Influence of human pressure and environment variables to seagrass community in Sarangani, Davao Occidental, Philippines

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Abstract. Seagrasses are vital marine plants that deliver essential ecological services, including shoreline protection, carbon sequestration, and nursery habitats for diverse marine species. This study presents the first comprehensive baseline assessment of seagrass ecosystems in Sarangani, Philippines, using transect-quadrat surveys to evaluate species composition, shoot density, percent cover, diversity, and associated environmental and anthropogenic drivers. Seagrass cover indicated excellent conditions (> 75%) in Tinina, Tagen and Batuganding, good in Mabila (55.28%), and fair in Camahual (48.29%). Diversity was highest in the low-disturbance site (Tagen; H' = 1.53) and lowest in high-disturbance areas (Mabila; H' = 0.92). Hierarchical cluster analysis revealed three main site groupings: Tinina and Tagen exhibited the highest similarity (84.9%); Mabila showed moderate similarity with both Batuganding (75.9%) and Tinina (70.8%); while the high-disturbance site in Camahual emerged as the most distinct. The canonical correspondence analysis revealed that seagrass species abundance and distribution were highly influenced with environmental variables such as chlorophyll concentration, dissolved oxygen, temperature, depth, pH and salinity. These findings underscore the ecological variability of seagrass habitats in Sarangani Islands, influenced by both environmental characteristics and anthropogenic disturbances. This study provides a critical baseline for future monitoring and highlights the need for habitat-specific strategies in seagrass conservation.

Key Words: canonical correspondence analysis, diversity, seagrass cover, shoot density.

Introduction. Seagrasses are flowering plants that thrive in marine and brackish waters. These underwater meadows drive high primary productivity, forming critical habitats for fish, crustaceans, and endangered species like dugongs. Seagrasses play a vital role in supporting fisheries (Nugraha et al 2021). Their function as nursery habitats and fishing grounds contributes significantly to the productivity of coastal fisheries and global food security (Unsworth et al 2019). A healthy seagrass meadow is estimated to provide approximately Php 1,445,850 (USD 25,000) per hectare per year in total economic services (Azanza et al 2017). Beyond their role in fisheries, seagrass ecosystems also perform important geomorphological functions. East et al (2023) quantified their contribution to sediment dynamics, showing that healthy seagrass meadows can supply over 541,000 kilograms (kg) of sediment annually to reef islands. This natural sedimentation process is crucial for maintaining beach stability and reducing coastal erosion, particularly in vulnerable island communities.

Despite the economic and ecological services, seagrasses are among the least protected marine ecosystems globally (Hu et al 2021). It is estimated that approximately 29% of the world’s seagrass areas have been lost (Waycott et al 2009), while in the Philippines, the decline ranges between 30 and 50% (Fortes 2013). Recent studies have highlighted widespread degradation driven by destructive fishing practices, coastal development, and pollution (Iacarella et al 2018; Arriesgado et al 2024). This global trend is particularly alarming in the Pacific region, where a comprehensive review by Singh (2019) reported that seagrass ecosystems are disappearing at rates comparable to coral reefs and mangroves - yet they continue to receive considerably less conservation attention. Protecting and restoring seagrass beds is essential to sustain their ecological functions, particularly their role in supporting biodiversity and providing critical ecosystem services (Sumbayak et al 2023). In this context, regular monitoring is required to assess if seagrass conditions are stable, deteriorating, or improving over time (Molina & Bersaldo 2024).

Assessments of the extent and relative impact of anthropogenic activities on seagrass meadows remain scarce in the southern Philippines (Arriesgado et al 2024), and large areas in the Davao Region still lack documentation of seagrass presence (Capin et al 2020). Notably, certain areas in Davao Occidental are estimated to support a population of at least 12 individual dugongs (Lucero 2010), highlighting the ecological importance of its seagrass habitats. Protecting these critical areas, which provide essential refuge and feeding grounds for dugongs, could enhance the potential for successful dugong-watching ecotourism in the region (Lucero 2010), especially in areas were tourism are one of its sources of income like in Balut Island, Sarangani, Davao Occidental.

The island municipality of Sarangani, Davao Occidental, Philippines, comprises two main islands (Balut and Sarangani) and one islet (Olanivan), with fisheries and tourism serving as the economic backbone of local communities. This marine-dependent economy makes the health of coastal ecosystems particularly crucial for sustaining livelihoods and food security in the region. To date, no scientific information is available on the seagrass resources in Sarangani. With the rapid expansion of tourism and coastal development, these ecosystems are increasingly under threat. If this situation continues, the extent of seagrass habitats is expected to decline each year (Wang et al 2025). Therefore, understanding the key drivers of seagrass degradation and identifying areas most vulnerable to loss are essential for improving the conservation and sustainable management of these critical ecosystems (Turschwell et al 2021). This study addresses a significant knowledge gap by establishing the first comprehensive baseline assessment of seagrass ecosystems in Sarangani. It covers key ecological indicators, including species composition, shoot density, percent cover, diversity indices, as well as associated anthropogenic pressures and environmental drivers. By quantifying ecosystem health indicators, the study aims to inform management strategies that balance ecological protection with sustainable fisheries - a crucial consideration for this fishing-dependent community. The data will particularly support the development of locally-appropriate marine protected areas and habitat restoration initiatives to safeguard Sarangani's vital seagrass ecosystems.

