Spatial Planning for Coastal Area Based on Tsunami Hazard in Bulukumba Regency

***Harry Hardian Sakti[1], Yan Radhinal[1], Despry Nur Annisa Ahmad[2], Farhan Aldiansyah[2]**
[1]Urban and Regional Planning Department, School of Architecture, Faculty of Engineering, Tadulako University, Indonesia
[2]Department of Urban and Regional Planning, Faculty of Science and Technology, Muhammadiyah University of Bulukumba, Indonesia

Email Address: harryhardiansakti@untad.ac.id

*Corresponding Author, Submitted: 30 April 2025, Revised: 14 Aug. 2025, Accepted: 24 Sept. 2025

ABSTRACT: *The record of disasters in coastal areas that have occurred in Bulukumba Regency is the tsunami event due to an earthquake on December 29, 1820. The epicenter in the Flores Sea and the death toll in Bulukumba Regency at that time reached around 500 people. This event needs to be an early preparedness because tectonic disasters have the potential for a period of repetition. The purpose of this study is to analyze the tsunami hazard level and formulate coastal spatial planning policies based on the potential tsunami hazard of Bulukumba Regency. The methods used are statistical, descriptive qualitative, and spatial analysis approaches. The parameters used in determining the tsunami hazard level are earthquake hazard level, land elevation, slope, distance from rivers, and morphology. The results show that the coastal area is predominantly classified into low- and medium-hazard categories. Low-hazard zones occupy the largest spatial extent (notably Gantarang: 16,659.42 ha; Ujung Loe: 14,535.05 ha), while medium-hazard zones are more spatially limited but concentrated in critical locations (e.g., Bonto Bahari: 732.35 ha; Kajang: 423.06 ha; Herlang: 365.75 ha). Under a worst-case seismic scenario (7.0–7.5 Mw), the potentially affected area is estimated at 19,784 ha (25.85% of the coastal land area), with an exposure of >67,000 buildings, predominantly in Ujung Bulu (42,213 buildings). These findings have direct implications for the Regional Spatial Plan (RTRW). We recommend (1) restricting new development in identified medium-/high-exposure coastal segments, (2) designating Temporary Evacuation Sites (TES) on topographically safe locations (slope > 2%), and (3) integrating evacuation routes with the existing urban road network to ensure rapid accessibility. By providing quantitative hazard maps and concrete policy recommendations, this study fills a critical gap between tsunami hazard assessment and coastal spatial planning in Bulukumba, offering an evidence base for resilience-building and further risk-focused research.*

Keywords: *coastal; hazard*; *spatial planning; tsunami*

1. INTRODUCTION

Coastal areas are the areas that are currently experiencing rapid development in terms of development [1], including Bulukumba Regency. The development of coastal areas of Bulukumba Regency is directed at optimal utilization in the development of tourism and fisheries [2]. Referring to the main objectives of sustainable development, the direction for the development of the tourism and fisheries sector in Bulukumba Regency would be even better if it was integrated with disaster studies as a form of effort to protect coastal area ecosystems from disaster threats. The integration of coastal spatial planning based on disaster studies is based on the placement of development priorities that provide protection and safety for the community in order to create harmony between the economy, environment, and social welfare [3].

One of the types of disasters that is synonymous with coastal areas is a geological disaster such as a tsunami. Tsunami is one of the natural disasters that can have a huge impact on the development of coastal areas [4]. Over the past 20 years, the country has experienced frequent devastating geological disasters that have caused significant loss of life and property [5]. Bulukumba Regency in particular, has also had a record of tsunami events due to the earthquake on December 29, 1820, with an epicenter in the Flores Sea and the victims who died in Bulukumba at that time reached around 500 people [6]. Bulukumba Regency has a historical record of a tsunami triggered by an earthquake on December 29, 1820, with its epicenter in the Flores Sea, which claimed approximately 500 lives [6]. This event demonstrates that the coastal area of Bulukumba is vulnerable to tsunami hazards. Pertiwi et al. [7] also reported that the Flores Sea tsunami in 1920 caused 2,500 people died, 500 people were missing, more than 500 people were injured and more than 5,000 people were displaced. The earthquake and tsunami also destroyed more than 18,000 homes. These data emphasize that although the 1820 tsunami in Bulukumba was a localized event with hundreds of casualties, the potential consequences today could be far greater due to increasing population density and coastal development.

Seismic events accompanied by secondary effects in the form of tsunami disasters are indeed classified as rare disasters, but each incident often costs far more lives. On a global scale in the last 3,500 years, deaths caused by tsunami disasters due to earthquakes were recorded at 600,000 and 260,000 of them were fatalities that occurred in the last 25 years [8]. This can be a form of initial preparedness for all local governments to build areas that are resistant to natural disasters such as tsunamis. Based on this, the purpose of this study is to analyze the level of tsunami hazard and conduct coastal spatial planning modeling based on the potential tsunami hazard of Bulukumba Regency.

2. MATERIALS AND METHODS

The research location was conducted in the coastal area of Bulukumba Regency. Referring to the zoning of coastal area boundaries in Law Number 1 of 2014, it is justified that the land boundary of coastal areas follows the administrative boundaries of the sub-district which includes Gantarang District, Ujung Bulu District, Ujung Loe District, Bonto Bahari District, Bonto Tiro District, Herlang District, and Kajang District. An overview of the research location is shown in Figure 1.

