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Corresponding Author:
Name: Deli Wakano
Email: deli.wakano@lecturer.unpatti.ac.id

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Plant Diversity and Environmental Vulnerability of Coastal Ecosystem on Osi Island, West Seram, Maluku Province

Deli Wakano[1*], Iskandar Zulkarnaen Siregar[2], Fredinan Yulianda[3], Irman Firmansyah[4]

[1]Department of Biology, Faculty of Science and Technology, Pattimura University, Ambon - Indonesia
[2]Department of Silviculture, Bogor Agricultural University (IPB), Department of Aquatic Resources, Bogor – Indonesia
[3] Management, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB), Bogor - Indonesia
[4]System Dynamics Center – Indonesia

Abstract
Osi Island in West Seram, Maluku, Indonesia, possesses interconnected coastal habitats that support both biodiversity and the livelihoods of the local community. However, changes in land cover and intensive resource utilization threaten the ecological functions of these habitats. This study examines the plant community structure within seagrass, mangrove, and terrestrial habitats, while also analyzing land-cover changes and environmental vulnerability to inform the management of coastal ecosystems. Field observations were conducted from December 2023 to December 2024. The research employed a plot-based transect method, utilizing 33 observation plots (each 50 × 50 m) selected purposively based on land systems and land use. Within these, subplots measuring 1 × 1 m were used for seagrass habitats, while 5 × 5 m subplots were used for mangrove and terrestrial habitats. Community structure was analyzed using species composition, the Shannon–Wiener diversity index (H') and the dominance index (D). Landsat imagery was utilized to compare land cover between 2008 and 2023, and environmental vulnerability was assessed using a framework based on island vulnerability indicators and the Indonesian National Board for Disaster Management (BNPB) Regulation No. 2/2012. The results indicate H values of 0.553 for mangroves, 0.375 for seagrass, and 2.54 for terrestrial habitats. Mangrove cover decreased from 479.4 ha in 2008 to 429.9 ha in 2023 (−10.3%), while seagrass cover shifted from 583.3 ha in 2008 to 579.5 ha in 2023 (−0.7%), following a decline in 2013. The area designated as coastal zone shrank from 21.8 ha to 5.9 ha, whereas the area occupied by settlements expanded from 1.3 ha to 24.9 ha. These findings indicate that changes in coastal land cover, combined with the low diversity indices recorded in mangrove and seagrass habitats, necessitate monitoring and management strategies tailored specifically to each of these habitats.

INTRODUCTION

Small islands possess high ecological value, yet they are characterized by limited land area and a strong dependence on coastal resources. Mangrove ecosystems, seagrass beds, and terrestrial coastal vegetation play vital roles in providing habitats, protecting shorelines, trapping sediments, and supporting both the fisheries sector and the livelihoods of local communities. These functions are interconnected; changes in one habitat can affect

surrounding habitats as well as the resources utilized by coastal populations. Conversely, the limited land area renders small islands vulnerable to land conversion, coastal erosion, sea-level rise, and unsustainable resource exploitation.

Osi Island is located in the West Seram Regency, Maluku Province, Indonesia, specifically in a coastal area adjacent to Kotania Bay (Assagaf et al., 2023; Assagaf et al., 2024). As a small island, Osi possesses significant coastal resources, including mangroves, seagrass beds, rocky shores, coral reefs, and fisheries. Local activities on the island include capture fisheries, the collection of coastal organisms, aquaculture, and mangrove-based tourism. While these activities create livelihood opportunities, they can also exert cumulative pressure on the coastal ecosystem if they exceed the environment's carrying capacity (Putra et al., 2016; Hehanussa et al., 2020).

Previous research on Osi Island has addressed tourism development and infrastructure, while broader studies have examined coastal vulnerability, ecosystem services, and the management of small islands. However, management-oriented assessments need to integrate information regarding plant communities at the habitat level with the spatial patterns of land-cover change and environmental vulnerability. A description of species diversity alone is insufficient to indicate where changes in habitat extent have occurred, while land-cover maps by themselves cannot depict the structure of plant communities within the remaining habitats. Integrating these various lines of evidence can help establish priorities for conservation and monitoring efforts.

