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# ANALYSIS OF SEAGRASS ECOSYSTEM HEALTH AND THE PRESENCE OF ASSOCIATED BIOTA IN GILI BALU, WEST NUSA TENGGARA

Analisis Kesehatan Ekosistem Lamun dan Keberadaan Biota Asosiasinya di Gili Balu, Nusa Tenggara Barat

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**ABSTRACT**

Seagrass ecosystem health is a key indicator that reflects the condition of seagrass meadows in a given location and plays an important role in determining the level of biodiversity they support (Dewi *et al*. 2019). This study aims to analyze the health status of seagrass ecosystems and the presence of associated biota in the Gili Balu marine conservation area, West Nusa Tenggara. Data were collected at three stations using the quadrat-transect method to assess seagrass cover, epiphytes, macroalgae, and water quality parameters. The Seagrass Ecosystem Health Index (IKEL) was calculated based on seagrass cover, epiphytes, macroalgae, water transparency, and species richness. The associated biota community structure was analyzed using the Shannon-Wiener diversity index (H'), dominance index (C), and evenness index (E'). Results showed that IKEL values at Station 1 (0.72) and Station 2 (0.716) were categorized as good, while Station 3 (0.623) was categorized as moderate. The highest diversity index was found at Station 1 (H'=3.565) with a stable community, while Station 2 (H'=2.024) and Station 3 (H'=1.651) indicated moderate diversity. Spearman's Rank correlation analysis showed a positive relationship between IKEL values and diversity index, but the correlation was not statistically significant, indicating that biodiversity is also influenced by other factors such as substrate, water quality, and anthropogenic pressures.

Keywords: Associated Biota, Diversity, Ecosystem Health, Gili Balu, Seagrass

**ABSTRAK**

Kesehatan ekosistem lamun menjadi indikator utama yang mencerminkan kondisi padang lamun di suatu lokasi serta berperan dalam menentukan tingkat keanekaragaman hayati yang didukungnya (Dewi *et al*. 2019). Penelitian ini bertujuan untuk menganalisis kesehatan ekosistem lamun serta keberadaan biota asosiasinya di kawasan konservasi perairan Gili Balu, Nusa Tenggara Barat. Pengambilan data dilakukan pada tiga stasiun dengan metode transek kuadrat untuk menilai persentase tutupan lamun, epifit, makroalga, serta parameter kualitas perairan. Indeks Kesehatan Ekosistem Lamun (IKEL) dihitung berdasarkan penutupan lamun, epifit, makroalga, kecerahan, dan kekayaan jenis. Analisis komunitas biota asosiasi menggunakan indeks keanekaragaman Shannon-Wiener (H'), dominansi (C), dan keseragaman (E'). Hasil penelitian menunjukkan nilai IKEL pada Stasiun 1 (0,72) dan Stasiun 2 (0,716) termasuk kategori baik, sedangkan Stasiun 3 (0,623) berada pada kategori sedang. Indeks keanekaragaman tertinggi terdapat pada Stasiun 1 (H'=3,565) dengan komunitas stabil, sedangkan Stasiun 2 (H'=2,024) dan Stasiun 3 (H'=1,651) tergolong sedang. Hasil analisis korelasi Rank Spearman menunjukkan hubungan positif antara nilai IKEL dan indeks keanekaragaman, namun tidak signifikan secara statistik, sehingga keanekaragaman biota juga dipengaruhi faktor lain seperti substrat, kualitas perairan, dan tekanan antropogenik.

Kata kunci : Biota Asosiasi, Gili Balu, Keanekaragaman, Kesehatan Ekosistem, Lamun

## INTRODUCTION

The increase in greenhouse gas emissions, which trigger global warming, is a serious global environmental problem. Nearly all countries contribute to this increase, with Asia being the largest contributor. This condition causes global temperatures to rise as more solar heat is trapped in the atmosphere (Haiqal *et al.,* 2021). Various mitigation efforts have been implemented, one of which is through the utilization of forests as carbon sinks. However, terrestrial ecosystems are considered to be suboptimal in this function (Rahmawati, 2011; Runtuboi *et al.,* 2018). Since 2009, the concept of blue carbon has been introduced by UNEP, FAO, and UNESCO to highlight the role of coastal ecosystems, such as mangroves, seagrasses, and coral reefs, which have been shown to be more efficient at sequestering carbon than terrestrial ecosystems (Hartati *et al.,* 2017; Tokoro *et al.,* 2014).