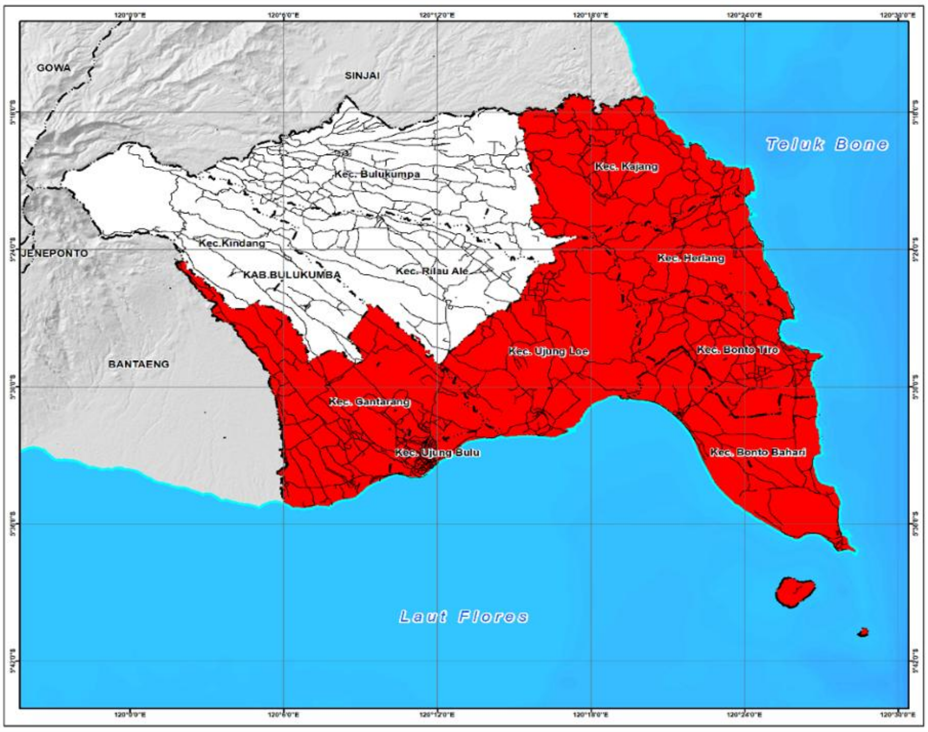


Figure 1. Research location in the coastal area of Bulukumba Regency

This study was designed using a multidisciplinary approach that integrates statistical, qualitative, and spatial analyses. The statistical approach was applied to calculate ground acceleration values and seismic parameters associated with tsunami potential. The qualitative approach was used to interpret and contextualize the statistical results, thereby providing a more comprehensive understanding of the findings. Meanwhile, the spatial approach was employed to visualize the integrated hazard assessment results in the form of maps that clearly represent the distribution of tsunami hazard levels across the study area.

The methodological framework was guided by the Disaster Risk Reduction (DRR) paradigm, particularly the Sendai Framework [9] for Disaster Risk Reduction, which emphasizes hazard identification, risk assessment, and integration into spatial planning. In this study, the analysis is deliberately focused on hazard assessment only, rather than a comprehensive risk analysis. This focus is based on the scientific premise that hazard mapping constitutes the fundamental step in disaster studies, providing the geophysical baseline upon which exposure and vulnerability analyses can later be developed. Moreover, hazard data are relatively more accessible and measurable compared to social and economic vulnerability indicators, which remain limited in the Bulukumba context. By establishing a robust hazard assessment, this study lays the groundwork for subsequent research on tsunami risk that incorporates exposure and vulnerability dimensions. Importantly, the results of this hazard-focused analysis already provide essential inputs for integration into coastal spatial planning, serving as an initial yet crucial stage in mainstreaming disaster considerations into regional development policies.

The data employed in this research consisted of both primary and secondary sources. Primary data were obtained through direct observations of land use conditions and limited field surveys. Secondary data included earthquake catalogs from BMKG [10] and USGS [11], the national elevation dataset (DEMNAS) provided by BIG, and high-resolution satellite imagery from Digital Globe. To ensure data reliability, DEM data were validated against ground control points, while seismic data were cross-checked with official records from BMKG and USGS.

Spatial analyses were conducted using ArcGIS 10.8, with the Weighted Overlay technique applied to integrate multi-criteria parameters. Statistical analyses and tabulation were carried out using Microsoft Excel. This approach allowed each parameter to be assigned an appropriate weight according to its relative contribution to tsunami hazard, ensuring that the analysis reflects the differential significance of each factor as supported by existing literature.

The assessment of tsunami hazard levels was based on six parameters: earthquake hazard, morphology, slope, elevation, distance from rivers, and distance from the coastline. The selection of these parameters was not arbitrary but rather grounded in previous studies [8, 12, 13, 14, 15; 16, 17], which consistently identified them as the most influential physical determinants of tsunami hazard. Details of the tsunami hazard level assessment parameters used in this study are outlined in Table 1.

Table 1. The parameter of tsunami hazard criteria

No	Parameter	Criteria	Score	Level of Hazard	Source
1	Earthquake hazard	>0,70 gal	1	High	BMKG
		0,2501-0,70 gal	2	Medium	
		< 0,2501 gal	3	Low	

No	Parameter	Criteria	Score	Level of Hazard	Source
2	Morphology	Lowland	4	High	DEMNAS BIG
		Sloping	3	Medium	
		Hills	2	Low	
		Mountains	1	Very low	
3	Slope	0-3%	5	Very high	DEMNAS BIG
		3-8%	4	High	
		8-15%	3	Medium	
		15-25 %	2	Low	
		>25%	1	Very low	
4	Elevation	0-10 m	3	High	DEMNAS BIG
		10-15 m	2	Medium	
		>15 m	1	Low	
5	Distance from the river	0-100 m	3	High	Satellite imagery interpretation Digital Globe USGS and field survey
		100-200 m	2	Medium	
		>200 m	1	Low	
6	Distance from the coast	<250 m	4	High	Satellite imagery interpretation Digital globe USGS and field survey
		250-500 m	3	Medium	
		500-1000 m	2	Low	
		>1000 m	1	Very low	

