

# LAND AND SEA INTEGRATION FOR DISASTER MITIGATION-BASED SPATIAL PLANNING IN COASTAL AREAS: A CASE STUDY IN TANAH LAUT REGENCY, SOUTH BORNEO, INDONESIA

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## Abstract

Coastal regions face multifaceted challenges, primarily concerning susceptibility to natural disasters and environmental degradation, compounded by the lack of integrated terrestrial and marine spatial planning. This research aims to analyze the integration of disaster mitigation-based land and sea spatial planning in Tanah Laut Regency, South Kalimantan, utilizing both qualitative and quantitative approaches. The study focuses on the coastal areas of Tanah Laut Regency, characterized by an extensive coastline divided into two distinct zones: West and South. This study examines disaster potential within the coastal region by integrating disaster risk analyses in terrestrial areas with the Coastal Vulnerability Index (CVI) in marine areas. The findings indicate that Tanah Laut Regency exhibits a considerably high level of disaster risk, both on land and in the sea. Protected areas, such as water bodies, mangrove ecosystems, and protected forests, predominantly occupy regions with moderate to high terrestrial disaster risk. Cultivated areas, particularly plantations, settlements, and food crops, also occupy a significant portion of areas with moderate to high terrestrial disaster risk. This research provides specific recommendations for each sub-district in Tanah Laut Regency, based on disaster risk levels and coastal typologies. These recommendations include mangrove restoration and conservation, relocation of settlements in disaster-prone zones, implementation of disaster-resilient building codes, and development of community-based ecotourism.

Keywords: spatial planning, disaster mitigation, coastal regions, Tanah Laut Regency, Coastal Vulnerability Index (CVI).

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## Introduction

Coastal regions constitute complex and dynamic ecosystems, playing a crucial role as hubs of economic, social, and ecological activities [1]. Economically, these regions support vital sectors such as fisheries, tourism, and maritime transportation [2]. Socially, they serve as home to millions of residents and contribute to the preservation of community cultural heritage [3]. Ecologically, coastal areas exhibit high biodiversity and provide essential ecosystem services, including coastal protection, flood regulation, and carbon sequestration [4]. However, their geographical positioning at the interface of land and sea renders them vulnerable to a variety of natural disasters, such as abrasion, tidal flooding, tsunamis, and storms [5]. Tanah Laut Regency, with its extensive 72 km coastline [6], faces significant challenges concerning

coastal disaster vulnerability, potentially leading to infrastructure damage, economic losses, and even fatalities [7].

Spatial planning in the coastal region of Tanah Laut Regency faces challenges in integrating terrestrial and marine aspects, thereby exacerbating vulnerability to disasters and environmental degradation [8]. Land-use conversion in upstream areas, such as deforestation for palm oil plantations, leads to increased erosion and sedimentation in coastal zones [9]. Excessive sedimentation results in the shallowing of river estuaries, creating transitional waters (i.e., brackish zones blending freshwater and seawater) [10], mangrove ecosystem damage, and heightened risks of tidal flooding [11]. Furthermore, infrastructure development in coastal areas, including settlements and tourism facilities, often neglects disaster potential and environmental carrying capacity [12]. This is evidenced by numerous infrastructure systems and buildings erected in disaster-prone zones [13], such as along coastlines susceptible to abrasion and tsunamis, thereby escalating the risk of damage and loss of life during disasters.

Given the vulnerability of coastal regions to natural disasters, the integration of disaster mitigation into spatial planning is crucial for risk reduction and the promotion of sustainable development [8]. A disaster mitigation approach not only focuses on post-disaster management, such as evacuation and reconstruction, but also on prevention and risk reduction through comprehensive spatial planning [14]. This includes the identification and mapping of hazard zones, the establishment of protection zones like protected areas and coastal buffer zones, and the implementation of disaster-resilient building standards [13]. By integrating disaster mitigation into spatial planning, it becomes possible to minimize disaster-induced losses, safeguard communities and valuable assets, and achieve resilient and sustainable coastal regional development [15].

Tanah Laut Regency, with its extensive coastline and rich coastal ecosystems, serves as a strategic location for examining the integration of disaster mitigation-based terrestrial and marine spatial planning [6]. This region faces various challenges, including increased coastal disaster risk, mangrove ecosystem degradation, and land-use conflicts [6]. Therefore, this study aims to analyze the integration of disaster mitigation-based land and sea spatial planning in Tanah Laut Regency, employing both qualitative and quantitative approaches. Primary data were collected through field observations, and document reviews, while secondary data were obtained from government statistics and scholarly literature. Data analysis involved policy analysis, spatial analysis using Geographic Information Systems (GIS), and disaster vulnerability assessments. The findings of this research are expected to provide recommendations to local authorities for enhancing the effectiveness of integrated terrestrial and marine spatial planning to reduce disaster risks and support sustainable development in coastal regions.

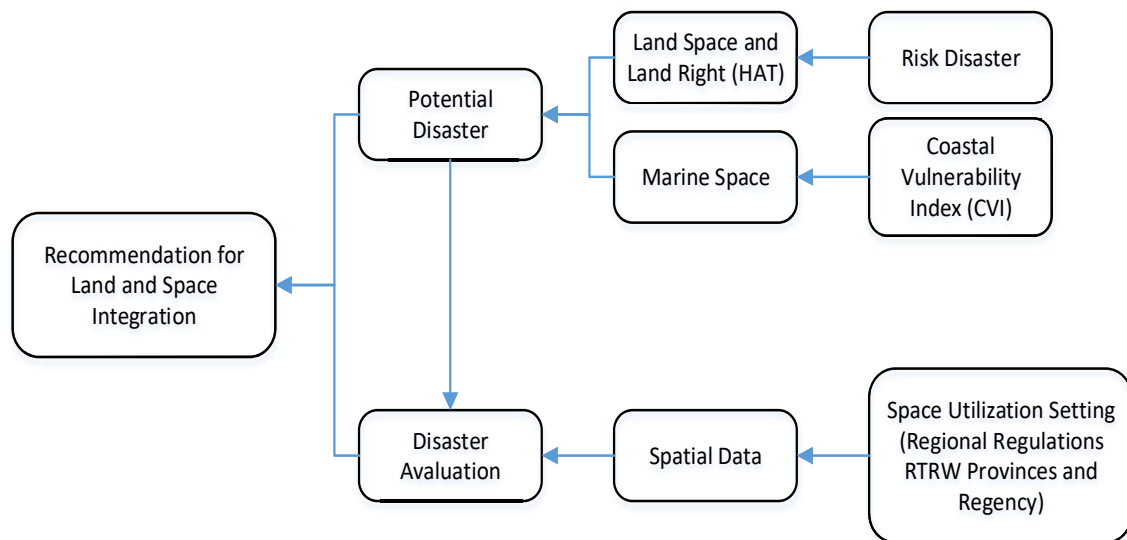
While the integration of terrestrial and marine spatial planning has been extensively discussed in the literature [16], studies that specifically analyze this integration with an emphasis on disaster mitigation in Tanah Laut Regency remain limited. Most previous research has focused on specific aspects such as coastal vulnerability [7], [17], [18] or coastal resource management [3], [19], while comprehensive studies linking spatial planning [20], disaster