Material and Method

Description of the study sites. The municipality of Sarangani in Davao Occidental is a remote island group composed of Balut Island, Sarangani Island, and Olanivan Islet. Its economy thrives on fishing and tourism, with coastal communities heavily dependent on marine resources for food security and livelihood. The surrounding waters are rich in biodiversity, supporting coral reefs, seagrass beds, and mangrove forests, critical habitats that sustain fish populations and marine life. Five representative sites were selected along a gradient of anthropogenic disturbance, based on field observations conducted during the survey period. Sites were categorized into three levels of disturbance: high, moderate, and low. This classification and level of disturbance were adapted from human disturbance assessment frameworks by various literatures (Waycott et al 2009; Angulo et al 2016; Arriesgado et al 2024; Mwikamba et al 2024). Mabila (5°25'1.73"N, 125°25'45.14"E) and Camahual (5°27'15.78"N, 125°27'37.89"E) were classified as high-disturbance sites; Tinina (5°22'31.89"N, 125°24'23.92"E) and Batuganding (5°23'36.27"N, 125°25'36.99"E) as moderate; and Tagen (5°22'38.17"N, 125°21'7.81"E), which exhibited as a low-disturbance site. This classification enabled a comparative assessment of seagrass ecosystem condition across varying levels of human impact (Figure 1 and Table 1).

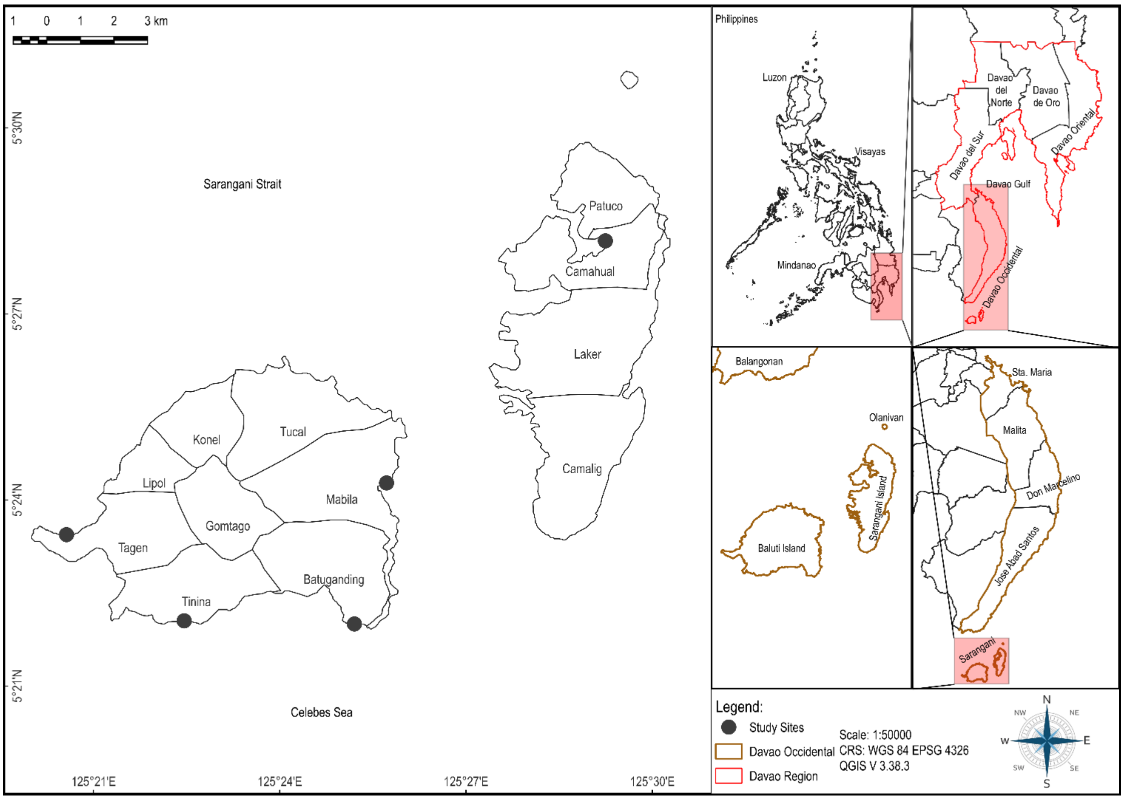

Figure 1. Map showing the five sampling sites in Sarangani, Davao Occidental.

