Enhancing Biodiversity and Seagrass Ecosystem Health: Identifying Key Conservation and Restoration Areas in the Bangka Belitung Islands, Indonesia

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ABSTRACT

Seagrass meadows, integral components of global coastal ecosystems, function as biodiversity hotspots and provide essential ecosystem services. Despite their ecological significance, these habitats face increasing threats from anthropogenic activities. This study assesses the species richness and ecological health of seagrass habitats in the Bangka Belitung Islands, Indonesia. We evaluated seagrass coverage, species richness, water transparency, and the cover of epiphytes and macroalgae using the Seagrass Ecology Quality Index (SEQI). Conducted in 2023, our research encompassed nearly all districts within the Bangka Belitung Province that contain seagrass ecosystems. Our findings reveal the presence of 11 out of the 14 seagrass species identified in Indonesia, with an average seagrass coverage of 20.48%±18.10%. Macroalgae and epiphyte coverages were recorded at 1.35%±1.22% and 2.22%±2.58%, respectively. The overall ecosystem health was generally categorized as moderate, with a mean SEQI of 0.68±0.11. Notably, Belitung Regency exhibited the highest SEQI score of 0.77±0.04, categorized as 'Good,' whereas West Bangka Regency had the lowest score at 0.57, categorized as 'Moderate.' Based on these findings, we recommend targeted conservation efforts in areas exhibiting good ecological health and prioritizing restoration initiatives in regions with moderate to poor health. These measures are essential for maintaining ecological balance and ensuring the sustainability of these vital habitats.

Keywords: Ecological health, Seagrass Ecology Quality Index (SEQI), Seagrass meadows, Species richness

INTRODUCTION

Seagrass ecosystems, composed of higher plants fully adapted to marine environments, play a crucial role in supporting biodiversity and human livelihoods, particularly in intertidal zones. Indonesia boasts one of the highest seagrass diversities globally, offering extensive ecological and economic benefits. These ecosystems serve as bioindicators of water quality, contribute to sediment stabilization (James *et al*., 2020), provide habitat for diverse aquatic life (Ambo-Rappe *et al*., 2013), enhance primary productivity (Sun *et al*., 2020), and play a significant role in carbon sequestration (Wahyudi *et al*., 2020; Heckwolf *et al*., 2021). For local communities, seagrasses are essential for food, medicinal uses, and livelihoods through the harvesting of economically valuable marine biota and aquaculture (Nordlund *et al*., 2016; McKenzie *et al*., 2021; Wallner-Hahn *et al*., 2022; Risandi *et al*., 2023).

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Despite their importance, seagrass ecosystems in the Bangka Belitung Islands face significant threats from anthropogenic activities such as coastal development and dredging, leading to habitat degradation and loss. These activities not only directly remove seagrass but also degrade water quality, indirectly affecting seagrass health through increased sedimentation and reduced light penetration (Waycott *et al*., 2009; Sari *et al*., 2017). Such changes profoundly impact the ecosystem's ability to provide essential services to the environment and the communities that depend on them.

Addressing the health and resilience of these ecosystems in the face of ongoing environmental pressures is currently a critical gap in conservation and restoration efforts. This study hypothesizes that the degradation of seagrass beds due to anthropogenic stressors significantly impacts the Seagrass Ecology Quality Index (SEQI) or Health Value, indicating a direct correlation between the extent of coastal development activities and the ecological health of seagrass ecosystems. To develop effective conservation and restoration strategies, this research evaluates the distribution, species richness, cover, and health of seagrass ecosystems. Although prior studies (Rosalina *et al*., 2018; Supratman and Adi, 2018) have begun to map out distribution and abundance, they have not provided a comprehensive view, especially regarding ecosystem health, which is critical for setting conservation priorities. By focusing on the health of seagrass ecosystems and their responses to environmental stressors, this study aims to guide effective conservation and restoration strategies in the Bangka Belitung Islands, Indonesia.

