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# Small island seagrass ecosystem management based on ecosystem approach fisheries management principles

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ABSTRACT

Healthy seagrass beds have high ecological value, characterized by high diversity and even distribution in the water. However, currently, the health condition of seagrass beds is threatened both naturally and by human activities. For example, the loss of seagrass meadows due to human activities in coastal areas, including on Maitara Island, North Maluku Province, Indonesia. The objective of this research is to identify the community structure of seagrass, and the proper management options to minimize negative impacts on damage to the seagrass meadow ecosystem and sustain seagrass resources. The study was conducted in the South Maitara and the North Maitara, during the dry season from September to October 2020 using vertical transect methods. The result shows that the average index of diversity, evenness, and dominance on Maitara Island of 1.0970, 0.6470, and 0.5892, respectively. The beaches of South Maitara and North Maitara have poor diversity, a good category for evenness , and a stable community. *Enhalus acoroides* has the highest density of 294 ind/m$^2$, followed by *Thalassia hemprichii* around 287 ind/m$^2$. Based on the ecosystem aproach fisheries management (EAFM) analysis, to effectively manage seagrass ecosystems in Maitara Island, a social development strategy is needed through community awareness, counseling, and capacity building in the management and utilization of seagrass ecosystems in Maitara Island to effectively manage the seagrass ecosystem in Maitara Island, a social development strategy is needed through public awareness, counseling, and capacity building in the management and utilization of the seagrass ecosystem in Maitara Island

## Introduction

Seagrasses are critical components of marine ecosystems, providing essential services such as carbon sequestration, habitat for marine life, and coastal protection (Scott, *et al.*, 2018; Unsworth, *et al.*, 2019; Wilson and Lotze, 2019; Van Dam, *et al.*, 2020; Adharini, *et al.*, 2022). These flowering plants thrive in shallow waters and support a diverse range of organisms, contributing significantly to the ecological balance of coastal environments (Lefcheck, *et al.*, 2015; Pilotto, *et al.*, 2020; Kenzie *et al*, 2020; Murphy, *et al.*, 2021; Kindeberg, *et al.*, 2022). However, seagrass ecosystems face increasing threats from human activities, including coastal development, pollution, and climate change. The degradation of these habitats jeopardizes marine biodiversity and threatens the livelihoods of communities that rely on healthy marine ecosystems.

Current research highlights the multifaceted benefits of seagrasses, emphasizing their role in enhancing biodiversity and mitigating climate change impacts. Studies have shown that seagrasses are more effective than other submerged vegetation in facilitating water and carbon dioxide exchange, making them vital for carbon cycling in marine environments (Scott *et al.*, 2018; Unsworth *et al.*,

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2019). Furthermore, seagrasses serve as crucial nursery habitats for various fish species, which are essential for sustaining fisheries and maintaining the health of marine food webs. Despite this growing body of knowledge, there remains a significant gap in understanding the cumulative impacts of multiple stressors on seagrass ecosystems.

While existing literature has focused on the ecological functions of seagrasses, many studies have not adequately addressed the socio-economic implications of their decline. The importance of species diversity for ecosystem health is well-documented; however, the interactions between various stressors and their cumulative effects on seagrass ecosystems are less understood (Lefcheck *et al.*, 2015; Pilotto *et al.*, 2020). This disconnect between theoretical frameworks and real-world observations highlights the need for comprehensive assessments that incorporate both ecological and socio-economic factors in seagrass management.

Urbanization, residential development, and industry on Maitara Island threaten the existence of seagrass ecosystems that are vital for the health of the marine environment. As an area that has been declared in the Regional Spatial Plan (RTRW) of Tidore Islands City as a beach tourism area, these activities add to the pressure on the seagrass ecosystem. Uncontrolled development can lead to the loss of natural habitats, increased pollution, and sedimentation that inhibits seagrass growth.

In addition, industrial activities have the potential to pollute waters through hazardous waste, damaging the balance of coastal ecosystems. These threats result in the degradation of seagrass ecosystems, negatively impacting the biodiversity and local economies that depend on these marine resources. Therefore, holistic and sustainable ecosystem-based fisheries management is needed. This approach considers the complex interactions between ecosystem components and impacts from human activities, to ensure the sustainability of seagrass ecosystem functions and the well-being of communities that rely on these resources, while still supporting sustainable tourism development. This reality necessitates a more integrated approach to seagrass management that encompasses ecological, economic, social, and institutional dimensions.