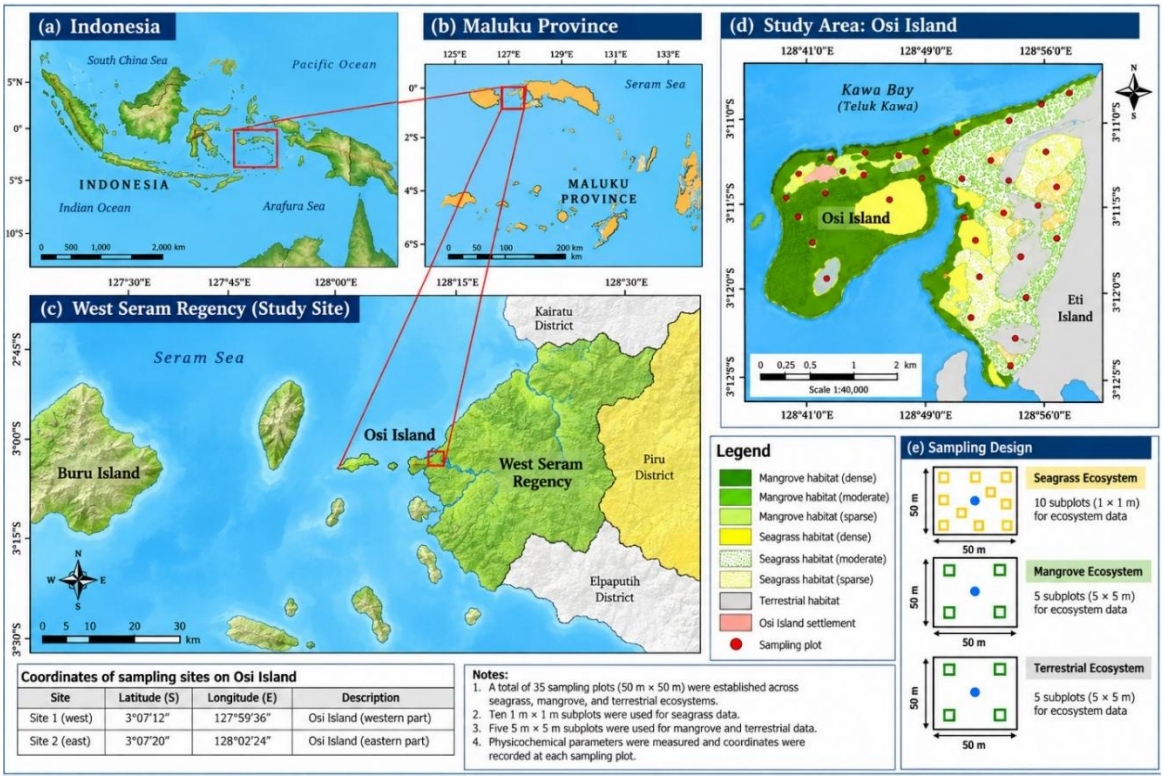
The findings of this research indicate that mangrove ecosystems and seagrass beds are key ecological components of Osi Island, and that its coastal landscape has undergone changes between 2008 and 2023. The study documents a reduction in the extent of mangrove and coastal areas, a net decline in the area of seagrass beds—despite some inter-annual fluctuations—and a significant expansion of residential areas. Low Shannon diversity index values were observed for both mangrove and seagrass communities. These results provide a site-specific basis for evaluating the condition of coastal habitats on the island.

Therefore, this research aims to: (1) describe the plant species composition and community structure within the seagrass, mangrove, and terrestrial habitats on Osi Island; (2) report indicators of habitat diversity and dominance; (3) quantify changes in mapped land-cover classes between 2008 and 2023; and (4) outline an environmental vulnerability assessment applied to the island. The contribution of this research lies in its integrated interpretation of plant community observations and spatial indicators, which can serve as a reference for ecosystem-based management of small islands.

RESEARCH METHODS

Study area and period

The study was conducted on Osi Island, West Seram Regency, Maluku Province, Indonesia, from December 2023 to December 2024. The study covered three plant-habitat groups: seagrass, mangrove, and terrestrial vegetation. The location map is presented as Figure 1(Sondak et al., 2019).



Coordinates of sampling sites on Osi Island

Site	Latitude (S)	Longitude (E)	Description
Site 1 (west)	3°07'12"	127°59'36"	Osi Island (western part)
Site 2 (east)	3°07'20"	128°02'24"	Osi Island (eastern part)

Notes:
1. A total of 35 sampling plots (50 m × 50 m) were established across seagrass, mangrove, and terrestrial ecosystems.
2. Ten 1 m × 1 m subplots were used for seagrass data.
3. Five 5 m × 5 m subplots were used for mangrove and terrestrial data.
4. Physicochemical parameters were measured and coordinates were recorded at each sampling plot.

Figure 1. Map of the research location of Osi Island

Field sampling and vegetation observations

Observation plots were selected purposively, utilizing land system and land-use information to represent varying vegetation conditions: dense, moderate, and sparse. A total of 33 observation plots, each measuring 50 × 50 m, were established. Within each plot, seagrass was sampled using ten 1 × 1 m subplots, while mangrove and terrestrial vegetation were sampled using five 5 × 5 m subplots. Plant observations included species identification and abundance; for tree vegetation, structural variables—specifically diameter and height—were also recorded. Seagrass observations involved documenting species, density, and percentage cover, with sampling conducted within 1 × 1 m quadrats. Mangrove observations included recording species and the number of individuals. Terrestrial vegetation observations covered species, number of individuals, diameter, height, density, frequency, and dominance (Brown & Williams, 2018).

Diversity, density, and dominance indices

Species diversity is assessed using the Shannon–Wiener index, $H' = -\Sigma\ p_i\ \ln(p_i)$, where p_i represents the proportion of individuals of the i-th species. Species density is calculated as the number of individuals of a given species divided by the area of the sample plot, using the formula $D = \Sigma p_i^2$.

Land-cover classification and change analysis

Land cover change was assessed using Landsat imagery spanning the years 2008–2023. The imagery utilized was acquired from Landsat 5 and Landsat 8/9 OLI-TIRS. Five land cover classes were examined: mangroves, seagrass beds, coastal forests, settlements, and coastal areas.

Changes in area were calculated based on the extent of each class. The percentage of change was determined using the following formula: [(area in 2023 − area in 2008) / area in 2008] × 100. (Wulder et al., 2016).

Environmental vulnerability assessment

Environmental vulnerability is assessed based on BNPB (National Board for Disaster Management) Regulation No. 2 of 2012 and literature concerning island vulnerability. The parameters measured include sea-level rise, coastal abrasion, tidal range, wave height, tsunami occurrence, population growth, population density, elevation, land slope, coastal typology, land use, and the location of settlements. Vulnerability encompasses three components: exposure, sensitivity, and adaptive capacity. The exposure index is formulated as IE = 0.41(SR × ER) + 0.21(GL) + 0.14(PS) + 0.14(TS) + 0.10(PD × KD); the sensitivity index as IS = 0.43(EL) + 0.21(TP) + 0.14(SL) + 0.11(PL) + 0.11(PP); and the adaptive capacity as IAC = 0.40(HP) + 0.20(TK) + 0.20(MR) + 0.11(LM) + 0.11(KL).

