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Sea-grass assessment and soil substrates along the coast of Barangay Union and Malinao, Siargao Island, Surigao Del Norte, Philippines

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Key words: Seagrass assessment, Species Diversity, Siargao Island, Transect Method, Siargao Island Protected Landscape and Seascape (SIPLAS)

Abstract

This research study comprehensively assessed seagrass characteristics using the transect quadrat method in Siargao Island, Surigao del Norte. Three 50 m transect lines and laid parallel, separated by a 25 m distance, and readings were taken using steel quadrats placed every 5 m along the transects. A total of 11 quadrats were laid in each transect, and five seagrass species were recorded: *Cymodocea serrulata, Cymodocea rotundata, Thalassia hemprichii, Enhalus acoroides, and Halodule pinifolia*.As displayed in Tables 2, 3, and 4, the outcomes showed the percentage of seagrass coverage in each quadrat and the corresponding seagrass species. The dominant species varied across the quadrats, highlighting the spatial variability in seagrass distribution. Transect 1 had the highest species richness, while Transect 3 exhibited the most dominance and evenness. The study also analyzed the substrate types in the site, including clay, silt, sand, gravel, and rock. The preference of seagrass species for coarse sand substrate was seen, while rocky substrates had minimal seagrass cover. Transect 3 predominantly featured a coarse sand substrate. The findings indicate that it is suggested to implement conservation and management measures to protect and preserve the seagrass ecosystems. Restoration efforts should be considered in areas with absent or poor seagrass coverage. The dominant seagrass species should receive special attention in conservation efforts. Long-term monitoring programs are crucial to track changes in seagrass coverage and species composition. Lastly, this research provides valuable insights into the seagrass characteristics and their interplay with substrate types in Siargao Island, Surigao del Norte. The findings contribute to the area's understanding and conservation of seagrass ecosystems.

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Introduction

Laws and policies have been implemented to preserve the Philippines' coastal and marine ecosystems. Siargao Island Protected Landscape and Seascape (SIPLAS) is a significant conservation area that protects its biological integrity and beauty while encouraging sustainable development and wise use of its resources. It is a protected area under Republic Act No. 7586, spanning 278,914.131 acres of landscape and seascape in Surigao del Norte, Mindanao. These municipalities were Burgos, Dapa, Del Carmen, General Luna, Pilar, San Benito, San Isidro, Socorro, and Santa Monica (Calagui *et al.*, 2022). On October 10, 1996, the island was designated a National Integrated Protected Areas System (NIPAS) protected area Law, Presidential Proclamation No. 902. The protected area promotes sustainable practices, responsible tourism, and community-based conservation activities to preserve Siargao Island's distinctive biodiversity and natural resources. This serves as a significant conservation area, preserving Siargao's natural heritage and enhancing the livelihoods of nearby communities. The Department of Natural Resources and Environment published DAO 2016-26 in October 2016, which sets guidelines for maintaining and protecting coastal and marine ecosystems in the Philippines.

Since then, the Department has created and implemented policies and programs to address the issues causing the deterioration of natural ecosystems across the country. The efforts undertaken as part of this program aim to restore the coastal and marine ecosystem services to their original state and to improve their natural resilience.

This is accomplished using scientific research, community participation, and practical experience, all guided by precautionary principles. The primary purpose is to ensure the conservation and management of the Philippines' coastal and marine habitats. These legislative frameworks aim to guarantee these priceless natural resources conservation and sustainable management (Department of Environment and Natural Resources, 2016).

Seagrass meadows play a physical benefit and are critical components of SIPLAS, supporting marine life, carbon sequestration, sediment stability, and water quality enhancement. Seagrasses are marine flowering plants that constitute ecologically and commercially significant ecosystems in coastal zones worldwide (Potouroglou, 2017).This contributes significantly to the Philippine coastal ecology, and some sections of the country have effectively mapped seagrass areas to manage the coast (Brazas & Lagat, 2022). Its ecosystems are significant for commercial and subsistence fisheries because they provide feeding grounds and shelter for fish, crabs, and shellfish, sustaining local fishing populations. However, anthropogenic activities, such as climate change, adversely affect seagrass meadows' health and functionality (Dunic *et al.,* 2021).

Environment change and human activity both have an impact on seagrass habitats. Furthermore, rising temperatures, sediment erosion, and acidity are some of climate change's direct and indirect effects on seagrass meadows (Wilson & Lotze, 2019). Due to their role as trophic and nursery crucial for fishes and bigger vertebrates, seagrasses are a vital component of the coastal environment. Animal species like crabs, prawns, shellfish, and fishes devour them directly in the form of leaves and indirectly in the form of detritus and epiphytes (Edgar *et al.*, 2001).

