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COMMUNITY STRUCTURE AND SEAWEED DENSITY ON BARRANG CADDI ISLAND, MAKASSAR CITY

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ABSTRACT

Seaweed plays an essential ecological role in coastal ecosystems by providing habitat, primary productivity, and supporting marine biodiversity. Despite its ecological and economic importance, information regarding the community structure and density of seaweed in Barrang Caddi Island, Makassar City, remains limited. This study aimed to analyze the community structure, species density, and environmental conditions influencing seaweed distribution in the coastal waters of Barrang Caddi Island. The research was conducted from April to May 2025 at three sampling stations using a quantitative descriptive approach. Seaweed data were collected using the line transect–quadrat method (1 × 1 m quadrats along 50 m transects), while water quality parameters, including temperature, salinity, and pH, were measured in situ. Community structure was evaluated using the Shannon–Wiener diversity index (H'), Pielou's evenness index (E), Simpson's dominance index (C), and species density (individuals m^{-2}). The results showed that the seaweed community exhibited moderate diversity (H' = 1.2456–1.2932), high evenness (E = 0.8985–0.9328), and moderate dominance (C = 0.2896–0.3156), indicating a relatively stable community structure. Species density varied among stations, with *Caulerpa* sp. (3.2 ind. m^{-2}), *Sargassum* sp. (1.12 ind. m^{-2}), and *Turbinaria ornata* (1.4 ind. m^{-2}) representing the dominant species at Stations 1, 2, and 3, respectively. Water quality remained within suitable ranges for tropical seaweed growth, with temperatures of 27–29°C, salinity of 29–30 ppt, and pH of 8.07–8.46. These findings indicate that the coastal ecosystem of Barrang Caddi Island continues to support diverse and relatively stable seaweed communities. The study provides baseline ecological information that can support sustainable coastal management, biodiversity conservation, and future monitoring of macroalgal resources in the Spermonde Archipelago.

INTRODUCTION

Indonesia is the world's largest archipelagic country, consisting of more than 17,000 islands with marine waters covering approximately 5.8–6.4 million km^2. This vast marine territory supports exceptionally high biodiversity and provides substantial ecological and economic resources, particularly within coastal ecosystems (Lasabuda, 2013). Among these resources, seaweeds constitute one of the most important groups of marine macrophytes because they perform essential ecological functions while simultaneously supporting fisheries, aquaculture, food industries, pharmaceuticals, cosmetics, and bioenergy development (Litaay et al., 2022; Pokhrel, 2024). Ecologically, seaweeds contribute significantly to primary productivity, oxygen production, nutrient cycling, shoreline stabilization, and the provision of habitat and nursery grounds for numerous marine organisms. Consequently, the sustainability of seaweed communities is closely associated with the ecological stability and productivity of tropical coastal ecosystems (Ferawati et al., 2014; Litaay et al., 2022).

Indonesia possesses one of the richest seaweed floras in the world. More than 900 species have been documented, representing approximately 268 genera and 89 families distributed among the three major divisions: Chlorophyta (green algae), Phaeophyceae (brown algae), and Rhodophyta (red algae) (Litaay et al., 2022; Pokhrel, 2024). This remarkable diversity reflects Indonesia's extensive coastline, varied coastal habitats, and favorable tropical environmental conditions. Seaweeds have become economically important commodities, particularly species belonging to the genera Eucheuma, Kappaphycus, Gracilaria, Sargassum, and Caulerpa, which are widely utilized as sources of hydrocolloids, antioxidants, functional foods, pharmaceuticals, and cosmetic ingredients (Pamungkas et al., 2023). As global demand for marine bioresources continues to increase, sustainable management of natural seaweed communities has become increasingly important to maintain ecosystem resilience while supporting local coastal livelihoods.

Despite their ecological and economic importance, natural seaweed communities are increasingly threatened by both anthropogenic activities and environmental change. Coastal urbanization, domestic wastewater discharge, destructive fishing practices, sedimentation, marine pollution, tourism development, and land-use changes have substantially altered coastal habitats, resulting in declining water quality and degradation of benthic ecosystems (Lasabuda, 2013). In addition, climate change has intensified environmental stress through increasing sea surface temperatures, ocean acidification, altered salinity regimes, and extreme weather events, all of which influence seaweed physiology, reproduction, distribution, and community composition (Wilopo et al., 2023). These pressures may reduce species diversity, alter competitive interactions among macroalgae, and ultimately decrease ecosystem services provided by coastal vegetation. Consequently, understanding the current structure and density of seaweed communities has become increasingly important for biodiversity conservation and coastal resource management.