RESULTS AND DISCUSSION

Plant species composition and community structure

Vegetation identification results indicate that the mangrove ecosystem on Osi Island is dominated by four primary species yaitu *Rhizophora mucronata* (273 ind/m^2), *Rhizophora apiculata* (101 ind/m^2), *Rhizophora stylosa* (86 ind/m^2), and *Bruguiera cylindrica* (230 ind/m^2) (Table 1). Data indicate that *Rhizophora mucronata* is the species with the highest level of dominance compared to others, as reflected by a recorded density of 273 ind/m^2. The high abundance of this species suggests a significant ecological role in the formation and stability of the mangrove community structure, while also demonstrating a strong capacity to adapt to local environmental conditions (Sukuryadi et al. 2021). The adaptive capacity of *R. mucronata* is supported by physiological characteristics that enable it to withstand various forms of ecological stress, such as extreme salinity fluctuations, physical disturbances, and substrates ranging from mud to sandy mud (Onrizal et al. 2017). Adaptation to salinity dynamics is a key factor for the survival of mangrove species, given that this ecosystem frequently undergoes sharp environmental shifts due to tidal variations and water availability. Consequently, species with high physiological tolerance possess a competitive advantage in maintaining their populations and achieving reproductive success, which leads them to dominate the structure of the mangrove community.

Table 1. Mangrove Species Diversity on Osi Island

Habitat	Family	Genus	Species	Σ (ind./1,675 m^2)	H'
Mangrove	Rhizophoraceae	Rhizophora	*R. stylosa*	86	
			R. mucronata	273	
			R. apiculata	101	
		Bruguiera	*B. cylindrica*	230	0.553
Total				**690**	

Source: Primary research data (2026)

Data indicate that the seagrass community on Osi Island is dominated by the species *Thalassia hemprichii*, with a density of 6,085 individuals/m², followed by *Enhalus acoroides* (2,111 individuals/m²), *Cymodocea rotundata* (442 individuals/m²), and *Cymodocea serrulata* (300 individuals/m²). The high dominance of *T. hemprichii* suggests that this species possesses an ecological advantage over other seagrass species in utilizing local environmental conditions. This advantage is generally linked to its high adaptability to the variable conditions of shallow-water environments—such as sufficient light intensity, substrate stability, and tolerance toward the dynamics of coastal environments. Ecologically, *T. hemprichii* is known for its ability to form relatively dense beds through a robust root (rhizome) system, which effectively stabilizes the substrate and secures growing space against competition from other species. Furthermore, the species exhibits a strong capacity for vegetative regeneration, enabling rapid population expansion under favorable environmental conditions. This dominance may also reflect a habitat well-suited for the growth of *T. hemprichii*, characterized by shallow waters with sandy to muddy-sand substrates. Nevertheless, this high level of species dominance directly results in low seagrass diversity, as reflected by a diversity index (H') value of 0.375 (Table 2).

Table 2. Seagrass Species Diversity on Osi Island

Habitat	Family	Genus	Species	Σ (ind./150 m²)	H'
Seagrass	Hydrocharitaceae	Enhalus	*E. acoroides*	2111	
	Cymodoceaceae	Cymodocea	*C. rotundata*	442	
			C. serrulata	300	
	Hydrocharitaceae	Thalassia	*T. hemprichii*	6085	0.375
Total				**8938**	

Source: Primary research data (2026)

The coastal forest ecosystem on Osi Island serves a strategic role as a transition zone between coastal and terrestrial ecosystems, while also acting as a primary buffer for the environmental stability of this small island. The presence of 56 terrestrial plant species indicates that the coastal forest of Osi Island is still capable of supporting a relatively high level of vegetation diversity, fulfilling vital ecological functions such as protecting the land from wind-driven erosion and sea spray, stabilizing sandy soil, and regulating the coastal microclimate. Dominant species include *Kalanchoe pinnata*, *Imperata cylindrica*, *Cyperus rotundus*, *Stachytarpheta jamaicensis*, and *Chromolaena odorata*. The dominance of certain species, particularly *Kalanchoe pinnata* and *Imperata cylindrica*, reflects a high capacity for adaptation to extreme coastal environmental conditions, such as nutrient limitations, wind exposure, and salinity stress. However, this dominance also influences the structure of the vegetation community by restricting growth opportunities for other species (Jaiteh et al. 2017). A Shannon–Wiener diversity index (H') value of 2.54 indicates that plant diversity in the terrestrial habitat is moderate.

Land-cover change between 2008 and 2023

An analysis of land cover changes on Osi Island during the 2008–2023 period provides important insights into the dynamics of the coastal ecosystem. The land cover categories analyzed include mangroves, seagrass, coastal forests, human settlements, and other coastal areas. Monitoring of these changes was conducted using satellite imagery to identify trends in the extent of each land cover type, serving as an indicator of ecosystem health and the level of pressure on the coastal environment (Amin et al. 2016). The analysis results indicate that mangrove and seagrass cover experienced a significant decline throughout the observation period, while terrestrial land cover showed a relatively small but generally stable increase (Figure 2).