Table 1

Anthropogenic disturbance indicators and classification of five sampling sites based on field observations

Sites	*Habitat characteristics*	*Anthropogenic indicators*	*Level of disturbance*
Tinina	Seagrasses occur in the subtidal area in a sheltered bay characterized by a sandy-muddy to coralline substrate	The site is subject to occasional boat traffic, limited gleaning and tourism activities, and is located near a few small communities within 100 meters	Moderate
Batuganding	Seagrasses occur in the intertidal and subtidal area exposed to wave action characterized by a sandy-muddy substrate	The site is subject to occasional boat traffic, limited gleaning and tourism activities, and is located near a few small communities within 100 meters	Moderate
Tagen	Seagrasses occur in the subtidal area in a sheltered bay characterized by a sandy-muddy to coralline substrate	The site experiences minimal gleaning activity, is distant from tourism areas, and has only a few small communities located within 100 meters.	Low
Mabila	Seagrasses occur in the subtidal area in a sheltered bay characterized by a sandy-muddy substrate	The site is within 50 m of a community and a port, and is subject to intense fishing pressure, frequent boat traffic, visible solid waste and possible domestic waste input	High
Camahual	Seagrasses occur in the intertidal and subtidal area in a sheltered bay characterized by a sandy-muddy substrate. The seagrass area is adjacent to the planted mangrove area	The site is within 50 m of a community. The area experiences high vessel traffic, visible solid waste and potential domestic waste discharge	High

Sampling procedure. Sampling was conducted from November 12 to 30, 2024, using the transect-quadrat survey method at established sampling sites. At each site, three 50-meter (m) transects were laid perpendicular to the shoreline, each spaced 50 m apart. For ease of observation, sampling was conducted in the daytime during the lowest low tide. The sampling was conducted by snorkeling up to 1.5 m to 2 m depth. Along each 50-m transect, eleven 0.5 m × 0.5 m steel quadrats were placed at 5-m intervals, totaling 33 quadrats per site. Seagrass species present within each quadrat was identified at the study sites based on leaf morphology, rhizome and leaf sheath characteristics, flowers and fruits following the taxonomic keys of Fortes (2013). Valid scientific names and taxonomic identities were verified using the World Register of Marine Species (WoRMS) and SeaLifeBase databases.

To determine seagrass abundance, shoot density was assessed by carefully counting the number of shoots per species in each quadrat and expressing the results as density (shoots m^{-2}). Seagrass cover was estimated visually using the method of Saito & Atobe (1970), as adapted by English et al (1994). Each species within the quadrat's 25 sub-squares was assigned a cover class and its corresponding midpoint percentage. The seagrass covers for each transect was calculated by dividing the sum of the average cover values of all quadrats by the number of quadrats surveyed. The percentage of seagrass cover of each sampling site was then categorized using the categories used by Jackson & Nemeth (2007), where poor = 0-25%, fair = 26-50%, good = 51-75%, and excellent = 76-100%.

Determination of physicochemical parameters. During the seagrass assessment, water temperature, pH, salinity, dissolved oxygen (DO), depth and water chlorophyll concentration in each of the transects were determined in situ using a YSI ProDSS Multiparameter Digital Water Quality Meter. A total of 10 logged readings in the multiparameter were recorded from the start to the end of each transect line. Dominant substrate type in each quadrat was also noted.

Data analysis. Seagrass percent cover (C) and shoot density (Di) of each species was computed following the equation:

$$C = \Sigma(Mi \times fi)/\Sigma f \quad (1)$$

where: Mi was the mid-point percentage of class i and f was the frequency (number of subsquares with the same class of dominance (i)).

$$Di = Ni/A \quad (2)$$

where: Ni was the total number of shoots of each species and A was the total area of the quadrat.

Calculation of diversity indices. Using the seagrass shoot density data the following diversity indices were calculated: the Shannon-Wiener diversity index (H'), maximum diversity (H_{max}), Pielou's index of evenness (J') and Simpson's index of dominance (D).
The Shannon–Wiener diversity index (H') was calculated as:

$$H' = -\Sigma Pi \ln(Pi)$$

where $Pi = ni/N$ represents the relative abundance of each seagrass species; ni is the total number of shoots of seagrass species i; N is the total number of shoots of all seagrass species combined; and ln (Pi) is the natural logarithm of the proportion Pi.

Maximum diversity (H_{max}) was calculated as:

$$H_{max} = \ln(S)$$

where S is the total number of seagrass species; and ln is the natural logarithm function.

Pielou's index of evenness (J') and Simpson's index of dominance (D) were calculated as:

$$J' = H'/H_{max}$$

$$D = \Sigma(Pi)^2$$

The diversity indices were analysed using Paleontological Statistics (PAST) Software. A hierarchical cluster analysis with single linkage, based on the Bray-Curtis similarity of the community, was also performed in R using the seagrass shoot density data to determine community similarity across five sampling sites.

Statistical analysis. Seagrass density and percent cover data were analyzed for normality using the Shapiro-Wilk test and for equal variances using Levene's test, both at a significance level of 0.05. As these data met the assumptions of normality and equal variances, a one-way Analysis of Variance (ANOVA) was used to determine significant differences ($p < 0.05$) across five sites. Further, Tukey's HSD post hoc test was used to determine which study sites statistically differ from the other. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 20. Canonical correspondence analysis (CCA) were performed in R software to examine the relationship of seagrass shoot density and environmental variables.

