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# Seagrass Meadow Conditions in Coastal Waters of Siwak Bay Central Lombok

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**Abstract:** Seagrass is a flowering plant thriving in shallow sea waters and estuaries. Seagrass ecosystems are essential in supporting life in shallow seas as primary producers, biota habitats, sediment trappers, and nutrient trappers. Environmental factors affecting seagrass growth include temperature, salinity, pH, and substrate. The study was conducted in March-June 2023. This study aimed to determine the type and condition of seagrass beds in the waters of Siwak Bay. The method used in this study is the quadrant transect method at three research stations. There are seven types of seagrass identified, namely *Thalassia hemprichii, Halophila ovalis, Cymodocea rotundata*, *Cymodocea serrulata*, *Halodule pinifolia*, *Halodule uninervis*, and *Syringodium isoetifolium*. The percentage of total seagrass cover is at a value of 37%-61%, indicating that the condition of seagrass beds in the waters of Siwak Bay is included in the unhealthy category. The highest species density found at station III in *Halodule pinifolia* was 483.5 stands/m², and the lowest was found at stations II and III in *Thalassia hemprichii* and *Cymodocea serrulata* with 0 stands/m². The average density value of seagrass beds in the waters of Siwak Bay is very dense. The highest type frequency was found in *Cymodocea rotundata,* with a value of 2.53. The tallest species diversity and diversity index was found at station II with values of 1.56 and 0.8, respectively. In contrast, the highest dominance index was found at station I, with a value of 0.44.

**Keywords:** Health Status; *Seagrass meadows*; Siwak Bay

## Introduction

Seagrass ecosystems are one of the most productive shallow marine ecosystems. In addition, seagrass ecosystems have an essential role in supporting life and the development of living bodies in shallow seas, namely as primary producers, biota habitats, sediment trappers, and nutrient trappers [1]. Seagrass ecosystems are known as shallow marine ecosystems close to the coast that support the life of associated biota. Their existence is essential for maintaining the survival of biota in these ecosystems. Seagrass ecosystems are essential in coastal economies because they have relationships with other coastal ecosystems, such as coral reefs and mangroves [2].

The function of seagrass ecosystems, in addition to being wave absorbers and sea abrasion barriers, also has an essential function as a habitat for aquatic biota, a place to forage, spawn, nurture larvae, and as a protection area from natural threats of small biota [3]. The lack of public attention to seagrass ecosystems and the response that seagrass ecosystems are only complementary to other coastal ecosystems are problems in seagrass ecosystem management, which has an impact on the low management and utilization of seagrass ecosystems in the community [4]. Seagrass beds have an essential role as the main source of primary productivity or organic matter producers, as well as habitats for various kinds of biota, nurturing sites, spawning sites, food sources for rare biota, and supporting the diversity of marine life species, as well as the economic value of seagrass ecosystem services [5]. Judging from the function of seagrass beds that have been described, the existence of seagrass must be maintained. Seeing these various functions makes it very important to keep seagrass beds.

Lombok Island is an island that has many coastal locations overgrown by seagrass beds. Seagrass species that can be found in the coastal waters of Lombok Island are as many as nine species [6] from 13 seagrass species in Indonesian waters [7]. The coastal waters of Lombok Island are currently used not only to support fisheries and aquaculture activities but also to support tourism development. This can be seen from the designation of several coastal areas, such as on several small islands, namely in Gili Trawangan, Gili Air, Gili Meno, and the coastal regions and small islands in Central Lombok Regency, which are tourism development areas [8]. Several coasts in Central Lombok Regency, especially the Mandalika coastal area, can support the development of the tourism economy, namely Siwak Bay.

The choice of research location in the Siwak Bay area is due to related aquaculture, fishermen, and madak activities that can potentially disrupt ecosystems in coastal regions, including seagrass meadow ecosystems. Establishing the Mandalika SEZ in 2014 increased the rate of change in the seagrass cover area. The location of Siwak Bay is taken because the waters of Siwak Bay have not been researched related to the type or condition of seagrass beds [9]. Therefore, it is necessary to collect data through research on seagrass meadow communities in Siwak Bay to determine the condition of seagrass meadows in these locations.

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## Research Methods

### Location and Time of Research

This research is exploratory, descriptive research. The study was conducted in March-June 2023 in Siwak Bay, Central Lombok Regency (Figure 1), and data analysis at the Marine Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University.