Seagrass beds were decimated by siltation and excessive harvesting of the plants and wildlife that were present there. In their ruthless removal of the plant in the quest for bivalves, the gleaners destroy the plant and its habitat (Tanduyan *et al.*, 2021). Seagrasses endure natural pressures such as storms, excessive grazing, and disease, but this valuable ecosystem also suffers from human threats. Due to their coastal proximity, seagrass beds are especially vulnerable to runoff pollution from urban and agricultural areas, carrying contaminants such as pesticides, household chemicals, oils, automotive wastes, fertilizers, and other chemicals and debris. This excess leads to algae blooms, which deplete oxygen supplies and smother seagrasses, causing massive die-offs. Dredging and prop scarring also tear up meadows, leaving open spaces that take years to regrow. In addition, seagrass plants promote nutrient cycling; they act as a nutrient pump. Plants absorb nutrients from the earth through their leaves and discharge them into the water. In nutrient-deficient locations. (Reynolds *et al., 2018*).

Human actions have significantly impacted the seagrasses' current state. Therefore, to create plans for sustainability and conservation, it is required to evaluate its status and condition. In addition, Siargao Island's crystal-clear ocean results from this ecosystem, making it a well-liked vacation spot. In Barangay Union, Dapa, and Barangay Malinao, General Luna, seagrass beds play a significant role. It must also keep monitoring and safeguarding this ecosystem. The study aims to assess the soil substrate and determine the seagrass species in a region where several fishermen regularly fish for various species, including fish, shrimp, and grabs.

Materials and method

Research environment

General Luna is a municipality located in the southern part of Siargao Island, within the the grid coordinates span from 9° 47' to 9° 50' North Latitude and 126° 9' to 146° 10' East Longitude-someone positions on the mainland and part of the beautiful Province of Surigao del Norte. General Luna shares its borders with Pilar to the north, while the Daku and La Januza islands embrace the southern side.

The western boundary is formed by municipality of Dapa, and on the east lies the majestic Philippine Sea. This scenic destination is approximately 16 kilometers from Dapa and 40 nautical miles from Surigao City.

Malinao, a vibrant barangay in General Luna, is located on Siargao Island at approximately 9.7698, and 126.1276. Situated in this tropical paradise, Malinao enjoys an elevation of around 10.6 meters or 34.8 feet above mean sea level, providing stunning panoramic views. Dapa, officially known as the Municipality of Dapa, is a 4th class municipality in Surigao del Norte, Philippines. While most of the municipality situates on Siargao Island, it also encompasses Middle Bucas Grande and East Bucas Grande Islands. Barangay Union, another beautiful spot, is situated on the island of Siargao at approximately 9.7561, 126.1093. The elevation is approximately 10.5 meters or 34.4 feet above mean sea level.