mitigation, and the specific characteristics of Tanah Laut Regency are lacking. Therefore, this research offers novelty by conducting an in-depth analysis of the integration of disaster mitigation-based terrestrial and marine spatial planning in Tanah Laut Regency, considering local factors such as land-use patterns, physical coastal characteristics, and local government policies. This study will also generate specific recommendations to enhance the resilience of Tanah Laut Regency's coastal regions to disasters.

**Methods**

The study area is located in the coastal region of Tanah Laut Regency, South Kalimantan, which features a coastline that forms a cape projecting into the Java Sea, thus dividing it into two coastal zones: West and South. Tanah Laut Regency encompasses six coastal sub-districts, namely Bumi Makmur, Kurau, Takisung, Panyipatan, Jorong, and Kintap, as illustrated in Figure 2. The landward research boundary is defined by geomorphology (landforms) that are still influenced by marine processes, while the seaward boundary extends 12 nautical miles from the coastline (based on Law No. 32 of 2014).

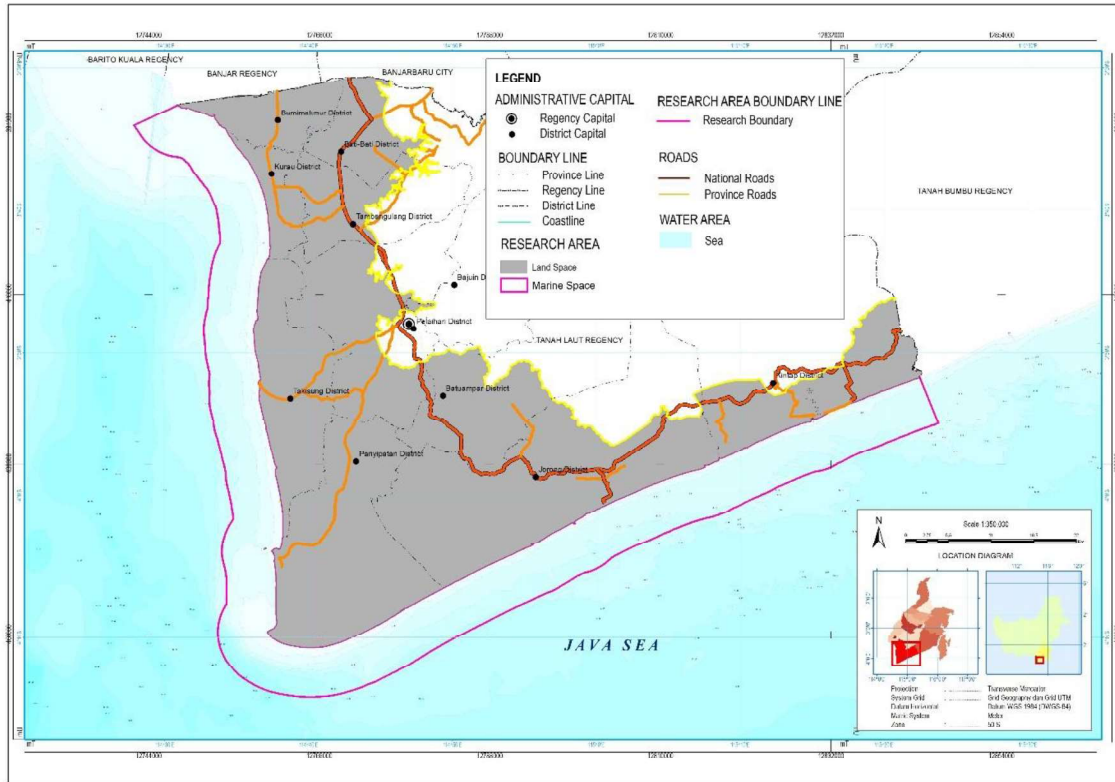
This study examines disaster potential in the coastal region by integrating terrestrial disaster risk analyses with the Coastal Vulnerability Index (CVI) for marine areas. Data collection was conducted through field surveys, secondary data analyses, and in-depth interviews with community members [21]. The CVI assessment included parameters such as geomorphology, beach slope, average tidal range, sea-level rise, abrasion and sedimentation rates, average wave height, bathymetry, and land-use changes [22]. A spatial evaluation of terrestrial and marine spatial plans was performed to identify their suitability concerning disaster potential [18]. The integration analysis of terrestrial and marine spaces was conducted through spatial analysis and qualitative descriptive methods.



Gambar 1. Integration Process Mindset

Oriented to the Indonesian context, specifically the coastal region of Tanah Laut Regency, South Borneo, this research (August-November 2024) conducted an integrated

analysis of terrestrial and marine spaces using quantitative spatial methods and qualitative descriptive approaches. This integration considered disaster risk levels [8], coastal typologies [23], [24], and land and sea spatial pattern directives presented in a comparative table to generate integration process recommendations [25]. The qualitative descriptive approach facilitated an in-depth understanding of the characteristics and dynamics of Tanah Laut's coastal regions [21], while the spatial analysis provided visualization and interpretation of spatial patterns related to disaster potential and land use [26].



