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SUSTAINABLE MANAGEMENT OF COASTAL RESOURCES IN MENTAWAI ISLANDS DISTRICT, WEST SUMATRA PROVINCE, INDONESIA

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Abstract: This study aims to analyze the level of sustainability of coastal resources in the Mentawai Islands District. As an area that has various potential resources. Many developments in coastal areas are essential means of regional economic growth. It turns out that development in coastal regions raises problems for their natural resources in the form of a decrease (degradation) of their natural resources in quality and quantity. The decline includes shrinking mangrove forests, decreasing fishers' catch, sedimentation, and coastal abrasion around coastal areas. The MDS (Multidimensional Scaling) analysis approach will be used to determine the status of coastal resources as a foundation for sustainable coastal resource management based on the carrying capacity of the resources. The investigation findings suggest that the Mentawai Islands District's coastline management situation is not promising. The index for the ecological dimension is 42.31. In the moderate category, the economic dimension of the sustainable development index has a value of 51.31. The sustainable development index has a social dimension of 50.01. This dimension's legal and institutional dimension index is 51.84. The Mentawai Islands district's coastal management has to improve, given the increasing pressure to develop coastal resources in the future.

Key words: Coastal Degradation, Management, Multidimensional Scaling, Sustainability

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INTRODUCTION

Infrastructure development to support regional economic growth is critical to the Mentawai Islands District's success in the era of long-term development phase one. This situation is due to the Mentawai Islands District being a complete marine tourism area in western Indonesia (Figure 1). Geographically, the Mentawai Islands District has an area of the coast and oceans almost the same as the land area (Mentawai, 2021). The size of the coast holds various potentials, including marine fishery resources, marine tourism, aquaculture ponds, and mangrove forests (mangrove forests). The large and varied potential of coastal resources has generally been utilized for economic development. Using coastal resources for economic growth raises success and problems in coastal areas (Clark, 1996; Cicin-Sain and Knecht, 1998; Rizal et al., 2020b; Mentawai, 2022). The development problem in coastal areas of The Mentawai Islands District has not paid attention to the sustainability of its resources, namely not taking into account the biophysical carrying capacity of resources, economic carrying capacity, and social carrying capacity (Clarke and Warwick, 1997; Rizal et al., 2019; Rizal et al., 2020a). This causes a decrease in coastal resources, both in quality and quantity. The Regional Infrastructure Settlement Service of The Mentawai Islands District report

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(2022) revealed that there had been a reduction in mangrove forests throughout the Mentawai Islands District, including the coastal area, a decrease in the catch of fishers (CPUE), small fishers, and the amount of sedimentation and coastal abrasion in the coastal zone, all of which indicates that the management of the coastal regions is not yet sustainable.

Coastal and marine ecosystems are among the world's most biologically and economically productive ecosystems, and the Mentawai Islands District is no exception. These ecosystems provide a source of livelihood and a variety of ecological services that are critical for the day-to-day well-being of thousands of people, particularly in the district's coastal communities. Coastal and marine ecosystems in the Mentawai Islands are increasingly threatened, despite their enormous ecological and economic importance and a robust legislative and regulatory framework. Coastal and marine biodiversity are being harmed across the islands due to various direct and indirect stresses from economic development and associated activities. Habitat conversion to other land uses, overexploitation of species and associated destructive harvesting practices, the spread of invasive alien species, and the impacts of agricultural, domestic, and industrial sewage and waste are all major anthropogenic direct drivers of ecosystem degradation and destruction. Tsunamis, cyclones, hurricanes, and storms are all-natural meteorological events affecting coastal environments. Demographic, sociopolitical, cultural, economic, and technical variables are indirect drivers of ecosystem change (Rizal et al., 2019; Khan et al., 2020; Rizal et al., 2020b). The coastal area is the meeting point between land and sea with various resources. The dynamics of coastal resources interact with each other and need each other between these resources. If one of these resources decreases or decreases in quality and quantity, it will disrupt other resources. To reduce the impact of coastal development on its resources, integrated management must be implemented to maintain the sustainability of sustainable coastal resources (Pitcher and Preikshot, 2001; Tesfamichael and Pitcher, 2006; Nielsen et al., 2015; Kumar et al., 2022). Integrated management is sustainable development, namely to meet the needs of today's life without destroying or reducing the ability of future generations to meet their daily needs. Meanwhile, Edwards (1987) states that sustainable development aims to balance economic, social, and environmental sustainability.