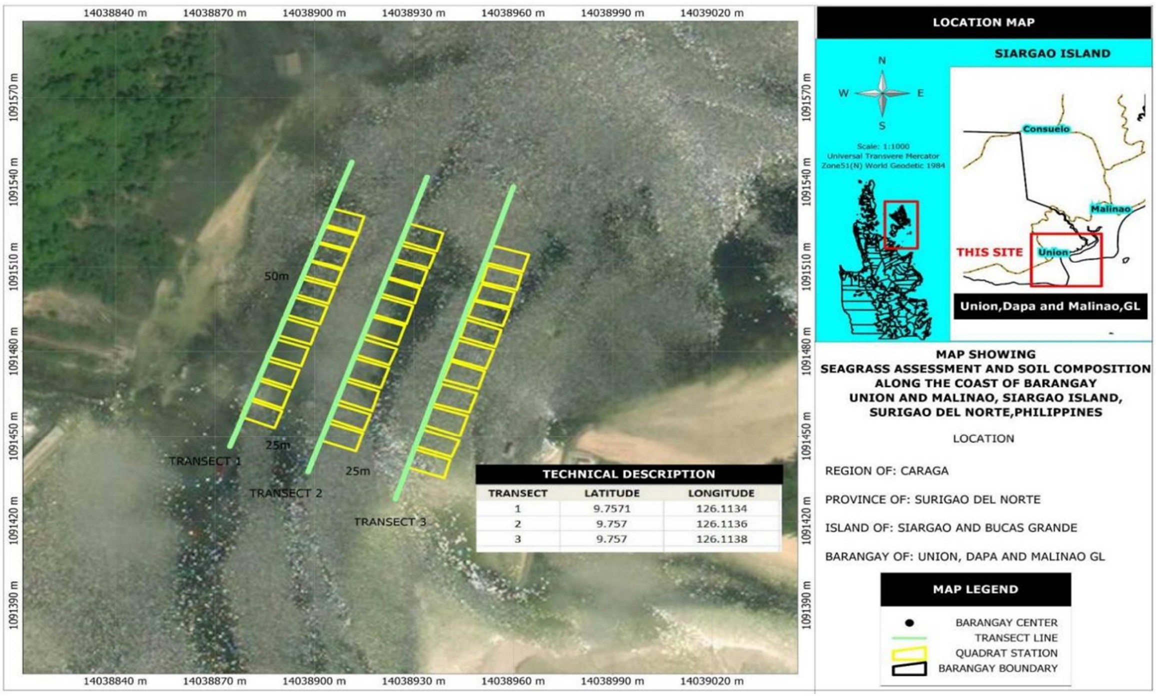

Fig. 1. The study includes a map that displays the sampling sites.

Research subject

The subject of this study was the Seagrasses found the in the locality of Barangay Union, Dapa, Surigao del Norte, connecting to Barangay Malinao, General Luna, Surigao del Norte.

Fig. 2. Laying of the quadrat in the deeper areas.

Study period

Researchers conducted the study from April 10 to 25, 2023.

Sampling procedure

Assessment of the seagrass characteristics someone did using the transect quadrat method—three (3) 50 m transect lines someone laid parallel, separated by a 25 m distance. Transect lines were laid perpendicular to the shore, from the shallow intertidal zone to a depth until where Seagrass was present. Readings someone conducted using a steel quadrat placed every 5 m along the 50 m stretch transects. A total of 11 quadrats were laid in each transect as shown in Fig. 3 (Mckenzie *et al.*, 2001; Tanduyan *et al.*, 2021).

Site Layout

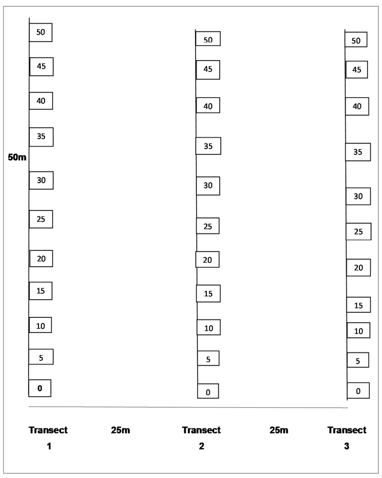

Fig. 3. Assessing the Seagrass Characteristics Using the Transect Quadrat Method.

Identification of species

The species were identified in situ using reliable identification manuals. The total percent cover someone recorded, including the percent cover estimation per species. Seagrass composition equals 100% of the Seagrass in the quadrat regardless of the total cover. Sediment type within each quadrat was noted (McKenzie *et al.*, 2009; Calumpong & Meñez, 2009). For species with difficulty in identification, some samples someone observed using a magnifying glass and a dissecting microscope to determine the leaf structure variation, which helped identify the species (Jumawan *et al.*, 2015). The condition of the seagrass beds was determined using the criteria set by Fortes (1989), as stated below in Table 1:

Table 1. Criteria of the Seagrass Beds Condition.

Condition	Criteria
Excellent	76-100% coverage
Good	51-75% coverage
Fair	26-50% coverage
Poor	0-25% coverage

Statistical analysis

Percent cover was also evaluated in seagrasses (McKenzie *et al.*, 2009), and the observed species count, and the Seagrass's percent cover were determined. Paleontological Statistics (PAST) was used to calculate biodiversity measures such as evenness, species richness index (S), Shannon-Wiener index (H'), and Simpson's Dominance index (D).

Result and discussion

Five species someone recorded between Barangay's Union and Malinao, Siargao Island, Surigao del Norte. The species identified were *Cymodocea serrulata, Cymodocea rotundata, Thalassia hemprichii, Enhalus acoroides, Halodule pinifolia.* The percentage of seagrass cover in a quadrat someone presents in Tables 2, 3, and 4.

Table 2 presents the results of a comprehensive seagrass assessment conducted at Transect 1 of the study site, providing valuable information about the presence and distribution of seagrass species. The table displays the percentage of seagrass coverage in each quadrant (Q1-Q11) and lists the corresponding seagrass species identified. The seagrass species found, *Cymodocea rotundata (Cr), Thalassia hemprichii (Th), Enhalus acoroides (Ea), and Halodule minor (Hp)* someone recorded in the study area.

Table 2. Seagrass species found in the study site.

