	7855.6	25.3	Low	1	0.1
5	Usapa	38177.9	24891.5	65.2	Tall	3	0.3

Source: Analysis Results, 2024

Table 4. 10 Scoring and Weighting Results of the Power Grid

No	Neighborhoods	Road Network					
		Network Length Electricity (m)	Electricity Grid Affected by Tsunami (m)	Percentage of Affected Electricity Grid (%)	Vulnerability Classes	Shoes	Weight
1	Nunbaun Sabu	9923.9	1125.9	11.4	Keep	2	0.2
2	Fatubesi	4781.6	2065.8	43.2	Keep	2	0.2
3	Pasir Panjang	13864.7	4646.1	33.5	Keep	2	0.2
4	West Oesapa	24597.4	3664.1	14.9	Keep	2	0.2
5	Usapa	29332.9	3407.2	11.6	Keep	2	0.2

Source : Analysis Results, 2024

Based on the results of data processing, 5 villages (Nunbaun Sabu Village, Fatubesi Village, Pasir Panjang Village, West Oesapa Village, Oesapa Village) which are the focus areas of the research are included in the high vulnerability class because they have an estimated total price of house buildings >800 million rupiah, public facility buildings >1 billion rupiah and critical facility buildings >1 billion rupiah in accordance with the 2012 Disaster Management Agency Perka.

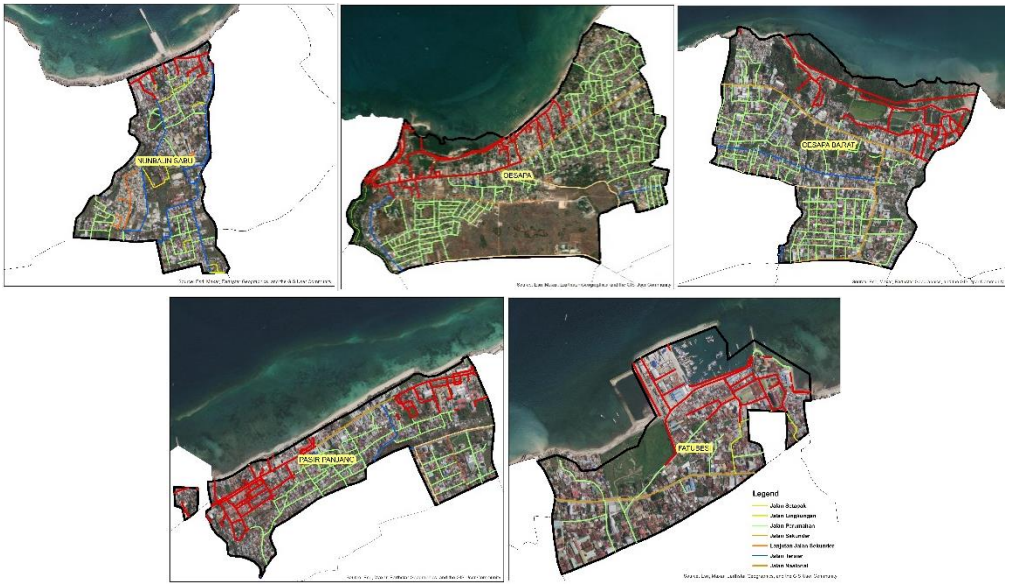

Figure 4. 3 Map of Road Network Affected by Potential Tsunami Hazards in Kupang City (Analysis Results, 2024)

Visualization of roads affected by potential tsunami hazards can be seen in Figure 4.3. The vulnerability of the road network at the research site has varying vulnerability values. Fatubesi Village and Oesapa Village have a high level of vulnerability because the percentage of affected road networks is >65%. Pasir Panjang Village is categorized as moderately vulnerable because the percentage of roads affected by tsunami danger is 49.1%, while Nunbaun Sabu and West Oesapa Villages are categorized as low vulnerable because the percentages are 26.5% and 25.3%.

The electrical installation network at the research site is mapped in Figure 4.4. The vulnerability of the power grid at the research site has a moderate vulnerability value. The percentage of the affected power grid is <50%. The village with the percentage of affected electricity network is in Fatubesi Village, which is 43.2%. Meanwhile, the lowest percentage of beada is in Nunbaun Sabu Village with a percentage of 11.4%.