One coastal area with potential for blue carbon ecosystems is Gili Balu in West Sumbawa Regency, West Nusa Tenggara Province. This conservation area covers 5,845.67 hectares with several management zones (NTB Marine Affairs and Fisheries Department, 2016; Ministry of Marine Affairs and Fisheries, 2021). It contains a seagrass ecosystem that serves a vital role as primary producers, habitat, food source, and protection for various marine organisms. Seagrass also has a close relationship with mangrove and coral reef ecosystems, making it a key element in maintaining the balance of coastal ecosystems (Hartati *et al.,* 2012).

In the Gili Balu area, particularly Belang Island, at least five species of seagrass have been recorded: *Thalassia hemprichii, Enhalus acoroides, Cymodocea rotundata, Halodule pinifolia, and Halophila ovalis* (Yusuf, 2020). These seagrass meadows are associated with a variety of biota, ranging from mollusks and crustaceans to fish and marine mammals (Rasyid, 2001). However, the health of seagrass ecosystems is significantly influenced by environmental conditions. If degradation occurs, seagrass's function as a carbon sink and habitat for associated biota will be disrupted (Bongga *et al.,* 2021; Supratman *et al.,* 2024). Therefore, studies on the health of seagrass ecosystems and their relationship to the presence of associated biota are crucial, particularly in conservation areas like Gili Balu.

Based on the description above, the issues reviewed in this study include the status of the seagrass ecosystem health index, the value of the diversity of associated biota, and the relationship between the health of the seagrass ecosystem and the diversity of associated biota in the Gili Balu area, NTB. The purpose of this study is to measure and analyze the health index of the seagrass ecosystem, assess the diversity of associated biota, and understand the relationship between the two as a basis for sustainable coastal ecosystem management.

Accordingly, the general hypothesis proposed is that there is a positive relationship between the level of seagrass ecosystem health and the diversity of associated biota.

## RESEARCH METHODS

### Time and Place

The research was conducted in the Gili Balu marine conservation area, West Sumbawa Regency, West Nusa Tenggara (NTB) Province, in May 2025. A map of the research location is shown in Figure 1.