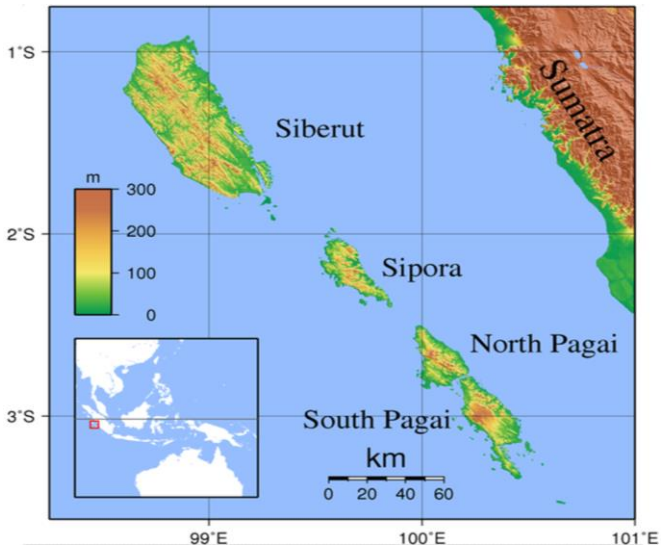

Figure 1. Map of Mentawai Island District, West Sumatra, Indonesia (Source: Regional Infrastructure Settlement Service of The Mentawai Islands District, 2022)

The concept of sustainability has been at the center of economic, social, and environmental debate for decades. Sustainable development, according to the Mentawai Islands District Department of Marine Affairs and Fisheries (2020), is "the management and conservation of the natural resource base, as well as the orientation of technological and institutional change in such a way as to ensure the continued satisfaction of human needs for present and future generations." Such sustainable development protects land, water, plants, and animal genetic resources while remaining environmentally friendly, technologically appropriate, economically viable, and socially acceptable" (Mentawai, 2020). The Brundtland Commission (1987) defined it more simply as "development that meets current needs without jeopardizing future generations' ability." The scientific community has derived related definitions of sustainable development. This study aims to analyze the sustainability of coastal resources in the Mentawai Islands District using the Multidimensional Scaling (MDS) model. The benefits obtained from this MDS analysis model can serve as the foundation for ecologically, economically, socio-culturally, and institutionally coastal resource management policies in optimizing coastal area development.

LITERATURE REVIEW AND METHODS

Literature Review

The conservation paradigm of sustainable fishing (Rizal et al., 2019; Khan et al., 2020; Rizal et al., 2020b), which focuses on protecting the ecological system without considering human and social goals, has been defined as sustainability in a fishery concerning catch levels that can be maintained (e.g., Maximum Sustainable Yield) (Edwards, 1987; Clarke and Warwick, 1997; Coppedge et al., 2008; Rostika et al., 2018). In contrast to the conservation paradigms, Charles (2002) said that the best means to achieve fishery sustainability is through a complex and systematic social-ecological analysis. This analysis focuses not only on the conservation of the fish and maximizing economic rent but also on the human dimensions of preserving the way of life of fishers and ensuring the principle of justice in fishing communities. Likewise, Norton (1992) defines sustainability as "a relationship between dynamic human economic systems and larger, dynamic, but normally slower changing the ecological system." In the economic dimension, the neoclassical approach to environmental economics aims to turn the environment into a commodity that can be analyzed just like other commodities. In line with this approach, neo-classical economists think that the climate is frequently undervalued because it can often be used free of charge; it tends to be overused and, therefore, degraded (Norton, 1992; Mostafa and Mahmood, 2018; Fuhlendorf et al., 2012). Alternatively, ecological economists like Costanza and Daly (1992) argue that "a minimum necessary condition for sustainability is maintaining the total natural capital stock at or above the current level." So, sustainability occurs only when there is no decline in natural capital.

All researchers accept three dimensions of sustainability: social, economic, and ecological, but a deeper analysis requires consideration of ethics (Charles, 2002; Mustaina et al., 2015; Santiago et al., 2015). Justice relates to equity or the fair distribution of benefits and harm, classifying two broad types of justice: ecosystem and social justice. Fisheries that realize the two forms of justice will be prudent, viable, resilient, participatory, equitable, and sustainable (Norton, 1992; Costanza and Daly, 1992; Charles, 2002; Santiago et al., 2015; Nielsen et al., 2017). The sustainability of fisheries is dependent on reconciling fundamental human rights such as food and livelihood with the environmental impacts of fishing.