The objective of this research is to assess the seagrass community structure on Maitara Island and identify effective management strategies to mitigate negative impacts on these ecosystems. By employing a vertical transect method, the study will evaluate seagrass diversity, evenness, and dominance, providing valuable insights into the current state of seagrass habitats in the region. Ultimately, this study aims to bridge the gap between theory and practice, fostering collaboration among stakeholders to enhance the resilience of seagrass ecosystems and ensure the sustainability of the services they provide.

## Materials and Methods

### Location and time of research

The location of the study was Maitara Island, including two main areas in the South Maitara and the North Maitara, and one in the main village of Maitara as seen in Figure 1. The environmental and oceanographic conditions of Maitara Island are characterized by uneven distribution of seagrass growth due to factors such as extreme wave conditions and the substrate being remnants of coral rubble. The seagrass distribution in the area is influenced by the shoreline position, with seagrass found in open coastal areas with extreme wave conditions, hindering proper growth. The uneven distribution of seagrass growth is observed in the East of Maitara Island, North Maitara, and parts of Central Maitara Village, while seagrass grows well in South Maitara.

The challenges of the area include the degradation of seagrass meadows due to human activities, such as oyster searching and anchoring boats, leading to damage to the seagrass ecosystem.

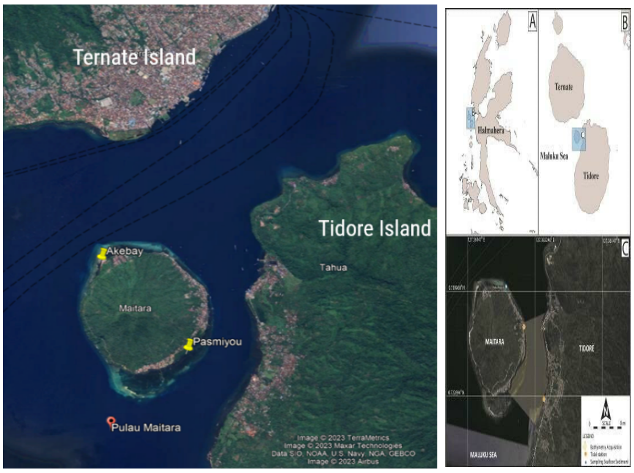


**Figure 1.** Study site location (generated from Google Earth and Novico, *et al.*, 2021).

Maitara Island is located between Tidore Island and the south of Ternate Island, or more precisely in the City of Tidore Islands (Tikep) which is administratively included in North Tidore District, Tidore City, North Maluku Province. Maitara Island is a small island with a population. This island has 4 (four) villages which were formed in July 2013 consisting of South Maitara Village, Central Maitara, North Maitara and Maitara Main Village. Maitara Island enshrined on the 1000 banknote is located at 0°43'56,000" N and 127°22'16,000" E, with an Island

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Area of ±2,821 $km^2$ with a coastline length of ±6,336 km.

**Data analysis**

A pair of 100 m perpendicular transect lines were laid out on the shorelines with three sampling stations. This is based on Ganzon-Fortes (2012) which mentioned vertical or perpendicular positioned transect was conducted for more or less homogeneous vegetation. If the vegetation is heterogeneous, with visible changes in floral composition from the shore to the subtidal zone, the transect should be laid perpendicular to the shore. Five replicate quadrats (0.50 m x 0.50 m) will be sampled on each transect. A total of 30 quadrats are sampled at the site.

The indicator of biodiversity and evenness indexes to measure seagrass condition is shown in Table 1 (Wibisono, 2005).