Transect 1	% Seagrass	Species			
		Cr	Th	Ea	Hp
Q1	0	0	0	0	0
Q2	0	0	0	0	0
Q3	25	30	70	0	0
Q4	15	80	0	0	0
Q5	0	0	0	0	0
Q6	0	0	0	0	0
Q7	70	70	30	0	0
Q8	20	0	100	0	0
Q9	0	0	0	0	0
Q10	30	70	0	30	0
Q11	85	90	0	0	10

Note: Ho = Halophila ovalis, Hu = Halodule uninervis, Cs = Cymodocea serrulata, Cr = Cymodocea rotundata, Th = Thalassia hemprichii, Si =Syringodium isoetifolium, Ea = Enhalus acoroides, Hp = Halodule minor, Hm = Halophila minor

Quadrants Q2, Q5, Q6, and Q9 displayed no seagrass coverage, indicating the absence of any seagrass species. Q1 had no seagrass coverage, and someone therefore excluded from the table. In Q3, seagrass coverage someone observed at 25%, with *Thalassia hemprichii* accounting for 30% and *Cymodocea rotundata* for 70%. However, *Enhalus acoroides* and *Halodule minor* some did not detect in this quadrant. Q4 exhibited a seagrass coverage of 15%, primarily dominated by *Cymodocea rotundata* (80%), while *Enhalus acoroides and Halodule minor* were absent.

Q7 showed a substantial% seagrass coverage of 70%, primarily attributed to *Cymodocea rotundata* (70%) and *Thalassia hemprichii* (30%). In Q8, the seagrass coverage reached 20%, with *Enhalus acoroides* comprising 100% of the observed seagrass, while *Cymodocea rotundata* and *Halodule minor* were absent. Q10 displayed a seagrass coverage of 30%, with *Cymodocea rotundata* (70%) and Halodule minor (30%) being the identified species, while *Thalassia hemprichii* and *Enhalus acoroides* some not observed.

In addition, Q11 exhibited the highest seagrass coverage at 85%, primarily characterized by *Thalassia hemprichii* (90%) and *Halodule minor* (10%). *Cymodocea rotundata* and *Enhalus acoroides* were not present in this quadrant.

The seagrass assessment along Transect 1 revealed a diverse distribution of seagrass species. The dominant species varied across the quadrants, with *Cymodocea rotundata, Thalassia hemprichii,* and *Halodule minor* being the most frequently identified. The absence of certain species in specific quadrants highlights the spatial variability in seagrass distribution within the study site.

Table 3. Seagrass species found in the study site.

Transect 2	% Seagrass	Species				
		Cs	Cr	Th	Ea	Hp
Q1	30	0	60	30	10	0
Q2	50	0	80	0	20	0
Q3	25	0	80	0	20	0
Q4	15	0	70	0	0	0
Q5	0	0	0	0	0	0
Q6	0	0	0	0	0	0
Q7	0	0	0	0	0	0
Q8	0	0	0	0	0	0
Q9	10	0	0	90	0	0
Q10	15	10	0	90	10	0
Q11	5	0	0	100	0	10

Note: Ho = Halophila ovalis, Hu = Halodule uninervis, Cs = Cymodocea serrulata, Cr = Cymodocea rotundata, Th = Thalassia hemprichii, Si =Syringodium isoetifolium, Ea = Enhalus acoroides, Hp = Halodule minor, Hm = Halophila minor

The results of the seagrass assessment, as presented in Table 3, Transect 2 exhibited varying degrees of seagrass coverage, with percentages ranging from 0% to 50%. Among the seagrass species identified, *Cymodocea serrulata (Cs), Cymodocea rotundata (Cr), Thalassia hemprichii (Th), Enhalus acoroides (Ea),* and *Halodule minor (Hp)* some observed.

In quadrant Q1, the seagrass coverage was 30%, and the dominant species were *Cymodocea rotundata* (60%) and *Thalassia hemprichii* (30%), while *Cymodocea serrulata, Enhalus acoroides,* and *Halodule minor* were absent. Similarly, in Q2, the seagrass coverage was higher at 50%, primarily attributed to *Cymodocea rotundata (80%),* with *Enhalus acoroides* and *Halodule minor* absent.

Quadrant Q3 exhibited a seagrass coverage of 25%, primarily consisting of *Cymodocea rotundata* (80%), while *Enhalus acoroides* and *Halodule minor* were absent. In Q4, the coverage decreased to 15%, mainly constituted by *Cymodocea rotundata* (70%), with *Enhalus acoroides* absent. Quadrants Q5-Q8 displayed no seagrass coverage.