**Gambar 3.** Oriented Area Research

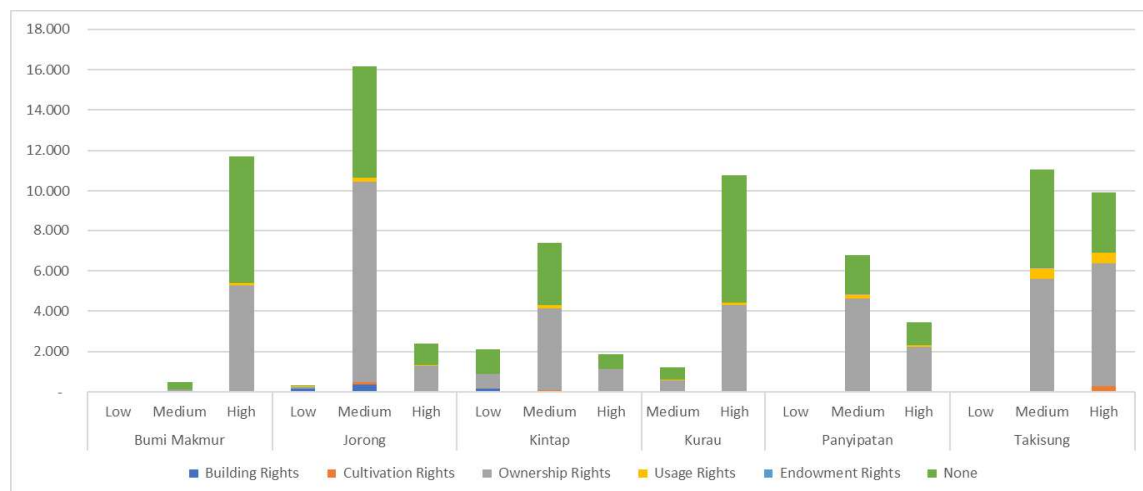
This study analyzed disaster potential in Tanah Laut Regency by mapping terrestrial disaster risks and coastal vulnerability (CVI) [22]. The disaster potential maps were overlaid with the Regional Spatial Plan (RTRW) maps of Tanah Laut Regency and South Kalimantan Province to evaluate and formulate the integration of terrestrial and marine spatial plans. Terrestrial spatial evaluation considered existing land use/land utilization and zoning regulation indicative directives, while marine spatial evaluation was based on marine spatial plan directives with a space utilization inventory [27]. The integration of terrestrial and marine spatial utilization plans was conducted descriptively based on previous case studies and related regulations (Ministerial Regulation of Marine Affairs and Fisheries No. 28 of 2021, Ministerial Regulation of Agrarian Affairs and Spatial Planning/National Land Agency No. 14 of 2021). The overlay of terrestrial and marine spatial pattern maps and coastal vulnerability levels resulted in spatial patterns that accommodated coastal disaster potential [28].

## Results

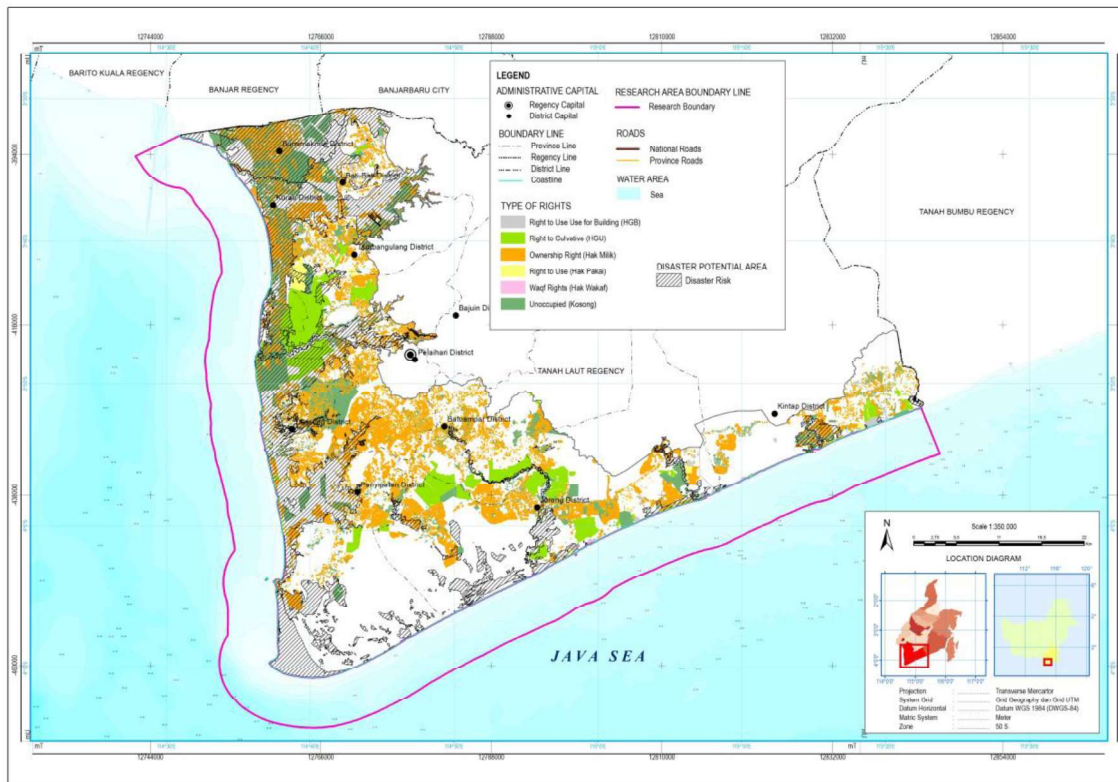
Spatial analysis of Land Rights (HAT) vulnerability encompasses the following: Ownership Rights (Hak Milik), which are heritable, strongest, and most complete land rights; Cultivation Rights (Hak Guna Usaha or HGU), which are rights to cultivate state land for agriculture, plantations, or livestock, with a 25-year term (renewable); Building Rights (HGB), which are rights to erect/own buildings on non-owned land, with a 30-year term (renewable); Usage Rights (Hak Pakai), which are rights to use/collect yields from state land or land owned by others, with a term as per agreement or regulations; and Endowment Rights (Hak Wakaf), which are rights to transfer owned land for social/religious purposes, valid indefinitely (Law No. 5 of 1960; Law No. 41 of 2004; and Government Regulation No. 18 of 2021). Blank data entries indicate data processing is ongoing by the National Land Agency.

The spatial analysis of Land Rights (HAT) vulnerability to tidal flooding in Tanah Laut Regency reveals significant variations among sub-districts. The high number of affected HAT in Panyipatan Sub-district corroborates research findings on the correlation between tidal flood vulnerability and factors such as coastal morphology, land use, and population density [15]. Panyipatan's geographical conditions, characterized by predominantly low-lying plains and settlement activities concentrated in coastal areas, amplify the potential impact of tidal flooding [5], [29].