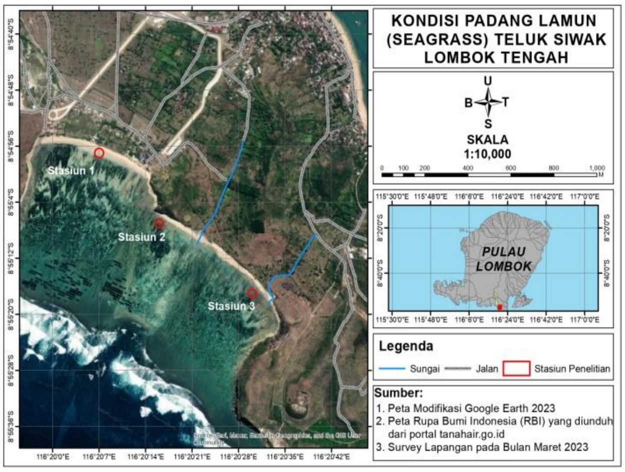


**Figure 1.** Map of Research Location

### Tools and Materials

The tools used in this research are stationary, seagrass identification book *A Guide to Tropical Seagrasses of the Indo-West Pacific* [10], GPS (Global Positioning System), camera, quadrant 50X50cm, labels, laptops, pH meters, refractometers, thermometers, and transects. The research materials are aquades and seagrasses.

### Seagrass Observation and Data Collection

Data collection in the field using the quadrant transect method at low tide time with a transect length of 100 meters following the lowest tidal length of Siwak Bay. Each station has three transects perpendicular to the coastline. Each transect has five plots of 50x50 cm in size. The distance between the transects used is 20 meters, and the distance between each plot is 25 meters. The study was conducted at three stations using purposive s*ampling*, a technique for determining stations with specific considerations [11]. The determination of stations is based on differences in community activities in Siwak Bay. Station I with the main activity of high seaweed cultivation and tourism activities, station II with medium seaweed and madak cultivation activities, and Station III with madak activity. Seagrass observations in the field include seagrass identification, seagrass density calculation, seagrass species calculation, percentage cover calculation, and total number of seagrass stands (figure 2). All seagrass species found in squares were identified using a reference to the book *A Guide to Tropical Seagrasses of the Indo-West Pacific* [10].

**Figure 2.** Seagrass Observations

### Data Analysis

Seagrass conditions can be seen based on the percentage of seagrass cover obtained, divided into three categories [12]. In addition, measurements of seagrass ecological indices were also carried out, including:

The density calculation is done by sampling in the field and calculating the number of stands [13]. Seagrass condition criteria based on density are divided into five categories [14]. Frequency represents the probability of a type being found in the observed instance point [15]. The diversity index is calculated using the *Shannon-Wiener* diversity index (H') [16]. The value of the diversity index is divided into three categories [17]. The uniformity index calculation refers to the *Simpson* uniformity index [18]. The criteria for diversity index values [19]. The dominance index value describes whether or not a species dominates in a water area. The calculation of the dominance index value refers to the dominance index *Simpson* [18]. The criterion of the level of dominance index [19] is divided into 3. Important Value Index (INP) is a value that can provide an overview of the influence or role of a plant species in a location.

## Results and Discussion

### The Presence of Seagrass Species

The types of seagrass found in the waters of Siwak Bay are based on research that has been carried out on as many as seven types that fall into two families, namely Hydrocharitaceae and Cymodoceaceae (Table 1).

**Tablel 1.** The Presence of Seagrass Species

| Family | Types of Seagrass | Station |
|---|---|---|
| Hydrocharitaceae | *Thalassia hemprichii* (Th) | I, II |
| | *Halophila ovalis* (Ho) | I, II, III |
| Cymodoceaceae | *Cymodocea rotundata* (Cr) | I, II, III |
| | *Cymodocea serrulata* (Cs) | I |
| | *Halodule pinifolia* (Hp) | I, II, III |
| | *Halodule uninervis* (Hu) | I, II, III |
| | *Syringodium isoetifolium* (Si) | I, II, III |
| Number of Types | | 7 |

Station I found all types of seagrass, Station II found six, and Station III found only five. The substrate of the aquatic bottom is dominated by fine sand and coarse sand with dead coral fragments and muddy sand. The number of seagrass species found at Station I is the seven types. This is because the type of substrate is fine sand and coarse sand with dead coral fragments and muddy sand, which is only found at Station I. Seagrass can thrive at that location if the bottom of coastal waters is sand and dirty sand [20]. The muddy sand substrate at station I is caused by the station I, which is located right in front of the settlement of fishermen whose disposal goes directly to the beach.

Seagrass-type *Thalassia hemprichii* is only found at station I and station II. This is because Station I dominates the muddy sand substrate, followed by sand and coral fragments; in Station II, the substrate is dominated by sand, sandy stone, and coral fragment sand, while at Station III, the substrate is in the form of sand with dead coral fragments. *Seagrass Thalassia hemprichii* can grow in muddy sand substrates and coral fragments from the highest tide boundary area to the lowest low tide and sometimes emerge to the water's surface during the lowest low tide [21]. *Thalassia hemprichii* has also been observed growing on muddy sand substrates, soft mud, and coral-covered mud [22]. *Seagrass species Thalassia hemprichii* can adapt to sandy substrate habitats and is also able to adapt well to rigid substrates [23]. *Cymodocea* serrulata is only found at station I because at station I, the substrate is dominated by muddy sand, fine sand, and seagrass-type *Cymodocea serrulata* is more commonly found in habitats with delicate sand substrates [24].