In Q9, the seagrass coverage was 10%, and *Thalassia hemprichii* (9%) was the only species observed, while *Cymodocea serrulata, Cymodocea rotundata, Enhalus acoroides,* and *Halodule minor* were absent. Q10 exhibited a slightly higher coverage of 15%, with Cymodocea *serrulata* (10%) and *Thalassia hemprichii* (9%), while *Enhalus acoroides* and *Halodule minor* were absent.

In the last quadrat, Q11, seagrass coverage was limited to 5%, and *Thalassia hemprichii* (100%) dominated, with minor contributions from *Cymodocea serrulata* and *Halodule minor* (10%). Other seagrass species not observed. The seagrass assessment along Transect 2 revealed a diverse composition of seagrass species. The dominant species varied among the quadrats, with *Cymodocea rotundata* and *Thalassia hemprichii* being the most frequently observed. The absence of certain species in specific quadrants highlights the spatial heterogeneity in seagrass distribution at the study site.

Table 4. Seagrass species found in the study site.

Transect	3%	Seagrass Species								
		Ho	Hu	Cs	Cr	Th	Si	Ea	Hp	Hm
Q1	45	0	0	0	20	80	0	0	0	0
Q2	40	0	0	0	0	100	0	0	0	0
Q3	0	0	0	0	0	0	0	0	0	0
Q4	40	0	0	0	50	50	0	0	0	0
Q5	25	0	0	0	0	100	0	0	0	0
Q6	10	0	0	0	70	30	0	0	0	0
Q7	0	0	0	0	0	0	0	0	0	0
Q8	0	0	0	0	0	0	0	0	0	0
Q9	0	0	0	0	0	0	0	0	0	0
Q10	0	0	0	0	0	0	0	0	0	0
Q11	0	0	0	0	0	0	0	0	0	0

Note: *Ho = Halophila ovalis, Hu = Halodule uninervis, Cs = Cymodocea serrulata, Cr = Cymodocea rotundata, Th = Thalassia hemprichii, Si =Syringodium isoetifolium, Ea = Enhalus acoroides, Hp = Halodule minor, Hm = Halophila minor*

Table 4 presents the results of a comprehensive seagrass assessment conducted at Transect 3 of the study site, providing valuable information about the presence and distribution of seagrass species. The table displays the percentage of seagrass coverage in each quadrant (Q1-Q11) and lists the corresponding seagrass species identified.

Among the seagrass species found in Transect 3, Halophila ovalis *(Ho), Halodule uninervis (Hu), Cymodocea serrulata (Cs), Cymodocea rotundata (Cr), Thalassia hemprichii (Th), Syringodium isoetifolium (Si), Enhalus acoroides (Ea), Halodule minor (Hp),* and *Halophila minor* (Hm) were recorded. Quadrants Q3, Q7, Q8, Q9, Q10, and Q11 displayed no seagrass coverage, indicating the absence of any seagrass species. Therefore, these quadrats some should someone includes in the table. In Q1, seagrass coverage reached 45%, primarily dominated by *Thalassia hemprichii* (80%) and *Cymodocea rotundata* (20%)—*Halophila ovalis, Halodule uninervis*, and the remaining seagrass species not detected in this quadrant.

Q2 exhibited a seagrass coverage of 40%, exclusively consisting of *Syringodium isoetifolium* (100%), with no other seagrass species observed. Q4 showed% seagrass coverage of 40%, mainly attributed to *Cymodocea rotundata* (50%) and *Thalassia hemprichii* (50%). The remaining seagrass species were not present in this quadrat.

In Q5, seagrass coverage reached 25%, solely comprising *Syringodium isoetifolium* (100%), while other seagrass species were absent. Q6 displayed a seagrass coverage of 10%, predominantly characterized by Cymodocea rotundata (70%) and Thalassia hemprichii (30%)—the remaining seagrass species some not observed in this quadrat.

In summary, the seagrass assessment in Transect 3 revealed a spatially variable distribution of seagrass species. *Thalassia hemprichii, Cymodocea rotundata,* and *Syringodium isoetifolium* were the primary seagrass species identified in the study area.

The absence of seagrass species in certain quadrats highlights the localized nature of seagrass distribution within Transect 3.

Diversity Indices

The table below (Table 5) shows the diversity indices of the seagrasses between the areas of Barangay Malinao and Barangay Union. These indices allow researchers to summarize and compare various communities' makeup based on species' number and relative abundance. The method quantifies the number of individuals within a particular group and finds application across diverse disciplines to evaluate population diversity (Agrawal & Gopal, 2013).