MATERIALS AND METHODS

Study area

The research was conducted around the Bangka Islands and Belitung Islands, encompassing almost all regencies with seagrass ecosystems in the Province of Bangka Belitung Islands in 2023. The selection of research sites was based on the distribution of seagrass across the Bangka Belitung Islands. The highest number of sampling points was in South Bangka due to the wide distribution of seagrass compared to other sites. Conversely, the fewest sampling points were in West Bangka, where seagrass distribution was limited to the area of Kelabat Bay in the Bakit village. The map and description of the research sites are presented in Figure 1 and Table 1.

Measurement of seagrass ecosystem health parameters

The health of the seagrass ecosystem was assessed using the Seagrass Ecology Quality Index (SEQI) analysis developed by Hernawan *et al*. (2021). The categories of of Seagrass Ecology Quality Index are listed in Table 2. The measured parameters included the richness of seagrass species, seagrass cover percentage, water transparency, and the percentage of epiphytic and macro-algae covers. These parameters were assessed at each research site or station. The formula for calculating seagrass health was based on the following equation (Hernawan *et al*., 2021), as follows:

$$\text{SEQI} = \frac{St}{Sref}\times 0.2 + \frac{Ct}{Cref}\times 0.2 + \frac{Wt}{Wref}\times 0.2 + \left(1 - \left(\frac{Mt}{Mmax}\right)\right)\times 0.2 + \left(1 - \left(\frac{Et}{Emax}\right)\right)\times 0.2$$

where,

St = seagrass species richness observed

Sref = max value of seagrass species richness (9)

Ct = seagrass percent cover observed

Cref = max value of seagrass percent cover (100)

Wt = water transparency observed

Wref = max value ofwater transparency (2)

Mt. = macroalga percent cover observed

Table 1. Description of the research location.

Regency	Location	Coordinates		Main Activity
South Bangka	Tanjung Ru	-3.01836	106.74005	Mining area activity
West Bengka	Bakit	-1.64974	105.70506	Mining area activity
Belitung	Tanjung Binga	-2.58577	107.64371	Fishing areas
South Bangka	Kumbung	-2.90109	106.78776	Fishing areas
Belitung	Pegantungan	-2.87742	107.57825	Fishing areas
Belitung	Sungai Samak	-2.84604	107.59052	Fishing areas
South Bangka	Tukak	-2.97085	106.65409	Fishing areas
South Bangka	Tanjung Labu	-2.94150	106.90800	Fishing areas
South Bangka	Penutuk	-2.99419	106.76393	Fishing port
South Bangka	Tanjung Sangkar	-2.89580	106.78972	Fishing port
South Bangka	Puding	-2.99193	106.68465	Shrimp ponds
South Bangka	Tanjung Krasak	-3.07160	106.73434	Shrimp ponds
Belitung	Tanjung Kelayang	-2.55535	107.66701	Tourism
Belitung	Tanjung Tinggi	-2.55416	107.70949	Tourism
Central Bangka	Ketawai Island	-2.26853	106.33006	Tourism
Central Bangka	Panjang Island	-2.14668	106.27362	Tourism