Sustainable development emphasizes four dimensions, namely the ecological dimension, the economic dimension, the socio-cultural dimension, the institutional dimension, and the utilization of coastal resources using environmentally friendly technology. Of the four dimensions, it must be integrated and synergized in achieving sustainable development goals. Besides sustainable development, resources must be effective, efficient, targeted, and orderly for population growth (Alder et al., 2001; Pitcher and Preikshot, 2001; Alder et al., 2002; Tesfamichael and Pitcher, 2006; Rizal et al., 2020a).

Methods

The sustainability analysis method used is the Rapfish method. Rapfish (Rapid Appraisal for Fisheries) is a new technique developed by the University of British Columbia, Canada, which is an analysis to evaluate the sustainability of a multidisciplinary fishery. The principles of Rapfish are (1) will be used to quickly assess the status of sustainability by referring to several attributes; (2) the attributes used will be redefined or replaced according to the current information; (3) is a decision-making method referring to multi-criteria with a multidimensional scale; and (4) use the ordinance technique to determine the sustainability status. The Rapfish Flowchart and overall assessment of Rapfish sustainability using the MDS method approach (Fig 2). This method can cover a wide range of dimensions related to the existence of coastal resources (by determining two points as the basis of reference, namely "good" (good) and "not good" (bad) (Tesfamichael, and Pitcher, 2006; Rizal et al., 2020a). MDS can thoroughly analyze the description of the state of coastal and marine resources. This multivariate method can handle non-metric data and is also known as ordination in reduced space. The ordination itself is a process in the form of "plotting" object points (positions) along the axes arranged according to a particular relationship (ordered relationship) or in a visual system consisting of two or more (Alder et al., 2001; Pitcher and Preikshot, 2001; Alder et al., 2002; Tesfamichael and Pitcher, 2006; Rizal et al., 2020a). Another advantage of this method is that it can summarize the multidisciplinary data obtained in the field to produce a lot of quantitative and projected information. This method has been developed to analyze the environment (Bustosa et al., 2022).

Each attribute is scored using Multidimensional Scaling (MDS) to analyze coastal resources. The attributes relating to the aspects of coastal resources, ecological, economic, socio-cultural, institutional, and legal, are assessed as "good" and "bad." The number of ratings differs between the two ratings depending on the theoretical basis for the number of ratings. For example, determining the level of coastal land use consists of three (3) ranks: small, medium, and large. If the ranking is not clear in assessing an attribute, it is determined by "scientific judgment." Other assessments related to fishery resources refer to the standard provisions of Rapfish and the conditions of FAO (Alder et al., 2001; Pitcher and Preikshot, 2001; Alder et al., 2002; Tesfamichael and Pitcher, 2006; Rizal et al., 2020a). The application of the MDS method model for coastal resource assessment is a development in SPSS software that combines the rotation process, reversal position (flipping), and sensitivity analysis into a Kavanagh (2001) software package. The analysis using MDS is as follows (Alder et al., 2001; Pitcher and Preikshot, 2001; Kavanagh, 2001; Alder et al., 2002; Tesfamichael and Pitcher, 2006; Rizal et al., 2020a):

1) The results of field data (primary and secondary) for coastal areas from all dimensions are scored.

2) Determined the primary reference of good and bad by scoring good and bad on all attributes

3) Make two other main points, namely the "middle point," which is a bad and good point. These two additional main points of reference become the reference for the vertical direction ("up" or "up" and "down" or "down").

4) Create additional reference points known as anchors that can be used to assist with the ordinance results. These points act as stabilizers that form a kind of envelope. The research locations in the Mentawai Islands District and Mentawai Islands District are not outside the envelope. These points are also valuable for performing regression analysis to calculate the "stress" that is part of the MDS

5) Standardize the score for each attribute with the method (Pitcher and Preikshot, 2001; Tesfamichael and Pitcher, 2006):

$X_{ik}sd = (X_{ik} - X_k)/ S_k$ where: $X_{ik}sd$ = the standard score of the research location (including the reference points) to i = 1, 2,...n, on each attribute to k = 1,2, ... p; X_{ik} = the initial score of the research location (including the reference point) to i = 1,2,...n on each attribute to k = 1, 2, ...p; X_k = the mean score on each attribute to k = 1, 2,....p;

S_k = standard deviation of scores on each attribute to k = 1, ...2,..... p. Calculating the distance between coastal area resource locations using the n-dimensional Euclidean distance method is written.

$D^2(ij) = \Sigma(X_{ik} - X_{ik})^2$ (Pitcher,and Preikshot, 2001; Tesfamichael,and Pitcher, 2006)

Create ordinances for all attributes for each dimension based on aspects of the multidimensional scaling analysis algorithm. In the MDS analysis, the initially many attribute dimensions become only two dimensions remaining which will become the -X and -Y axes. The result of the ordination is a matrix V (n x 2), where n is the number of locations studied.