Species Richness (Taxa)

Transect 1 has five taxa, transect 2 contains four taxa, and Transect 3 contains two taxa. With five taxa, transect 1 has the highest species richness, followed by Transects 2 (4 taxa) and Transect 3 (2 taxa). Low species richness results in low species diversity, as defined by the number of diverse species in each area (Babu, 2016).

Individuals

There are 610 individuals inhabiting Transect 1, 700 individuals within Transect 2, and 500 individuals in Transect 3. Transect 1 has the highest species richness with five taxa, followed by Transects 2 (4 taxa) and Transect 3 (2 taxa). The existence of 610 individuals in transect 1 suggests that this transect may have a bigger population size or a higher abundance of species. When compared to Transect 1, transect 2 implies a higher number of individuals. Transect 3 has a lower population level than Transect 1 and Transect 2. More individuals indicate a better representation of a specific species, and this information someone used to assess species richness, evenness, and overall diversity.

Simpson Index

The dominance value in Transect 1 is 0.4245, and in Transect 2, it is 0.3836. Compared to Transects 1 and 2, Transect 3 has the most dominance, as indicated by its result of 0.596. Higher dominance indicated by values closer to 1. The higher the diversity value, the lower the dominance value, and in reverse, the higher the dominance value, the lower the diversity (Ulfah *et al.*, 2019).

Shannon- Wiener Index

The Shannon index evaluates the overall diversity of a community by considering both species richness and evenness. Higher values imply greater diversity (Rain, 2022). The Shannon index is 1.028 in Transect 1, 1.048 in Transect 2, and 0.592 in Transect 3. This results in Transect 2 having a high diversity.

Evenness

An indicator of a more balanced distribution of abundance among taxa would be a number closer to 1. The evenness values reveal how evenly or fairly the species distributed throughout each transect. The species abundance distribution more evenly distributed along Transect 3, which has the highest evenness score. Indicating potential changes in the abundance of various taxa, transect two also exhibits a reasonably high evenness value, while Transect 1 has a lower evenness value.

Table 5. Diversity Indices of the Five Seagrass Species Identified between Barangay Union, Dapa, SDN and Barangay Malinao, General Luna, SDN.

Diversity Indices	Transect 1	Transect 2	Transect 3
Taxa_S	5	4	2
Individuals	610	700	500
Dominance_D	0.4245	0.3836	0.596
Shannon_H	1.028	1.048	0.592
Evenness_e^H/S	0.5591	0.713	0.9038

The table results show differences in species richness, number of individuals, dominance, overall diversity, and evenness among the three transects. Transect 1 has the highest species richness but lesser dominance and diversity than Transect 2. Transect 3 contains the least number of species yet the most dominance and evenness. These biodiversity indexes provide context on the ecological characteristics and relationships of the various transects.

Identification of Soil Substrate

The USDA identified substrate types using the Soil Texture Triangle, which visually represents the silt, clay, and sand components (Whiting, et, al. (2014.). Furthermore, McKenzie (2003) suggested a method for assessing substrate texture, wherein individuals can manually probe the top centimeter of the substrate using their fingers and describe the dominant grain size in sequential order, such as sand, fine, and fine sand/mud.

Result and discussion

Tables 6, 7, and 8 find some of the various substrate types in the study site. Furthermore, we identify some substrates using the Soil Texture Triangle. The substrate was clay, silt, very fine sand, fine sand, medium sand, coarse sand, very coarse sand, gravel, and rock. According to the data, transects 1, 2, and 3 substrates are coarse sand and rocky/sandy, respectively. The Transect 1 substrate has two types of soil substrate found in Transect 1: coarse sand and rocky substrate. However, it should note that no seagrass species are present in the rocky substrate.

On the other hand, the coarse sand substrate has a dominant seagrass species. Seagrass species are more likely to thrive in the coarse sand substrate than the rocky substrate. In transect 2, the soil substrate types are coarse sand and rocky. Seagrass species dominate the coarse sand substrate, whereas the rocky/sandy substrate has a minimal seagrass cover. Despite this, some seagrass species remain in the rocky/sandy substrate. Lastly, transect 3 is generally coarse sand. The composition of the soil substrate in transect 3 is that the area may have unique environmental conditions, which can influence the types of Seagrass found in that area. Furthermore, Seagrass that thrive in this area may have an advantage, while those adapted to other substrates may not fare as well.

Soil Substrate and Percentage seagrass cover in Study Site

Based on Table 6, the results show that two types of soil substrate are present in Transect 1: coarse sand and rocky substrate. However, it should note that no seagrass species were present in the rocky substrate. On the other hand, the coarse sand substrate has a dominant seagrass species. Seagrass species are more likely to thrive in the coarse sand substrate than the rocky substrate.