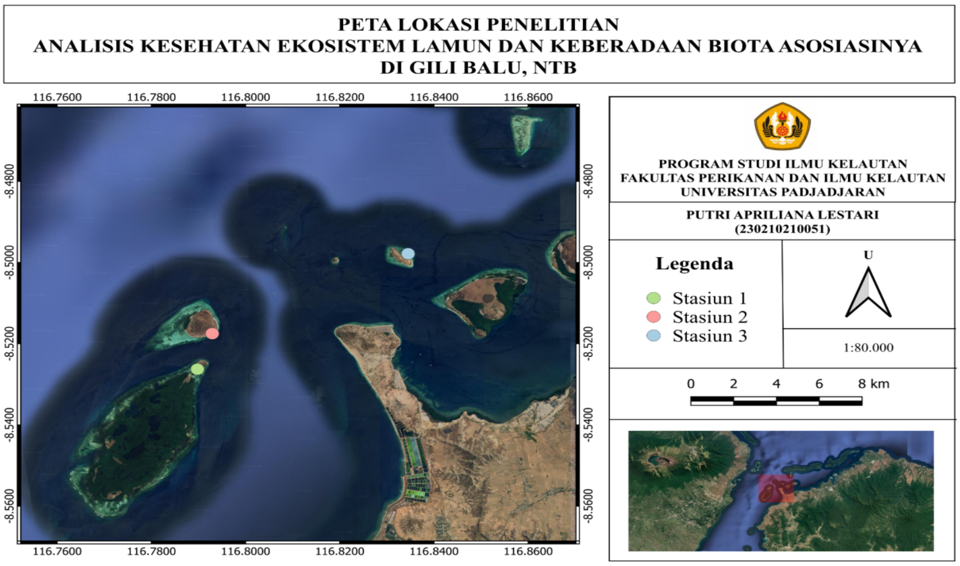


Figure 1. Research Location Map

### Tools and Materials

The tools used in this study were sampling bottles, GPS (Global Positioning System), roll meter, 50x50 cm² squares made of PVC, wooden stakes, thermometers, pH meters, DO meters, refractometers, plastic basins, field worksheets, pencils, whiteboards, seagrass species identification guides, seagrass cover area guides from Seagrass Watch, underwater cameras, basic diving equipment, shovels, shieve nets with a mesh size of 1mm, Microsoft Excel software. The materials used in this study were alcohol and distilled water.

### Research Procedures

The station locations were determined by considering human activity around the research area. Three stations were established: Station 1 near the mangroves, Station 2 near the pier with villas, and Station 3 on a tourist island. These locations were chosen to ensure that the data obtained represented the variation in environmental characteristics within the research area. Observations were conducted based on the seagrass inventory guidelines from Coremap-CTI LIPI and the Seagrass Watch guide, using in-situ transect and quadrat methods.

At each station, three transects were established with a maximum length of 100 meters towards the sea and a distance of 50 meters between transects parallel to the shoreline. Quadrat transects measuring 50 x 50 cm² were placed at 10-meter intervals, or 10% of the transect length. Within each quadrat, the percentage of seagrass cover, algae cover, epiphyte cover, and the number of macrofauna present were observed and documented. If seagrass cover was less than 3%, the number of shoots was counted directly and converted to percentage cover. Identification of seagrass species is carried out by observing morphological characteristics such as leaves, rhizomes, flowers, and fruit according to lifeform guidelines.

The parameters observed were seagrass cover percentage, macroalgae cover percentage, epiphyte cover percentage, water clarity, and epifauna. Macroalgae cover percentage was calculated based on the substrate area covered, while epiphytes were observed from the percentage of seagrass leaf surface covered by algae. Epifauna were recorded separately to avoid mixing with epiphytes. All data were collected in triplicate at each station to ensure representativeness of ecosystem conditions.

**Data Analysis**

**Seagrass Cover Percentage**

The process of calculating the area of seagrass cover on each transect was carried out using the following method (Rahmawati *et al.,* 2019):

$$\text{Average area of cover of transect} = \frac{Total\ area\ of\ all\ transect\ cover}{Sum\ of\ squares\ of\ all\ transects}$$

$$\text{Average station coverage area} = \frac{Average\ area\ cover\ of\ station\ transects}{3}$$

**Seagrass Ecosystem Health Index**

The seagrass health index calculation can be used as a guideline to assess the health of seagrass ecosystems based on various influencing factors. The seagrass health index parameter is calculated using the following formula (Hernawan *et al.,* 2021):

$$\text{Seagrass Ecosystem Health Index} = (\frac{St}{Sref})\text{x } 0{,}2+(\frac{Ct}{Cref})\text{x } 0{,}2+(\frac{Wf}{Wref})\text{x } 0{,}2+(1-(\frac{Mt}{Mmax}))\text{x } 0{,}2+(1-(\frac{Et}{Emax}))\text{x } 0{,}2$$

Information:
St = Observed seagrass species richness
Sref = Maximum species richness
Ct = Observed seagrass cover percentage
Cref = Maximum seagrass cover percentage (100)
Wt = Observed water clarity value
Wref = Maximum water clarity value (2)
Mt = Macroalgae cover percentage
Mmax = Maximum macroalgae cover percentage (100)
Et = Epiphyte cover percentage
Emax = Maximum epiphyte cover percentage (100)

**Indeks Keanekaragaman Jenis (H')**

The calculation of the diversity index is carried out using the Shannon-Wiener formula, namely (Larasati *et al.,* 2022):

$$H' = -\Sigma \text{ Pi Ln Pi}$$

Information:
H' = Diversity index
Pi = ni/N (i-th type composition)
ni = Number of biota type i
N = Number of all biota

**Dominance Index (C)**

Dominance calculations are carried out using the following formula (Setyobudiandi *et al.,* 2009):

$$C = \Sigma\ (ni/N)^2$$

Information:
C = Dominance index

ni = Number of individuals of the i-th species
N = Total number of individuals of all species