The distance between objects is calculated by regressing the Euclidean distance (dij) with the origin (D_{ij}); the equation can be written, namely: $d_{ij} = \alpha + \beta\delta_{ij} + \varepsilon$ (Pitcher,and Preikshot, 2001; Tesfamichael and Pitcher, 2006)

Regression analysis in MDS includes stress assessment by doing Goodness of fit in MDS is very important because Goodness of fit reflects an indicator of the magnitude of the S value (stress) when referring to the RAPFISH level of S value (stress > 0.25). For making a sustainability scale from "Bad" to "Good" (0 to 100) on the x-axis, the top point is +50 on the –y-axis scale, and the bottom point is -50 on the –y-axis scale, which refers to: For i = 1, 2,....n;

f (i,1) = 100 [($V_{(i,1)} - V_{(I\ bad,1)}$) / ($V_{(I\ up,2)} - V_{(I\ down,2)}$)] (Pitcher and Preikshot, 2001)

Vf(i,2) = 100 [($V_{(i,2)} - V_{(I\ down,2)}$) / ($V_{(I\ up,2)} - V_{(I\ down,2)}$)] – 50 (Pitcher and Preikshot, 2001)

Then obtained : Vf (i,2) = Vf (i,2)- Vf (I good, 2) (Pitcher and Preikshot, 2001).

Index values for the dimensions of coastal resources in the Mentawai Islands District. The index value is sustainable if > 50 and the index value < 50 is not sustainable (not sustainable). For this study, four (4) categories of sustainability index were made; the complete details are presented in Table 1 below.

Sensitivity Analysis

This sensitivity analysis uses "attribute leveraging" to see changes in the results of the MDS analysis. The effect of each attribute is seen in the form of changes in the root mean square (RMS), especially on the x-axis, especially on the scale of resource sustainability, and changes in the y-axis are not taken into account. This thing is because only to see the changes in the RMS. The RMS formula is:

$RMS = \sqrt{((\sum_{i=1..n} \{Vf_{(i,1)} - Vf_{(..,1)}\}^2)/n)}$ (Pitcher and Preikshot, 2001)

Where: Vf (i1) = MDS result value (after rotation and flipping)

Vf(..,1)= The mean value of MDS results in Column 1

Table 1. Coastal Area Resource Sustainability Index of Mentawai Islands District (Source: adaptation from Alder et al. (2001) and Pitcher and Preikshot, 2001)

Index Value	Category
0 – 25	Bad
26 – 50	inadequate
51 – 75	moderate
76 – 100	Good

Monte Carlo Analysis

Monte Carlo analysis helps evaluate the effect of errors (errors) on the results of the MDS analysis. The objectives of the Monte Carlo analysis are (Alder et al., 2000; Pitcher and Preikshot, 2001; Muth'en and Muth'en, 2002; Tesfamichael and Pitcher, 2006):

1) Effect of errors in attribute scores caused by understanding resource conditions;

2) The effect of variations in scoring due to differences in opinions or judgments by different studies;

3) The stability of the repeated MDS analysis process (iterations) looks at the quality of the stability of the reference points. The method used (RapCoastal);

4) Error entering data or missing data;

5) The high value of stress analysis results. For clarity, the process of MDS analysis, Leverage analysis, and Monte Carlo analysis is schematically described below.