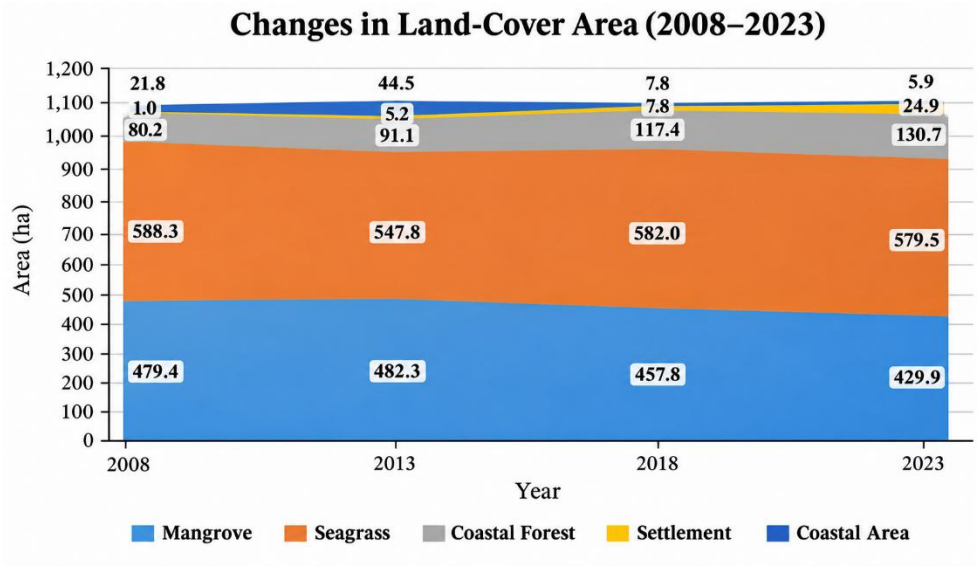


Figure 2 Land cover of Osi Island

The area covered by mangroves decreased by 49.5 ha (10.3%) between 2008 and 2023. Seagrass me adow coverage declined by 3.8 ha (0.7%); data indicate a drop to 547.8 ha in 2013, followed by a recovery to 579.5 ha by 2023. Coastal forest cover expanded by 50.5 ha (63.0%), while residential areas increased by 23.6 ha from 1.3 ha to 24.9 ha. Other coastal areas saw a reduction of 15.9 ha (72.9%). The observed changes in land cover reflect landscape dynamics.

Environmental vulnerability

A vulnerability map for Osi Island, based on an assessment framework that considers physical exposure, sensitivity, and adaptive capacity. The indicators used include coastal and climatic conditions, topography, land use, population characteristics, and coastal habitat features. This map is intended to identify areas that require attention in the context of coastal management (Figure 3).

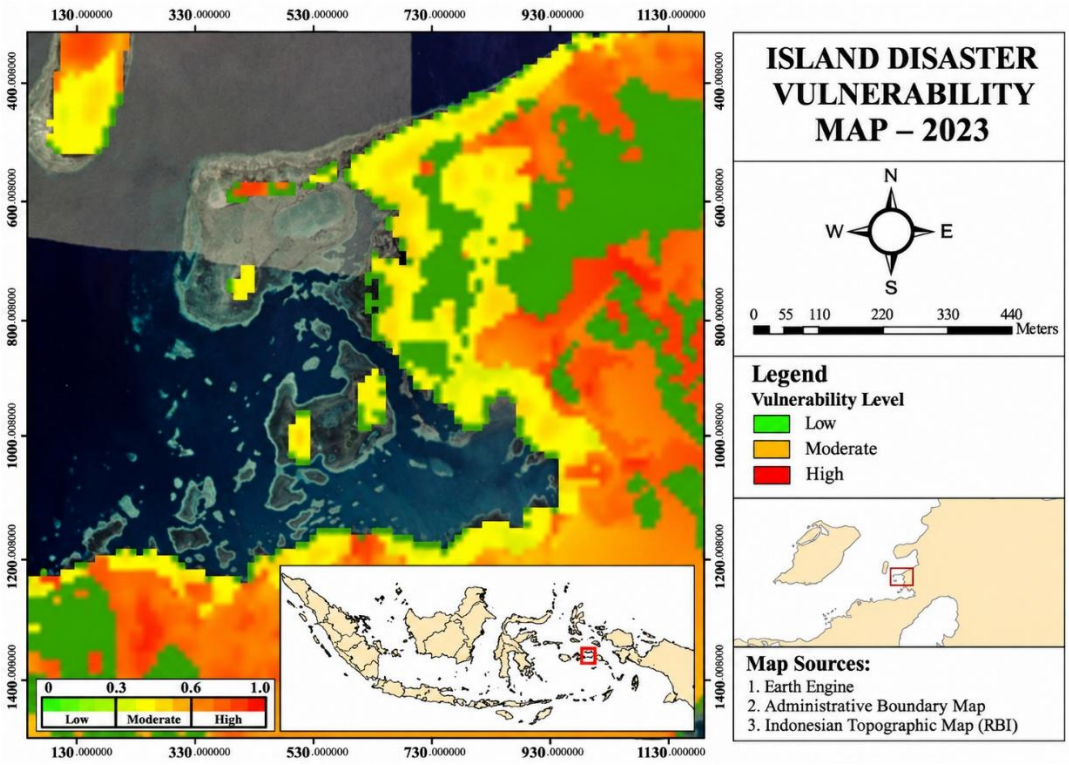


Figure 3. Vulnerability of the Osi Island ecosystem based on BNPB data.

The coastal forest ecosystem on Osi Island plays a strategic role as a transitional zone between marine and terrestrial environments and serves as an important ecological buffer for maintaining the environmental stability of small islands. The identification of 56 terrestrial plant species indicates that this habitat supports relatively diverse vegetation, contributing to the structural and functional complexity of the island's terrestrial ecosystem. Ecologically, coastal forests provide essential ecosystem services, including protection against wind erosion and salt spray, stabilization of sandy soils, regulation of coastal microclimatic conditions, and maintenance of terrestrial biodiversity. These functions are particularly important on small islands, where terrestrial habitats are relatively limited and highly exposed to environmental disturbances associated with coastal processes.