Variations in the number of affected Land Rights (HAT) across sub-districts indicate differences in vulnerability levels and the effectiveness of mitigation strategies. Sub-districts with lower numbers of affected HAT, such as Bati-Bati, Batu Ampar, and Tambang Ulang, have likely implemented effective adaptation measures, such as the construction of flood control infrastructure or spatial planning that considers disaster risks [26]. However, further analysis is necessary to identify the specific factors influencing HAT vulnerability in each sub-district.



**Gambar 3.** Number of Land Rights (HAT) Types Affected by Tidal Flood Disaster Risk in Each Sub-district of Tanah Laut Regency (BPBD, 2023, BPN, 2023, and Data Processing, 2024)



**Gambar 3.** Overlay of Land Rights Types Affected by Tidal Flood Disasters in Coastal Areas of Tanah Laut Regency

The results of this study are divided based on the research objectives, namely the potential for disasters in terrestrial spaces and marine spaces, prior to their integration. The potential for coastal disasters (terrestrial spaces) was determined based on a study by the Regional Development Planning Agency in 2021 regarding disaster risks to terrestrial spaces and an analysis of the Coastal Vulnerability Index (CVI) for marine spaces, land-use changes, and a potential matrix. Factors contributing to and impacts resulting from coastal disasters were identified through field surveys and in-depth oral interviews with community and government stakeholders in the study area (Table 1).

Based on the overlay analysis of marine and terrestrial spatial pattern plans with disaster risks and coastal vulnerability in Tanah Laut Regency, South Kalimantan, several significant conclusions can be drawn. Firstly, protected areas such as water bodies, mangrove ecosystems, and protected forests dominate the land area in regions with moderate to high terrestrial disaster risks. This indicates that these areas play a crucial role in mitigating natural disasters, such as floods, landslides, and seawater intrusion [23]; Secondly, cultivated areas, particularly plantations, settlements, and food crops, also occupy a significant land area in regions with moderate to high terrestrial disaster risks. This suggests a potential conflict between economic interests and conservation in the region [30]; Thirdly, within marine protected areas, there is a trend that as coastal vulnerability increases, the area size decreases. This implies that the regions most vulnerable to coastal disasters (abrasion, inundation) receive less protection. Fourthly,

capture fisheries dominate the land area in regions with very low coastal vulnerability. This indicates that capture fishery activities tend to concentrate in areas relatively safe from coastal disasters [19].

Table 1. Overlay of Marine and Terrestrial Spatial Plans with Disaster Risk and Coastal Vulnerability Index (CVI)

No	TERRESTRIAL AND MARINE SPATIAL PLAN	Terrestrial Disaster Risk (Ha)	Indeks Kerentanan Pantai (Ha)	
		High	High	Very High
Protected Areas				
1	Water Bodies	863,92	-	-
2	Mangrove Ecosystem Area	1.212,52	-	-
3	Protected Forest Area	17,62	-	-
4	Local Protection Area	647,97	-	-
5	Wildlife Reserve	1.930,52	-	-
6	Natural Tourism Park	1.373,32	-	-
7	Marine Conservation Reserve Area	-	782,17	1.371,92
Cultivation Areas				
1	Horticultural Area	6,45	-	-
2	Permanent Production Forest Area	4.235,20	-	-
3	Convertible Production Forest Area	11,39	-	-
4	Tourism Area	267,38	18,24	-
5	Power Generation Area	12,33	-	-
6	Aquaculture Area	3.202,84	-	-
7	Capture Fisheries Area	-	834,02	174,10
8	Plantation Area	19.718,99	-	-
9	Rural Settlement Area	1.773,76	-	-
10	Urban Settlement Area	3.618,10	-	-
11	Defense and Security Area	428,22	-	-
12	Industrial Zone	664,78	-	-
13	Livestock Area	328,13	-	-
14	Food Crop Agriculture Area	23.610,53	-	-
15	Transportation Area	89,56	290,40	-

Source : Analysis Result 2024

Fifthly, industrial and livestock areas exhibit relatively small coverage compared to other areas, in terms of both terrestrial disaster risk and coastal vulnerability. Sixthly, several areas exhibit overlap between terrestrial disaster risks and coastal vulnerabilities, such as plantations and settlements. This indicates the need for an integrated approach in managing disaster risks in these regions. Seventhly, overall, this overlay analysis demonstrates that Tanah Laut Regency experiences a considerably high level of disaster risk, both on land and in the sea. Therefore, serious efforts are required to integrate terrestrial and marine spatial planning, considering aspects of disaster mitigation and adaptation.

Increased land-use changes along watershed areas have rendered South Kalimantan, particularly Tanah Laut Regency, highly vulnerable to flooding in terms of morphometry and

morphology. Flood disasters predominantly impact settlement, industrial, and agricultural areas, necessitating spatial planning regulations and recommendations that accommodate recurrent disasters and outline flood mitigation strategies in Tanah Laut Regency. For this study, the researcher's area of focus for risk analysis is limited to Cultivation Areas directly involving human activity, specifically rural settlements, urban settlements, tourism areas, power generation facilities, aquaculture areas, plantations, defense and security areas, industrial zones, livestock areas, food crop areas, horticultural areas, and transportation areas (Table 1).

The determination of coastal disaster potential in the western and southern regions of Tanah Laut Regency was conducted based on the Coastal Vulnerability Index. Areas exhibiting coastal vulnerability potential include both protected and cultural areas. Within protected areas, high coastal vulnerability potential is observed in marine conservation reserve zones (Table 1). In cultural areas, coastal vulnerability risk is present in tourism areas, industrial zones, and transportation areas. Based on the spatial analysis of terrestrial and marine Spatial Pattern Maps concerning disaster risks and the Coastal Physical Vulnerability Index, tourism areas and settlement activities are highly impacted, necessitating the development of zoning and spatial pattern directives to mitigate the impact of tidal flooding (ROB) accompanied by high waves.