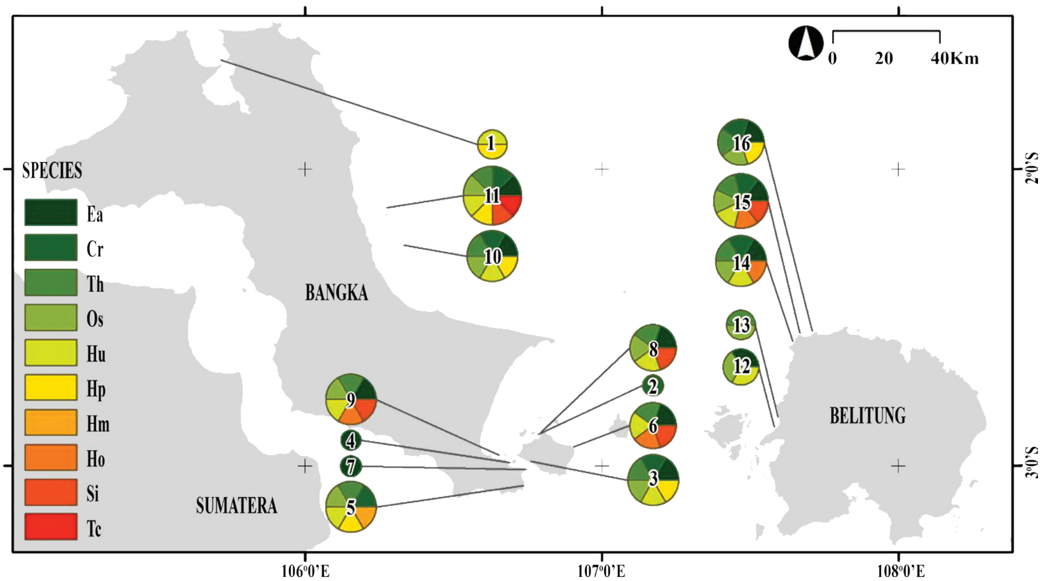

Figure 1. Distribution map of seagrass species richness in the Bangka Belitung Islands.
Note: 1 = Bakit; 2 = Kumbung; 3 = Penutuk; 4 = Puding; 5 =Tanjung Kerasak; 6 = Tanjung Labu; 7 = Tanjung Ru; 8 = Tanjung Sangkar; 9 = Tukak; 10 = Ketawai Island; 11 = Panjang Island; 12 = Pegantungan; 13 = Sungai Samak; 14 = Tanjung Binga; 15 = Tanjung Kelayang; 16 = Tanjung Tinggi; Species abbreviation as follow: Ea = *Enhalus acoroides*; Cr = *Cymodocea rotundata*; Th = *Thalassia hemprichii*; Os = *Oceana serrulata*; Hu = *Halodule uninervis*; Hp = *Halodule pinifolia*; Hm = *Halophila minor*; Ho = *Halophila ovalis*; Si = *Syringodium isoetifolium*; Tc = *Thalassodendron ciliatum*

Table 2. Categories of Seagrass Ecology Quality Index (SEQI) according to Hernawan *et al*. (2021).

No	Value SEQI	Health status of seagrass ecosystem
1	0–0.36	Bad
2	0.37–0.52	Poor
3	0.53–0.68	Moderate
4	0.69–0.84	Good
5	0.85–1	Excellent

Mmax = max value of macroalga percent cover (100)

Et = epiphyte percent cover observed

Emax = max value of epiphyte percent cover (100)

Seagrass cover percentage was determined using the quadratic transect method, with a 50×50 cm square quadrat, as described by Rahmawati *et al*. (2017). Data collection involved deploying a 100 m transect extending towards the sea, with each site having three transects or sub-stations spaced 50 m apart. Quadrats were placed on the right side of the 100–m transect, with a distance of 10 m between quadrats. Visual observations were made within the quadrats to determine the percentage of seagrass cover. The richness of seagrass species was assessed by identifying seagrass species within the quadrats. Additionally, seagrass species outside the quadrats were observed and identified directly at the research site.

Epiphyte and macroalgae covers were determined within the seagrass observation quadrats. Epiphytes, which are algae or organisms attached to the surface of seagrass leaves, were quantified based on the method outlined by SeagrassWatch (McKenzie *et al*., 2003). The percentage of epiphytes was calculated by estimating the area covered by epiphytes on the surface of seagrass leaves in the quadrats. Macroalgae percentage cover was directly observed within the observation quadrats and ranged from 0–100%, following the methodology described by McKenzie *et al*. (2003) and Hernawan *et al*. (2021).

Water transparency was assessed based on predetermined categories: muddy (0 value) when the seagrass and substrate were invisible from above, medium (1 value) when the seagrass was faintly visible, and clear (2 value) when both the seagrass and substrate were clearly visible (Hernawan *et al*., 2021).