Results

Species composition and distribution of seagrasses. A total of eight seagrass species belonging to the families Hydrocharitaceae and Cymodoceaceae were recorded across five sampling sites in Sarangani, Davao Occidental, Philippines. The species identified includes *Thalassia hemprichii* (Ehrenberg) Ascherson, 1871, *Halophila ovalis* (R. Brown) J.D. Hooker, 1858, *Enhalus acoroides* (Linnaeus f.) Royle, 1839, *Halodule pinifolia* (Miki) Hartog, *Halodule uninervis* (Forsskål) Ascherson, 1882, *Syringodium isoetifolium* (Ascherson) Dandy, 1939, *Thalassodendron ciliatum* (Forsskål) Hartog, 1970, and *Cymodocea rotundata* Ascherson and Schweinfurth, 1870 (Table 2). Among the five sites, Tagen recorded the highest species richness, with all eight seagrass species present while Batuganding and Mabila had the lowest richness, with only five species each.

Table 2

Species composition of seagrasses in five sampling sites

Family	*Species name*	*Sampling sites*				
		Tinina	*Batuganding*	*Tagen*	*Mabila*	*Camahual*
Hydrocharitaceae	*Thalassia hemprichii*	+	+	+	+	+
	Halophila ovalis	+	+	+	+	+
	Enhalus acoroides	+	+	+	+	+
Cymodoceaceae	*Halodule pinifolia*	-	-	+	-	+
	Halodule uninervis	+	-	+	-	-
	Syringodium isoetifolium	+	+	+	+	+
	Thalassodendron ciliatum	+	-	+	-	-
	Cymodocea rotundata	+	+	+	+	+

(+) indicates the presence, and (-) indicates the absence of seagrass species in the study sites.

Seagrass abundance and condition. Seagrass cover and shoot density showed significant variation among the five sampling sites. One-way ANOVA revealed significant differences in cover ($F = 62.32$, $p = 0.019$) and shoot density ($F = 3.601$, $p = 0.045$). Post hoc analysis using Tukey's test indicated that seagrass cover between Mabila and Tagen differed significantly ($p = 0.02804$) while Camahual was significantly different from those in Tinina ($p = 0.01346$), Tagen ($p = 0.03945$), and Batuganding ($p = 0.0394$). Tagen recorded the highest mean cover at 90.99%, while Camahual had the lowest at 48.29%. According to the categories used by Jackson & Nemeth (2007), Tinina (82.18%), Batuganding (84.25%), and Tagen (90.99%) were categorized as having excellent seagrass condition. Mabila (55.28%) was rated as good, and Camahual (48.29%) as fair. At the species level, *T. hemprichii* was the most dominant seagrass observed across all sites, except in Camahual, with an average percent cover of 35.14% (classified as fair) and a shoot density of 355.55 ± 129.78 ind m^{-2}. This was followed by *S. isoetifolium*, which exhibited a lower average cover of 15.78% (poor) and a shoot density of 210.59±78.73 ind m^{-2}. *H. uninervis* showed the lowest representation, with a mean cover of only 0.92% (poor) and a shoot density of 3.92±4.81 ind m^{-2} (Figures 2 and 3). Notably, *T. ciliatum* exhibited a patchy distribution, typically occurring along the 40 to 50 m segment of the transect at depths of approximately 1.5 to 2 m. Its shoot density and percent cover ranged from 15.81 to 78.54 ind m^{-2} and 3.95 to 13.70%, respectively, contributing only 6.17% to the total seagrass cover across all five sites.