Vegetation composition analysis revealed that several species were relatively dominant in the coastal forest habitat, *including Kalanchoe pinnata*, *Imperata cylindrica*, *Cyperus rotundus, Stachytarpheta jamaicensis, and Chromolaena odorata*. The occurrence and dominance of these species may reflect their ecological adaptability to the environmental characteristics of coastal terrestrial habitats, particularly nutrient-poor soils, high solar radiation, limited freshwater availability, and exposure to salt-laden winds. Among these species, the dominance of *K. pinnata and I. cylindrica* suggests their capacity to persist under relatively challenging environmental conditions. Their ecological success may be associated with physiological and morphological adaptations that facilitate survival, regeneration, and resource acquisition under environmental stress.

The dominance of *K. pinnata and I. cylindrica* further reflects the potential influence of environmental filtering on vegetation community structure. Under conditions characterized by limited nutrient availability, wind exposure, and salinity stress, species with greater

environmental tolerance may have a competitive advantage over less-adapted species. Although these characteristics facilitate their establishment and persistence, excessive dominance may also influence community composition by limiting the availability of space, light, and other resources required by coexisting species (Jaiteh et al. 2017). Similarly, the occurrence of Imperata cylindrica and Chromolaena odorata warrants particular ecological attention because these species may become dominant under disturbed habitat conditions. Chromolaena odorata, in particular, is recognized as an invasive plant in many tropical ecosystems and may compete with native vegetation, potentially affecting vegetation regeneration and community dynamics. Nevertheless, the ecological implications of their dominance should be assessed in relation to their abundance, spatial distribution, and interactions with native plant species.

The Shannon–Wiener diversity index (H' = 2.54) indicates a moderate level of plant diversity in the terrestrial habitat. This value suggests that, despite the dominance of certain species, the coastal forest maintains a relatively diverse plant community. Compared with the mangrove (H' = 0.553) and seagrass (H' = 0.375) habitats, the terrestrial habitat exhibits substantially higher species diversity, indicating differences in community structure and species distribution among the three ecosystems. The relatively higher diversity in the coastal forest may be associated with greater variation in terrestrial microhabitats and environmental conditions that provide opportunities for the establishment of different plant species. However, the coexistence of relatively high species richness and the dominance of particular species indicates that diversity alone does not fully characterize ecosystem condition. Species evenness, vegetation structure, regeneration capacity, and the ecological status of dominant species should also be considered when evaluating habitat integrity.

From an ecosystem functioning perspective, the coastal forest contributes to the stability of Osi Island by protecting terrestrial surfaces from wind erosion, stabilizing sandy substrates, and maintaining favorable microclimatic conditions. Vegetation cover also provides habitats and resources for terrestrial fauna, thereby supporting ecological interactions within the terrestrial ecosystem. Changes in vegetation composition, particularly the expansion of disturbance-tolerant or invasive species, may alter these ecological functions by affecting native plant regeneration and the structural complexity of the habitat. Therefore, maintaining species diversity and vegetation structure is essential for sustaining the ecological resilience of the coastal forest.

At the broader landscape scale, the coastal forest ecosystem complements the ecological functions of mangrove and seagrass habitats, forming an interconnected coastal socio-ecological system. While mangroves provide protection to intertidal environments and seagrass meadows stabilize submerged sediments, coastal forests contribute to the protection of terrestrial areas and the regulation of environmental conditions along the shoreline. These interconnected habitats collectively support biodiversity, coastal stability, and the availability of natural resources for local communities. Consequently, disturbances affecting coastal forest vegetation may have implications for the overall ecological integrity of the island, particularly where land-use conversion and human activities increase pressure on terrestrial habitats.

From a management perspective, conservation of the coastal forest on Osi Island should prioritize maintaining existing vegetation cover, restoring disturbed areas using locally appropriate native species, controlling the expansion of potentially invasive plants, and preventing uncontrolled land conversion. Monitoring vegetation composition, species dominance, and natural regeneration is also necessary to detect ecological changes and evaluate the effectiveness of conservation interventions. Such integrated management measures are essential for maintaining terrestrial biodiversity, strengthening coastal stability, and supporting the long-term sustainability and resilience of Osi Island's natural resources

CONCLUSION

The coastal ecosystems of Osi Island exhibit distinct ecological characteristics in terms of species composition, diversity, and habitat functions. The mangrove and seagrass ecosystems showed relatively low species diversity (H' = 0.553 and H' = 0.375, respectively), with *Rhizophora mucronata* and *Thalassia hemprichii* as the dominant species, whereas the coastal forest supported 56 terrestrial plant species with moderate diversity (H' = 2.54). Despite their important ecological contributions, the decline in mangrove area from 479.4 ha in 2008 to 429.9 ha in 2023 indicates increasing pressure on coastal habitat sustainability. These findings highlight that the ecological integrity of Osi Island is influenced not only by species diversity and habitat extent but also by species dominance, community structure, and ecological connectivity among habitats. Therefore, an integrated ecosystem-based management approach that prioritizes habitat conservation and restoration, control of potentially invasive species, and sustainable resource utilization through community participation is essential to strengthen ecosystem resilience and ensure the long-term sustainability of Osi Island's natural resources

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Author Contributions

D.W contributed to Conceptualization, methodology, investigation, data collection, data curation, formal analysis, visualization, and writing original draft. I. Z.R contributed to Methodology, supervision, validation, and review. F.Y contributed to data analysis, validation, and review dan I.F. contributed to supervision. review and editing.

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Declaration of Interest

The authors declare no conflict of interest.

Data Sharing Statement

The data used in this are available upon reasonable request and in accordance with established procedures.