RESULTS AND DISCUSSION

Distribution and richness of seagrass species in Bangka Belitung

A total of 11 seagrass species were identified in the Bangka Belitung Islands, occurring in various locations (Figure 1). The seagrass species observed at the research site included *Cymodocea rotundata* (Cr), *Oceana serrulata* (Os), *Halodule pinifolia* (Hp), *Halodule uninervis* (Hu), *Halophila minor* (Hm), *Halophila ovalis* (Ho), *Halophila spinulosa* (Hs), *Syringodium isoetifolium* (Si), *Thalassodendron ciliatum* (Tc), *Thalassia hemprichii* (Th), and *Enhalus acoroides* (Ea). In terms of seagrass species diversity, the Bangka Belitung Islands exhibited high richness, with 11 out of the 14 seagrass species reported in Indonesia being found in the region (Fortes *et al*., 2018; Rahmawati *et al*., 2022). Notably, three seagrass species reported in Indonesia were not found in Bangka Belitung Islands, namely *H. major*, *H. sulawesii*, and *H. decipiens*. These species have limited distributions within Indonesia, with *H. sulawesii* being an endemic species found in Sulawesi (Kuo, 2007), while *H. major* was recently reported as a new record Indonesia in 2020 (Kurniawan *et al*., 2020). Additionally, *H. decipiens* has a restricted distribution within Indonesia, primarily occurring in several locations, especially in eastern Indonesia.

The number of seagrass species found at a single site within the Bangka Belitung Islands ranged from 1 to 8, indicating the presence of both monospecific and multispecific seagrass communities. Particularly, Tanjung Kerasak, Tanjung Kelayang, and Panjang Island were frequently identified as areas with high seagrass diversity, where up to 8 species were observed at a single site (Figure 1 and Table 3). According to Rahmawati *et al*. (2022), seagrass communities in Indonesia typically exhibit multispecific compositions, with an average of 4–5 seagrass species and a maximum of 9 species recorded at one site. Conversely, Tanjung Ru, Puding Beach, and Kumbung were identified as sites with the lowest seagrass diversity, where only one species of seagrass, known as monospecific seagrass, was found. The most widely distributed seagrass species across the observation sites was *E. acoroides*, present in 14 out of the 16 sites surveyed (Figure 1 and Table 3). *E. acoroides* is commonly found in the waters of Southeast Asia and Indonesia (Fortes *et al*., 2018; Rahmawati *et al*., 2022; Monthum *et al*., 2023), with studies by Hernawan *et al*. (2021) and Nugraha *et al*. (2023) corroborating its extensive distribution across research sites. Moreover, this species is considered a keystone species in the Indo-Pacific region (Short *et al*., 2007) and exhibits resilience to disturbances, as observed in the research sites where it persisted despite adverse environmental conditions (Rahmawati *et al*., 2022).

The seagrass species with the most limited distribution was *H. spinulosa*, observed only at one site, exclusively outside the designated observation area. It was predominantly absent from the quadrats, likely due to its preference for deeper waters and

Table 3. Species richness of seagrass in the Bangka Belitung Islands.

No	Location	Ea	Cr	Th	Os	Hu	Hp	Hm	Ho	Si	Tc	Hs	Species richness
	West Bengka												
1	Bakit	-	-	-	-	+	+	*	-	-	-	-	3
	South Bangka												
2	Kumbung	-	++	-	-	-	-	-	-	-	-	-	1
3	Penutuk	++	+	+	+	+	+	-	-	-	-	-	6
4	Puding	++	-	-	-	-	-	-	-	-	-	-	1
5	Tanjung Krasak	*	+	+	++	+	+	+	-	-	-	*	8
6	Tanjung Labu	++	-	+	-	+	-	-	+	+	-	-	5
7	Tanjung Ru	++	-	-	-	-	-	-	-	-	-	-	1
8	Tanjung Sangkar	+	-	+	++	+	-	-	-	+	-	-	5
9	Tukak	+	-	+	+	++	-	-	+	+	-	-	6
	Central Bangka												
10	Ketawai Island	+	++	+	+	+	+	-	-	-	*	-	7
11	Panjang Island	+	++	+	+	+	+	-	-	+	+	-	8
	Belitung Island												
12	Pegantungan	+	-	-	++	+	-	-	-	-	-	-	3
13	Sungai Samak	*	-	++	+	-	-	-	-	-	-	-	3
14	Tanjung Binga	+	++	+	+	+	-	-	+	-	-	-	6
15	Tanjung Kelayang	+	+	+	+	++	*	-	+	+	-	-	8
16	Tanjung Tinggi	+	+	++	+	-	+	-	-	-	-	-	5
	Seagrass distribution	14	8	11	11	11	7	2	4	5	2	1	