Source: Reis et al. [8], Mili et al. [12], Oktaviana et al. [13], Akbar et al. [14], Latue et al. [15], Hasan et al. [16], Fachri et al. [17]

3. RESULTS AND DISCUSSIONS

Bulukumba Regency is one of the regencies in South Sulawesi Province which is approximately 153 km2 from the capital city of South Sulawesi Province. The area of Bulukumba Regency is 1,154.58 km2 and the population is 440,090 people [18]. Bulukumba Regency has 10 sub-districts, 27 sub-districts, and 109 villages. Geographically, Bulukumba Regency is located at coordinates between 05° 20′ - 05° 40′ South Latitude (LS) and 119° 58′ - 120° 28′ East Longitude (BT). The administrative boundaries are: To the north it borders Sinjai Regency The south is bordered by the Flores Sea the east is bordered by Bantaeng Regency To the west it borders Bone Bay The area of Bulukumba Regency is 1154.58 km^2 or about 2.5% consisting of 10 sub-districts and is divided into 27 villages and 109 villages. In terms of area, Gantarang and Bulukumpa Districts are the two largest sub-districts, covering an area of 173.51 km^2 and 171.33 km^2 respectively. The smallest district is Ujung Bulu district which is the center of the regency city with an area of 14.44 km^2 or only 1%. Furthermore, the coastal area of Bulukumba Regency has an area of 726.67 km^2 or 72,667 hectares. The coastal area is located in seven districts, namely Gantarang District with an area of 175.84 km^2, Ujung Bulu with an area of 14.63 km^2, Ujung Loe with an area of 146.25 km^2, Bonto Bahari with an area of 110.06 km^2, Bonto Tiro with an area of 79.39 km^2, Kajang with an area of 130.79 km^2, and Herlang with an area of 69.71 km^2. The percentage area of each location is presented in Figure 2. The basic physical aspects of Bulukumba Regency which is a parameter of the tsunami hazard level includes the earthquake hazard level, altitude, slope

slope, morphology, distance from the river, and

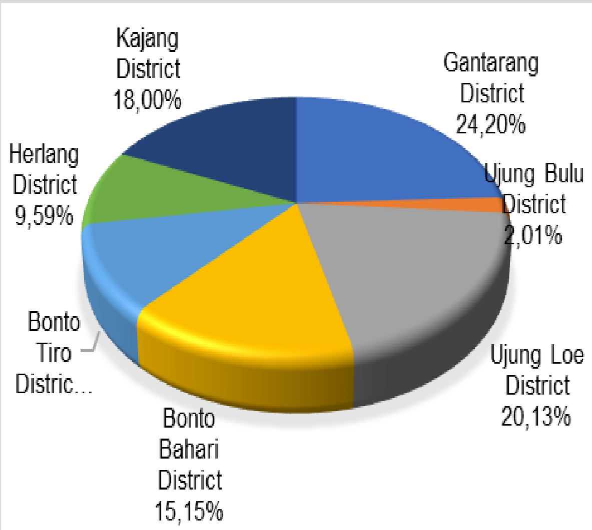


Figure 2. Percentage of coastal area of Bulukumba Regency

distance from the coastline, as shown in Figure 3. The condition of the earthquake hazard level in Bulukumba Regency based on the results of research by Ahmad et al. [19] has a hazard value of 67.00-120.86 gal. The slope condition in the coastal area of Bulukumba Regency is 0-8%. Morphological conditions in the coastal area of Bulukumba Regency include flat areas and gently sloping hills. Altitude conditions in the coastal area of Bulukumba Regency are 25-150 meters above sea level (masl). The distance from the river of the coastal area of Bulukumba Regency is relatively close because each sub-district area is drained by a river. The distance of the mainland to the coastline, ranging from 0-1000 meters.