**Table 1**. The criteria for assessing the condition of the seagrass community structure are based on the Diversity and Evenness Index values.

| H' | Community structure | Category | Scale |
|---|---|---|---|
| >2.41 | Very stable | Very good | 5 |
| 1.80–2.40 | Stable | Good | 4 |
| 1.21 – 1.80 | Moderate | Moderate | 3 |
| 0.61 – 1.20 | Mild | Poor | 2 |
| <0.61 | Non-stable | Severe | 1 |
| **E** | **Species distribution** | **Category** | **Scale** |
| >0.81 | Highly evenness | Very good | 5 |
| 0.61–0.80 | More evenness | Good | 4 |
| 0.61 – 0.40 | Moderate | Moderate | 3 |
| 0.41 – 0.20 | Low evenness | Poor | 2 |
| <0.20 | Uneven | Severe | 1 |

Data was collected for a week in each sampling site during the dry season (September to mid-October 2020) with analytical statistics SPSS. The location selection was carried out on Maitara Island because in addition to this island being designated as an island with tourism designation, this island is also closer to Ternate Island which allows data collection and its influence to be more complete. In addition, data collection is carried out in the dry season, which tends to provide more stable environmental conditions. Temperature fluctuations and water salinity are minimal compared to the rainy season, so the data obtained is more consistent and reliable. Species identification and percentage of coverage are the parameters that must be measured. In general, parameter measurements include seagrass density, dominance index, diversity index, and evenness index. Those measurements followed the equation below (Krebs, 1972; Pratiwi and Ernawati, 2018; Bengen, 2000).

a. Seagrass density, Di = ni/A, in which ni is the number of individuals in transect quadrates, and A is the observation area (in $km^2$).
b. Dominance index, $C = \Sigma(ni/N)^2$, in which ni is the weight of each species, and N is the weight of the whole species.
c. Diversity index based on Shannon-Wiener
$$H' = -\sum_{t=1}^{S} (ni/N) \ln (ni/N)$$
d. Evenness index $e = \dfrac{H'}{\ln S}$

The seagrass ecosystem management strategy is carried out using FGD (focus group discussion) for experts and the community involved in making decisions regarding ways and forms of managing the seagrass ecosystem so that it is sustainable. FGD was conducted with 20 respondents consisting of fishermen, fisheries services, village stakeholders, and communities who often carry out activities in areas around seagrass on Maitara Island. The focus of the research was to analyze models and policy strategies for sustainable fisheries development on Maitara Island; by examining the ecological dimension, economic dimension, social dimension, legal and institutional dimensions and infrastructure and technology dimensions.

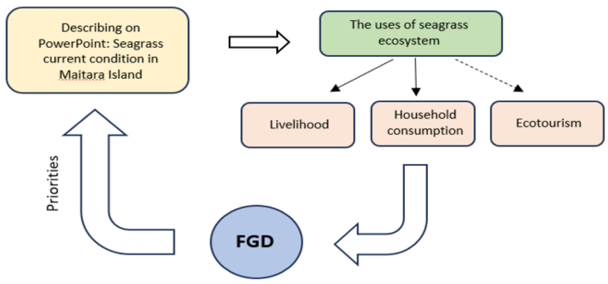


**Figure 2.** FGD activity process to discuss management strategy of seagrass restoration. (→ is a direct effect and --> is the indirect effect)

The target of achieving research on "Indicators for Assessment of the Seagrass Ecosystem on Maitara

Island" is to find models and strategies for utilizing the potential of the seagrass ecosystem as an ecosystem that can be utilized for policies to develop Maitara Island as an ecotourism area. The scheme of FGD is depicted in Figure 2.

Statistical analysis was performed on SPSS 26 packages and displayed on the histograms. The current condition of seagrass was matched with the index category table (Wibisono, 2005). Descriptive elucidation for FGD results was informed structurally. The data and information obtained were analyzed using Raphfish, namely using a data flag model with a Likert scale technique. The steps in data analysis using Rapfish are: (1) Determination of dimensions and indicators of fisheries utilization management; (2) Analysis by Multidimensional Scaling (MDS) method. Technically, the research flow chart can be seen in Figure 2, with Achievement Indicators in the form of (1) the availability of the latest data on the condition of the seagrass ecosystem on Maitara Island, (2) the preparation of an EAFM-based management model, and (3) the availability of applicable policy recommendations.

## Results

The results of research on Maitara Island showed that seagrass consists of 2 families and 7 types, namely the Potamogetonaceae family with 5 types, namely *Cymodocea rotundata, Cymodocea serrulata, Syringodium isoetifolium, Thalassodendron ciliatum* and *Enhalus acoroides*. Meanwhile, the Hydrocharitaceae family has 2 types, namely *Halophila minor* and *Thalassia hemprichii*.