Table 6.

Transect 1	Percent Seagrass Cover	Substrate
Q1	0	coarse Sand
Q2	0	coarse Sand
Q3	25	coarse Sand
Q4	15	coarse Sand
Q5	0	Rocky
Q6	0	Rocky
Q7	70	coarse Sand
Q8	20	coarse Sand
Q9	0	coarse Sand
Q10	30	coarse Sand
Q11	85	coarse Sand

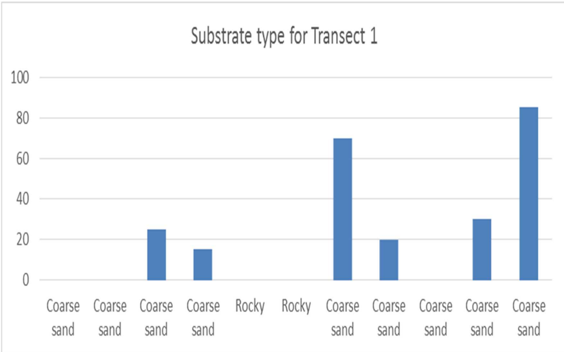

Fig. 4. Graph for percentage seagrass cover per substrate.

It indicates that the type of soil substrate can significantly impact the growth and distribution of seagrass species in Transect 1. The absence of seagrass species in rocky substrates could be due to unfavorable conditions or a lack of suitable habitat. Meanwhile, dominant seagrass species in the coarse sand substrate may indicate that this type of substrate provides a more conducive environment for seagrass growth.

Table 7.

Transect 1	Percent Seagrass Cover	Substrate
Q1	30	coarse Sand
Q2	50	Sandy/Rocky
Q3	25	coarse Sand
Q4	15	Sandy/Rocky
Q5	0	Coarse Sand
Q6	0	Sandy/Rocky
Q7	0	coarse Sand
Q8	0	coarse Sand
Q9	10	coarse Sand
Q10	15	coarse Sand
Q11	5	coarse Sand

Based on the results presented in Table 7, it can be observed that in Transect 2, the soil substrate types present are coarse sand and rocky. It was found that seagrass species dominate the coarse sand substrate, whereas the rocky/sandy substrate has a minimal seagrass cover. Despite this, some seagrass species were still found in the rocky/sandy substrate.

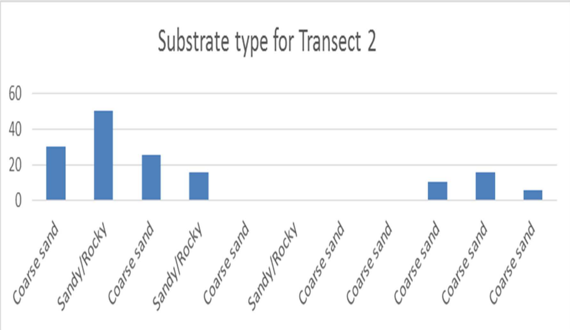

Fig. 5. Graph for percentage seagrass cover per substrate.

Based on the graph Fig. 6. The dominant seagrass species were found in the coarse sand substrate, while the rocky/sandy substrate had a lower seagrass cover. These results suggest that soil substrate type may significantly affect seagrass distribution and abundance.

Table 8.

Transect 1	Percent Seagrass Cover	Substrate
Q1	45	coarse Sand
Q2	40	coarse Sand
Q3	0	coarse Sand
Q4	40	coarse Sand
Q5	25	coarse Sand
Q6	10	coarse Sand
Q7	0	coarse Sand
Q8	0	coarse Sand
Q9	0	coarse Sand
Q10	0	coarse Sand
Q11	0	coarse Sand

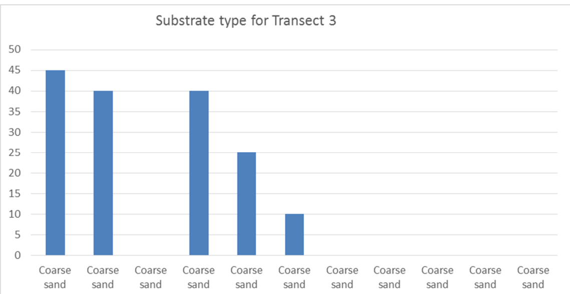

Fig. 6. Graph for percentage seagrass cover per substrate.

Based on Table 8, the results indicate that the soil substrate in transect 3 is exclusively composed of coarse sand. This suggests that the area is dominated by this type of soil substrate, with no significant substrate present.

The graph shows the composition of the soil substrate in transect three that the area may have a unique set of environmental conditions, which can influence the types of Seagrass found in that area. Furthermore, Seagrass that thrive in this area may have an advantage, while those adapted to other substrates may not fare as well.