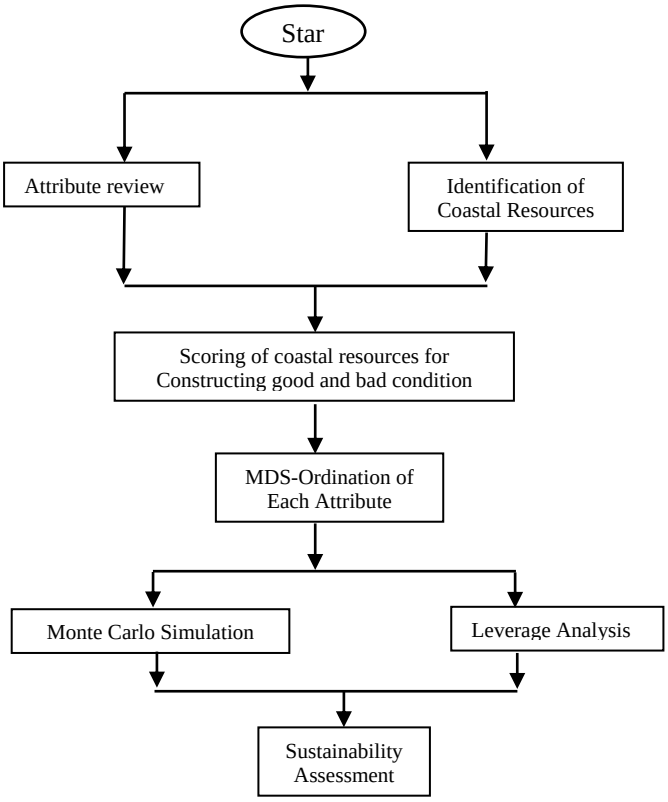

Figure 2. MDS Analysis Flowchart (adopted from Alder et al., 2001)

RESULTS DISCUSSIONS

Sustainable Management of Coastal Resources in Mentawai Island District

The coastal of the Mentawai Islands are residential areas, fish industries, and ports that can directly or indirectly affect the quality of this coastal area. Changes in the quality of the Mentawai Islands' coastal environment can be caused by human activities originating from land and sea waters. The Regional Infrastructure Settlement Service of The Mentawai Islands District report (2022) revealed that The entry of organic and inorganic materials in the form of waste into the coastal waters will affect the biological properties of these coastal waters. The high organic matter in the coastal waters will have an extreme effect on the availability of dissolved oxygen. If this situation lasts a long time, it will cause the seas to become anaerobic, so aerobic organisms will die. The increase in human activities, especially the activities of the sago mill in the Mentawai Islands, is the leading cause of pollution in the waters that causes ecosystem disturbances. In addition, around of coastal of the Mentawai Islands, many residential areas and fish industry activities have the potential to provide input of organic and inorganic materials in these waters. The organic matter at certain levels is a pollutant that pollutes the waters. The input of organic matter starts from the upstream of the river, which has densely populated residential activities, and urban and industrial activities are dumped into the river and carried by the current to the estuary. Some organic matter will experience deposition and form sedimentation, which causes siltation in the waters. Some of the organic material that does not share deposits will be carried away by currents, which causes the waters to have a high organic matter content and potentially disrupt aquatic ecosystems (Regional Infrastructure Settlement Service, 2022).

To determine the condition and status of coastal resources in the Mentawai Islands District, an analysis of the four dimensions (ecological, economic, social, institutional, and legal) was analyzed by analyzing all these dimensions to obtain an index of coastal area resources sustainability. The five dimensions have 56 attributes.

Condition and Status of Coastal Resources in Mentawai Islands District

The assessment results of coastal and marine resources in the Mentawai Islands District consisting of ecological,

economic, social, legal, and institutional dimensions are presented in the following figure. The index value in Figure 3 shows that the ecological index is in the interval 26 - 50. In the status of sustainable development, the ecological index in the Mentawai Islands is in the inadequate category. This condition explains that based on the assessment of conditions and the index value in Figure 3, the economic index is 51 - 75. This condition explains that based on the assessment of sustainable conditions and status, the economic index in the Mentawai Islands is in the moderate category.