Note: (-) = Absent; (+) = Present; (++) = Dominant; * found outside the square; Species abbreviations as shown in Figure 1 sandy substrates with low density. Additionally, *H. spinulosa* is classified as a pioneer species owing to its rapid growth rate (Waycott *et al*., 2009). The presence of pioneer seagrass species is of significant importance as they possess the ability to swiftly recover in the face of threats or disturbances (Rahmawati *et al*., 2022; Nugraha *et al*., 2023).

Seagrass cover percentage

The results of seagrass cover percentages across the Bangka Belitung Islands revealed notable variations at each research site. Belitung Island exhibited the highest seagrass cover percentage, averaging at 34.69%, whereas West Bangka recorded the lowest percentage at merely 3.65%. These findings suggest that, according to the criteria outlined in the Ministerial Decree of Environmental No. 200 of 2004, the condition of seagrass can be categorized as ranging from poor to unhealthy. Specifically, the seagrass health condition was deemed unhealthy in Belitung, while all locations on Bangka Island fell within the poor category. However, it is crucial to note that assessing seagrass health entails considering not only the cover percentage but also other critical factors such as species richness, water transparency, and the presence of potential stressors like epiphytes and macroalgae (Hernawan *et al*., 2021).

The higher seagrass covers on Belitung Island compared to Bangka Island can be attributed to various environmental factors, particularly anthropogenic activities. The observation site on Belitung Island remained in good condition in terms of water transparency and other environmental parameters (Table 4). Transparency measurements conducted across Belitung Island consistently yielded a value of 100%. Water transparency, a crucial biophysical feature, supports resilience by indicating sufficient light availability for seagrass photosynthesis (Rahmawati *et al*., 2022). The high transparency levels and favorable environmental conditions on Belitung Island are a result of the absence of marine mining activities, mandated by the Regional Regulation of RZWP3K of Bangka Belitung Islands. Additionally, anthropogenic activities on Belitung Island are primarily limited to tourism and fishing (Table 1).

The lowest seagrass cover was observed in West Bangka, with an average cover of 3.65%. The diminished seagrass cover on West Bangka Island can be attributed to prolonged mining activities conducted in the area. Specifically, the study site in West Bangka was located in Teluk Kelabat, Bakit Village. Seagrass distribution in West Bangka was confined to the vicinity of Tanjung Kelabat, as reported in several previous studies (Fifiyanti *et al*., 2020). Tanjung Kelabat is renowned as a tin mining area within the Bangka Belitung Islands (Ambalika *et al*., 2021). Mining operations in the waters of Tanjung Kelabat have led to a decline in water quality and ecosystem equilibrium (Ambalika *et al*., 2021), consequently affecting various ecosystems, including the seagrass ecosystem. The findings indicate that the pioneer seagrass species observed in Kelabat Bay include *H. uninervis, Hd. pinifolia,* and *H. minor*. These pioneer seagrass species possess the ability to rapidly regenerate following disturbances (Short *et al*., 2011; Rahmawati *et al*., 2022).