Conclusion

This study comprehensively assessed seagrass and soil composition in three transects along Siargao Island, Surigao del Norte, yielding compelling findings. The identification of five seagrass species, namely *Cymodocea serrulata, Cymodocea rotundata, Thalassia hemprichii, Enhalus acoroides,* and *Halodule pinifolia*, underscores the biodiversity of the area.

Transect 1 revealed a remarkable spatial variability in seagrass distribution, with *Cymodocea rotundata, Thalassia hemprichii,* and *Halodule minor* emerging as the dominant species. The absence of seagrass coverage in specific quadrats further highlights the localized nature of species distribution.

Transect 2 exhibited varying degrees of seagrass coverage, showcasing the presence of *Cymodocea serrulata, Cymodocea rotundata, Thalassia hemprichii, Enhalus acoroides,* and *Halodule minor*. The absence of seagrass coverage in certain quadrats reinforces the significance of localized distribution patterns.

Transect 3 shed light on the prevalence of *Thalassia hemprichii, Cymodocea rotundata,* and *Syringodium isoetifolium* as the primary seagrass species. Seagrass coverage needed to be improved in specific quadrats, suggesting a constrained distribution in those areas.

The diversity indices highlighted species richness in Transect 1, followed by Transect 2 and Transect 3. The Simpson Index reflected varying dominance values, with Transect 3 exhibiting the highest dominance. The Shannon-Wiener Index indicated a high level of diversity in Transect 2, while the evenness scores underscored a more balanced distribution in Transect 3.

The analysis of substrate types unveiled the preference of seagrass species for coarse sand, whereas rocky substrates exhibited minimal seagrass cover. Transect 3 predominantly featured a coarse sand substrate, suggesting the influence of unique environmental conditions on seagrass distribution.

The comprehensive seagrass assessments conducted along three transects (Transect 1; Transect 2, and Transect 3) reveal variations in seagrass coverage and species composition. These assessments were conducted based on the criteria established by Fortes (1989), which classifies the condition of seagrass beds into four categories: Excellent (76-100% coverage), Good (51-75% coverage), Fair (26-50% coverage), and Poor (0-25% coverage).

The seagrass beds at Transect 1 demonstrate spatial variability in distribution and exhibit diverse conditions ranging from Poor to Good, according to the coverage criteria. Similarly, the seagrass beds at Transect 2 display spatial heterogeneity in distribution and show conditions that range from Poor to Fair based on the coverage criteria. Lastly, the seagrass beds at Transect 3 reveal localized distribution patterns and exhibit conditions ranging from Poor to Fair, per the coverage criteria.

In addition, this study provides robust insights into the composition and distribution patterns of seagrass species and their interplay with different substrate types in the study area. These findings significantly enhance our understanding of seagrass ecosystems and their conservation in Siargao Island, Surigao del Norte.

Recommendations

Based on the results and discussion of the research study, the following comprehensive recommendations can be made:

1. Conservation and Management: Considering the spatial variability in seagrass distribution and the diverse composition of seagrass species, it is essential to implement conservation and management measures to protect and preserve the seagrass ecosystems in the study area. This can include establishing marine protected areas, implementing sustainable fishing practices, and monitoring seagrass beds regularly to detect any changes or threats.
2. Restoration Efforts: Given the absence of seagrass coverage in certain quadrats and the localized distribution patterns observed, targeted restoration efforts should be considered. Restoration techniques such as transplanting seagrass fragments, reseeding, or habitat enhancement can be explored to promote the recovery and expansion of seagrass beds in areas where they are currently absent or in poor condition.
3. Monitoring Programs: Establishing long-term monitoring programs for seagrass beds is crucial to track changes in seagrass coverage, species composition, and overall ecosystem health. Regular monitoring can provide valuable data on the effectiveness of conservation measures, identify emerging threats, and guide adaptive management strategies.
4. Public Awareness and Education: Raising public awareness about the importance of seagrass ecosystems and their role in coastal biodiversity and ecosystem services is essential. Educational campaigns targeting local communities, fishermen, and tourists can help foster a sense of stewardship and encourage responsible practices that minimize human impacts on seagrass habitats.
5. Collaborative Research: Encouraging collaboration among researchers, government agencies, local communities, and other stakeholders is vital for a comprehensive understanding of seagrass ecosystems. Collaborative research efforts can facilitate knowledge exchange, resource sharing, and the development of integrated management approaches that consider social, economic, and ecological aspects.

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Conflict of interest

The authors state that they have no conflicts of interest.

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