Community structure analysis provides valuable ecological information regarding species composition, abundance, diversity, dominance, evenness, and spatial distribution within an ecosystem. These ecological indices are widely used to assess ecosystem stability and environmental quality because changes in community composition often reflect variations in habitat conditions and anthropogenic disturbances (Magurran, 2013). Likewise, seaweed density serves as an important ecological indicator describing the abundance of individuals occupying a given area. Variations in density are commonly influenced by environmental factors such as substrate type, water transparency, temperature, salinity, current velocity, dissolved oxygen, nutrient availability, and human disturbance (Kepel et al., 2019). Therefore, evaluating both community structure and density simultaneously provides a more comprehensive understanding of the ecological condition of coastal ecosystems.

Previous studies conducted in various Indonesian waters have consistently demonstrated strong relationships between environmental characteristics and seaweed community composition. Erniati et al. (2023) identified approximately 50 seaweed species along the western coast of Aceh and reported moderate diversity indices, indicating relatively stable ecological conditions supported by suitable water quality parameters. Similarly, Kepel et al. (2019) documented approximately 45 seaweed species in Tanjung Merah, Rap-Rap Island, and Mantehage Island, North Sulawesi, where species distribution was strongly associated with substrate characteristics. Species such as *Halimeda opuntia*, *Caulerpa racemosa*, and *Gracilaria edulis* were predominantly found on rocky and coral substrates, emphasizing the importance of habitat heterogeneity in determining macroalgal distribution patterns. Furthermore, Adharini et al. (2025) reported seasonal variations in seaweed community structure along the southern coast of Yogyakarta, demonstrating that fluctuations in temperature, salinity, and wave exposure significantly influenced species diversity and community stability throughout the year.

Systematic assessments conducted by Litaay et al. (2022) further emphasized that

Indonesia possesses tremendous seaweed biodiversity with considerable ecological and economic potential. Their review highlighted the urgent need for conservation strategies based on scientific evidence because increasing environmental degradation and overexploitation threaten many coastal ecosystems. In addition, studies conducted in Ambon waters recorded 23 edible seaweed species with promising nutritional and commercial value, illustrating the importance of preserving natural seaweed resources while promoting sustainable utilization (Litaay et al., 2022). These studies collectively demonstrate that ecological investigations of seaweed communities provide fundamental information required for conservation planning, biodiversity monitoring, and sustainable coastal management.

Barrang Caddi Island, located within the Spermonde Archipelago off the coast of Makassar City, South Sulawesi, represents one of Indonesia's ecologically important small islands. The island supports diverse marine ecosystems, including coral reefs, seagrass beds, and macroalgal communities that contribute significantly to coastal productivity and local fisheries. However, increasing human activities such as settlement expansion, tourism, fishing, and domestic waste disposal may gradually affect environmental quality and the sustainability of coastal biological communities. Despite its ecological significance, scientific information regarding the community structure and density of seaweeds on Barrang Caddi Island remains limited. Most previous studies in the Spermonde Archipelago have focused primarily on coral reef ecology and fisheries, whereas comprehensive investigations of natural seaweed communities remain relatively scarce.

Therefore, this study aims to analyze the community structure and seaweed density on Barrang Caddi Island and to examine the environmental characteristics that influence their distribution. The findings are expected to provide baseline ecological information for future biodiversity monitoring, support evidence-based management of coastal ecosystems, and contribute to the sustainable conservation and utilization of marine resources within the Spermonde Archipelago. Furthermore, this study is anticipated to strengthen scientific understanding of macroalgal ecology in eastern Indonesian waters and provide valuable references for future ecological and conservation research.