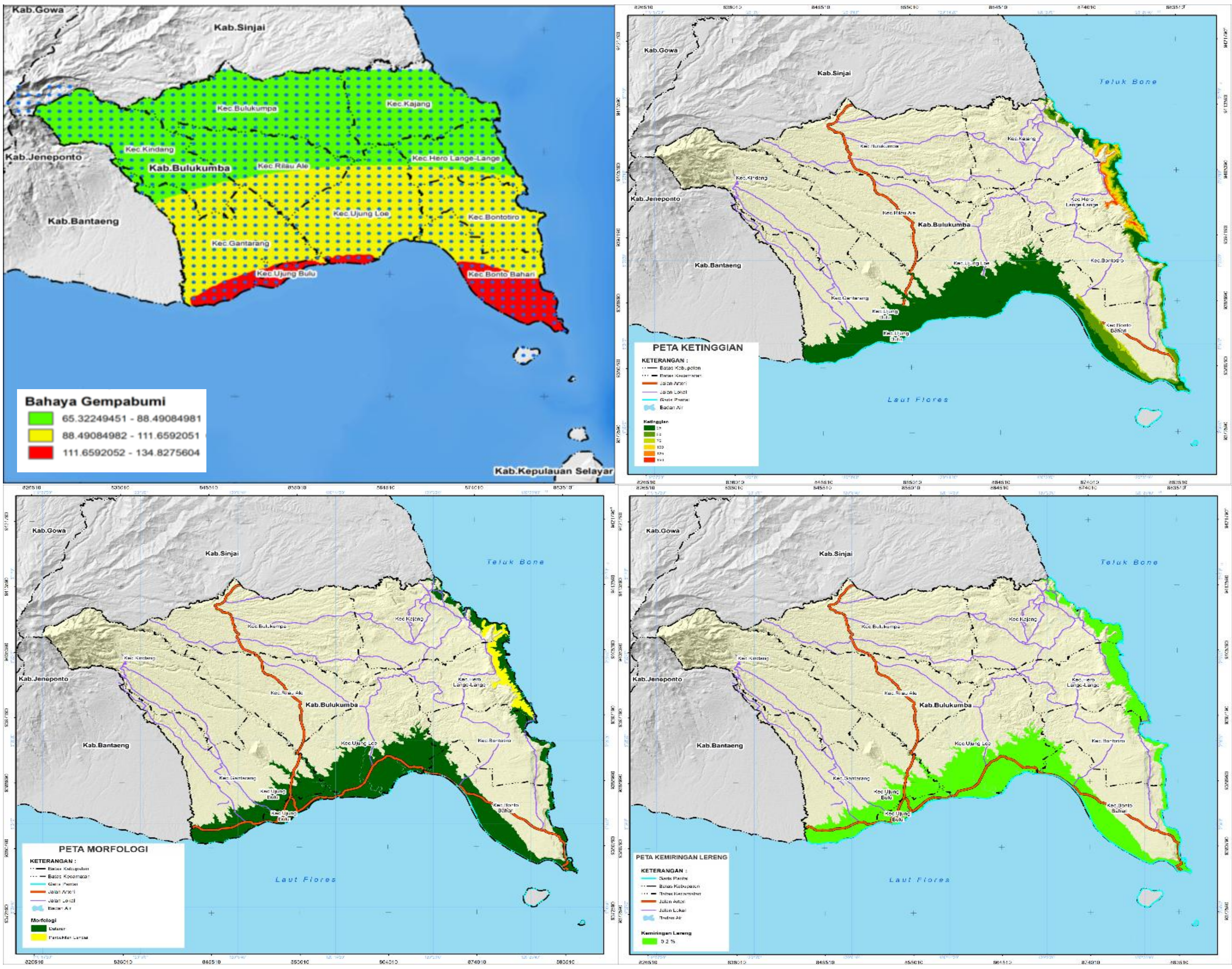
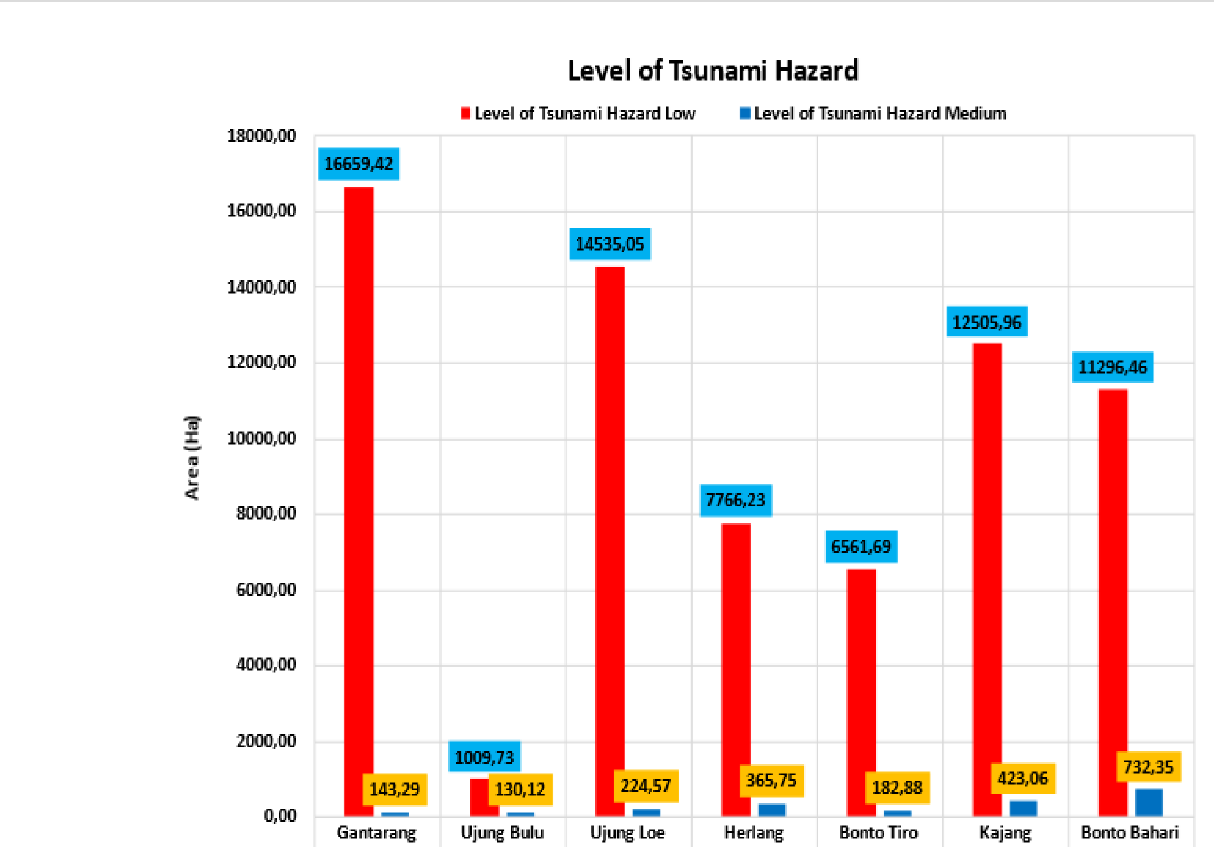


Figure 3. The basic physical condition of Bulukumba Regency as a tsunami parameter

The results of spatial analysis that have been carried out show that; (1) conversion of earthquake hazard value of Bulukumba Regency to tsunami hazard parameters is included in the category of high hazard class; (2) the condition of the height of the coastal area of Bulukumba Regency has a high hazard class category; (3) the slope condition of the coastal area of Bulukumba Regency has a high hazard class category; (4) the morphological condition of the coastal area of Bulukumba Regency has a high hazard class category; (5) the distance condition from the river has a high hazard class category, and the distance from the shoreline, and (6) the distance condition from the coast has a high hazard class category. Based on the results of clustering the tsunami hazard parameter score, it is justified that the coast of Bulukumba Regency has a medium and low tsunami hazard level.