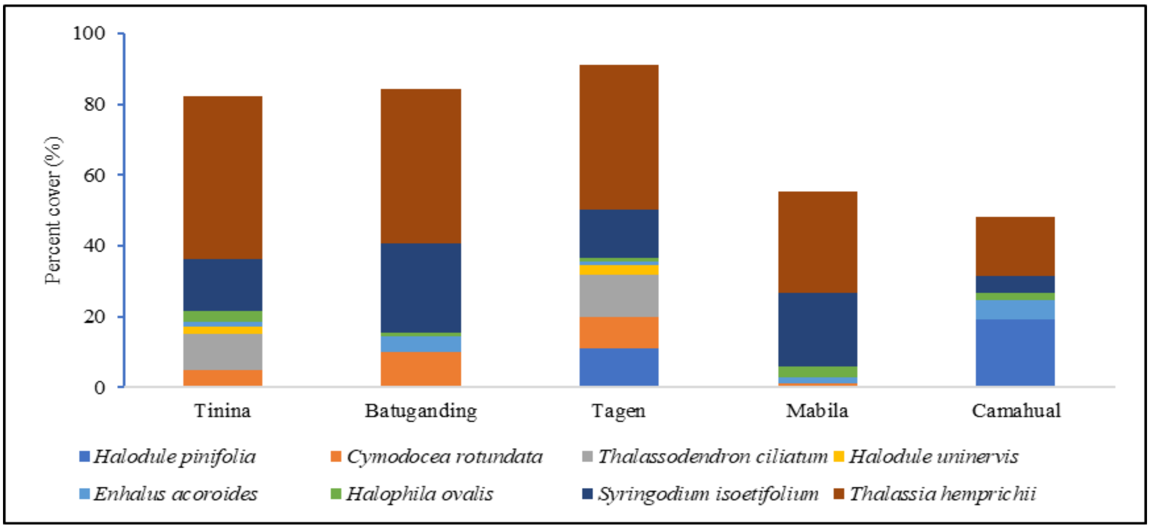

Figure 2. Seagrass percent cover (%) in five sampling sites.

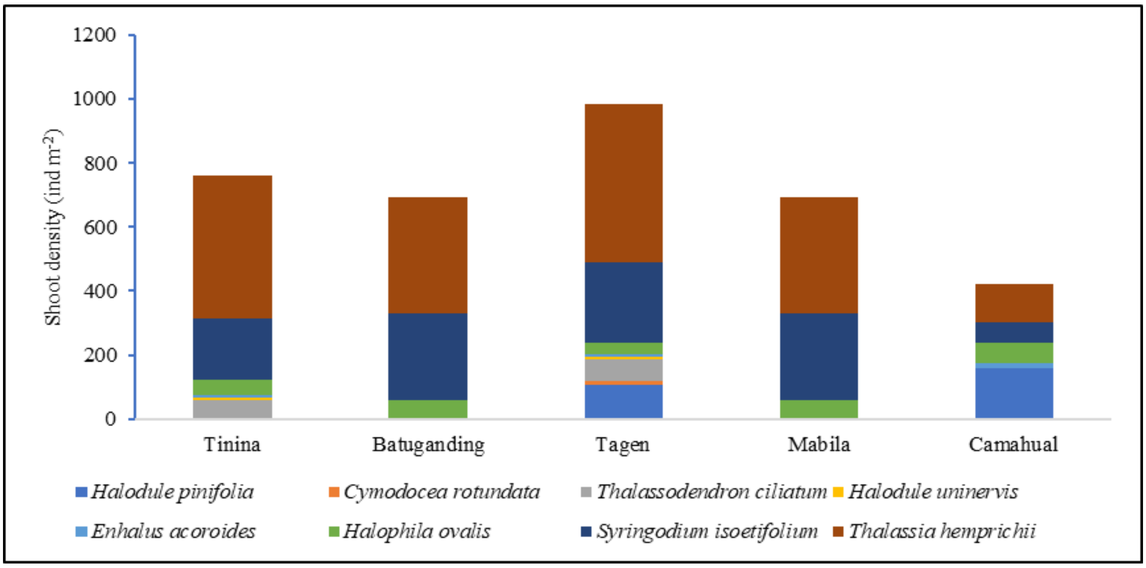

Figure 2. Shoot density (ind m^{-2}) of seagrasses in five sampling sites.

Hierarchical clustering of seagrass communities revealed three major site groupings based on species composition and abundance (Figure 4). Tinina and Tagen formed a core cluster with 84.9% similarity. Mabila showed moderate similarity with Batuganding (75.9%) and Tinina (70.8%), but lower similarity with Tagen (62.1%). Camahual emerged as the most distinct site, with the lowest similarity across all sites.

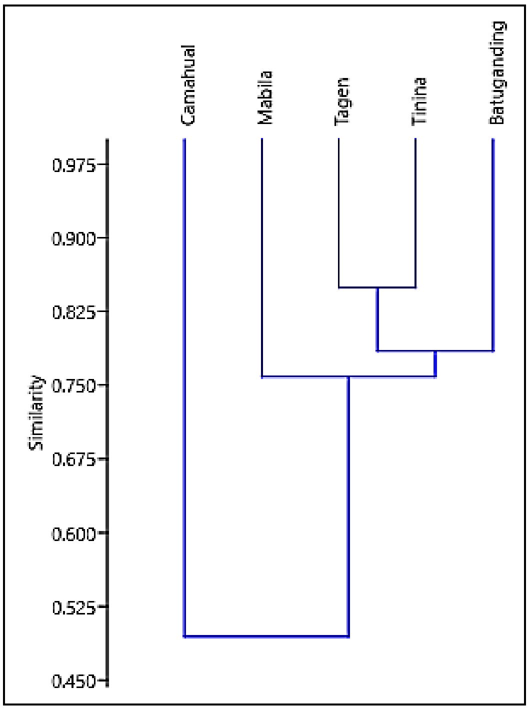

Figure 4. Hierarchical clustering based on Bray-Curtis similarity of the five sampling sites.