The highest and widest distribution of seagrass cover were *O. serrulata* and *C. rotundata* (Figure 2). This type of seagrass which belonged to the opportunist seagrass group (Rahmawati *et al*., 2022), dominated in several research sites. The opportunist seagrass species had several characteristics, such as tolerant of changing conditions, fast growth, but susceptible to disturbance. Therefore, *O. serulatta* and *C. rotundata* had quite a dominant cover percentage compared with other types in Bangka Belitung Islands.

Seagrass health was assessed using the Seagrass Ecology Quality Index (SEQI) equation developed by Hernawan *et al*. (2021). Previously, seagrass health was primarily evaluated based on seagrass cover, as per Ministerial Decree of Environment No. 200 of 2004. However, seagrass cover alone cannot fully determine its health, considering other crucial parameters such as species richness, water transparency, epiphytes, and macroalgae. The research results categorized the seagrass status in Bangka Belitung Islands as ranging from poor to good (Figure 3 and Table 4). Good seagrass status was notably found on Belitung Island and Central Bangka, with all research sites in these areas demonstrating good seagrass conditions. The

Table 4. Seagrass Ecological Quality Index (SEQI)and Parameters in the Bangka Belitung Islands.

Location	Species richness	Seagrass cover	Water transparency	Epiphyte cover	Macroalgae cover	Health value of seagrass	Health status of seagrass
West Bengka							
Bakit	3±0	3.65±8.23	1±0	0.62±1.99	0.19±1.09	0.57	Moderate
South Bangka							
Kumbung	1±0	32.41±35.15	1±0	2±0	0±0	0.58	Moderate
Penutuk	6±0	22.04±20.87	1±0	1.25±0	0.38±1.51	0.67	Moderate
Puding	1±0	0.19±1.09	1±0	0.19±1.09	0.76±4.35	0.52	Poor
Tanjung Krasak	8±0	14.55±19.95	1±0	1±0	1.33±4.88	0.70	Good
Tanjung Labu	5±0	1.8±3.89	1±0	1.25±0	3.71±8.22	0.60	Moderate
Tanjung Ru	1±0	0.14±0.60	0±0	0±0	0±0	0.42	Poor
Tanjung Sangkar	5±0	15.01±23.85	2±0	1.25±0	2.84±9.26	0.73	Good
Tukak	6±1.33	22.41±17.43	2±0	0.75±0.16	2.71±8.33	0.77	Good
Central Bangka							
Ketawai Island	7±2.07	8.17±12.44	2±0	0.96±0.82	0.22±1.53	0.77	Good
Pulau Panjang Island	8±2.17	27.11±26.09	1±0	0.73±0.17	1.71±4.94	0.73	Good
Belitung Island							
Pegantungan	3±0	73.28±46.35	2±0	3.75±3.55	0.53±1.95	0.80	Good
Sungai Samak	3±0	31.72±35.75	2±0	9.06±3.30	0.38±1.51	0.71	Good
Tanjung Binga	6±0	18.32±18.16	2±0	2.23±3.56	2.46±6.03	0.76	Good
Tanjung Kelayang	8±0.5	27.96±20.73	2±0	3.05±2.97	1.7±6.60	0.82	Good
Tanjung Tinggi	5±0	28.88±20.29	2±0	7.48±8.71	2.7±10.71	0.75	Good