METHOD

This study employed a quantitative descriptive field survey to investigate the community structure and density of seaweeds in the coastal waters of Barrang Caddi Island, Spermonde Archipelago, Makassar City, South Sulawesi. A field survey approach was selected because it allows the direct observation of biological communities under natural environmental conditions while simultaneously measuring physicochemical parameters that influence species distribution (English et al., 1997; Krebs, 1999; Magurran, 2013). The research was conducted from April to May 2025 at three purposively selected sampling stations representing different habitat characteristics around Barrang Caddi Island. Seaweed sampling was carried out using the line transect–quadrat method, in which a 50-m transect line was established parallel to the shoreline at each station, and 1 × 1 m quadrats were placed systematically along the transect. Within each quadrat, all seaweed species were identified to the lowest possible taxonomic level, and the number of individuals of each species was recorded to determine species composition and density. Simultaneously, water quality parameters, including temperature, salinity, and pH, were measured using a thermometer, salinometer, and portable pH meter because these environmental variables are recognized as important factors influencing the distribution and growth of marine macroalgae (Littler & Littler, 2000; Luning, 1990).

The structure of the seaweed community was evaluated using four complementary ecological metrics: the Shannon–Wiener Diversity Index (H'), Pielou's Evenness Index (E), Simpson's Dominance Index (C), and species density (individuals m^{-2}). These indices provide integrated information on species richness, distribution uniformity, ecological stability, and dominance, and are widely accepted as standard measures for assessing marine macroalgal communities (Krebs, 1999; Magurran, 2013; Odum & Barrett, 2005). The mathematical expressions used for each index are presented in Equations (1)–(4).

RESULT AND DISCUSSION

The seaweed community structure at Barrang Caddi Island was evaluated using ecological indices consisting of species diversity (H'), evenness (E), dominance (C), species density, relative density, and supporting water quality parameters. These indicators collectively describe the stability of the seaweed community and its relationship with environmental conditions.

Table 1.
Diversity, Evenness, and Dominance Indices

Index	Station 1	Station 2	Station 3
Diversity (H')	1.2477	1.2932	1.2456
Evenness (E)	0.9000	0.9328	0.8985
Dominance (C)	0.3156	0.2896	0.3093

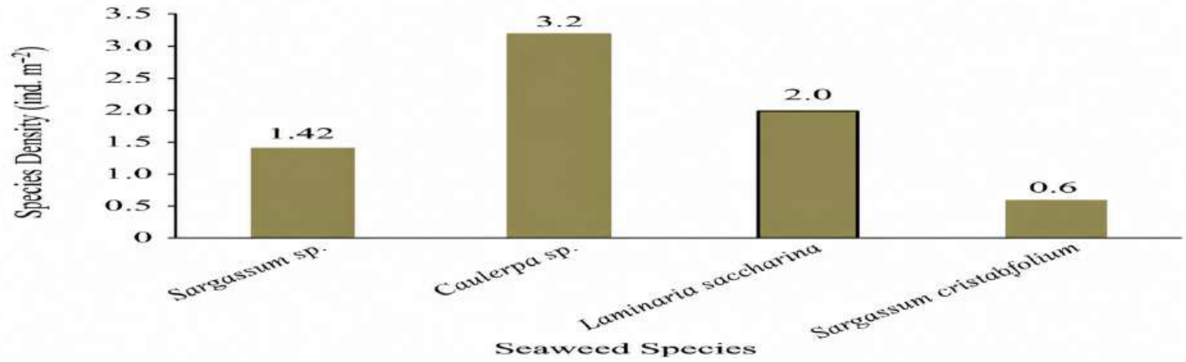
Source: research results

Table 1 shows that the Shannon–Wiener diversity index ranged from 1.2456 to 1.2932, indicating a moderate level of species diversity across all sampling stations. Station 2 exhibited the highest diversity value (H' = 1.2932), suggesting relatively more favorable environmental conditions that support a greater variety of seaweed species. According to Magurran (2013), moderate diversity generally reflects ecosystems that remain ecologically stable despite experiencing natural environmental variations. Similar findings were reported by Adharini et al. (2025), who observed that tropical coastal waters with relatively stable physicochemical conditions generally exhibit moderate to high macroalgal diversity.