Diversity of seagrasses. The highest Shannon-Wiener diversity index and Pielou's index of evenness was recorded in Tagen (H' = 1.53, J' = 0.79) while Mabila (H' = 0.92, J' = 0.57) has obtained the least (Table 3). Additionally, Tinina (D = 0.68) and Camahual (D = 0.66) exhibited the highest Simpson's index of dominance, which could be attributed to the high density and cover of dominant species per study sites, i.e. *T. hemprichii* in Tinina and *H. pinifolia* in Camahual.

Table 3

Diversity profile in five sampling sites in Sarangani, Davao Occidental

Sampling sites	*Diversity indices*				
	Species richness (S)	*Shannon-Wiener diversity index (H')*	*Maximum diversity (Hmax)*	*Pielou's index of evenness (J')*	*Simpson's index of dominance (D)*
Tinina	7	1.42	1.94	0.73	0.68
Batuganding	5	1.28	1.60	0.67	0.58
Tagen	8	1.53	2.07	0.79	0.54
Mabila	5	0.92	1.60	0.57	0.60
Camahual	6	1.08	1.79	0.72	0.66

Physicochemical conditions in the seagrass area. The physicochemical parameters of the water at the five sampling sites were presented in Table 4. The average water temperature and salinity were 30.11±0.25ºC and 36.05±0.02 ppt respectively. The average DO concentration was 6.51±1.18 mg L^{-1} with Mabila having the highest DO values recorded at 6.74 mg L^{-1}. The average pH of the water in Sarangani was 7.75±0.02, which is mildly alkaline. The average chlorophyll-*a* concentration was at 0.041±0.02 μg L^{-1} and significantly higher in Camahual at 0.067 μg L^{-1}. The average depth where seagrasses sampled was 1.05±0.03 m. Substrate type in each site was generally sandy.

Table 4

Physicochemical conditions in the five sampling sites

Environmental parameters	*Tinina*	*Tagen*	*Batuganding*	*Mabila*	*Camahual*
Temperature (ºC)	29.95±0.23	29.76±0.15	30.14±0.11	30.51±0.08	30.20±0.13
pH	7.72±0.21	7.74±0.01	7.77±0.16	7.77±0.05	7.74±0.06
Dissolved oxygen (mg L^{-1})	6.16±0.32	6.38±0.20	6.67±0.17	6.74±0.09	6.60±0.10
Salinity (ppt)	36.13±0.09	36.04±0.02	36.17±0.22	35.93±0.18	35.98±0.05
Chlorophyll-*a* (μg L^{-1})	0.02±0.01	0.033±0.01	0.04±0.02	0.045±0.01	0.067±0.11
Depth (m)	1.08±0.10	1.05±0.13	1.07±0.11	1.00±0.13	1.08±0.15
Substrate type	Sandy-coralline	Sandy-coralline	Sandy-muddy	Sandy-coralline	Sandy-muddy

The CCA result showed that the first canonical axis (CCA1) explained 55.0% of the constrained variation, while the second axis (CCA2) explained an additional 29.7%, together accounting for 84.7% of the total constrained variation. This indicates that CCA1 and CCA2 effectively capture the major environmental gradients influencing seagrass community structure. This result was statistically significant, as confirmed by the permutation test ($p < 0.05$, $p = 0.001$). Based on the CCA biplot, chlorophyll, DO, pH, and salinity emerged as the most influential environmental variables shaping seagrass community composition, as indicated by their longer vector length. CCA also showed that *T. hemprichii* located near the center of the ordination plot, suggesting broad tolerance to environmental conditions. *C rotundata* was positively associated with temperature and salinity. *T ciliatum* and *H. uninervis* are strongly associated with depth and temperature, but negatively associated with pH and DO. *S. isoetifolium*, *H. ovalis*, and *E. acoroides* are found in areas with higher pH, DO, and chlorophyll (Figure 5).