The types of seagrass found at each station have different numbers of stands. More details can be seen in (Figure 3) below:

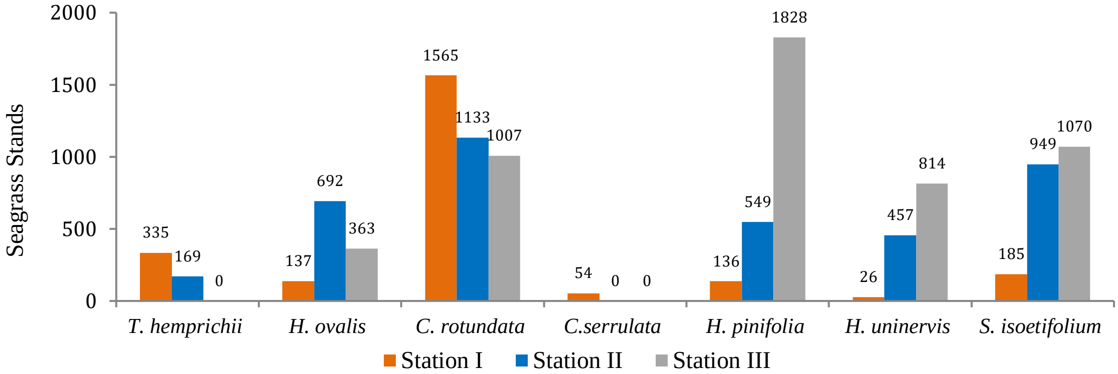


**Figure 3.** Number of Seagrass Stands

The most common type of seagrass found at stations I and II is *C. rotundata*. This is because the substrate of sand and coral fragments is a suitable substrate for *C. rotundata* seagrass to grow. Seagrass type *C. rotundata* was found to be the most common seagrass in intertidal areas, grew on open substrates of sand and coral fragments at low tide, and was constantly flooded [25]. *C. rotundata* usually grows on clear and shallow water beaches with areas that experience the lowest tides [22]. C. *rotundata* is a type of seagrass commonly found at every station. It has a high coverage because this type can adapt and tolerate various environmental parameters. Besides that, the substrate in the Siwak Bay area is dominated by sandy substrate, which is a suitable substrate for seagrass species *C. rotundata.*

The most common type of seagrass found at station III is *H. pinifolia*, located in almost all waters of Siwak Bay on sandy substrates. *Seagrass*-type *H. pinifolia* is usually found in intertidal areas and grows in coastal areas of sandy or muddy substrates [26].

Differences in the distribution of seagrass growth and density are influenced by environmental factors such as tidal patterns, turbidity, salinity, and water temperature [27]. In addition, it is also affected by human activities in coastal areas. This is related to the activities of coastal residents of Siwak Bay, which are dominated by seaweed cultivation activities. They are also looking for corals using environmentally unfriendly tools that are always done at low tide.

**Seagrass Cover**

Seagrass bed cover percentage describes the extent of seagrass covering a body of water [28]. Based on (Figure 4), the seagrass cover area at each station has different values of 37%, 48%, and 61%, respectively at stations I, II, and III. Seagrass conditions at stations I and II are less healthy because it is included in the value range of 30-59.9% (Less Healthy), while at station III the condition of seagrass meadows is classified as healthy because ≥60% [12]. The low potential for damage by community activities causes the high value of seagrass cover at station III. In contrast, stations I and II are the location of many community activities such as seaweed cultivation madak activities, namely biota extraction with tools and materials that are not environmentally friendly such as soil dredges or sickles that can lift and break seagrass root systems [29]. In addition, the station I directly faces the settlement of seaweed fishermen who can increase organic waste in seagrass areas.

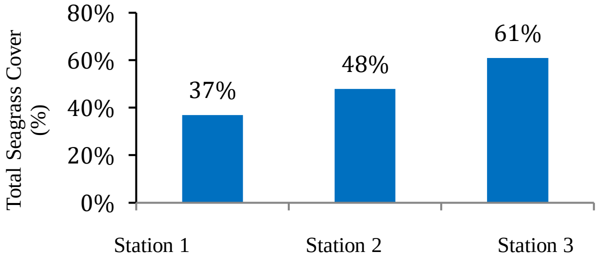


**Figure 4.** Percentage of Total Seagrass Cover in Siwak Bay Waters, Central Lombok

**Type Density and Relative Density**

Seagrass density is the number of individuals/stands of a seagrass species in a certain area. Seagrass density is influenced by factors where seagrass grows [30]. Seagrass density values vary at three stations. The highest density value was found in *H. pinifolia* seagrass at station III, and the lowest density value was found in *T. hemprichii* seagrass at station III and *C. serullata* at station II and station III. More details of the density value can be seen in Figure 5 below:

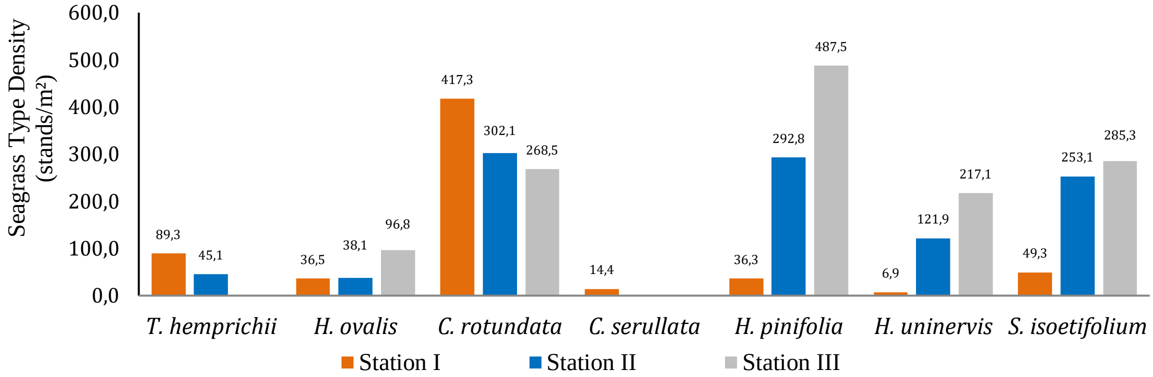


**Figure 5.** Seagrass Type Density

The highest overall density was found at station III with a total of 1355.20 stands / m², the type of *H. pinifolia as the* type of seagrass with the highest density with a value of 487.47 stands / m². This is because this type is found to grow on a suitable type of substrate, which is sandy [26]. At the same time, the lowest type density value was found at station I, with a total of 650.13 stands/m², with the highest density by *C. rotundata* with a total of 417.3 stands/m². *Cymodocea rotundata* lives in shallow areas and is covered with coral sand; this species has a high tolerance for areas that are not submerged in water [31].

The highest relative density was found in the type of C. *rotundata* at station I at 64%, followed by the type of *H. pinifolia* at station III with a percentage of 36%, and the lowest relative density in the type of *C. serullata* at stations II, III at 0% and the type of *T. hemprichii* at station III at 0%. The relative density results can be seen in Figure 6.

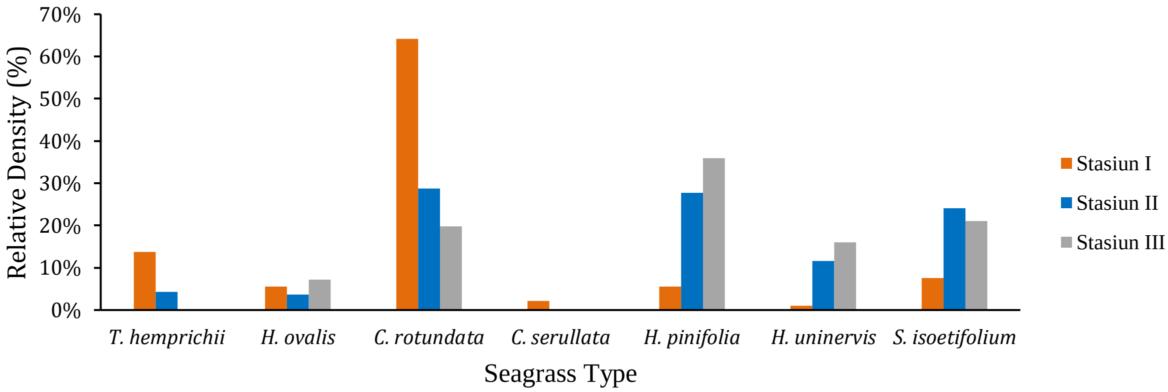


**Figure 6.** Seagrass Relative Density

Seagrass species' density in Siwak Bay waters is arguably very dense, with an average density of 1,019.47 stands / m². This corresponds to the criteria of the type density value category, which includes the density value of type >175 in very tight conditions [14]. The highest seagrass density was found at station III, with a total of 1,355.20 stands/m², and the lowest density was found at station I, with a total of 650.13 stands/m². The cause of the difference in density intensity at each station is the high level of human activity in seaweed cultivation, and madak is the activity of looking for fish or other marine life when the sea water recedes. This activity is carried out by communities around Siwak Bay, which has an impact on seagrass damage as a result of trampling. The most influential environmental pressure factor on the decline in the amount of seagrass vegetation comes from humans [32]. Several natural factors, such as differences in topography, tides, and organic matter content in each sediment, also cause the difference in density at each location. Other factors can be the main reason for differences in density at each area [33], such as seagrass density and growth, which are also influenced by water depth [34]. This is related to the process of photosynthesis that occurs in seagrass plants. The deeper the water, the less light intensity it gets.