**Indeks Keseragaman (E')**

The calculation is carried out by comparing the diversity index value to the maximum value that can be achieved, using the formula proposed by Odum (1993) and explained in Fachrul (2007):

$$E = \frac{H'}{H' maks}$$

Information:
E = Evenness index
H' = Diversity index
H' max = Maximum diversity index (ln S)
S = Number of species

**Correlational Descriptive**

The research data were analyzed using a descriptive correlational method to determine the relationship between two variables without manipulation. The Seagrass Ecosystem Health Index values from each station were correlated with the associated biota diversity index to determine whether there was a significant relationship. The analysis was performed using the Spearman Rank Correlation Test, a non-parametric method for measuring the strength and direction of relationships between monotonic ordinal variables, where changes in one variable are followed by changes in the other, although not always linearly (Mustofani & Hariyani, 2023). All data were processed using SPSS or Microsoft Excel software.

**Comparative Descriptive**

A comparative descriptive analysis was conducted by comparing the current health of the seagrass ecosystem with previous monitoring data. The goal was to identify changes over time, whether in the form of improvements or declines in seagrass health. This comparison also helped identify factors likely influencing these changes, such as variations in physical and chemical water parameters, such as temperature, salinity, clarity, pH, and nutrient content.

## RESULT

**Seagrass Ecosystem at Each Station**

From the identification results, a total of 9 types of seagrass were found, namely *Enhalus acoroides, Cymodocea rotundata, Syringodium iseotifolium, Halophila ovalis, Thalassia hemprichii, Cymodocea serrulata, Halophila minor, Halodule pinifolia,* and *Halophila decipiens*. At Station 1, 6 types of seagrass were found, at Station 2, 8 types of seagrass were found, and at Station 3, 3 types of seagrass were found. Of the 9 types of seagrass found in the waters of Gili Balu, there are 2 types of seagrass found at all three stations, namely *Cymodocea rotundata* and *Thalassia hemprichii*. The distribution of seagrass species at each station can be seen in Table 1.

Tabel 1**.** Sebaran Spesies Lamun di Setiap Stasiun

| Station | Seagrass Species | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ea | Cr | Si | Ho | Th | Cs | Hm | Hp | Hd |
| 1 | + | + | - | + | + | - | + | + | - |
| 2 | + | + | + | + | + | + | - | + | + |
| 3 | - | + | - | - | + | + | - | - | - |

*(+) there is, (-) there is not, (Ea) *Enhalus acoroides,* (Cr) *Cymodocea rotundata,* (Si) *Syringodium iseotifolium,* (Ho) *Halophila ovalis,* (Th) *Thalassia hemprichii,* (Cs) *Cymodocea serrulata,* (Hm) *Halophila minor,* (Hp) *Halodule pinifolia,* dan (Hd) *Halophila decipiens*.

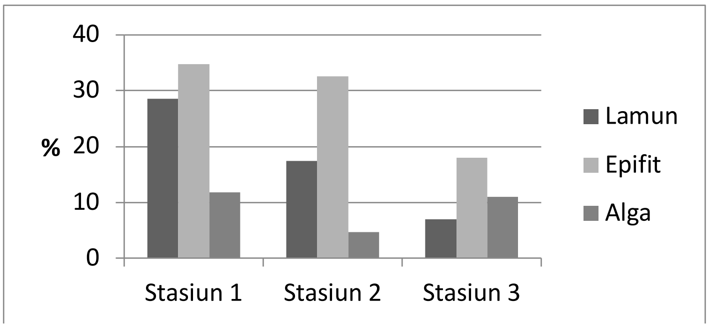

Figure 2. Percentage of Seagrass, Epiphyte, and Macroalgae Cover

Seagrass cover at the three research stations showed relatively low conditions. The average value of seagrass cover at Station 1 was recorded at 28.57% ± 24.51, Station 2 at 17.4% ± 21.76, and Station 3 at 6.98% ± 9.26 (Figure 2). All three values are below the threshold of 29.9% and are therefore categorized as damaged (poor). Epiphyte cover showed variation between stations, with values of 34.73% at Station 1 and 32.64% at Station 2 (Figure 2), both of which are in the moderate category. In contrast, Station 3 had epiphyte cover of only 18% (Figure 2), which is in the good (low) category. Macroalgae cover also showed variation. Station 1 had a value of 11.76% and Station 3 at 11.03% (Figure 2), both of which are in the poor category. In contrast, Station 2 had the lowest macroalgae cover, namely 4.61% (Figure 2), which is in the good (slight) category.