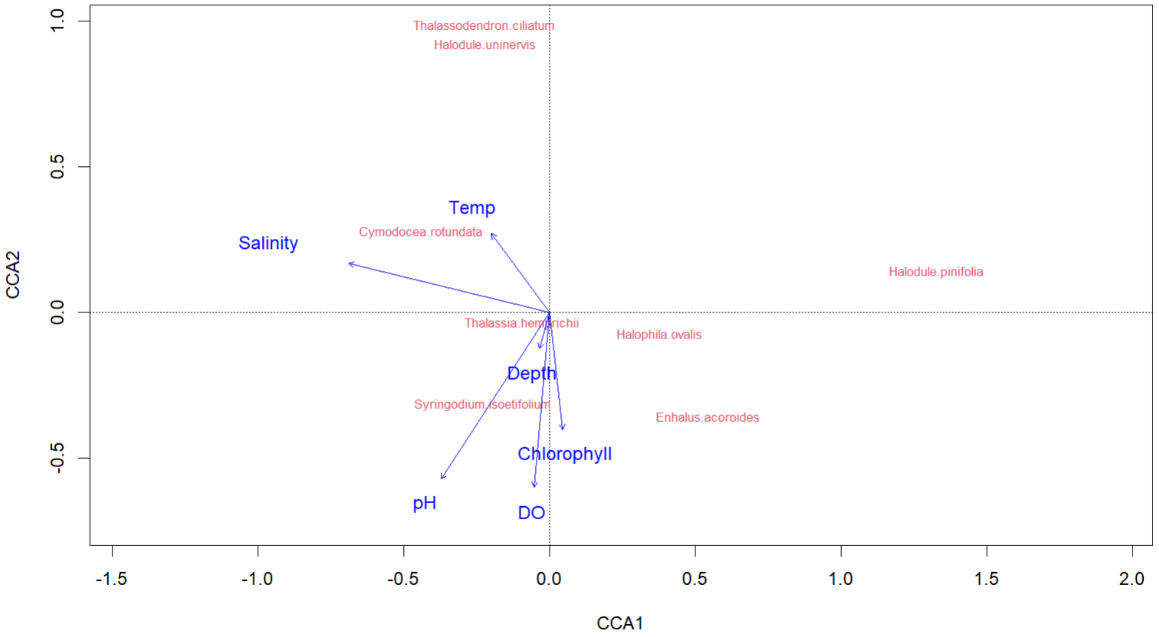

Figure 5. Canonical correspondence analysis – biplot of environmental variables and seagrass shoot density.

Discussion. A total of eight seagrass species were recorded in Sarangani, Davao Occidental, Southern Philippines, representing approximately 55.56% of the total seagrass species reported in the Philippines (Short et al 2007). The area exhibited a mixed seagrass meadow composed of both small-sized species (e.g., *H. ovalis*) and large-sized species (e.g., *E. acoroides*), suggesting a diverse and structurally complex habitat. Seagrass bed condition is often assessed based on species richness, with the presence of more than seven species considered indicative of a healthy and stable system (Hernawan et al 2021). The highest species richness was recorded in Tagen, where seagrasses were widely distributed. This may be attributed to its subtidal location within sheltered bays and reefs, characterized by sandy to coralline substrates and low levels of disturbance, which likely support higher biodiversity. In contrast, diversity values were lower in more disturbed sites. These patterns underscore the influence of human pressures in shaping seagrass community structure, where only resilient species persist and dominate. The reduced diversity in Mabila and Camahual may reflect the combined effects of environmental stressors and anthropogenic impacts. As emphasized by Dedel et al (2018), seagrasses are particularly vulnerable to both natural disturbances and human activities, which can result in habitat degradation and biodiversity loss. Supporting these findings, hierarchical clustering of seagrass communities revealed that Tinina and Tagen formed a core cluster, indicating highly similar species composition and abundance. In contrast, Camahual emerged as the most distinct site, showing the lowest similarity across all locations. This distinctness likely reflects its unique species composition, lower overall cover, and evident human disturbance, as well as its location on a separate island with different habitat characteristics.

Seagrass cover and shoot density varied significantly across sites, reflecting a disturbance gradient. Higher values were recorded in less disturbed areas, whereas reduced cover and density were observed in sites facing greater anthropogenic pressures. These patterns are consistent with previous studies showing that site-specific human impacts contribute to habitat fragmentation, declining seagrass health, and potential habitat loss (McCloskey & Unsworth 2015; Arriesgado et al 2024). Seagrass cover is also a widely accepted indicator of ecosystem health, and areas with intense human activity often exhibit signs of degradation (Arriesgado et al 2024). For instance, in high level disturbance sites, Mabila and Camahual was rated as good and fair respectively according to the categories used by Jackson & Nemeth (2007) on seagrass condition. The fair condition in Camahual may be attributed to multiple stressors, including high vessel activity, the presence of domestic waste, and increased sedimentation. As described by Mascariñas & Otadoy (2022), such fair seagrass conditions are characterized by sparse coverage and habitat fragmentation, likely resulting from the degradation of a previously continuous meadow, potentially caused by anthropogenic activities. Although Mabila was rated as good, its proximity to a port and frequent boat anchoring may introduce physical disturbances and pollution that threaten seagrass integrity. If unmanaged, such pressures can lead to long-term degradation and seagrass loss (Waycott et al 2019; De Guzman et al 2025).