REFERENCES

Allan, E., Manning, P., Alt, F., Binkenstein, J., Blaser, S., Blüthgen, N., Böhm, S., Grassein, F., Hölzel, N., Klaus, V. H., Kleinebecker, T., Morris, E. K., Oelmann, Y., Prati, D., Renner, S. C., Rillig, M. C., Schaefer, M., Schloter, M., Schmitt, B., … Fischer, M. (2015). Land Use Intensification Alters Ecosystem Multifunctionality via Loss of Biodiversity and Changes to Functional Composition. *Ecology Letters*, *18*(8), 834–843. https://doi.org/10.1111/ele.12469

Alsaffar, Z., Cúrdia, J., Irigoien, X., & Carvalho, S. (2020). Composition, Uniqueness and Connectivity Across Tropical Coastal Lagoon Habitats in the Red Sea. *BMC Ecology*, *20*(1). https://doi.org/10.1186/s12898-020-00329-z

Ardli, E. R., Yuwono, E., & Purwanto, A. D. (2022). Land Cover Changes and Impacts of Massive Siltation on the Mangrove Segara Anakan Lagoon System, Cilacap Indonesia. *Journal of Ecological Engineering*, *23*(7), 29–41. https://doi.org/10.12911/22998993/149821

Assagaf, K. G., Barcinta, M. F., Ukratalo, A. M., & Rijoly, S. M. (2023). Analisis Tingkat Kesejahteraan Rumah Tangga Nelayan Tradisional di Dusun Pulau Osi, Desa Eti, Kabupaten Seram Bagian Barat. *Journal of Coastal and Deep Sea*, *1*(2), 48-59.

Assagaf, K. G., Ukratalo, A. M., & Barcinta, M. F. (2024). Kontribusi usaha budidaya rumput laut dalam meningkatkan kesejahteraan masyarakat pesisir di Dusun Wael Kabupaten Seram Bagian Barat. *Journal of Coastal and Deep Sea*, *2*(1), 1-13.

Asif, A. A., Hamli, H., Kamal, A. H. M., Idris, M. H., Gerusu, G. J., Ismail, J., & Karim, N. U. (2020). Benthic Macrofaunal Assemblage in Seagrass-Mangrove Complex and Adjacent Ecosystems of Punang-Sari Estuary, Lawas, Sarawak, Malaysia. *Biodiversitas Journal of Biological Diversity*, *21*(10). https://doi.org/10.13057/biodiv/d211019

Attrill, M. J., Strong, J., & Rowden, A. A. (2000). Are Macroinvertebrate Communities Influenced by Seagrass Structural Complexity? *Ecography*, *23*(1), 114–121. https://doi.org/10.1034/j.1600-0587.2000.230112.x

Bagheri, M., Ibrahim, Z. Z., Akhir, M. F., Talaat, W. I. A. W., Oryani, B., Rezania, S., Wolf, I. D., & Pour, A. B. (2021). Developing a Climate Change Vulnerability Index for Coastal City Sustainability, Mitigation, and Adaptation: A Case Study of Kuala Terengganu, Malaysia. *Land*, *10*(11), 1271. https://doi.org/10.3390/land10111271

Bian, Y., Wu, Q., Zheng, R., Fu, J., Chen, J., Mi, X., Yu, M., & Wang, Y. (2025). Temporal and Habitat-Specific Variations in Drivers of Aboveground Biomass Dynamics in a Chinese

Subtropical Forest. *Frontiers in Plant Science*, *15*. https://doi.org/10.3389/fpls.2024.1531654

Biswas, S., Rahman, M. A. R., & Mojumdar, S. (2022). Developing an Empirical Model for Climate Change Adaptation in River Management Planning Using DPSIR Framework at Nabaganga River of Narail District, Bangladesh. *JBS*, *5*(3), 457–472. https://doi.org/10.62400/jbs.v5i3.7059

Blumstein, M., & Thompson, J. R. (2015). Land-use Impacts on the Quantity and Configuration of Ecosystem Service Provisioning in Massachusetts, <scp>USA</Scp>. *Journal of Applied Ecology*, *52*(4), 1009–1019. https://doi.org/10.1111/1365-2664.12444

Boruff, B., Emrich, C. T., & Cutter, S. L. (2005). Erosion Hazard Vulnerability of US Coastal Counties. *Journal of Coastal Research*, *215*, 932–942. https://doi.org/10.2112/04-0172.1

Brown, E. D., & Williams, B. K. (2018). The Potential for Citizen Science to Produce Reliable and Useful Information in Ecology. *Conservation Biology*, *33*(3), 561–569. https://doi.org/10.1111/cobi.13223

Delgado-Baquerizo, M., Maestre, F. T., Reich, P. B., Jeffries, T. C., Gaitán, J., Encinar, D., Berdugo, M., Campbell, C. D., & Singh, B. K. (2016). Microbial Diversity Drives Multifunctionality in Terrestrial Ecosystems. *Nature Communications*, *7*(1). https://doi.org/10.1038/ncomms10541

Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J., Chan, F., English, C., Galindo, H. M., Grebmeier, J. M., Hollowed, A. B., Knowlton-, N., Polovina, J. J., Rabalais, N. N., Sydeman, W. J., & Talley, L. D. (2012). Climate Change Impacts on Marine Ecosystems. *Annual Review of Marine Science*, *4*(1), 11–37. https://doi.org/10.1146/annurev-marine-041911-111611

Dorenbosch, M., Grol, M. G. G., Nagelkerken, I., & Velde, G. v. d. (2006). Different Surrounding Landscapes May Result in Different Fish Assemblages in East African Seagrass Beds. *Hydrobiologia*, *563*(1), 45–60. https://doi.org/10.1007/s10750-005-1428-2

Doxa, A., Albert, C. H., Leriche, A., & Saatkamp, A. (2017). Prioritizing Conservation Areas for Coastal Plant Diversity Under Increasing Urbanization. *Journal of Environmental Management*, *201*, 425–434. https://doi.org/10.1016/j.jenvman.2017.06.021