**Seagrass Ecosystem Health Index Value**

The Seagrass Ecosystem Health Index (SEI) shows varying conditions between stations. Stations 1 and 2 have SEI values of 0.72 and 0.716, respectively (Figure 3), which are considered good. Meanwhile, Station 3 has a value of 0.623 (Figure 3), which is considered moderate.

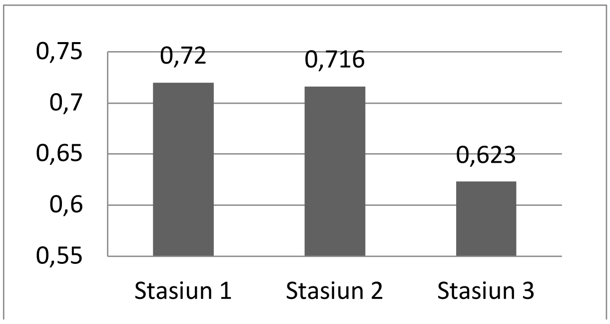

Figure 3. Seagrass Ecosystem Health Index Value

**The Existence of Associated Biota**

Ten classes of associated biota were found across all research stations: Gastropoda, Bivalvia, Malacostraca, Polychaeta, Clitellata, Asteroidea, Holothuroidea, Hexacorallia, Actinopterygii, Cephalopoda, and Echinoidea.

The most dominant class is Gastropoda, with 28 species. The next class is Actinopterygii, with 10 species. Seven species were found in the Bivalvia class. Four species were found in the Holothuroidea class. Next, four species were found in the Malacostraca class. Within the Echinodermata group, two species of Asteroidea and two species of Echinoidea were found.

Two species were also found in the Hexacorallia class, representing the sea anemone group. Other groups identified were Polychaeta with one species, Clitellata with one species, and Cephalopoda with one species.

At the three stations, 116 biota were found, with a distribution of 69 biota at Station 1, 22 biota at Station 2, and 25 biota at Station 3. The biota found at Station 1, 67% were of the Gastropoda class, 10% of the Bivalvia class, 10% of the Holothuroidea class and the rest were a mixture of other phyla. At Station 2, 64% of the biota found were of the Actinopterygii class, 12% of the Asteroidea class, and the rest were a mixture of other phyla. Then at Station 3, 52% of the biota found were of the Echinoidea class, 44% of the Actinopterygii class, and the rest were a mixture of other phyla.

**Diversity (H'), Dominance (C), and Uniformity (E') Values of Associated Biota**

Table 2. Diversity (H'), Dominance (C), and Uniformity (E') Values

| | H' | C | E' |
|---|---|---|---|
| Station 1 | 3,585 | 0,033 | 0,847 |
| Station 2 | 2,024 | 0,165 | 0,655 |
| Station 3 | 1,651 | 0,277 | 0,513 |

As seen in Table 2, the highest Species Diversity Index (H') was found at Station 1 with a value of 3.565, which is included in the high category (H' > 3). Meanwhile, Station 2 obtained a value of 2.024 and Station 3 1.651, both of which are included in the medium category (1 ≤ H' ≤ 3). The highest Dominance Index (C) value was found at Station 3, namely 0.277, while Station 2 was 0.165, and Station 1 was 0.034. All of these values are still classified as low dominance (0.00 < C ≤ 0.50). The highest Uniformity Index (E') was found at Station 1 with a value of 0.842 (stable category), followed by Station 2 at 0.655 (stable), and Station 3 at 0.513.