The diversity, evenness and dominance of seagrass found on Maitara Island in detail can be seen in Table 2.

**Table 2.** Diversity, Evenness, and Seagrass Dominance at Maitara Island.

| Observed station | Diversity (H') | Evenness (E) | Dominance (C) |
|---|---|---|---|
| 1 | 1.4133 | 0.6356 | 0.6154 |
| 2 | 0.2322 | 0.3350 | 0.8838 |
| 3 | 1.6455 | 0.9706 | 0.2684 |
| Average | 1.0970 | 0.6470 | 0.5892 |

The highest Diversity Index on Maitara Island is located at observation station 3 which was 1.6455, while the lowest diversity index found at observation station 2 was 0.2322. The highest Uniformity Index on Maitara Island was found at observation station 3 at 0.9706, while the lowest uniformity index was found at observation station 2 at 0.3350. Index The highest dominance on Maitara Island is found at observation station 2 at 0.8838, while the lowest dominance index is found at observation station 3 at 0.2684. The average index of diversity, uniformity, and dominance on Maitara Island of 1.0970; 0.6470 and 0.5892. The beaches of South Maitara and North Maitara have poor diversity, good uniformity values, and a stable community. The average values of diversity, uniformity and dominance of seagrass on Maitara Island can be seen in Figure 3, and Figure 4 show as Seagrass density (ind/m$^2$) of species collection in Maitara Island.

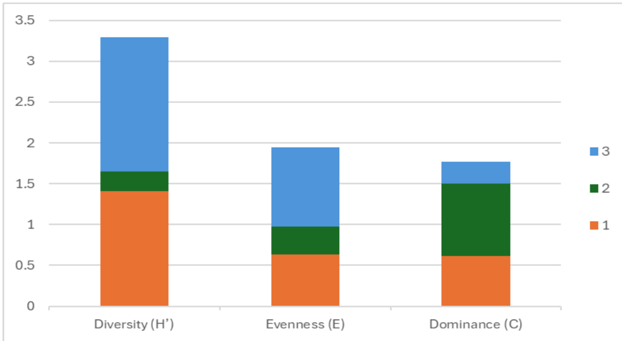


**Figure 3**. The average of Diversity (H'), Dominance (C), and Evenness (E) in the observed stations of Maitara Island

Based on the criteria indexes table in Table 1, the diversity is categorized as a poor condition because 0.23<H'<1.64 (poor level). Index dominance shows a very low number, which means that no seagrass types are dominated in the observed station.

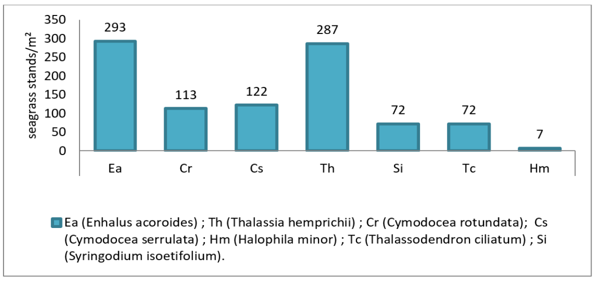


**Figure 4**. Seagrass density (ind/m$^2$) of species collection in Maitara Island.

It shows that there are differences in the density of each type of seagrass at each research station. *Enhalus acoroides* has the highest density which is 294 stand/m$^2$, followed by *Thalassia hemprichii* around 287 stand/m$^2$. The result was similar to seagrass densities collected by Ramili, *et al*., (2018). The lowest dominance is found at station 3, that is *Halophila minor* which only has 7 stand/m$^2$. This condition is affected by the exposed waters when the sea water recedes, and the substrate is dominated by the remains of broken coral (rubble) where in these conditions the *Halophila minor* seagrass species will find it difficult to grow and develop. According to Conte *et al* (2023), the *Halophila minor* seagrass species can thrive in waters that are always stagnant with water, and it is difficult to grow in shallow areas.