Figure 5 provides a visual representation of the zoning or regional division in Bumi Makmur and Kurau Sub-districts. This map indicates that these regions possess diverse functions and potentials, ranging from conservation to industrial areas. The dominant land uses in these two sub-districts are fisheries and cultivated crops, followed by plantations and settlements. Bumi Makmur and Kurau Sub-districts are among the most severely affected areas (Figure 5). Based on the map and observed events, the proposed spatial patterns for marine and terrestrial areas include Marine Conservation Reserve Zones and mangrove ecosystems, adjusted to the muddy coastal conditions. Consequently, suitable mangrove species for muddy areas, such as *Rhizophora mucronata* and *Avicennia marina*, are recommended, as they thrive in these soil types [31]. Terrestrial areas are predominantly used for agriculture, with settlements located along collector and local sub-district roads, necessitating the planning of evacuation routes and sites. Spatial patterns in disaster-affected areas require specific arrangements based on high disaster risk levels.

The coastal region of Takisung Sub-district (Figure 6) encompasses diverse functions, ranging from protected areas such as protected forests and conservation zones to productive areas like agriculture, plantations, and fisheries. The dominant land uses are fisheries, agriculture, and plantations. This region falls under a high disaster risk category, characterized by shoreline changes and proximity to settlements with sandy beaches. Consequently, the addition of marine spatial patterns, specifically Marine Conservation Reserve Zones and Local Protection (Coastal Buffer Zones), is recommended to regulate and restrict land-use permits along the coast. For tourism areas, spatial planning can involve community participation in the development of tourism spaces during planning and implementation. Community involvement fosters a sense of ownership and responsibility for sustainable resource management and ensures successful tourism management [32], [33].

Panyipatan Sub-district (Figure 7), based on the map, indicates areas prone to flooding and tidal inundation, yet it exhibits very low coastal vulnerability. This suggests that spatial planning must consider natural factors such as topography and hydrology. Figure 5 reveals that the dominant terrestrial spatial plan comprises Production Forest Areas, Natural Tourism Parks, wildlife reserves, and marine areas designated for general capture fisheries. A religious tourism site, Datuk Island (Pulau Datu Pamulitan), is a small island located near Batakan Beach in Tanjung Dewa village, Panyipatan Sub-district, Tanah Laut, South Kalimantan. The island is named “Pulau Datuk” due to the presence of a datuk (sunan/Islamic propagator) tomb, known as “Datuk Pamulitan”.

The dominant land uses in Jorong Sub-district (Figure 8) include fisheries, transportation, and plantations. In this area, disaster-prone regions are predominantly located in estuary and riverbank areas, while the coastal vulnerability index remains in the low to moderate category. The dominant terrestrial spatial arrangement is Jorong Industrial Zone, with the existing Jorong Collector Port, and the marine spatial pattern comprises Capture Fisheries Areas and transportation route areas for port and specialized coal terminals. The coastal region of Jorong Sub-district features sandy beaches and high slopes, resulting in low risk of tidal flooding (ROB).

Given the dominance of industrial activities and coal port operations in Jorong Sub-district, the development of comprehensive zoning regulations for both terrestrial and marine spaces is essential. Although terrestrial spatial planning has considered disaster-prone areas, particularly flood risks, with measures such as early warning systems, drainage improvements, reservoir construction, and evacuation route provisions, disaster vulnerability aspects in marine spaces have not been specifically regulated.

In Kintap Sub-district (Figure 9), areas prone to high tidal flooding (ROB) predominantly occur within the terrestrial spatial patterns of Mangrove Ecosystem Zones and Aquaculture Areas. The coastal vulnerability, influenced by marine factors, falls into the low to moderate category. Consequently, zoning regulations for Mangrove Ecosystem Zones are not applied, as they fall within protected areas (Mahmud, et al., 2015). However, zoning regulations for Aquaculture Areas are implemented as specific provisions for high disaster-prone regions. Based on the conducted analyses, a map integrating terrestrial and marine spaces has been developed, as depicted in Figure 10.

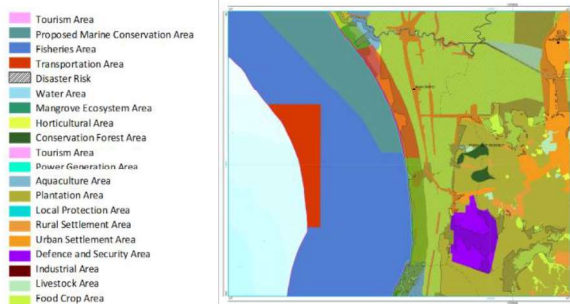


Figure 5. Integrated Terrestrial and Marine Spatial Plan of Bumi Makmur dan Kurau Sub-district

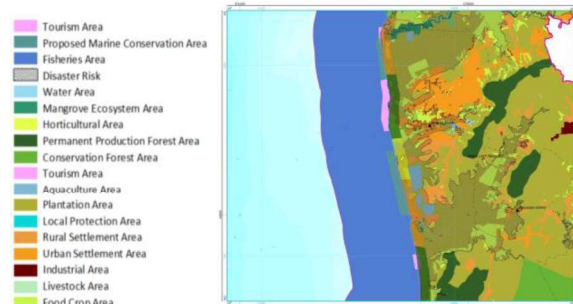


Figure 6. Integrated Terrestrial and Marine Spatial Plan of Takisung Sub-district



Figure 7. Integrated Terrestrial and Marine Spatial Plan of Panyipatan Sub-district

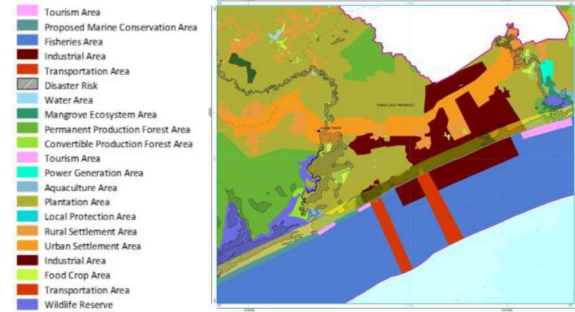


Figure 8. Integrated Terrestrial and Marine Spatial Plan of Jorong Sub-district

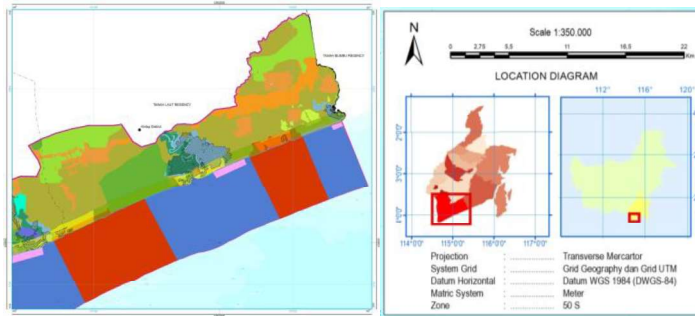


Figure 9. Integrated Terrestrial and Marine Spatial Plan of Kintap Sub-district.