**Relationship between Seagrass Ecosystem Health Index Status and Associated Biota Diversity Values with Spearman Rank**

Based on the results of the correlation analysis carried out using the Spearman Rank method, it was obtained that the relationship between the Seagrass Ecosystem Health Index and the Association Biota Diversity Index showed a positive correlation direction with a coefficient value of 0.5 with the calculation:

$$rs = 1 - \frac{6\sum_{i=1}^{n} di^2}{n\,(n^2 - 1)}$$

$$rs = 1 - \frac{6\sum_{i=1}^{2} 2^2}{3\,(3^2 - 1)}$$

$$rs = 1 - \frac{12}{24}$$

$$rs = 1 - 0{,}5$$

$$rs = 0{,}5$$

However, when compared with the t-table value of 1.000 (Appendix 14), the analysis results show that the test statistic value is smaller than the table value. This condition indicates that H0 is accepted, so it can be concluded that there is no significant relationship between the status of the Seagrass Ecosystem Health Index and the level of associated biota diversity at the research location.

**Comparison of Seagrass Ecosystem Health Index Now with Before**

Comparison of the Seagrass Ecosystem Health Index values in this study (2025) with the results of previous monitoring by the Center for Coastal and Marine Resources Studies, IPB University (PKSPL-IPB) (2023) was carried out to see the dynamics of seagrass ecosystem conditions temporally.

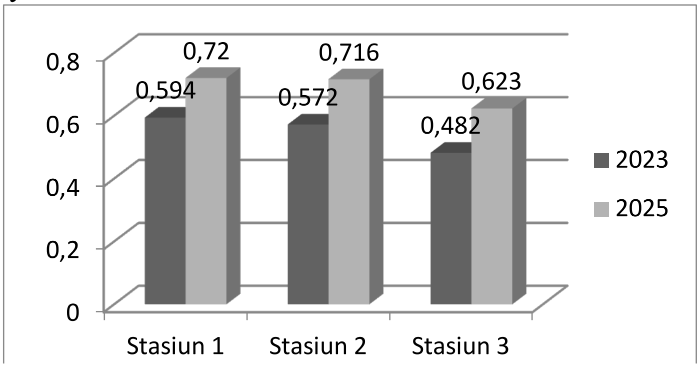


Figure 4. Comparison of Seagrass Ecosystem Health Index Values

Based on the graph presented in Figure 18, there is an increase in the Seagrass Ecosystem Health Index value at each observation station between 2023 and 2025. At Station 1, the IKEL value increased from 0.594 in 2023 to 0.72 in 2025. Station 2 also shows the same pattern, with an increase from 0.572 in 2023 to 0.716 in 2025. Meanwhile, Station 3, which previously had the lowest Seagrass Ecosystem Health Index value of 0.482 in 2023, also experienced an increase to 0.623 in 2025.

## DISCUSSION

**Seagrass Ecosystem Health Index**

The good Seagrass Ecosystem Health Index values at Stations 1 and 2 indicate that although seagrass cover does not reach healthy thresholds, ecosystem function can still be maintained because stressors from other organisms, such as epiphytes and algae, remain within a tolerable range. This condition indicates that the seagrass ecosystem at both stations remains capable of providing habitat, maintaining substrate stability, and fulfilling its role in supporting associated biota. Conversely, the Seagrass Ecosystem Health Index value at Station 3, which is only in the moderate category, indicates that the ecosystem condition at this location is more stressed. The very low seagrass cover, combined with higher levels of epiphyte and macroalgae growth, causes ecosystem function to be unbalanced and more vulnerable.

Thus, the relationship between seagrass ecosystem health indices and biota diversity is complex. A good seagrass ecosystem health index is important, but it does not automatically guarantee high diversity. Substrate factors, water quality, ecosystem associations, and human pressures also determine the structure of biota communities. Therefore, seagrass management requires attention to coastal ecosystem connectivity and the control of anthropogenic activities.