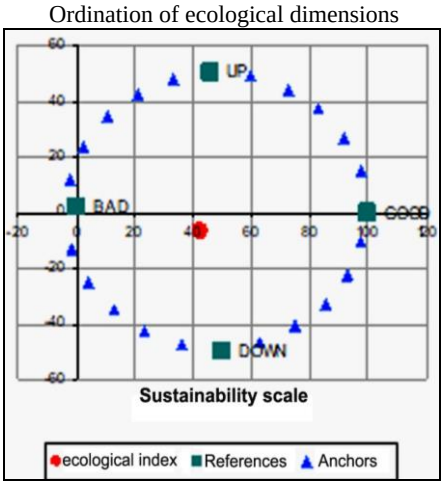

Figure 3. Sustainability index ecological dimension

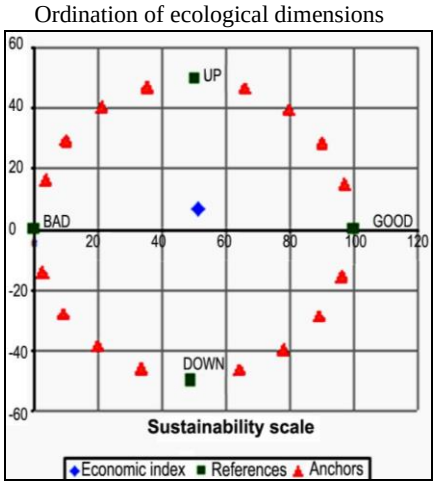

Figure 4. Sustainability index economic dimension

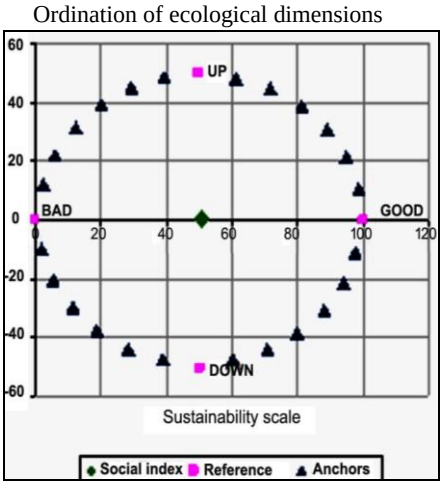

Figure 5. Sustainability index social dimension

The index value in Figure 5 shows that the social index is in the interval 26 - 50. This condition explains that the social index in the Mentawai Islands is in the inadequate category based on sustainable conditions and status. The index value in Figure 4 shows that the institutional index is in the interval 51 - 75. This condition explains that the institutional index in the Mentawai Islands is in a good category based on the assessment of sustainable conditions and status. The analysis of the four dimensions describes the condition and status of coastal and marine resources. The results of consecutive assessments are; the index value of the ecological dimension is 42.32, economic is 51.31, social is 50.01, and legal / institutional is 51.84. Of the four dimensions, the index of the ecological dimension is in the inadequate category, that the utilization of coastal resources in the Mentawai Islands District has not paid attention to the sustainability of the coastal resource ecosystem. The low social dimension index shows that the welfare of coastal communities is not evenly distributed, especially in the level of community income and unemployment. The institutional dimension of the index in the category of being at a sufficient level indicates that this dimension is quite good in the application, especially in monitoring and supervision. Still, evaluating the institutionalization of coastal resources in the Mentawai Islands District is necessary. The total index value is presented in the following table. Table 1 shows that the statistical value of the four dimensions has a value (stress) that follows the Rapfish procedure, which is less than 25%. At the same time, the R^2 level is very significant, namely 0.95 on average with a 5% confidence interval. Thus, all the variation attributes can explain the condition and status of the studied coastal area resources in the Mentawai Islands District.

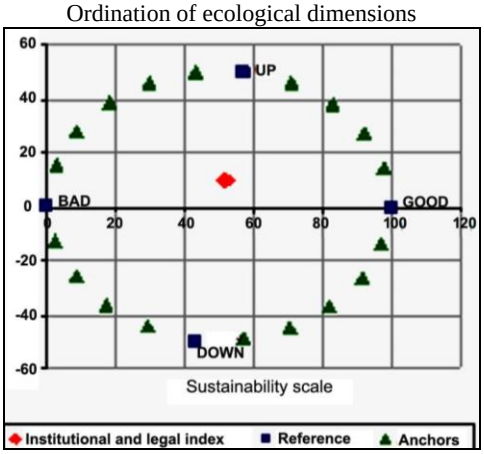

Figure 6. Sustainability index institutional and legal dimension

Table 1. Results of the assessment of index values and statistical values of the four dimensions of the condition and status of the sustainability of coastal resources of the Mentawai Islands District

Index Values and Statistics	Dimensions and Index Value			
	Ecological	Economic	Social	Institutional and legal
Index	42.32	51.31	50.60	51.91
Stress	0.1379575	0.1343904	0.130546376	0.1565892
R^2	0.9529636	0.9517044	0.953791916	0.9443238
Number of iterations	2	2	2	2
Rotation Angle (^{0})	262.87762	196.30698	-80.2814865	-6.33529

Leverage Analysis

Leverage analysis is used to analyze the attributes that play a sensitive role in the index value of the condition and status of coastal and marine resources. The calculation of leverage is based on the difference in standard error between scores and attributes; the results of the total leverage analysis are presented in Figure 6. Ecological dimensions, seven attributes are sensitive to sustainable development (Figure 3) that affect the condition and status of coastal and marine

resources in the Mentawai Islands District. These attributes are coastal abrasion, sedimentation, changes in the size of fish caught and overfished, mangrove rehabilitation, water pollution, and waste disposal in the waters.