Ferasari, F., Sara, L., Rianda, L., & Ola, O. L. (2019). *Ecological Study Coastal Management of Tanjung Tiram Village Konawe Selatan*. https://doi.org/10.4108/eai.1-4-2019.2287224

George, R., & Lugendo, B. R. (2023). Tidal Cycle and Time of Day Control pH Levels in Coastal Habitats of the Western Indian Ocean: The Case of Mnazi and Chwaka Bays in Tanzania. *Western Indian Ocean Journal of Marine Science*, *21*(2), 141–150. https://doi.org/10.4314/wiojms.v21i2.12

Goldberg, L., Lagomasino, D., Thomas, N., & Fatoyinbo, T. (2020). Global Declines in Human-driven Mangrove Loss. *Global Change Biology*, *26*(10), 5844–5855. https://doi.org/10.1111/gcb.15275

Gratwicke, B., & Speight, M. R. (2005). The Relationship Between Fish Species Richness, Abundance and Habitat Complexity in a Range of Shallow Tropical Marine Habitats.

Journal of Fish Biology, *66*(3), 650–667. https://doi.org/10.1111/j.0022-1112.2005.00629.x

Hautier, Y., Tilman, D., Isbell, F., Seabloom, E. W., Borer, E. T., & Reich, P. B. (2015). Anthropogenic Environmental Changes Affect Ecosystem Stability via Biodiversity. *Science*, *348*(6232), 336–340. https://doi.org/10.1126/science.aaa1788

Hoel, A. H., & Olsen, E. (2012). Integrated Ocean Management as a Strategy to Meet Rapid Climate Change: The Norwegian Case. *Ambio*, *41*(1), 85–95. https://doi.org/10.1007/s13280-011-0229-2

Hossain, M. S., Hein, L., Rip, F. I., & Dearing, J. A. (2013). Integrating Ecosystem Services and Climate Change Responses in Coastal Wetlands Development Plans for Bangladesh. *Mitigation and Adaptation Strategies for Global Change*, *20*(2), 241–261. https://doi.org/10.1007/s11027-013-9489-4

Htun, U. S. (2018). Seagrass Surveys in the Southern Rakhine Coastal Region, Myanmar: Biodiversity, Distribution and Coverage. *Journal of Aquaculture & Marine Biology*, *7*(2). https://doi.org/10.15406/jamb.2018.07.00193

Huxham, M., Emerton, L., Kairo, J. G., Munyi, F., Abdirizak, H., Muriuki, T., Nunan, F., & Briers, R. A. (2015). Applying Climate Compatible Development and Economic Valuation to Coastal Management: A Case Study of Kenya's Mangrove Forests. *Journal of Environmental Management*, *157*, 168–181. https://doi.org/10.1016/j.jenvman.2015.04.018

Hyndes, G. A., Nagelkerken, I., McLeod, R. J., Connolly, R. M., Lavery, P. S., & Vanderklift, M. A. (2013). Mechanisms and Ecological Role of Carbon Transfer Within Coastal Seascapes. *Biological Reviews*, *89*(1), 232–254. https://doi.org/10.1111/brv.12055

Jiménez-Alfaro, B., Auniņa, L., Carbognani, M., Dítě, D., Fernández-Pascual, E., Garbolino, E., Hájek, O., Hájková, P., Ivchenko, T. G., Jandt, U., Jansen, F., Kolari, T. H. M., Pawlikowski, P., Pérez-Haase, A., Peterka, T., Petraglia, A., Plesková, Z., Tahvanainen, T., Tomaselli, M., & Hájek, M. (2023). Habitat-based Biodiversity Responses to Macroclimate and Edaphic Factors in European Fen Ecosystems. *Global Change Biology*, *29*(23), 6756–6771. https://doi.org/10.1111/gcb.16965

Johnson, J. E., & Holbrook, N. J. (2014). Adaptation of Australia's Marine Ecosystems to Climate Change: Using Science to Inform Conservation Management. *International Journal of Ecology*, *2014*, 1–12. https://doi.org/10.1155/2014/140354

Khan, S., Qasim, S., Ambreen, R., & Syed, Z.-U.-H. (2016). Spatio-Temporal Analysis of Landuse/Landcover Change of District Pishin Using Satellite Imagery and GIS. *Journal of Geographic Information System*, *08*(03), 361–368. https://doi.org/10.4236/jgis.2016.83031

Lavorel, S., Colloff, M. J., McIntyre, S., Doherty, M. D., Murphy, H., Metcalfe, D. J., Dunlop, M., Williams, R. J., Wise, R. M., & Williams, K. J. (2014). Ecological Mechanisms Underpinning Climate Adaptation Services. *Global Change Biology*, *21*(1), 12–31. https://doi.org/10.1111/gcb.12689

Mayfield, M. M., Bonser, S. P., Morgan, J. W., Aubin, I., McNamara, S., & Vesk, P. A. (2010). What Does Species Richness Tell Us About Functional Trait Diversity? Predictions and

Evidence for Responses of Species and Functional Trait Diversity to Land-use Change. *Global Ecology and Biogeography*, *19*(4), 423–431. https://doi.org/10.1111/j.1466-8238.2010.00532.x

Mutaqin, B. W., Marfai, M. A., Helmi, M., Nurhadi, N., Umarella, M. R., & Munir, M. (2020). How important risk analysis of plastic pollution in coastal area? Case study in Masohi, Central Maluku. In E. Haryono, F. Lavigne, R. C. Omar, B. White, A. C. Tristan, D. R. Hizbaron, & R. F. Putri (Eds.), *1ST GEOSCIENCES AND ENVIRONMENTAL SCIENCES SYMPOSIUM (ICST 2020)* (Vol. 200, Issue 1st Geosciences and Environmental Sciences Symposium held as part of the 6th International Conference on Science and Technology (ICST)). https://doi.org/10.1051/e3sconf/202020002014 WE - Conference Proceedings Citation Index - Science (CPCI-S)