As illustrated in Figure 4, the tsunami hazard analysis indicates that the coastal areas of Bulukumba Regency are predominantly classified into the low-hazard category, with the largest extents found in Gantarang (16,659.42 ha) and Ujung Loe (14,535.05 ha), followed by Kajang (12,505.96 ha) and Bonto Bahari (11,296.46 ha). In contrast, the smallest extent of low-hazard areas is recorded in Ujung Bulu (1,009.73 ha), which represents the most urbanized district. The medium-hazard zones occupy relatively smaller areas, with the largest extents located in Bonto Bahari (732.35 ha), Kajang (423.06 ha), and Herlang (365.75 ha), while the smallest is in Ujung Bulu (130.12 ha). Although spatially limited, these medium-hazard zones are highly critical as they frequently overlap with densely populated settlements, thereby increasing the potential risk in the event of a tsunami.



	Gantarang	Ujung Bulu	Ujung Loe	Herlang	Bonto Tiro	Kajang	Bonto Bahari
Level of Tsunami Hazard Low	16659,42	1009,73	14535,05	7766,23	6561,69	12505,96	11296,46
Level of Tsunami Hazard Medium	143,29	130,12	224,57	365,75	182,88	423,06	732,35

Figure 4. Tsunami Hazard Potential in Bulukumba Regency

The accumulated hazard category scores further suggest a significant potential for tsunami inundation in Bulukumba's coastal region. The estimated inland inundation distance corresponds to slope conditions of 0–2%, with inundation heights ranging between 3.16 and 5.62 meters. These estimates are consistent with the empirical model of Agussaini et al. [20], who identified a quantitative relationship between earthquake magnitude and tsunami inundation height: a 7.0 Mw earthquake may generate an inundation height of 3.16 m, a 7.5 Mw event 5.62 m, an 8.0 Mw event 10.02 m, an 8.5 Mw event 17.82 m, and a 9.0 Mw event up to 31.69 m. Historical seismic records from USGS and BMKG (1921–2023) confirm that earthquakes around Bulukumba have reached magnitudes of 7.0–7.5 Mw. Under this worst-case scenario, the potentially affected area is estimated at 19,784 hectares, equivalent to 25.85% of the total coastal land area of Bulukumba Regency. The distribution of exposed buildings within these hazard zones is presented in Figure 5.

These findings are also consistent with those of Pertiwi et al. [7], who emphasized the high seismic potential of the Flores Sea, with magnitudes reaching up to M 7 SR, capable of generating tsunamis in surrounding regions including Bulukumba. Their study estimated that the potential tsunami inundation area in Bulukumba could cover 13.617 km², with Ujung Bulu District identified as the most at-risk area due to its dense urban character, experiencing an estimated inundation of 3.331 km². Furthermore, they mapped a total of 355.003 km² of coastal areas potentially exposed to tsunami hazards, distributed across six districts: Gantarang (132.726 km²), Bulukumpa (0.9425 km²), Bonto Bahari (114.569 km²), Bonto Tiro (23.206 km²), Ujung Bulu (27.784 km²), and Ujung Loe (55.773 km²).