The seven attributes that need serious attention, especially sedimentation that is quite disturbing, such as shallow harbor lanes and coastal abrasion, the local government must overcome these problems so that they do not impact coastal land—disposal of waste, especially household waste, in the Mentawai Islands District. To overcome the above, it is necessary to conduct outreach to the community. Furthermore, stricter supervision must reduce the pressure on coastal land, primarily residential land clearing. Economic dimension: There are five attributes (Figure 4) sensitive to the condition and status of coastal and marine resources. The five attributes are Regional Original Income (ROI), economic institutions and contributions to GRDP, the number of economic suggestions, and the total relative income of the regional minimum wage. The five attributes that have a prominent influence on the sensitivity of the economic index are economic institutions, changes in the number of economic facilities, and Regional Original Income. The small regional original income (ROI) of marine fisheries resources on the finances of the Mentawai Islands District Government and the contribution of marine fisheries resources shows the role of coastal area resources, especially marine fisheries resources, has not become a mainstay sector for the Mentawai Islands District Government.

The role of institutions in coastal areas gives a function to agencies that directly foster the fishery sector, in this case, the Department of Marine Affairs and Fisheries. To increase productivity and sustainability of coastal area resources, not only the Marine and Fisheries Service, it is necessary to have an integrated planner that includes the participation of all relevant agencies in the area. Policies that need to be carried out by encouraging the strengthening of economic institutions, especially the banking sector, and fostering carried out by making coordination between related agencies more effective (Baeta et al., 2005; Nielsen et al., 2017; Khan et al., 2020; Rizal et al., 2020a). For the sustainability of coastal resources management, the operationalization of sustainable development in the management of renewable coastal resources must incorporate environmental aspects in the development planning process from the beginning, utilizing the approach and environmental considerations in the process of resource management of coastal at every stage of Mentawai District development and apply the principles of efficiency and conservation in each step and activity. Therefore, the sustainable management of coastal resources in the management of renewable coastal resources uses an ecological approach in order to generate economic and social benefits of renewable coastal resources, preserve the environment while enhancing the skills, and improve the quality of individuals and communities involved in the management of renewable coastal resources (Butler et al., 2012; Suresha et al., 2015; Rizal et al., 2020b). Sustainable development must be done not only to reduce the impacts of resource conflicts that have occurred but also to prevent the conflicts that may arise. Therefore, to prevent conflicts or violence mostly caused by the scarcity of coastal resources, the environmental aspects should be considered (Rizal et al., 2020a). In the sustainable natural resource management, the main finding of political ecology theory argues that patterns of resource development arise from interactions between natural systems (e.g., quality, quantity, and location of water) and social systems (e.g., the spread of economic power, social, and political in society). In the context of coastal resource management on forests as the place of biodiversity, it can be a description to show us that we can use the ecological mechanism of political progress, especially for the owner of coastal resources and the authority (Butler et al., 2012; Suresha et al., 2015; Bustosa et al., 2022).