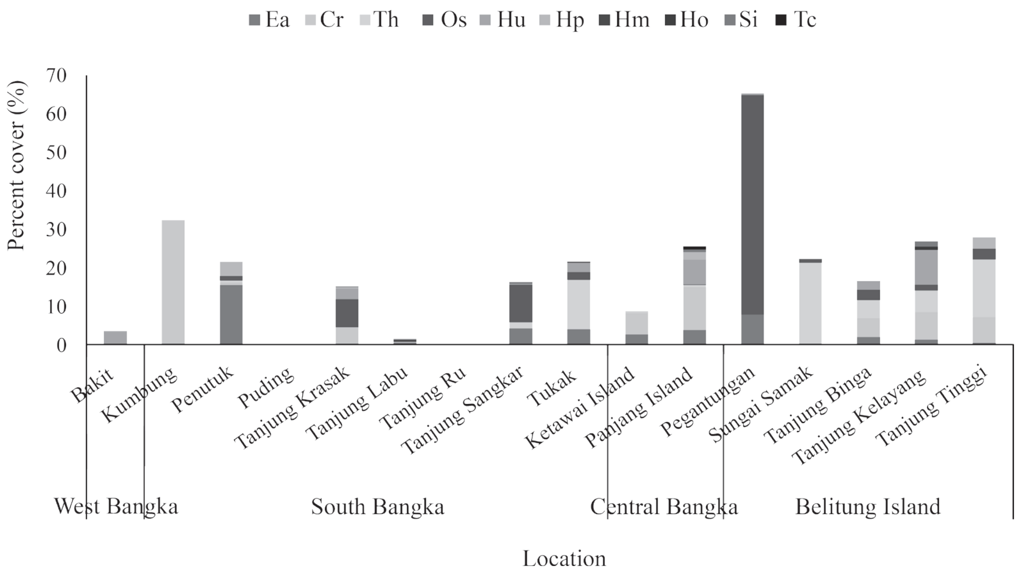

Figure 2. Percentage of seagrass cover in the Bangka Belitung Islands.
Note: Species abbreviation as shown in Figure 1.

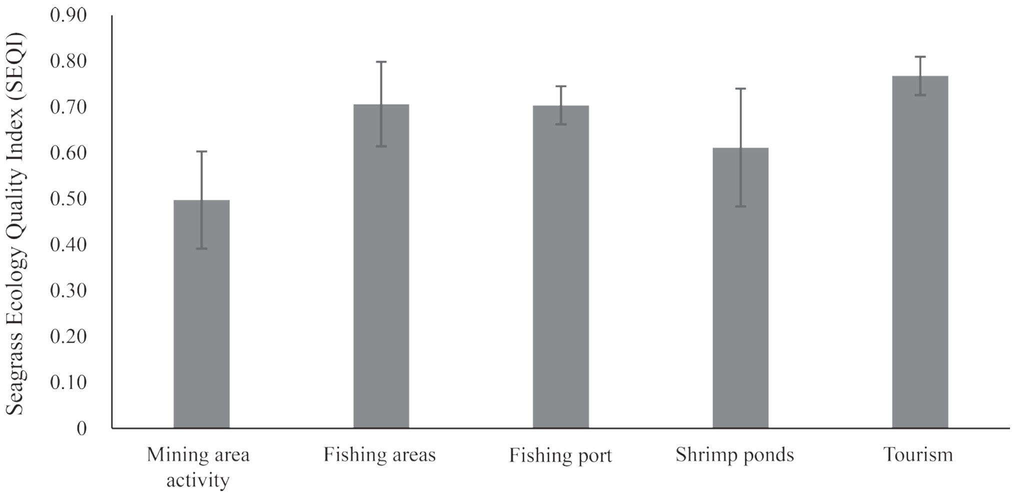

Figure 3. Seagrass ecology quality index based on the main activities at the research location.

favorable condition on Belitung Island can be attributed to its pristine waters and minimal human activity, mainly tourism and fishing. Additionally, Belitung Island boasts a high species richness of seagrass, with eight types found in one site. Similarly, Central Bangka exhibited good seagrass health due to its uninhabited small islands like Panjang and Ketawai, minimizing human-induced disturbances.

In contrast, South Bangka and West Bangka had a moderate average seagrass status, with sites ranging from poor to good conditions. Some areas like Puding Beach and Tanjung Ru Beach in South Bangka showed poor seagrass conditions, attributed to lower seagrass cover, reduced water transparency, and fewer seagrass species. These adverse conditions were linked to factors such as high sedimentation and muddy water substrates, likely stemming from activities like mining, shrimp pond waste disposal, and fishing.