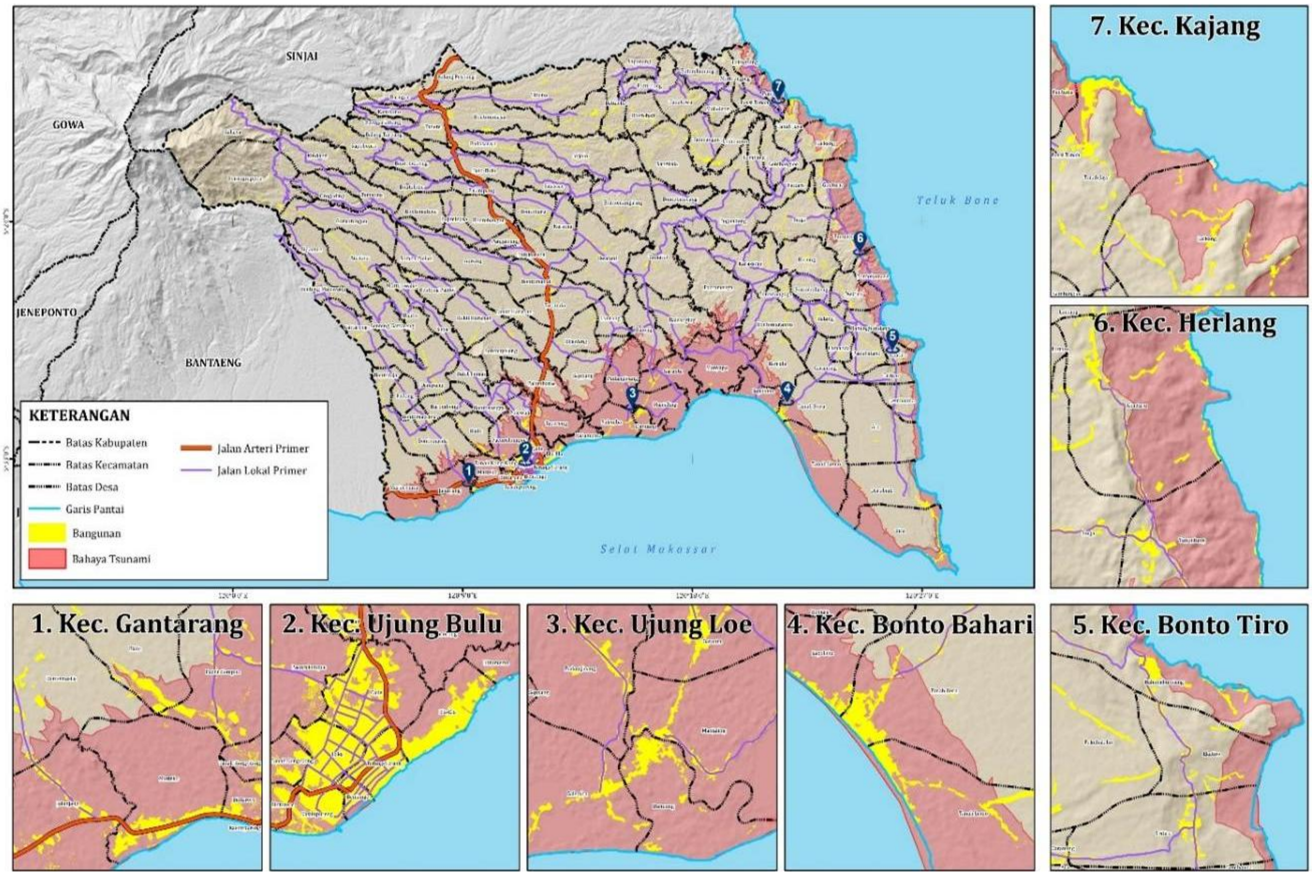


Figure 5. Distribution of buildings potentially affected by tsunami hazards

Figure 5 shows that the area with the highest building density is located in Ujung Bulu District. This is because Ujung Bulu District is the city center of Bulukumba Regency. Details of the number of buildings potentially affected by tsunami hazards are presented in Table 2.

Table 2. Total building distribution that affected tsunami hazard potential

No	District	Building Distribution (Unit)		
		Not Prone	Prone	Total
1	Gantarang	9.611	14.368	23.979
2	Ujung Bulu	0	42.213	42.213
3	Ujung Loe	10.208	2.275	12.483
4	Bonto Bahari	7.505	2.895	10.400
5	Bonto Tiro	9.846	205	10.051
6	Herlang	8.777	308	9.085
7	Kajang	11160	584	11.744

Source: Analysis Results, 2023

Information on the pattern of relationship between the strength of this earthquake and the height of tsunami inundation can be a form of initial preparedness steps to build community capacity to face tsunami hazards. Based on these potential hazards, the spatial planning model initiated as an effort to reduce the level of vulnerability is preparing temporary evacuation sites (TES) and designating evacuation routes. As a result of adopting research from Widyatuty *et al*. [21] regarding the lingkage approach, the determination of evacuation routes and temporary evacuation sites is also based on the spatial lingkage. The result of spatial linkage approach for spatial planning for coastal area in Bulukumba Regency presented in Figure 6.