**Type Frequency**

Type frequency is the chance of a species being found at the observation point to describe the distribution of seagrasses found [35]. The results showed that Cymodocea rotundata was the most common type, namely 38 out of 45 observation plots with a total frequency value of 2.53 followed successively by *Syringodium isoetifolium* (1.07), *Thalassia hemprichii* (0.93), Halodule *pinifolia* (0.93), *Halophila ovalis* (0.73), *Halodule uninervis* (0.67), *Cymodocea serullata* (0.07). The high frequency of *C. rotundata* species is caused by the substrate of Siwak Bay waters, which are dominated by sand. *C. rotundata* can generally live on all substrates but is more abundant in soft substrates dominated by sand [36].

**Ecological Index**

The Ecology Index consists of the diversity, uniformity, and dominance indexes. The diversity, uniformity, and dominance index can describe a community's stability level in an ecosystem [37]. The highest ecological index value in the waters of Siwak Bay is the Diversity index, and the lowest is the dominance index. The environmental index value can be seen in Figure 7.

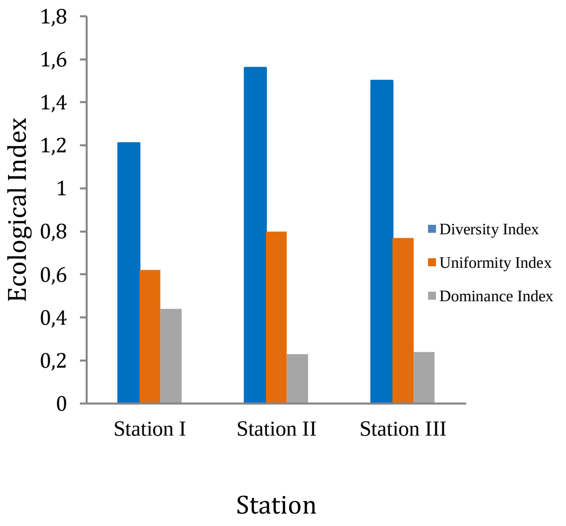


**Figure 7.** Ecological Index

Based on the results, the diversity index at 3 stations has different values of 1.21; 1,56; and 1.5 in a row at stations I, II, and III. Based on the criteria of Shannon-Wiener diversity index value, the value of H' < 1 diversity index is included in the requirements of low species diversity, the value of 1 < H' < 3 is included in the criteria of medium species diversity, and H' > three is included in the category of high species diversity [17]. The diversity index values at stations I, II, and III in the waters of Siwak Bay are included in the category of medium species diversity. The high and low values of the diversity index in an area can be influenced by the state of its waters' physical and chemical environment [38]. The seagrass species diversity index value at stations II and III is almost the same. In contrast, the temperature, pH, and salinity values at both locations are nearly identical. However, pH and salinity are relatively lower at station I than at other stations. This can affect the value of seagrass species diversity [38]. The temperature at each station has the same value of 30°C. This range is still in the excellent category for seagrass growth and health. The optimum temperature for seagrass growth is between 28-30 °C. The highest salinity found at stations II and III is 35 ppt, and the salinity value at station I is 34 ppt, with the average salinity value of Siwak Bay of 34.67, which is classified as suitable for seagrass growth [39]. Seagrass species have a tolerance range to salinity but mostly range from 10-40 ppt. The optimum salinity value for seagrass growth is 35 ppt [40].

The degree of acidity (pH) considerably influences seagrass growth and health. The pH value affects organisms' ability to regulate biochemical processes in their bodies [41]. The pH value based on measurements in the waters of Siwak Bay averages 7.7. Based on [42], the optimum pH value for the growth of marine life is between 7.0 to 8.5. The pH value in the waters of Siwak Bay is still classified as optimal for seagrass growth.

The uniformity index value indicates the stability of a community [16]. The seagrass uniformity index value in Siwak Bay waters can be seen in Figure 3. Seagrass uniformity index values at three stations were 0.62, 0.80; and 0.77 at stations I, II, and III. Based on the calculated uniformity index value, the three stations are included in the high uniformity category (Figure 6). The uniformity index criteria are as follows: E < 0.4 belongs to the low category, 0.4 < E < 0.6 belongs to the medium uniformity category, and E > 0.6 belongs to the high uniformity category [15]. A high uniformity index means that the number of individuals of one species from another is not much different, and environmental conditions are stable. If the uniformity index value is small, the more significant the difference in number between species (dominance), and vice versa if the uniformity index value is more excellent, the difference in number between species is smaller, so that the tendency to dominance by certain types does not exist [37].

The value of the dominance index shows the presence or absence of a species that dominates a water area. Based on the research that has been found, the calculation of the dominance index value at stations I, II, and III is 0.44, respectively, 0.23; and 0.24. Based on this value, the seagrass dominance index in the waters of Siwak Bay is included in the low dominance category. Values of 0 < C < 0.5 belong to the low dominance category [19]. Low dominance means that the number of individuals of no type is not too much different, so no dominating species is found.