Figure 4. 4 Map of the Electricity Network Affected by the Potential Danger of the Kupang City Tsunami (Analysis Results, 2024)

The results of scoring and weighting in Table 4.6, Table 4.7, Table 4.8, Table 4.9 and Table 4.10 against the indicators of house buildings, public facilities, critical facilities, road and electricity networks were then further analyzed to obtain a physical vulnerability index. The index was obtained from the sum of the weighting results, including 30% of the scoring of house buildings, 25% of public facilities, 25% of critical facilities, 10% of road networks, and 10% of electricity networks. The physical vulnerability index of Nunbaun Sabu Village has a value of 2.7 (high), the index value of Fatubesi Village is 2.9 (high), Pasir Panjang Village has an index value of 2.8 (high), West Oesapa Village has a physical vulnerability index value of 2.45 (high), and Oesapa Village has an index value of 2.9 (high). Figure 4.5. displaying the results of the physical vulnerability mapping of Kupang City.

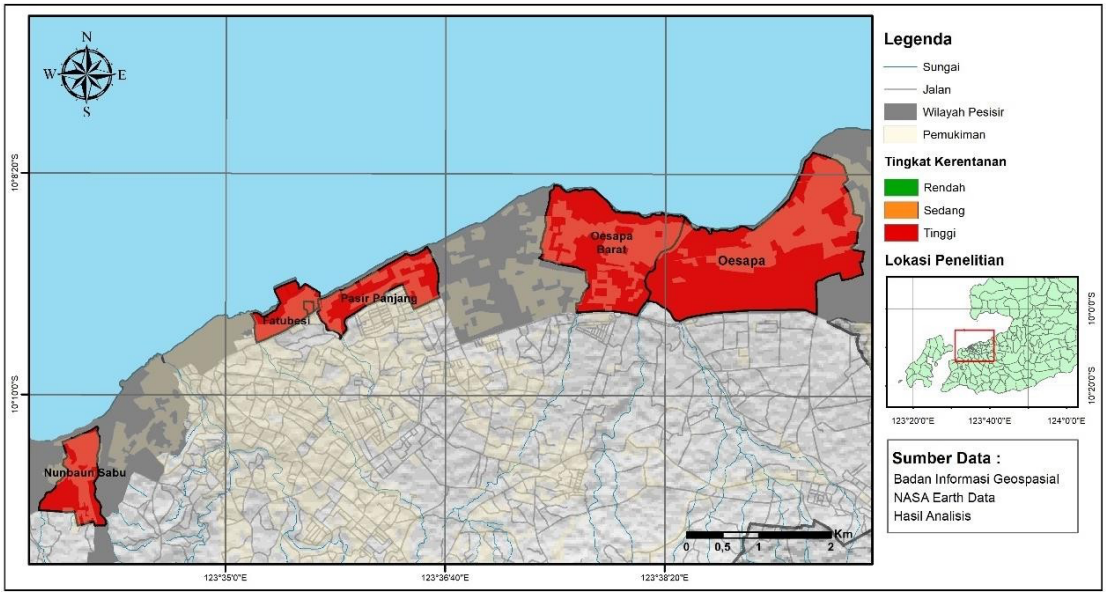

Figure 4. 5 Kupang City Physical Vulnerability Map (Analysis Results, 2024)

Social Vulnerability

The indicators used for social vulnerability are population density, sex ratio, poverty ratio, disability ratio and age group ratio. The results of the scoring and weighting of social vulnerability in Kupang City can be seen in Table 4.11, Table 4.12, Table 4.13, Table 4.14, and Table 4.15.

Table 4. 11 Results of Scoring and Weighting of Population Density

No.	Neighborhoods	Population Density (Soul/Km2)	Class	Score	Weight
1	Nunbaun Sabu	6250	Tall	3	1,8
2	Fatubesi	23629,17	Tall	3	1,8
3	Pasir Panjang	5311,36	Tall	3	1,8
4	West Oesapa	6667	Tall	3	1,8
5	Usapa	5174	Tall	3	1,8

Source: Analysis Results, 2024

Table 4. 12 Scoring Results and Weighting of Gender Ratio

No.	Neighborhoods	*Sex Ratio* (%)	Class	Shoes	Weight
1	Nunbaun Sabu	106,00	Tall	3	0,3
2	Fatubesi	102,80	Tall	3	0,3
3	Pasir Panjang	98,60	Tall	3	0,3
4	West Oesapa	104,00	Tall	3	0,3
5	Usapa	105,00	Tall	3	0,3

Source: Analysis Results, 2024

Table 4. 13 Results of Scoring and Weighting of Poverty Ratio

No.	Neighborhoods	Poverty Ratio (%)	Class	Shoes	Weight
1	Nunbaun Sabu	14,3	Low	1	0.1
2	Fatubesi	25,2	Keep	2	0.2
3	Pasir Panjang	26,2	Keep	2	0.2
4	West Oesapa	49,4	Tall	3	0.3
5	Usapa	29,2	Keep	2	0.2