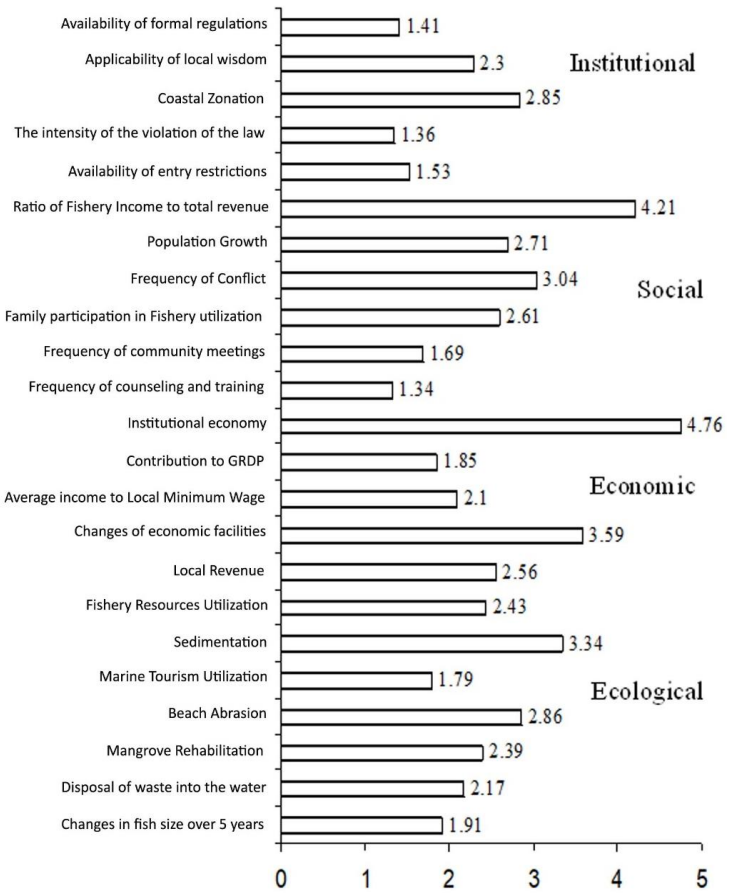

Figure 7. Analysis of leverage attributes of Mentawai Islands District

The social dimension that is sensitive to the index value of the condition and status of coastal and marine resources in the Mentawai Islands District; there are six social attributes (Figure 4) that are sensitive to the index of the condition and status of coastal resources, namely fishery business income to total income, the number of households working to utilize the resource. Coastal areas, conflict frequency, family participation in the use of coastal resources. Attributes that should be observed are income because the sensitivity is relatively high. Such conditions indicate that the dependence of coastal communities on coastal and marine resources is enormous. Efforts that need to be made are improving the skills of coastal communities through counseling so that coastal communities are responsible for the sustainability of resources for their

interests and resource sustainability. Meanwhile, the value of the conflict frequency attribute indicates the level of conflict that occurs between stakeholders is relatively high. The problem is the significant income disparity between small and large businesses in using coastal resources, mainly marine fisheries. Actions that need to be taken by local governments are to manage conflicts by minimizing their disputes (Baeta et al., 2005; Nielsen et al., 2015; Santiago et al., 2015; Viðarsson et al., 2018). Institutional dimensions attribute is sensitive to coastal and marine resources' condition index and status (Figure 6). The most sensitive attribute to the index value of the condition and level of coastal and marine resources in the Mentawai Islands District is the zoning of the coastal area of local archives and the availability of formal regulations.

These three attributes need serious attention. The zoning of the coastal area in the Mentawai Islands District has not run as it should, especially the conservation zoning as an area located in the coastal zone. The determination of conservation zoning is essential. The results of field observations of land use conditions still overlap (change of mangrove land into settlements). The attribute of the availability of regulations (local wisdom) needs to be encouraged to be developed simultaneously that it provides a role of a character. The feature of the availability of formal rules shows that the laws and regulations in coastal areas have not yet been implemented, and conflicts often occur.

Monte Carlo Analysis

The Monte Carlo analysis test results show that the error rate in the MDS analysis has a high level of confidence in determining the level of sustainability of the coastal resource status of the Mentawai Islands District. The details are presented in Table 2 below. The table above shows that the index value of the condition and status of coastal and marine resources in the Mentawai Islands District at a 95% confidence interval indicates that the index value has not changed too much from the original value. The relatively small change from the Monte Carlo analysis further strengthens the study results of the sustainability level of the coastal area resource status of the Mentawai Islands District at a high and significant level of confidence.

Table 2. Results of Monte Carlo Analysis of the Resource Status Index for the Coastal District of the Mentawai Islands District with a 95% confidence interval

Status Index	Rapfish Results	Monte Carlo Results	result distinct
Ecological	42.32	42.56	0.24
Economic	51.31	51.48	0.17
Social	50.60	50.24	0.36
Institutional and legal	51.84	51.91	0.7

CONCLUSION

The survey results show that the coastal management situation in the Mentawai Islands area is not promising. From the analysis of the sustainability of the coastal resources in the Mentawai Islands area, it can be explained using four dimensions that the state of the coastal resources in the Mentawai Islands area is unsustainable. The analysis results show that the sustainable state of the ecological dimension index is 42.31. Based on this value, it is classified as bad. Therefore, the above situation needs to be resolved as soon as possible. Possible solutions include (i) strong local government and other equipment in implementing regulations and laws, (ii) coordination between authorities on coastal development, and (iii) Zoning policy to overcome the pressure on coastal areas. The moderate category's economic dimension of the sustainable development index has a value of 51.31. However, the economic process does not coincide with long-term economic rents for coastal resources (fishery and mangrove forests). And the economic approach prioritizes production results over other factors such as the socioeconomic status of coastal communities.

The index of sustainable development has a social dimension of 50.01. Coastal stakeholders continue to share a sense of responsibility for the long-term viability of coastal resources. Furthermore, socialization on the sustainability of coastal resources remains insufficient, and community leaders in coastal areas have not been involved. The Mentawai Islands District has a sustainable development index of 51.84 in the legal and institutional dimensions. Understanding the development of coastal resources in the two areas needs improvement, particularly for policymakers, notably the Mentawai Islands District Legislative Institution, to make regional regulations on zoning the Mentawai Islands District's coastal areas.

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