**Important Value Index**

The important value index (INP) describes the species that dominate and the influence of a species on a seagrass meadow community [43]. The INP value shows the role of a species in a seagrass community, meaning that the higher the INP of a species, the more significant the role of the seagrass species. If the type is lost or low in the future, it can be used as a sign of a substantial change in the water environment of seagrass beds. Based on research conducted in the waters of Siwak Bay, the highest INP value results were obtained at station I, namely the *type of C. rotundata* of 199%. The high INP value of *C. rotundata* is due to the characteristics of sandy substrates on which this type of vegetation grows. Station II also has the highest INP value in type C. Rotundata is 99%. At station III, the highest INP value was found in the type of *H. pinifolia*, which was 113%. The high value of INP in *H. pinifolia* is caused by the rapid growth of this type with flattened, thin, long, and small leaves. The INP value in the waters of Siwak Bay can be seen in Figure 8.

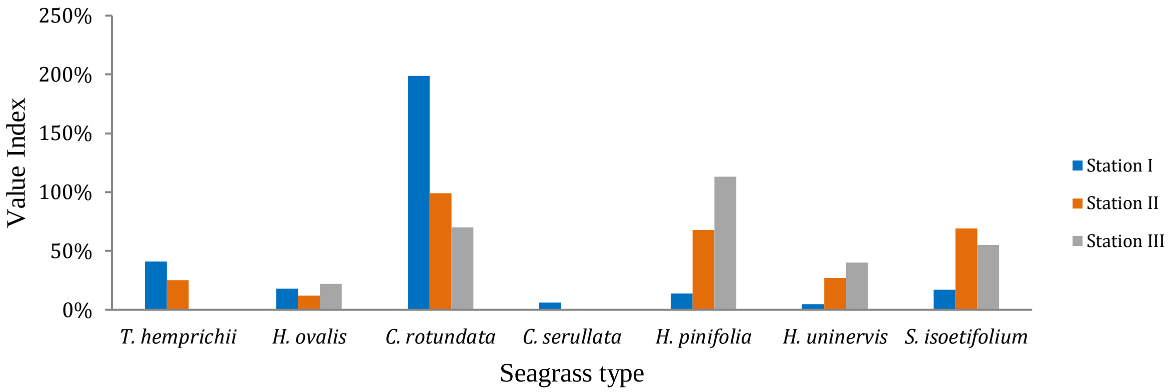


**Figure 8.** Siwak Bay Important Value Index

### Environmental Parameters

Environmental parameters measured in this study are temperature, salinity, and pH. Measurements were made at each station in conjunction with seagrass data collection. The results of measuring environmental parameters can be seen in (Table 20).

**Table 2.** Environmental Factor Variables

| Parameters | Station I | Station II | Station III |
|---|---|---|---|
| Temperature (°C) | 30 | 30 | 30 |
| Salinity (ppt) | 34 | 35 | 35 |
| pH | 7.2 | 8.12 | 7.8 |
| Substrate | Muddy sandy, sand coral fragments | Sandy rocks, sand coral fragments | Sandy, sand coral fragments |

Based on the measurement results obtained above, it can be said that environmental variable factors in Siwak Bay waters have met optimal seagrass growth and development standards.

## Conclusion

Based on the results of research that has been carried out show that there are seven types of seagrass found in the waters of Siwak Bay, *namely Thalassia hemprichii, Halophila ovalis, Cymodocea rotundata, Cymodocea serullata, Halodule pinifolia, Halodule Uninervis,* and *Syringodium isoetifolium*. The density of seagrass types and relative densities in Siwak Bay is very dense. The diversity and uniformity indices are each included in the medium and high categories, so they have a low dominance value. The highest INP in *C. rotundata* was 199%. The percentage of total seagrass cover, ranging from 37-61%, is included in the unhealthy category. The condition of aquatic environmental parameters does not show significant differences between stations. The values obtained are still good for seagrass growth and health.


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## References


[1] Romimohtarto, K. & Juwana, S. (2007). *Biologi laut: Ilmu Pengetahuan Tentang Biota Laut*. Jakarta: Djambatan.

[2] Bongga, M., C. Sodak, D. Kumampung, & K. Roeroe. (2021). Kajian Kondisi Kesehatan Padang Lamun di Perairan Mokupa Kecamatan Tombariri Kabupaten Minahasa. *Jurnal Pesisir dan Laut Tropis, 9(3), 44-54.*

[3] Hutomo, M. & Nontji, A. (2014). *Panduan Monitoring Padang Lamun*. COREMAP: CTI Lembaga Ilmu Pengetahuan Indonesia.