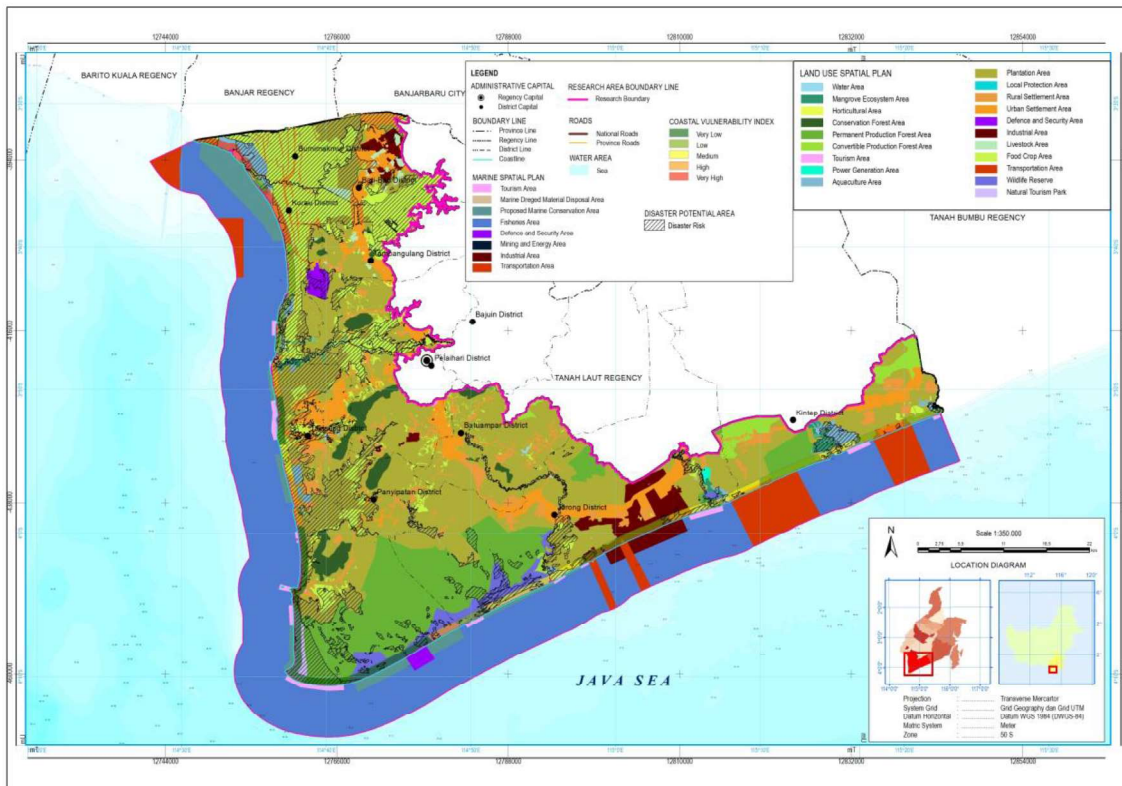


Figure 10. Integrated Spatial Plan Map of Terrestrial and Marine Areas in Tanah Laut Regency

Figure 10 illustrates the interaction between terrestrial and marine spaces in Tanah Laut Regency. Zonal delineation reflects varying functional divisions, and the map depicts how these zones interact, particularly in coastal areas. For instance, fishery zones are generally adjacent to coastlines, while forest areas often serve as buffer zones between land and sea. The map also indicates potential natural resources both on land and in the sea. In terms of spatial planning, the map demonstrates local government efforts to integrate terrestrial and marine spatial planning. This integration is crucial for maintaining ecosystem balance and preventing land-use conflicts.

Based on the initial hypothesis, the integration process of terrestrial and marine spaces must align and mutually support each other in planning, ensuring no contradictions exist. As a recommendation, in Bumi Makmur, Kurau, and Takisung Sub-districts, which exhibit high disaster risks both from marine and terrestrial sources, the dominant land-use directive is Cultivation activities, specifically Food Crop Agriculture Areas and Settlement Areas, necessitating regulations for terrestrial space utilization. To safeguard and mitigate disasters in terrestrial spaces, marine spatial directives recommend designating these areas as protected Marine Conservation Reserve Zones, which include maintaining the sustainability of mangrove areas [34].

The integration of terrestrial and marine space utilization (Figure 10) with high disaster risk areas as protected zones in Takisung and Panyipatan Sub-districts, including Mangrove Ecosystem Zones, Local Protection Areas, and Marine Conservation Reserve Zones, necessitates regulatory measures to ensure space utilization remains intact and land-use conversion does not harm coastal ecosystems. The integration of high disaster risk cultivation areas in Jorong and Kintap Sub-districts requires zoning regulations and permit conditions that consider building intensity in disaster adaptation, such as mandatory building height requirements.

The integration of terrestrial and marine spaces in each sub-district within the study area is summarized in Table 2. Recommendations concerning spatial pattern directives for both terrestrial and marine areas are detailed for each sub-district, based on their respective coastal typologies. According to Table 2, sub-districts with very high coastal vulnerability are Bumi Makmur and Kurau. These two sub-districts also exhibit high terrestrial disaster risks, influenced by their fluvial plain coastal typology. Consequently, appropriate recommendations include mangrove planting, where soil type and species characteristics are crucial factors for successful mangrove ecosystem restoration. *Rhizophora* spp., such as *Rhizophora mucronata* and *Rhizophora apiculata*, are generally suitable for planting on muddy or sandy-mud substrates in the lower intertidal zone, which is inundated during high tide. [35], [36]. Reef ball techniques can enhance planting success in areas with soft substrates and strong currents, as their concrete structures provide protection and stability for mangrove seedlings [37]. Early warning systems play a vital role in reducing disaster risks and informing communities about the potential for tidal flooding, enabling them to take preventive measures. Understanding tidal cycles based on local wisdom and community experience is also crucial for adaptation and disaster mitigation in coastal regions. Integrating scientific knowledge and local wisdom in

mangrove management can enhance the resilience of ecosystems and coastal communities to climate change and natural disasters [38].