## Management Restoration Options

Sustainable environmental management has ecological, economic, and social dimensions (Sjafrie, 2018). The ecological dimension emphasizes the importance of efforts to prevent disruption of the basic functions of the seagrass ecosystem so that it will not reduce the function of ecological services. The economic dimension emphasizes that growth and efficiency in the utilization of natural resources must be pursued continuously. The social dimension includes issues related to the distribution of wealth or equitable distribution as well as the eradication of poverty (Tan *et al*, 2021). Therefore, the demand for the conservation of seagrass meadow ecosystems is getting bigger because of the increasing threats to the preservation of resources and their biodiversity.

Based on the results of FGD discussions and EAFM analysis, the condition of seagrass beds in the Maitara Island area has been damaged by around 45%-60%. This condition is strongly influenced by waste disposal and population growth. Similar to the coast of Bali Island and Lombok Island, disturbance comes from the use of potassium cyanide in catching reef fish which hurts reducing the value of seagrass cover and density (Rosalina *et al*, 2022). Research conducted by Habibah *et al* (2023), shows that seagrass ecosystem management using Management Effectiveness Tracking Tools or METT data will visualize the results of management measurements in the effectiveness level category.

The quality of seagrass beds may decline because of improper use. Destructive activities have the potential to alter seagrass communities and impede the growth of seagrass beds entirely. Population-related pressure on seagrass beds has become apparent, including excessive resource extraction from seagrass beds and harm to various seagrass species because of coastal reclamation for industrial and port development (Kiswara and Winardi, 1999). These activities have reduced the area of seagrass beds in Banten Bay, where the area of seagrass beds has decreased by 25 hectares. Some changes in the RUTR of Banten Bay, initially designated for agriculture and fishery, have increased in the area that would disappear. The coastal portion of Banten Bay that has undergone seagrass reclamation is approximately 30% suitable for luxury residences, hotels, and marine tourism. The loss around seagrass beds reduces the area for spawning, foraging, and caring for fish and shrimp, resulting in a decrease in natural stocks of fish and shrimp seeds in these waters, which in turn reduces local fishery production, affecting the income of coastal fishermen due to reduced fishing catch (Hesdianti and Patria, 2020).

The results of aggregating seagrass ecosystem management with EAFM analysis show that from now to the next 3 years management in conservation efforts (Table 3). For information, red means the worst management, yellow means fairly good management, and green means good management.

**Table 3**. The aggregate of some indicators affected the short- and long-term seagrass ecosystem management plans.

| Indicators | Initial value (year 0) | Maintenance plan | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Short-term | | | | | Mid-term | | | | | Long-term | | | | |
| | | 1st year | 2nd year | 3rd year | 4th year | 5th year | 6th year | 7th year | 8th year | 9th year | 10th year | 11th year | 12th year | 13th year | 14th year | 15th year |
| **Fish Resources Domain** | | | | | | | | | | | | | | | | |
| 1. Standard CpUE | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Fish size trends | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 |
| 3. Proportion of fingerlings caught | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| 4. Species composition of the catch | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 |
| 5. "Range Collapse" sumberdaya ikan | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| 6. Spesies ETP | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **Ecosystem and Habitat Domain** | | | | | | | | | | | | | | | | |
| 1. Water quality | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Seagrass ecosystem status | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3. Mangrove ecosystem status | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| 4. Coral reef ecosystem status | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 5. Unique/specialised habitats | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 6. Climate change on water and habitat conditions | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| **Fishing Technique Domain** | | | | | | | | | | | | | | | | |
| 1. Destructive fishing | 0 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Modification of fishing gear and fishing aids | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| 3. Fishing Capacity and Effort | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4. Selectivity of capture | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 5. Conformity of function and size of fishing vessels with legal documents | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 6. Certification of fishing vessel crew in accordance with regulations | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Social Domain** | | | | | | | | | | | | | | | | |
| 1. Participation of stakeholders | 0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Fisheries conflict | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3. Utilisation of local knowledge in fish resource management | 0 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Economy Domain** | | | | | | | | | | | | | | | | |
| 1. Asset Holdings | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Fishery household income (RTP) | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3. Saving ratio | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Organisational Domain** | | | | | | | | | | | | | | | | |
| 1. Adherence to responsible fishing principles | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 2. Completeness of rules in fisheries management | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3. Decision-making mechanism | 0 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 4. Fisheries management plan | 0 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 5. Level of synergy of fisheries management policies and institutions | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 6. Capacity of stakeholders | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Utilization and management of seagrass ecosystem resources in the Maitara Island region should be carried out thoroughly, either by the government or the community in the region by involving all important elements in seagrass ecosystem management. The choice of the proper management scenario for the sustainability of seagrass ecosystems in supporting the life of fisheries resources is an integrated scenario (UNDP, 2012). This scenario is considered to be the best option that can optimize the role of seagrass ecosystems and reduce activities that are problems of resource degradation. Degradation of the seagrass ecosystem, such as the search for oysters and juvenile fish species and the anchoring of boats in the seagrass ecosystem area must be minimized. Opening fisheries production centers with poly-cultural fish activities (alternative livelihoods) which is an area-based marine and fisheries development concept based on the principles of integration, efficiency, quality, and acceleration.