Seagrass species respond differently to prevailing environmental conditions, and only those with high adaptability and flexibility to changing environments are able to thrive successfully across various habitats (Hemminga & Duarte 2000). The *T. hemprichii* was the most dominant species observed across all sites except in Camahual that was dominated by *H. pinifolia*. The dominance of *T. hemprichii* were consistent with other studies in the Philippines (Abubakar & Echem 2018; Capin et al 2020; Mascariñas & Otadoy 2022) and in other countries (Wahab et al 2017; Dewi et al 2020) and may be linked to the physical characteristics of the Sarangani seagrass beds, which are located in subtidal zones. Limited exposure during low tide, combined with sandy-muddy substrates, creates favorable conditions for *T. hemprichii* (Molina & Bersaldo 2024). Additionally, this species competitive ability in acquiring resources and occupying space may limit the growth of other seagrasses (Abubakar & Echem 2018; Capin et al 2020). This is further supported by the CCA biplot, where *T. hemprichii* was positioned near the center of the ordination plot, indicating its tolerance to a wide range of environmental conditions, which explains its prolific growth and dominance in the seagrass area. The CCA also showed that *C. rotundata* was associated with higher water temperature and salinity. Salinity plays a key role in seagrass growth by regulating osmotic balance and influencing photosynthetic efficiency (Tang et al 2025). Although higher salinity generally supports seagrass growth and reproduction, tolerance levels vary by species (Kowalski et al 2023). Temperature also affects seagrass health. Within the optimal range, it enhances photosynthesis, nutrient uptake, and shoot production. However, prolonged high temperatures can cause thermal stress, especially in intertidal species exposed during low tide. This can lead to reduced growth, increased respiration, and lower shoot density (Collier et al 2011). In this study, the water temperature (30.11±0.25°C) and highly saline water (36.05±0.02 ppt), along with subtidal conditions that prevented seagrass exposure during low tide, favored the growth of *C. rotundata*. Therefore, changes in these environmental variables could significantly affect its abundance and distribution.

Notably, among the various seagrass studies conducted in the Davao Region, *T. ciliatum* was recorded only in Sarangani, making it the only site in the region where this species has been documented to date. The species *T. ciliatum* was recorded only at the moderate and low disturbance sites in Tinina and Tagen respectively, accounting for just 6.17% of the total seagrass cover across all five sites which was categorized as poor, occurring at depths of around 1.5 to 2 m in areas with sandy-coralline substrates near coral reefs. The restricted occurrence of *T. ciliatum* in these locations may suggest that the species favors relatively undisturbed or near-pristine environments, potentially making it an indicator of habitat quality. The CCA results revealed that the abundance of *T. ciliatum* along with *H. uninervis*, were positively correlated with depth and temperature. Depth is also a key factor influencing seagrass cover, primarily due to its impact on light availability. Since seagrasses require adequate light for photosynthetic activity, reduced light availability negatively affects their growth, often resulting in morphological adaptations and lower biomass production (Xu et al 2016). Mayol et al (2022) reported a sharp decline in shoot density beyond a depth of approximately 1.9 m. In this study, seagrass beds were generally located at depths below 1.5 m, within subtidal zones where they remain fully submerged. These permanently submerged conditions are favorable for seagrass growth, as they offer more consistent light and temperature regimes (Khairunnisa et al 2019). *H. ovalis* and *E. acoroides* were also influenced by depth together with DO and chlorophyll concentration areas. The optimal DO concentration for seagrass beds was between 5 and 8 mg L^{-1} (Song et al 2025), which falls within the recorded DO levels in this study. Adequate DO allows seagrasses to perform aerobic respiration efficiently, supplying the energy needed for growth, reproduction, and physiological maintenance (Zhao et al 2025). This, in turn, can directly influence shoot density. Moreover, the chlorophyll concentration in the study sites was low (< 0.067 μg L^{-1}) creating favorable condition for seagrass growth. Low chlorophyll-*a* concentration usually implies low phytoplankton biomass, which results in greater water clarity. This improved light penetration enhances photosynthetic activity for benthic plants like seagrasses, promoting higher shoot density and coverage (Ralph et al 2007; Cognat et al 2018). Moreover, incorporating additional environmental parameters, such as nutrient concentrations (nitrate, nitrite, phosphate, and ammonia) and sediment grain size distribution, is essential for a more comprehensive characterization of the environmental conditions influencing seagrass ecosystems in the area.

Among the five sites, only Camahual was dominated by *H. pinifolia*, which accounted for 19.12% of the seagrass cover at that location. CCA revealed that *H. pinifolia* was positioned far in the positive direction along the CCA1 axis, without strong alignment to any of the measured environmental variables. *H. pinifolia* is well-known for its ecological plasticity and ability to colonize disturbed habitats (Lamit & Tanaka 2019; Molina & Bersaldo 2024). Its dominance, combined with observed anthropogenic stressors, points to a degraded seagrass condition in Camahual. In Sarangani, an increase in population and tourism has also been linked to human-induced stress on coastal ecosystems. These factors, combined with water quality conditions, influence seagrass cover and distribution patterns (Capin et al 2020; Dewi et al 2020). These findings support the premise that anthropogenic disturbances and environmental conditions are key drivers of seagrass species composition, distribution, and abundance in the area.

Conclusions. Species richness and community structure varied across sites, with Tagen exhibiting the highest biodiversity and best overall seagrass condition. The result of the study supports the premise that anthropogenic disturbances and environmental conditions are key drivers of seagrass species composition, distribution, and abundance in the area. Sites exposed to high levels of disturbance may exhibit reduced species diversity and increased dominance of disturbance-tolerant species. In contrast, areas with lower disturbance and suitable environmental conditions tend to support greater diversity and sustained coverage of climax species. These patterns highlight the importance of managing both land-based and marine-based pressures to preserve healthy and resilient seagrass ecosystems in Sarangani.

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