Panyipatan Sub-district exhibits very low coastal vulnerability risk, despite its protected areas facing a high potential for terrestrial disasters. Recommendations for this region include constructing seawalls or revetments composed of stacked stones, gabions, or riprap. This measure is crucial considering that coastal regions also serve as strategic development areas, providing numerous livelihood resources such as agriculture, fishponds, capture fisheries, mining, and other resource extraction activities [39], [40]. Research conducted by Mujio [20] has yielded similar conclusions regarding the integration of terrestrial and marine spaces. Mujio suggests that the most applicable scenario optimizes coastal resource management while preserving the coastal environment, aiming to allocate 75% of conservation features (mangroves, coral reefs, and seagrass beds) for conservation purposes.

**Discussion**

Table 2 demonstrates that Tanah Laut Regency encompasses diverse coastal typologies, ranging from fluvial plains to rocky shores, each possessing distinct characteristics and levels of vulnerability to disasters. Terrestrial and marine spatial planning directives in Tanah Laut Regency are based on disaster risk levels and these coastal typologies. Recommendations include mangrove restoration and conservation, relocation of settlements in disaster-prone zones, implementation of disaster-resilient building codes, and development of community-based ecotourism. Furthermore, detailed mapping, establishment of protection zones, and periodic environmental monitoring are also recommended. In the fisheries sector, implementing catch quota systems, fishing gear regulations, and developing sustainable aquaculture are advised. For the agricultural sector, sustainable farming practices and crop diversification are recommended. In the industrial sector, developing integrated industrial zones with proper waste management and clean technology implementation is suggested. For the tourism sector, promoting community-based ecotourism with a sustainable approach and environmental conservation considerations is recommended. Overall, these recommendations aim to achieve sustainable development in Tanah Laut Regency, based on disaster risk mitigation and environmental preservation.

Table 2. Recommendations for the Integration of Marine and Terrestrial Spatial Planning Directives Based on Disaster Risk Levels and Coastal Typologies in Each Coastal Sub-district of Tanah Laut Regency.

Location, Disaster Level, and Coastal Typology	Marine Spatial Plan Directives	Terrestrial Spatial Plan Directives	Recommendations
Bumi Makmur; Disaster Risk: High; CVI: Very High; Coastal Typology: Fluvial Plain (Muddy Coast)	<ul style="list-style-type: none"> <li>•Marine Conservation Reserve;</li> <li>•Capture Fisheries Area</li> </ul>	<ul style="list-style-type: none"> <li>•Mangrove Ecosystem Area;</li> <li>•Local Protection (Coastal Buffer Zone);</li> </ul>	<ul style="list-style-type: none"> <li>•Mangrove restoration and conservation with community involvement.</li> <li>•Establishment of core zones, limited use zones, and intensive use zones.</li> </ul>

Location, Disaster Level, and Coastal Typology	Marine Spatial Plan Directives	Terrestrial Spatial Plan Directives	Recommendations
		<ul style="list-style-type: none"> <li>•Settlement Area; Agriculture Area;</li> <li>•Aquaculture Area (directed towards special provisions for high disaster risk areas)</li> </ul>	<ul style="list-style-type: none"> <li>•Development of sustainable mangrove-based ecotourism.</li> <li>•Delineation of local protection zones based on vulnerability levels and ecological value.</li> <li>•Strict law enforcement against violations in protection zones.</li> <li>•Periodic monitoring of environmental conditions and biodiversity.</li> </ul>
<p>Kurau Disaster Risk: High; CVI: Very High; Coastal Typology: Fluvial Plain (Muddy Coast) and Fluvio-Marine Plain</p>	<ul style="list-style-type: none"> <li>•Marine Conservation Reserve;</li> <li>•Capture Fisheries Area</li> </ul>	<ul style="list-style-type: none"> <li>•Mangrove Ecosystem Area</li> <li>•Local Protection (Coastal Buffer Zone)</li> <li>•Settlement Area</li> <li>•Agriculture Area</li> <li>•Aquaculture Area (directed towards special provisions for high disaster risk areas)</li> </ul>	<ul style="list-style-type: none"> <li>•Relocation of settlements in disaster-prone zones to safer areas.</li> <li>•Implementation of disaster-resilient building codes for new buildings.</li> <li>•Capacity building for communities to cope with disasters.</li> <li>•Implementation of sustainable agricultural and fishery practices adaptive to climate change.</li> <li>•Diversification of crop types and fishery commodities.</li> <li>•Utilization of appropriate technology to increase productivity and resilience to disasters.</li> </ul>
<p>Takisung Disaster Risk: High (Tidal Flooding); CVI: Moderate-High. Coastal Typology: Fluvio-Marine Plain</p>	<ul style="list-style-type: none"> <li>•Marine Conservation Reserve</li> <li>•Capture Fisheries Area</li> </ul>	<ul style="list-style-type: none"> <li>•Mangrove Ecosystem Area</li> <li>•Local Protection (Coastal Buffer Zone)</li> <li>•Settlement Area</li> <li>•Tourism Area</li> <li>•Agriculture Area</li> <li>•Aquaculture Area (directed towards special provisions for high disaster risk areas)</li> </ul>	<ul style="list-style-type: none"> <li>•Establishment of marine conservation areas based on biodiversity and ecological value.</li> <li>•Regulation of core zones, limited use zones, and utilization zones.</li> <li>•Strict monitoring and law enforcement to protect marine ecosystems.</li> <li>•Implementation of catch quota systems and regulations on fish sizes allowed to be caught.</li> </ul>