The evenness index remained consistently high (E = 0.8985–0.9328), indicating that individuals were distributed relatively evenly among species. High evenness values imply that no single species overwhelmingly dominated the community, reflecting balanced resource utilization and relatively stable ecological conditions (Odum & Barrett, 2005). Comparable patterns were reported by Erniati et al. (2023), who associated high evenness with stable seaweed communities in western Aceh coastal waters.

Although diversity and evenness were relatively high, the dominance index ranged from 0.2896 to 0.3156, with the highest value occurring at Station 1. This indicates a moderate dominance pattern, where several species exhibited greater ecological success than others without completely excluding coexisting species. According to Krebs (1999), moderate dominance commonly characterizes coastal communities where habitat conditions favor several well-adapted taxa.

Figure 1.
Species Density at Station 1



Source: research results

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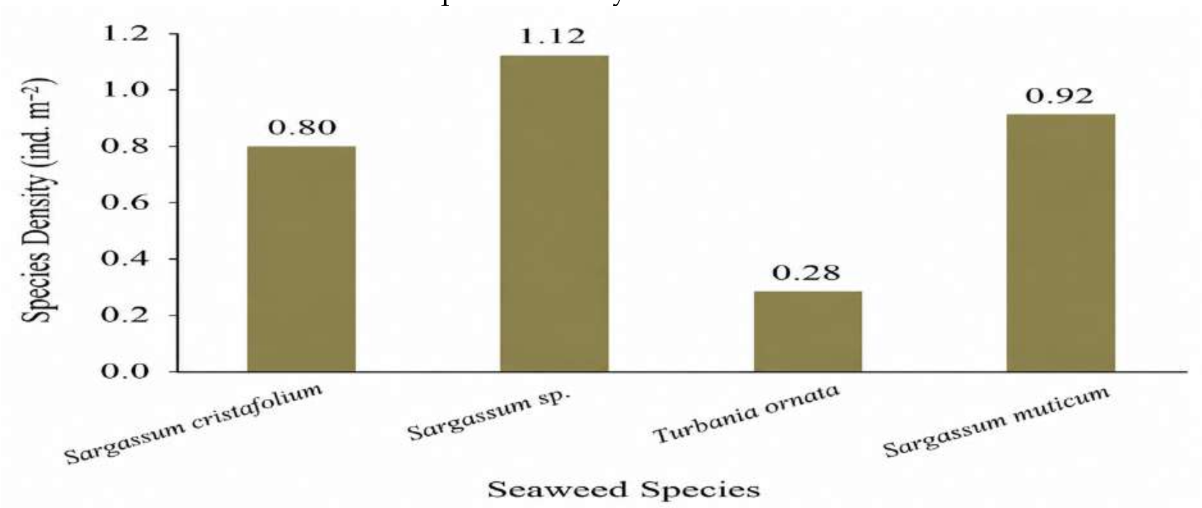
The density pattern at Station 1 demonstrated considerable variation among species. *Caulerpa* sp. exhibited the highest density (3.2 individuals m^{-2}), followed by *Laminaria saccharina* (2.0 individuals m^{-2}), *Sargassum* sp. (1.42 individuals m^{-2}), and *Sargassum cristaefolium* (0.60 individuals m^{-2}). The dominance of *Caulerpa* sp. suggests that the sandy substrate and sufficient light penetration at this station provided favorable conditions for its growth. Previous studies have shown that *Caulerpa* species thrive in shallow coastal habitats characterized by sandy substrates and high water transparency (Ferawati et al., 2014). Conversely, the relatively low abundance of *Sargassum cristaefolium* may indicate lower habitat suitability or stronger interspecific competition.