Notably, the SEQI varied across different anthropogenic activities in Bangka Belitung. Mining areas recorded the lowest SEQI value of 0.50, categorized as 'Poor', due to intense disturbances from tin mining activities, affecting water quality and seagrass beds. Shrimp farming areas showed a moderate SEQI value of 0.61, indicating the negative impact of shrimp pond waste on seagrass performance. Conversely, areas with lighter human activities like fishing and tourism demonstrated SEQI values above 0.70, suggesting minimal disturbance and better seagrass ecosystem health. These findings underscore the importance of mitigating anthropogenic pressures to maintain the health and stability of seagrass ecosystems in the region.

Implementation for conservation and restoration of seagrass ecosystems

Conservation and restoration initiatives can enhance the vitality of aquatic ecosystems, including seagrass beds (Liu *et al*., 2023). However, the effective execution of seagrass conservation and restoration requires careful consideration of suitable locations. Determining the location for seagrass conservation and restoration areas relies on data regarding species richness, seagrass cover, and the overall health of the seagrass ecosystem. Locations characterized by high species richness are inherently more resilient to disturbances and possess greater capacity for resilience, making them optimal candidates for seagrass conservation and restoration efforts (Unsworth *et al*., 2015; Hernawan *et al*., 2021). Moreover, as suggested by Riniatsih *et al*. (2023), seagrass beds exhibiting high species richness or diversity exhibit superior levels of resilience compared to monospecies seagrass beds or those with lower species diversity. Areas demonstrating high seagrass richness alongside favorable seagrass cover and health conditions warrant the establishment of conservation areas. Conversely, areas where seagrass species richness is high but seagrass cover and health conditions are poor to moderate necessitate restoration efforts. However, the identification of conservation and restoration areas necessitates additional considerations and research, including ecological and socio-economic suitability analysis.

The assessment of species richness, cover, and health of the seagrass ecosystem has identified recommended locations for establishing seagrass conservation areas in Belitung, Central Bangka, and several areas in South Bangka. Several of these locations coincide with marine conservation areas already designated under the regulations of the Zoning Plan for Coastal Areas and Small Islands (RZWP3K). The conservation map can be accessed on the website https://sidakokkhl.kkp.go.id/sidako/map. Therefore, by entering a marine conservation area, efforts can be directed towards identifying suitable locations for seagrass and adhering to established regulations to preserve the integrity of the seagrass ecosystem. Field observations reveal continued human activities such as mining, disposal of pond waste, and unregulated fishing within conservation areas.

Recommended locations for seagrass restoration include West Bangka and several areas in South Bangka, based on the evaluation of seagrass species richness, cover, and ecosystem health. However, prior to commencing restoration activities, it is essential to ascertain whether the seagrass area has undergone reduction and whether the species slated for restoration were previously present at the site (Boudouresque *et al*., 2021). Introducing seagrass species not native to the area can disrupt the natural community and precipitate ecological consequences (Boudouresque *et al*., 2021). Additionally, careful attention must be paid to ensure that the selected seagrass restoration site is devoid of activities that could compromise seagrass beds and impede restoration efforts. Furthermore, the success of restoration is contingent upon the selection of donor sites with excellent seagrass ecosystem health to mitigate adverse impacts on the donor site. Recovery of donor seagrass sites is largely influenced by the size of the cores used; opting for smaller cores facilitates faster recovery of the seagrass ecosystem (Mokumo *et al*., 2023).

CONCLUSIONS

In the Bangka Belitung Islands, eleven seagrass species are distributed across various locations, with seagrass cover averaging 18.83%. Belitung Island has the highest cover at 34.69%, while West Bangka has the lowest at 3.65%. Seagrass ecosystem health spans from poor to good, with "good" beds predominantly found on Belitung Island and Central Bangka, and beds ranging from "moderate" to "quite good" in South Bangka and West Bangka. These findings inform the identification of conservation and restoration areas, prioritizing sites with high species richness, substantial cover, and good health for conservation, while areas with high richness but poor to moderate cover are earmarked for restoration efforts.

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