Location, Disaster Level, and Coastal Typology	Marine Spatial Plan Directives	Terrestrial Spatial Plan Directives	Recommendations
			<ul style="list-style-type: none"> <li>•Regulation of fishing zones and fishing seasons.</li> <li>•Development of alternative livelihoods for fishermen to reduce pressure on fish resources.</li> </ul>
<p>Panyipatan; Disaster Risk: High in Protected Areas; CVI: Very Low Coastal Typology: Marine Deposition Coast &amp; Volcanic Coast</p>	<ul style="list-style-type: none"> <li>•Tourism Area</li> <li>•Capture Fisheries Area</li> </ul>	<ul style="list-style-type: none"> <li>•Protected Forest Area</li> <li>•Natural Tourism Park</li> <li>•Wildlife Reserve</li> <li>•Defense and Security Area</li> </ul>	<ul style="list-style-type: none"> <li>•Mangrove restoration and conservation with community involvement, considering high vulnerability and vital functions of mangroves.</li> <li>•Establishment of core zones, limited use zones (ecotourism, research), and intensive use zones (sustainable silvofishery).</li> <li>•Monitoring of mangrove growth and sedimentation to anticipate coastline changes.</li> <li>•Detailed mapping: identification of disaster-prone areas (floods, erosion, seawater intrusion) and high ecological value areas (habitat of endemic fauna and flora).</li> </ul>
<p>Jorong; Disaster Risk: High in Water Body Areas (Rivers); CVI: Low-Moderate; Coastal Typology: Marine Deposition Coast</p>	<ul style="list-style-type: none"> <li>•Industrial Zone</li> <li>•Shipping Transportation Area</li> <li>•Specialized Coal Terminal</li> </ul>	<ul style="list-style-type: none"> <li>•Industrial Zone</li> <li>•Shipping Transportation Area</li> <li>•Specialized Coal Terminal</li> </ul>	<ul style="list-style-type: none"> <li>•Establishment of protection zones based on vulnerability levels and functions: core zone (no activity), buffer zone, limited use zone.</li> <li>•Integration into spatial planning: local protection zones must have clear zoning regulations integrated with the Regional Spatial Plan (RTRW).</li> <li>•Gradual relocation: prioritize settlements in disaster-prone zones (coastline, floodplains) to safer locations, considering social and economic aspects.</li> <li>•Implementation of disaster-resistant building codes: new buildings must meet standards</li> </ul>

Location, Disaster Level, and Coastal Typology	Marine Spatial Plan Directives	Terrestrial Spatial Plan Directives	Recommendations
			for flood, strong wind, and earthquake resistance.
Kintap; Disaster Risk: High in Aquaculture Areas; CVI: Low-Moderate; Coastal Typology: Marine Deposition Coast	<ul style="list-style-type: none"> <li>•Industrial Zone</li> <li>•Shipping Transportation Area</li> <li>•Specialized Coal Terminal</li> <li>•Mangrove Ecosystem Area</li> </ul>	<ul style="list-style-type: none"> <li>•Capture Fisheries Area</li> <li>•Industrial Zone</li> <li>•Shipping Transportation Area</li> <li>•Specialized Coal Terminal</li> <li>•Aquaculture Area</li> </ul>	<ul style="list-style-type: none"> <li>•Capacity building for communities: evacuation training, early warning systems, and disaster preparedness.</li> <li>•Integrated agriculture: integrate agricultural land with mangrove forests (silvofishery) or ponds (aquaculture) to increase resilience and productivity.</li> <li>•Commodity diversification: reduce dependence on a single crop or fish species by developing varieties adaptive to environmental conditions and climate change.</li> <li>•Sustainable water and soil management: implement water conservation techniques, erosion control, and organic fertilization to maintain soil fertility.</li> </ul>

S: [6] and analysis Result, 2024

## Conclusions

This study analyzed the integration of disaster mitigation-based terrestrial and marine spatial planning in Tanah Laut Regency. The findings indicate that Tanah Laut Regency exhibits a considerably high level of disaster risk, both on land and at sea. Several significant conclusions emerge, including the dominance of protected areas in regions with moderate to high terrestrial disaster risks, the significant presence of cultivated areas in these regions, and the lack of adequate protection for areas most vulnerable to coastal disasters.

This research generates specific recommendations for each sub-district in Tanah Laut Regency, based on disaster risk levels and coastal typologies. These recommendations encompass mangrove restoration and conservation, relocation of settlements in disaster-prone zones, implementation of disaster-resilient building codes, and development of community-based ecotourism.

This study is expected to provide valuable recommendations to local authorities for enhancing the effectiveness of integrated terrestrial and marine spatial planning to reduce disaster risks

and support sustainable development in coastal regions. Furthermore, it is anticipated that this research will furnish researchers and academics in the fields of spatial planning and disaster mitigation with pertinent information.

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### **Conflict of Interest**

State any potential conflicts of interest here or "The authors declare no conflict of interest".

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## Integrated Land-Sea Spatial Planning for Disaster Risk Reduction in Tanah Laut Regency, South Kalimantan, Indonesia

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Manuscript ID	IEAM-2025-543-OA
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Keywords:	Spatial Planning, Disaster Risk Reduction, Coastal Vulnerability, Terrestrial and Marine Spatial Planning, Coastal Typology
Abstract:	<p>This research examines the potential of integrated land-sea spatial planning as a strategic approach to disaster risk reduction in Tanah Laut Regency, South Kalimantan Province, Indonesia. Specifically, it aims to 1) assess spatial overlaps between terrestrial-marine landuse patterns and hazard zones; 2) evaluate coastal typologies and their corresponding vulnerabilities; and 3) formulate sub-district-specific spatial planning recommendations to enhance regional resilience. A mixed-methods design was adopted, combining quantitative spatial techniques and qualitative descriptive analysis. Disaster potential in coastal regions is examined through an integrated assessment of terrestrial disaster risks and marine-based Coastal Vulnerability Index (CVI) analyses. Terrestrial disaster susceptibility was assessed using the Regional Development Planning Agency (RDPA) 2021 disaster risk assessment, while coastal vulnerability was evaluated using CVI parameters and overlaid with terrestrial and marine spatial planning categories. The spatial analysis shows a strong convergence between high terrestrial disaster risk and land-use categories associated with intensive human modification, notably food crop agriculture (23,610.53 ha), plantations (19,718.99 ha), aquaculture, and urban and rural settlements. Protected areas such as mangrove ecosystems, wildlife reserves, and natural tourism parks are located in high-risk coastal belts, while parts of marine conservation reserve areas and capture fisheries areas fall within high and very high CVI classes. Land-rights (LR) overlays demonstrate that high tidal-flood risk coincides with Ownership Rights (OR) and unregistered parcels. Overall, the research demonstrates that sustainable coastal development in Tanah Laut Regency cannot be achieved by treating land and sea as separate planning arenas. Risk-sensitive, typology-based integration of terrestrial and marine spatial plans, supported by ecosystem-based zoning, mangrove restoration, relocation from high-risk zones, and strengthened marine conservation and fisheries management, is essential to enhance disaster resilience and long-term spatial sustainability in Tanah Laut Regency.</p>



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