[4] Monita, D., Ernawati, H. & Riniatsih, I. (2021). Bioekologi Lamun di Perairan Teluk Awur, Jepara, Jawa Tengah. *Journal of Marine Research, 10(2), 165-174.*

[5] Supriyadi, I. H., Rositasari, R. & Iswari, M. Y. (2018). Dampak Perubahan Lahan Terhadap Kondisi Padang Lamun di Perairan Timur Pulau Bintan Kepulauan Riau. *Jurnal Segara*, *14(1), 1-10.*

[6] Syukur, A. (2015). Distribusi, Keragaman Jenis Lamun (Seagrass) dan Status Konservasinya di Pulau Lombok. *Jurnal Biologi Tropis*, *15(2),171-182.*

[7] Kuriandewa, T. E. (2009). *Tinjauan tentang lamun di Indonesia. Lokakarya Nasional I Pengelolaan Ekosistem Lamun: Peran Ekosistem Lamun dalam Produktivitas Hayati dan Meregulasi Perubahan Iklim*. Jakarta.

[8] Badan Perencanaan dan Pembangunan Daerah Provinsi Nusa Tenggara Barat. (2006). *Rencana Induk Pariwisata Berkelanjutan Pulau Lombok*.

[9] Hamit, L. S. (2022). Analisis Spasial Perubahan Luasan Tutupan Padang Lamun di Pesisir KEK Mandalika Menggunakan Data Landsat 8 Oli. *Skripsi*. Program Studi Biologi Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Mataram.

[10] Waycott, M., McMahon, K. J., Mellors, Calladine, A. & Kleine, D. (2004). *A Guide to Tropical Seagrasses of the Indo-West Pacific*. James Cook University: Townsville-Queensland-Australia.

[11] Sugiyono. (2011). *Metode Penelitian Kuantitatif dan Kualitatif*. Bandung: Alfabeta.

[12] Keputusan Mentri Negara Lingkungan Hidup (KEPMEN-LH) Nomor 200 Tahun 2004 tentang Kriteria Baku Kerusakan dan Pedoman Penentuan Status Padang Lamun. Jakarta. Kementrian Lingkungan Hidup.

[13] Gemilang, A. S., Kunarso, K., Handoyo, G. (2017). Pola Arus Laut Sebelum dan Sesudah Pembangunan Pelabuhan Tanjung Bonang Kabupaten Rembang. *Jurnal Oseanografi*, *6(2), 359-368.*

[14] Gosari, B. A. J., Haris, A. (2012). Studi Kerapatan dan Penutupan Jenis Lamun di Kepulauan Spermonde. *Jurnal Ilmu Kelautan dan Perikanan, 22(3), 156-162.*

[15] Odum, E. P., (1993). *Dasar-dasar Ekologi Edisi Ketiga*. Yogyakarta: Gadjah Mada University Press.

[16] Pratiwi, M. A. & Ernawati, N. M. (2018). Struktur Komunitas Ekosistem Padang Lamun pada Daerah Intertidal di Pantai Sanur Bali. *Journal Ecotrophic*, *12(1), 50-56.*

[17] Insafitri, I. (2010). Keanekaragaman Keseragaman dan Dominansi Bivalvia di Area Buangan Lumpur Lapindo Muara Sungai Porong. *Jurnal Kelautan*, *3(1), 54-59.*

[18] Suherlan, S., Oetama, D., Arami, H. (2016). Keragaman Jenis Lamun di Perairan Pantai Waha Kecamatan Tomia Kabupaten Wakatobi. *Jurnal Manajemen Sumber Daya Perairan*, *1(3), 311-321.*

[19] Madduppa, H. H. (2016). *Modul Pelatihan Teknik Analisis Kuantitatif Data Biologi Laut*. Bogor: Institut Pertanian Bogor.

[20] Feryatun, F. (2012). Kerapatan dan Distribusi Lamun (Seagrass) Berdasarkan Zona Kegiatan Yang Berbada di Perairan Pulau Pramuka Kepulauan Seribu. *Journal Management of Aquatic Resources*, *1(1), 44-50.*

[21] Hernawan, U. E., Sjafrie, N. D. M., Supriyadi, I. H., Suryarso, Iswari, M. Y., Agrraini, K. & Rahmat. 2017. *Status Padang Lamun Indonesia 2017*. Jakarta: Puslit Oseanografi LIPI Jakarta.

[22] Wagey, B. T. (2013). *Hilamun (Seagrass)*. Manado: Unstrat Press

[23] Ihwani, S., Idrus, A. A. & Mertha, I. G. (2022). Conditions of Seagrass Ecosystems in Gili Sulat Waters, Sambelia District, EastLombok Regency in 2022. *Jurnal Biologi Tropis*, *23(2), 176-182.*

[24] Riniatsih, I. (2016). Distribusi Jenis Lamun Dihubungkan dengan Sebaran Nutrien Perairan di Padang Lamun Teluk Awur Jepara. *Jurnal Kelautan Tropis*, *19(2), 101-107.*

[25] Hutomo, M., Kiswaran, W. & Azkab, M. H. (1988). *The Status of Seagrass Ecosystems in Indonesia: Resources, Probles, Research and Management.* Paper Presented at SEAGRAM I Manila.