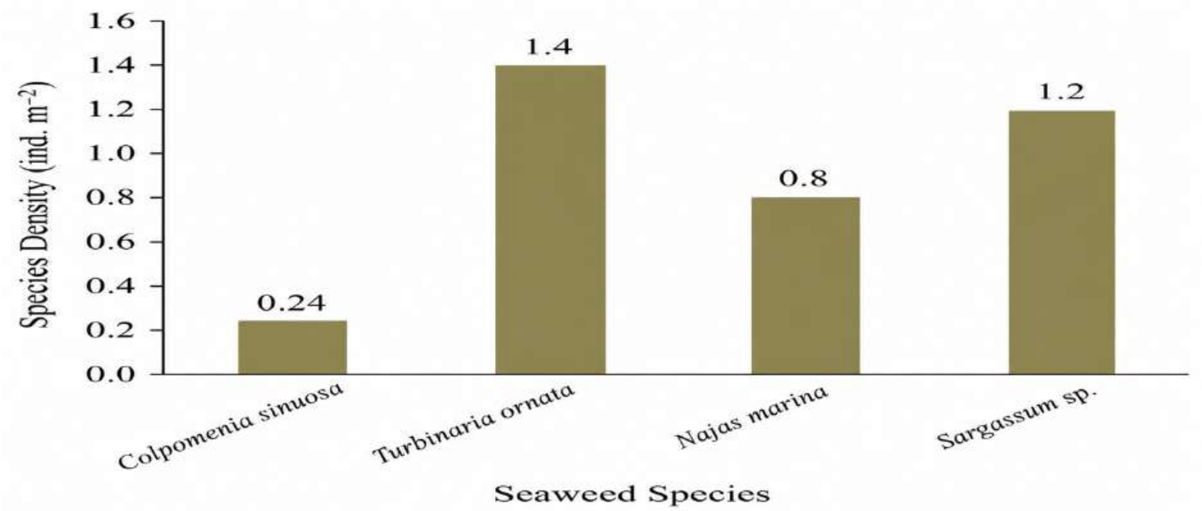
Figure 2.
Species Density at Station 2



Source: research results

Station 2 displayed a more balanced density distribution among species. *Sargassum* sp. remained the dominant species (1.12 individuals m^{-2}), followed by *Sargassum muticum* (0.92 individuals m^{-2}), *Sargassum cristaefolium* (0.80 individuals m^{-2}), and *Turbinaria ornata* (0.28 individuals m^{-2}). The coexistence of several species within the genus *Sargassum* indicates that environmental conditions, particularly salinity, pH, and substrate composition, were highly favorable for brown algae (Phaeophyceae). Similar observations were reported by Adharini et al. (2025), who identified *Sargassum* as the dominant genus in relatively undisturbed tropical coastal ecosystems.

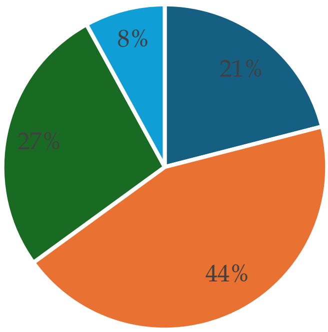
Figure 3.
Species Density at Station 3



Source: research results

At Station 3, *Turbinaria ornata* exhibited the highest density (1.40 individuals m^{-2}), followed by *Sargassum* sp. (1.20 individuals m^{-2}), *Najas marina* (0.80 individuals m^{-2}), and *Colpomenia sinuosa* (0.24 individuals m^{-2}). The predominance of *Turbinaria ornata* is consistent with its ecological preference for rocky substrates and areas exposed to moderate water movement. Kepel et al. (2019) similarly reported that *Turbinaria* and *Sargassum* frequently dominate rocky coastal habitats because of their strong attachment mechanisms and tolerance to wave action.

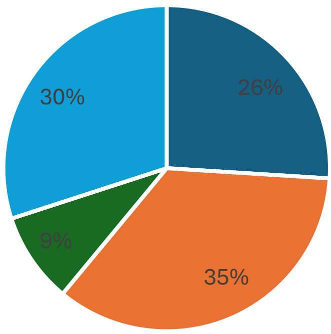
Figure 4.
Relative Density at Station 1



Source: research results

The relative density analysis showed that *Laminaria saccharina* contributed the largest proportion (44%) of the total seaweed community, followed by *Caulerpa* sp. (27%), *Sargassum* sp. (21%), and *Sargassum cristaefolium* (8%). This distribution suggests that although *Caulerpa* exhibited the highest absolute density, *Laminaria* occupied a greater proportion of the sampled community because of its wider spatial distribution.