Source: Analysis Results, 2024

Table 4. 14 Results of Scoring and Weighting of Disabled Ratio

No.	Neighborhoods	Ratio of Disabled Persons (%)	Class	Shoes	Weight
1	Nunbaun Sabu	0,72	Low	1	0.1
2	Fatubesi	0,08	Low	1	0.1
3	Pasir Panjang	0,10	Low	1	0.1
4	West Oesapa	0,06	Low	1	0.1
5	Usapa	0,05	Low	1	0.1

Source: Analysis Results, 2024

Table 4. 15 Scoring Results and Weighting of Age Group Ratios

No.	Neighborhoods	Age Group Ratio (%)	Class	Shoes	Weight
1	Nunbaun Sabu	50,82	Tall	3	0,3
2	Fatubesi	55,10	Tall	3	0,3
3	Pasir Panjang	35,92	Keep	2	0,2
4	West Oesapa	46,36	Tall	3	0,3
5	Oesapa	43,84	Tall	3	0,3

Source: Analysis Results, 2024

Social, Economic, and Environmental Vulnerability of Kupang City

Social vulnerability in the coastal city of Kupang involves various indicators such as population density, sex ratio, poverty ratio, ratio of people with disabilities, and ratio of age groups. The highest population density was found in Fatubesi Village (23,629.17 people/km^2), while the highest poverty ratio was in West Oesapa Village (49.4%). The index analysis shows that all villages have a high level of social vulnerability with index values ranging from 2.6 to 2.8. To reduce the impact of the tsunami disaster, an early warning system and other mitigation efforts such as increasing public awareness are needed.

Economic vulnerability is assessed from the area of productive land and the Gross Regional Domestic Product (GDP). The research location has a low productive land area (< Rp 50 million), while the GDP per sub-district is relatively high (> Rp 300 million). The economic vulnerability index for all urban villages is in the medium category with a value of 1.8. The low value of productive land is caused by the geographical nature of coastal areas that do not support agricultural activities. Mitigation efforts such as mangrove forest development can help reduce economic vulnerability due to tsunamis.

Environmental vulnerability is determined by the area of protected forests, natural forests, mangroves, and shrubs. Most of the research areas do not have protected forests or natural forests, but the mangrove forests in West Oesapa and Oesapa Villages provide protection with a moderate vulnerability category. Overall, the environmental vulnerability index at the research site was relatively low (1.0–1.1). However, strengthening conservation efforts such as mangrove planting is still needed to reduce the risk of environmental losses.

Tsunami Disaster Vulnerability Index

The results of the accumulation of social, physical, economic, and environmental vulnerability indices show that Fatubesi and Oesapa Villages have a high level of tsunami vulnerability, while the other three villages are in the medium category. The high vulnerability in Fatubesi and Oesapa Villages is caused by a combination of social and physical factors. For this reason, spatial planning and strengthening community capacity are very important to reduce the impact of the tsunami.

Community Preparedness of Kupang City

Community preparedness is measured through knowledge indexes, emergency response plans, disaster warnings, and resource mobilization. West Oesapa and Oesapa Villages have better preparedness with the ready category, while other villages are still less prepared. Overall, the community preparedness index is in the almost ready category with a score of 58.6. Although public knowledge is relatively good (62.6), emergency response plans (58.42), disaster warnings (50.9), and resource mobilization (49.7) need to be improved. Socialization, training, and economic capacity building efforts are urgently needed to increase community preparedness for tsunamis.

CONCLUSION

Based on the objectives and results of the study, it was concluded that the level of vulnerability to tsunami disasters on the coast of Kupang City, especially Nunbaun Sabu, Fatubesi, Pasir Panjang, West Oesapa, and Oesapa Villages, varied, divided into medium and high classes. Medium classes are found in Nunbaun Sabu, Pasir Panjang, and West Oesapa Villages, while high classes are found in Fatubesi and Oesapa Villages. The level of preparedness of coastal communities as a whole is in the almost ready category with an index of 58.6, where West Oesapa and Oesapa Villages are higher (indices 72.8 and 65.4) than other villages that are less prepared. The parameter with the highest index was knowledge (62.6), while the resource mobilization parameter had the lowest index (49.7) in the category of less preparedness. Based on these results, the community is advised to use the land according to its designation and increase preparedness until the category is very ready. The government is expected to compile vulnerability maps and evacuation routes, form disaster management organizations, expand mangrove areas, and organize socialization, training, and disaster skills for coastal communities to improve preparedness.

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