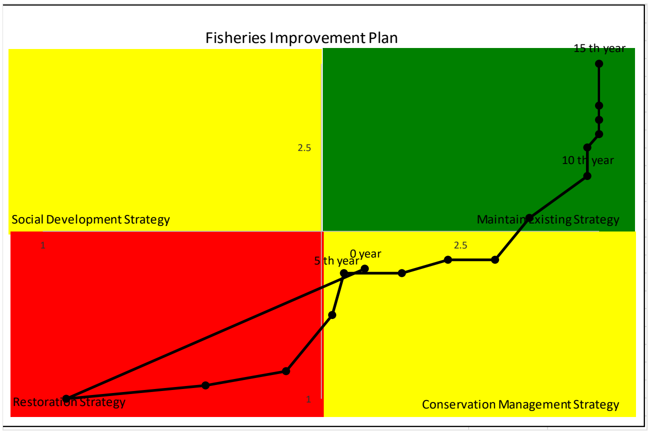


**Figure 5.** Efforts to plan for seagrass ecosystem improvement in Maitara Island.

To effectively manage the seagrass ecosystem in Maitara Island, a social development strategy is needed through public awareness, counseling, and capacity building in the management and utilization of the seagrass ecosystem in Maitara Island (Figure 5). The formation of ecosystem and environmental awareness groups need to be formed and assistance in the form of training and counseling for local communities, especially housewives about the importance of seagrass ecosystems. Livelihood activities for alternative economic sources as a substitute for fishing and shellfish activities in seagrass ecosystems need to be introduced and technical guidance is always carried out through training activities. In addition, local knowledge of kindergarten and primary school children about the importance of fisheries resources and ecosystems should be included in the school's local content curriculum.

## Discussion

The study identified the decline in seagrass quality due to various factors, including destructive human activities such as excessive resource extraction and coastal development. This aligns with findings from other researchers who have highlighted the detrimental impact of anthropogenic activities on seagrass ecosystems globally (Perry *et al.*, 2019; Satriani *et al.*, 2024; Kusnadi *et al.*, 2024).

Comparing the results of this study with previous research, it is evident that the challenges faced by seagrass ecosystems are widespread and require urgent attention to ensure their conservation and sustainable management. The data collected and analyzed in this study provide valuable insights into the current state of seagrass beds in Maitara Island and emphasize the need for effective conservation efforts to mitigate further degradation and loss of seagrass habitats.

The novelty of this research lies in its comprehensive examination of the community structure of seagrass in Maitara Island and the proposed management strategies tailored to the specific needs of the region. By focusing on the local context and engaging with stakeholders, the study offers a targeted approach to seagrass ecosystem management that considers the unique challenges and opportunities present in Maitara Island. This localized perspective adds depth to the existing body of knowledge on seagrass ecosystems and provides a valuable framework for future research and conservation initiatives.

## Conclusion

In conclusion, the findings of this research underscore the importance of proactive management and conservation efforts to safeguard seagrass ecosystems in Maitara Island and beyond. By building on the insights gained from this study and collaborating with stakeholders, policymakers, and researchers, it is possible to develop effective strategies for enhancing the resilience and sustainability of seagrass habitats in the face of ongoing environmental pressures.

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