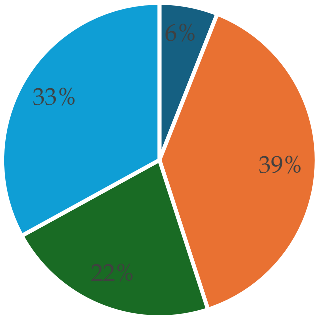
Figure 5.
Relative Density at Station 2



Source: research results

At Station 2, *Sargassum* sp. accounted for 35% of the community, followed by *Sargassum muticum* (30%), *Sargassum cristaefolium* (26%), and *Turbinaria ornata* (9%). The relatively balanced proportions among these brown algae indicate habitat homogeneity and favorable environmental conditions supporting multiple Phaeophyceae species simultaneously.

Figure 6.
Relative Density at Station 3



Source: research results

The community at Station 3 was dominated by *Turbinaria ornata* (39%), followed by *Sargassum* sp. (33%), *Najas marina* (22%), and *Colpomenia sinuosa* (6%). Although species richness remained moderate, the relatively high contribution of *Turbinaria* suggests that local environmental conditions favored this species over others. According to Wilopo et al. (2023), increasing dominance by a limited number of species may represent an early ecological response to habitat heterogeneity or environmental disturbance.

Table 2.
Water Quality Parameters

Parameter	Station 1	Station 2	Station 3	Mean
Temperature (°C)	27	27	29	27.67
Salinity (ppt)	30	30	29	29.67
pH	8.46	8.46	8.07	8.33

Source: research results

The measured water quality parameters remained within ranges generally considered suitable for tropical seaweed growth. Water temperature averaged 27.67°C, which falls within the optimum range (25–30°C) for photosynthesis, respiration, and nutrient metabolism in most tropical macroalgae (Lobban & Harrison, 1997). Salinity remained relatively stable (29–30 ppt), supporting osmotic regulation and nutrient uptake, while pH values (8.07–8.46) reflected slightly alkaline seawater conditions that are favorable for macroalgal growth.

Overall, the combination of moderate diversity, high evenness, moderate dominance, and suitable water quality indicates that the coastal waters of Barrang Caddi Island continue to provide favorable ecological conditions for seaweed communities. Nevertheless, the occurrence of localized species dominance and variations in species density among stations suggests that habitat characteristics, substrate composition, and human activities may influence community composition. These findings are consistent with previous studies emphasizing that tropical macroalgal communities are strongly regulated by the interaction between environmental quality and habitat heterogeneity (Adharini et al., 2025; Erniati et al., 2023; Kepel et al., 2019; Wilopo et al., 2023). Such information provides an important scientific basis for the sustainable management and conservation of coastal ecosystems in the Spermonde Archipelago.

CONCLUSION

This study demonstrated that the seaweed community at Barrang Caddi Island, Makassar City, exhibits a relatively stable ecological structure characterized by moderate species diversity, high evenness, and moderate dominance across the three sampling stations. The

Shannon–Wiener diversity index (H' = 1.2456–1.2932) indicates a moderately diverse community, while the high evenness values (E = 0.8985–0.9328) suggest that individuals are distributed relatively evenly among species. Simpson's dominance index (C = 0.2896–0.3156) further indicates that no single species overwhelmingly dominated the community, reflecting balanced ecological interactions within the coastal ecosystem. Species density varied among sampling stations according to habitat characteristics and substrate composition. At Station 1, *Caulerpa* sp. exhibited the highest density (3.2 ind. m^{-2}), whereas *Sargassum* sp. was dominant at Station 2 (1.12 ind. m^{-2}), and *Turbinaria ornata* showed the highest density at Station 3 (1.4 ind. m^{-2}). These variations indicate that substrate type and local environmental conditions strongly influence the spatial distribution of seaweed species in Barrang Caddi waters.

Water quality measurements, including temperature (27–29°C), salinity (29–30 ppt), and pH (8.07–8.46), remained within the optimal range for tropical seaweed growth, supporting the development and persistence of diverse macroalgal communities. Overall, the findings indicate that the coastal waters of Barrang Caddi Island remain ecologically suitable for seaweed communities and continue to provide favorable habitats for various macroalgal species. Nevertheless, continuous monitoring and sustainable coastal management are recommended to minimize the potential impacts of anthropogenic activities and environmental change on the long-term stability of the seaweed ecosystem.

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