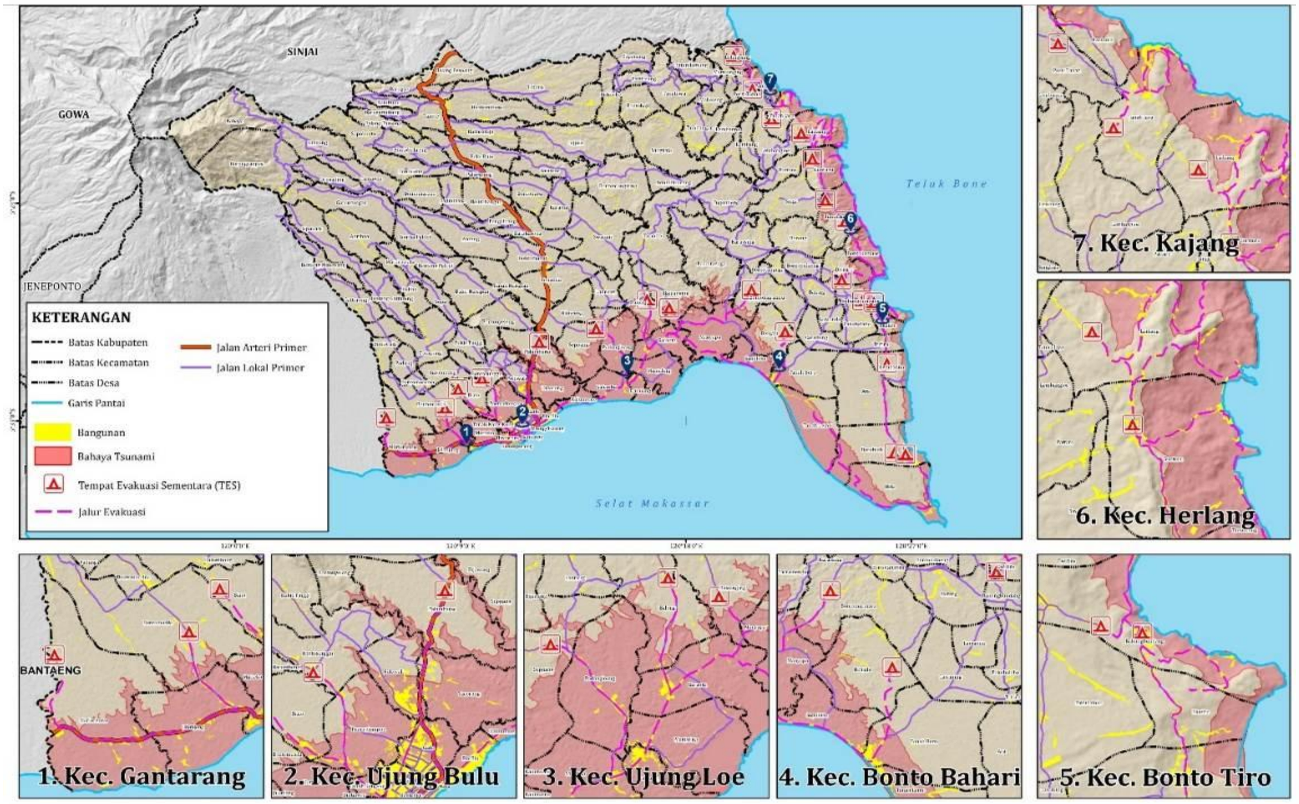


Figure 6. Spatial planning model based on potential tsunami hazard

Figure 6 illustrates that the determination of evacuation routes in Bulukumba Regency relies on the main road network, which ensures accessibility for residents across sub-districts. Temporary Evacuation Sites (TES) are strategically located in areas with topographic slopes greater than 2%, as these locations already provide a relatively safe distance from the coastline. The designated TES include vacant land as well as selected public and social facilities situated on elevated contours, thereby offering safer ground for temporary refuge during tsunami emergencies.

These spatial arrangements have direct implications for spatial planning (RTRW), particularly in regulating development within high-hazard coastal zones, integrating evacuation routes with the urban transportation system, and systematically designating safe zones as TES. Aligning tsunami hazard maps with development zoning is essential not only for reducing population and infrastructure exposure but also for ensuring the availability and accessibility of evacuation infrastructure critical for community safety.

By integrating hazard zoning results with magnitude–inundation modeling and previous inundation studies, this research contributes to a more comprehensive understanding of tsunami hazards in Bulukumba Regency. Although low-hazard areas dominate spatially, the presence of medium-hazard zones and the concentration of exposure in densely urbanized settlements—especially in Ujung Bulu—highlight the urgent need for disaster-informed spatial planning. Consequently, incorporating tsunami hazard maps into the Regional Spatial Plan (RTRW) of Bulukumba becomes indispensable, with implications for development control in high-risk areas, the designation of TES, and the reinforcement of evacuation infrastructure as part of long-term disaster risk reduction strategies.

When compared with other major tsunami events in Indonesia, such as Aceh in 2004 [22], Pangandaran in 2006 [23], and Palu in 2018 [24], the potential tsunami hazard in Bulukumba is of lower magnitude but presents similar levels of coastal vulnerability and exposure. These comparative insights emphasize the critical importance of integrating hazard maps into spatial planning frameworks to prevent the pitfalls experienced in other regions, where inadequate integration of hazard information into development policies contributed to high casualty rates.

4. CONCLUCIONS

This study concludes that the coastal areas of Bulukumba Regency are predominantly classified into medium and low hazard zones, with spatial variations that intersect with densely populated urban settlements, particularly in Ujung Bulu District. The findings highlight the urgent need to integrate tsunami hazard maps into the Regional Spatial Plan (RTRW) of Bulukumba, with concrete implications for spatial policy. These include (i) restricting new development in identified medium-/high-exposure coastal segments, (ii) designating Temporary Evacuation Sites (TES) on topographically safe locations (slope > 2%), and (iii) integrating evacuation routes with the existing urban road network to ensure rapid accessibility.

The incorporation of these hazard assessments into RTRW will allow the government to strengthen disaster-informed development zoning, regulate land use in coastal areas, and prioritize investment in critical evacuation infrastructure. Furthermore, this study provides an important scientific basis for reducing exposure and enhancing the resilience of coastal communities in Bulukumba Regency.

Nevertheless, several limitations should be acknowledged. The present analysis does not incorporate probabilistic tsunami simulations, which would provide more dynamic estimates of inundation probability under different seismic scenarios. In addition, social vulnerability indicators such as population density, socioeconomic status, and adaptive capacity were not integrated into the hazard assessment. Future research should therefore combine probabilistic hazard modeling with social vulnerability analysis to develop a more comprehensive tsunami risk assessment, which can further strengthen spatial planning policies in Bulukumba and other coastal regions.

ACKNOWLEDGMENTS

The author's gratitude is addressed to the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) for funding. This research is in the novice lecturer research scheme with Master Contract Number 185/E5/PG.02.00.PL/2023.