[26] Dewi, C. S. U., Subhan, B., Arafat, D. & Sukandar. (2018). Distribusi Habitat Pakan Dugong dan Ancamannya di Pulau-Pulau Kecil Indonesia. *Journal of Fisheries and Marine Science*, *2(2), 128-136.*

[27] Tangke, U. 2010. Ekosistem Padang Lamun (Manfaat, Fungsi dan Rehabilitasi). *Jurnal Ilmiah Agribisnis dan Perikanan (Agrikan UMMU-Ternate)*, *3(1), 9-29.*

[28] Krisye, Rahman, Fendjalang, S. N. M., & Fendjalang, N. T. (2023). Jenis dan Tutupan Lamun di Perairan Pulau Maginti, Kabupaten Muna Barat, Sulawesi Tenggara. *Jurnal Grouper*, *14(1), 24-28.*

[29] Tania, A. L., Yulianda, F. & Adrianto, L. (2014). Dinamika Sosial-Ekologi Masyarakat Terhadap Budaya Madak di Daerah Pesisir, Sumbawa Barat. *Jurnal Ilmu dan Teknologi Kelautan Tropis*, *6(2), 319-329.*

[30] Kiswara, W. (2004*). Kondisi Padang Lamun (Seagrass) di Teluk Banten 1998-2001*. Pusat Penelitian dan Pengembangan Oseanologi. Lembaga ilmu Pengetahuan Indonesia. Jakarta.

[31] Tomascik, T., Nontji, A. J. A. & Moosa, M. K. (1997). *The Ecology of the Indonesian Seas. The Ecology of Indonesia Series*. Singapore: Periplus Edition (HK) Ltd.

[32] Rahmawati, S. (2011). Ancaman Terhadap Komunitas Padang Lamun. *Oseana*, *36(2), 49-58.*

[33] Ikhsan, N., Zamani, N. P. & Soedharma, D. (2019). Struktur Komunitas Lamun di Pulau Wanci, Kabupaten Wakatobi, Sulawesi Tenggara. *Jurnal Teknologi Perikanan dan Kelautan*, *10(1), 27-38.*

[34] Zurba, N. (2018). *Pengenalan Padang Lamun, Suatu Ekosistem yang Terlupakan*. Aceh: Unimal Press.

[35] Brower, J. E., Zar, J. H. & Ende, C. N. V. (1989). *Field and Laboratory Method for General Ecology Fourth Edition.* Boston USA: McGraw-Hill Publication.

[36] Setyono, D. E. J. (1985). *Mengenal Lamun dan Lingkungan Lonawarta no. 3*. Ambon: Lembaga Oseanografi Nasional LIPI.

[37] Wijana, I. M. S., Ernawati, N. M. & Pratiwi, M. A. (2019). Keanekaragaman Lamun dan Makrozobentos sebagai Indikator Kondisi Perairan Pantai Sindhu, Sanur, Bali. *Jurnal Ecotrophic*, *13(2), 238-247.*

[38] Mahesswara, K. B. P., Watiniasih, N. L. & Kartika, I. W. D. (2021). Community Structure of Seagrass Beds in Pandawa Beach Aquatic Bali. *Journal Simbiosis*, *9(1), 12-21.*

[39] Pelafu, R. E. P., Wagey, B. T., Paruntu, C. P., Tilaar, S. O., Windarto, A. B. & Tilaar, F. F. (2022). Struktur Komunitas Padang Lamun di Perairan Bulutui Kecamatan Likupang Barat Kabupaten Minahasa Utara. *Jurnal Pesisir dan Laut Tropis*, *10(2), 1-13.*

[40] Dahuri, R. (2003). *Keanekaragaman Hayati Laut Aset Pembangunan Berkelanjutan Indonesia.* Jakarta: Gramedia Pustaka Utama.

[41] Suhendar, U., Imran, Z. & Krisanti, M. (2023). Struktur Komunitas Padang Lamun di Perairan Kupang Barat Kabupaten Kupang Provinsi Nusa Tenggara Timur. *Journal of Social Science Research*, *3(2), 9241-9249.*

[42] Keputusan Mentri Negara Lingkungan Hidup (KEPMEN-LH) Nomor 51 Tahun 2004 tentang Kriteria Baku Mutu Air Laut. Jakarta. Kementrian Lingkungan Hidup.

[43] Menanjang, F. S. I., Georis, J. F. K. & Billy, T. W. (2017). Komunitas Lamun di Pesisir Pantai Pulau Bangka Bagian Selatan Kabupaten Minahasa Utara Provinsi Sulawesi Utara. *Jurnal Ilmiah Platax*, *5(2), 121-134.*