Nugraha, A. H., Tasabaramo, I. A., Hernawan, U. E., Rahmawati, S., Putra, R. D., & Darus, R. F. (2021). Diversity, Coverage, Distribution and Ecosystem Services of Seagrass in Three Small Islands of Northern Papua, Indonesia: Liki Island, Meossu Island and Befondi Island. *Biodiversitas Journal of Biological Diversity*, *22*(12). https://doi.org/10.13057/biodiv/d221238

Phang, V., Chou, L. M., & Friess, D. A. (2015). Ecosystem Carbon Stocks Across a Tropical Intertidal Habitat Mosaic of Mangrove Forest, Seagrass Meadow, Mudflat and Sandbar. *Earth Surface Processes and Landforms*, *40*(10), 1387–1400. https://doi.org/10.1002/esp.3745

Riniatsih, I., Hartati, R., Widianingsih, W., & Mahendrajaya, R. T. (2023). Seagrass Ecological Quality Index of Seagrass Meadows in Jepara Waters, Central Java, Indonesia. *Iop Conference Series Earth and Environmental Science*, *1224*(1), 12027. https://doi.org/10.1088/1755-1315/1224/1/012027

Sangaji, M., Hulopi, M., Sahetapy, J. M. F., Sirajuddin, N. T., Lokollo, F. F., & Lestari, F. (2023). The Potential of Mollusca Communities in Seagrass Ecosystems on Buntal Island Waters West Seram Regency, Maluku Province. *International Journal of Science and Environment (Ijse)*, *3*(3), 78–84. https://doi.org/10.51601/ijse.v3i2.65

Sondak, C. F. A., Kaligis, E. Y., & Bara, R. (2019). Economic Valuation of Lansa Mangrove Forest, North Sulawesi, Indonesia. *Biodiversitas Journal of Biological Diversity*, *20*(4), 978–986. https://doi.org/10.13057/biodiv/d200407

Stevens, R. D., & Tello, J. S. (2014). On the Measurement of Dimensionality of Biodiversity. *Global Ecology and Biogeography*, *23*(10), 1115–1125. https://doi.org/10.1111/geb.12192

Suazo-Ortuño, I., Alvarado-Díaz, J., Mendoza, E., López-Toledo, L., Lara-Uribe, N., Márquez-Camargo, C., Paz-Gutiérrez, J. G., & Rangel-Orozco, J. D. (2015). High Resilience of Herpetofaunal Communities in a Human-Modified Tropical Dry Forest Landscape in Western Mexico. *Tropical Conservation Science*, *8*(2), 396–423. https://doi.org/10.1177/194008291500800208

Sugara, A., Kurniawati, E., Nurholis, N., & Suci, A. N. N. (2023). Identification of Seagrass Beds Using High-Resolution Satellite Imagery to Basic Inventory Data Supporting Coastal Ecosystem Management (Case Study: Lancang Island). *Iop Conference Series Earth and*

Environmental Science, *1251*(1), 12026. https://doi.org/10.1088/1755-1315/1251/1/012026

Sumarmi, S., Pakarti, T. I., Destari, L. F. P., Aini, N., & Tanjung, A. (2022). Preservation of Vegetation Diversity to Maintain the Riparian Ecosystem of the Sampean Watershed. *Kne Social Sciences*. https://doi.org/10.18502/kss.v7i16.12168

Sun, S., Lü, Y., Lü, D., & Wang, C. (2021). Quantifying the Variability of Forest Ecosystem Vulnerability in the Largest Water Tower Region Globally. *International Journal of Environmental Research and Public Health*, *18*(14), 7529. https://doi.org/10.3390/ijerph18147529

Takemoto, K., & Kajihara, K. (2016). Human Impacts and Climate Change Influence Nestedness and Modularity in Food-Web and Mutualistic Networks. *Plos One*, *11*(6), e0157929. https://doi.org/10.1371/journal.pone.0157929

Tezar, T., & Setiadi, R. (2023). Risk Perception of Small Islands Community on Climate Change: Evidence From Mepar and Baran Islands, Indonesia. *Island Studies Journal*, *19*(1). https://doi.org/10.24043/001c.89381

Vild, O., Chudomelová, M., Macek, M., Kopecký, M., Prach, J., Petřík, P., Halas, P., Juříček, M., Smyčková, M., Šebesta, J., Vojík, M., & Hédl, R. (2024). Long-term Shift Towards Shady and Nutrient-rich Habitats in Central European Temperate Forests. *New Phytologist*, *242*(3), 1018–1028. https://doi.org/10.1111/nph.19587

Wiser, S. K., Spencer, N., Cáceres, M. D., Kleikamp, M., Boyle, B., & Peet, R. K. (2011). Veg-X – An Exchange Standard for Plot-based Vegetation Data. *Journal of Vegetation Science*, *22*(4), 598–609. https://doi.org/10.1111/j.1654-1103.2010.01245.x

Wulder, M. A., White, J. C., Loveland, T. R., Woodcock, C. E., Belward, A., Cohen, W. B., Fosnight, E. A., Shaw, J. B., Masek, J. G., & Roy, D. P. (2016). The Global Landsat Archive: Status, Consolidation, and Direction. *Remote Sensing of Environment*, *185*, 271–283. https://doi.org/10.1016/j.rse.2015.11.03

Xu, C., Pu, L., Zhu, M., Li, J., Xin-jian, C., Wang, X., & Xie, X. (2016). Ecological Security and Ecosystem Services in Response to Land Use Change in the Coastal Area of Jiangsu, China. *Sustainability*, *8*(8), 816. https://doi.org/10.3390/su8080816