REFERENCES

[1] Yurnita A, Trisutomo S, Ali M. (2017). Model Reklamasi Pantai Secara Berkelanjutan. Kasus: Pantai Kota Makassar. Jurnal Tata Loka Vol. 19 No. 4.
[2] [BAPPELITBANGDA] Badan Perencanaan, Pembangunan, Penelitian, dan Pengembangan Daerah Kabupaten Bulukumba. Peraturan Daerah Kabupaten Bulukumba Nomor 12 Tahun 2012 tentang Rencana Tata Ruang Wilayah (RTRW) Kabupaten Bulukumba Tahun 2012-2032. *Edisi Revisi RTRW Tahun 2021*.
[3] Utami W. (2021). Analisis Rencana Tata Ruang Wilayah pada Wilayah Pesisir Rawan Tsunami (Studi Pesisir Aceh, Banten, dan Palu). Jurnal Tata Loka Vol. 23 No. 4.
[4] Majid RN dan Nurlambang T. (2020). Pandeglang regency spatial evaluation based on tsunami hazard potential. E3S Web of Conferences 156. DOI: org/10.1051/e3sconf/202015604010.
[5] Nugroho WF, Sagara A, Imran I. (2022). The evolution of Indonesian seismic and concrete building codes: From the past to the present. Structures Volume 41. pp. 1092-1108. DOI: 10.1016/j.istruc.2022.05.032.
[6] Daryono. (2021). Sejarah Gempa bumi dan tsunami sejak tahun 1800an di Busur Kepulauan Sunda Kecil, Nusa Tenggara Barat, dan Nusa Tenggara Timur. https://wartabulukumba.pikiran-rakyat.com/nasional/pr-873235178/sejarah-gempa-bumi-di-sulawesi-selatan-bulukumba-pernah-dilanda-tsunami-29-desember-1820.
[7] Pertiwi, Imanuela Indah., Fattah, M. Hattah., Rauf, Abdul. (2018). Estimasi Kawasan Terdampak Tsunami dan Mitigasi Bencana Kabupaten Bulukumba. Jurnal Geofisika. (Vol. 16 No. 01), pp 2-8.
[8] Reis C, Lopes M, Baptista MA, Clain S. (2022). Towards an integrated framework for the risk assessment of coastal structures exposed to earthquake and tsunami hazards. Resilient Cities and Structures I Volume 1 Issue 2, pp 57-75. DOI: 10.1016/j.rcns.2022.07.001.
[9] [UNDRR]. (2015). Sendai Framework for Disaster Risk Reduction 2015–2030. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030.
[10] [BMKG]. (2024). Catalog of Earthquake Periods 1991-2024.
[11] [USGS]. (2024). Catalog of Earthquake Periods 1921-1990.
[12] Mili RR, Hosseini KA, Yasamin OI. (2018). Developing a holistic model for earthquake risk assessment and disaster management interventions in urban fabrics. International Journal of Disaster Risk Reduction Vol. 27, pp 355-365. DOI: 10.1016/j.ijdrr.2017.10.022.
[13] Octaviana O, Dewi PU, Wahdini M, Prasiamratri N, Alghiffarry MB,Utami NA. (2020). Aplikasi SIG Untuk Pemetaan Zona Tingkat Bahaya Dan Keterpaparan Permukiman Terhadap Tsunami Kota Denpasar. Jurnal Geosains dan Remote Sensing Vol. 1 No. 2, pp. 80-88. DOI: 10.23960/jgrs.2020.v1i2.28.
[14] Akbar FS, Vira BA, Doni LR, Putra HE, Efriyanti A. (2020). Aplikasi Metode *Weighted Overlay* Untuk Pemetaan Zona Keterpaparan Permukiman Akibat Tsunami (Studi Kasus: Kota Bengkulu dan Kabupaten Bengkulu Tengah). Jurnal Geosains dan Remote Sensing Vol. 1 No. 1, pp. 43-51. DOI: 10.23960/jgrs.2020.v1i1.17.

[15] Latue PC dan Rakuasa H. (2022). Dinamika Spasial Wilayah Rawan Tsunami di Kecamatan Nusaniwe Kota Ambon, Provinsi Maluku. Jurnal Geosains dan Remote Sensing Vol. 3 No. 2, pp. 77-87. DOI: 10.23960/jgrs.2022.v3i2.98.
[16] Hasan MFAW, Tjahjono B, Mansyur. (2023). Evaluasi pola ruang kawasan permukiman Kota Palu pasca bencana Tsunami Tahun 2018. Dipresentasikan pada Seminar Hasil Sekolah Pascasarjana IPB University: Bogor.
[17] Fachri HT, Malik Y, Murtianto. (2022). Pemetaan tingkat bahaya bencana tsunami menggunakan sistem informasi geografis di Pesisir Kota Bengkulu. Jurnal Pendidikan Geografi Undiksha Volume 10, no. 2, pp. 166-178. DOI: 10.23887/jjpg.v10i2.43541.
[18] [BPS]. Badan Pusat Statistik Kabupaten Bulukumba. 2022. Kabupaten Bulukumba dalam Angka 2022.
[19] Ahmad DNA, Tarigan SD, Tjahjono B., Sitanggang IS, Sakti HH. (2023). The relationship between peak ground acceleration and landform for earthquake hazard assessment in Bulukumba Regency. IOP Conference Series: Earth Environmental Science 1266:012051. DOI: 10.1088/1755-1315/1266/1/012051.
[20] Agussasini H, Sirojuzilam S, Rujiman R, Purwoko A. (2022). A new approach of the Tsunami Mitigation Strategies for the City of Banda Aceh, Indonesia. Indonesian Journal of Geography Vol. 54. No. 1, pp.62-69. DOI: 10.22146/ijg.66500.
[21] Widyastuty AASA, Rukmana SN, Shofwan M, Waisnawayadnya AAGK. (2024). Distribution Patterns and Spatial Relationships in the Perspective of Tourism Destination Typology. Local Wisdom, 16 (1), pp. 37-51.
[22] Sakdiah H, Mauliza E. (2023). Pemulihan Pasca Tujuh Belas Tahun Tsunami Aceh dari Tinjauan Sosial dan Ekonomi pada Masyarakat Kota Banda Aceh. Jurnal Sains Riset Vol. 13 No. 1, pp. 140-149. DOI: 10.47647/jsr.v10i12.
[23] Lestari AS, Muzani M, Setiawan C. (2023). Mitigasi Bencana Tsunami Pantai Pangandaran, Jawa Barat. Jurnal Pendidikan dan Ilmu Geografi Vol. 8 No. 1, pp. 55-62.
[24] Fauzi M, Mussadun M. (2021). Dampak Bencana Gempabumi dan Tsunami di Kawasan Pesisir Lere Kota Palu. Jurnal Pembangunan Wilayah dan Kota Vol. 17 No. 1, pp.16-24. DOI: 10.14710/pwk.v17i1.29967.