**Diversity (H’), Dominance (C), and Uniformity (E’) Values of Associated Biota**

The Seagrass Ecosystem Health Index in Gili Balu, NTB, is in the good to moderate category, with the highest value at Station 1 (0.72), followed by Station 2 (0.716), and the lowest at Station 3 (0.623). Although seagrass cover is relatively low, pressure from epiphytes and macroalgae remains within tolerable limits, allowing ecosystem function to continue. Community analysis results show that Station 1 has the highest diversity (H’ = 3.565), low dominance, and stable evenness, reflecting a more balanced community structure. Conversely, Station 2 (H’ = 2.024) and Station 3 (H’ = 1.651) are in the moderate category with lower evenness, indicating environmental stress. This is in line with the findings of Barnes *et al.* (2022) who stated that seagrass meadows support a more balanced community structure than bare substrates.

**Relationship between Seagrass Ecosystem Health Index Status and Associated Biota Diversity Values with Spearman Rank**

The relationship between the Seagrass Ecosystem Health Index and the Associated Biota Diversity Index showed a positive correlation with a coefficient value of 0.5. When compared to the t-table value of 1.000, the analysis results indicate that the test statistic is smaller than the table value. In other words, although the detected relationship is positive, the strength of the relationship is not sufficient to prove a statistically significant association.

These results indicate that the diversity of associated biota is influenced not only by the health of the seagrass ecosystem but also by other environmental factors. At Station 1, the biota was dominated by mollusks associated with the fine sand substrate, while at Stations 2 and 3, fish dominated due to their direct association with coral reefs. The sandy substrate supports bivalves such as *Anadara granosa* as filter feeders (Gea *et al*., 2019), while seagrass fronds are also utilized by gastropods such as Trochus niloticus as embryo shelters (Fernandes & Podolsky, 2011).

In addition to the substrate, interconnectedness between ecosystems creates complex habitats that enhance food sources and protection (Hartati *et al.,* 2012; Prado *et al.,* 2014). The complexity of seagrass meadows with high densities also provides greater living space and supports stable communities (Unsworth *et al.,* 2019). However, anthropogenic activities such as tourism, ship traffic, and waste disposal suppress diversity, as seen at Station 3 (Cullen-Unsworth & Unsworth, 2018).

Thus, the relationship between seagrass ecosystem health indices and biota diversity is complex. A good seagrass ecosystem health index is important, but it does not automatically guarantee high diversity. Substrate factors, water quality, ecosystem associations, and human pressures also determine the structure of biota communities. Therefore, seagrass management requires attention to coastal ecosystem connectivity and the control of anthropogenic activities.

**Comparison of Seagrass Ecosystem Health Index Now with Before**

The pattern indicates that the condition of the seagrass ecosystem across all study sites tends to improve relatively well over time. Similar to previous monitoring results, Station 1 continues to have the highest seagrass ecosystem health index compared to Stations 2 and 3, indicating a relatively healthy and stable seagrass ecosystem at this location, supported by the presence of mangroves that maintain substrate stability and nutrient supply. Conversely, Station 3 consistently has the lowest score, despite improvements, due to low seagrass cover, coarse sand substrate mixed with rubble, and high tourism pressure on Kenawa Island. Activities such as snorkeling, boat traffic, and recreation cause physical damage and water turbidity, which lower the seagrass ecosystem health index (Sudiarta *et al.,* 2020).

In general, an increase in the seagrass ecosystem health index indicates potential for natural recovery. However, the sustainability of improvements depends heavily on the management of human activities, and long-term monitoring is crucial to ensure that improvements truly reflect improved ecological conditions.

## CONCLUSION

The conclusion of the study, analyzing the Seagrass Ecosystem Health Index and the Presence of Associated Biota in Gili Balu, West Nusa Tenggara (NTB), indicates that the Seagrass Ecosystem Health Index is in the good to moderate category, with the highest value at Station 1 (0.72), followed by Station 2 (0.716), and the lowest at Station 3 (0.623). This indicates that despite low seagrass cover, the presence of epiphytes and macroalgae remains within tolerable limits, allowing ecosystem function to continue. Community index analysis shows that Station 1 has the best condition with high diversity (H' = 3.565), low dominance, and stable evenness. While Station 2 (H' = 2.024) and Station 3 (H' = 1.651) are in the moderate category with lower evenness, indicating environmental stress and less stable biota communities. Furthermore, correlation analysis indicates a positive relationship between the seagrass ecosystem health index and associated biota diversity, but this relationship is not statistically significant.

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