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Analysis of Sustainability Status and Management of Brown Seaweed *Sargassum sp*. in the Waters of Ujung Kulon Conservation Area

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The potential of seaweed resources in Indonesia has a significant economic value that is quite competitive and useful in the food and non-food sectors. One of the habitats of Sargassum sp. in Indonesia is Ujung Kulon, Banten Province. However, the existence of this species has not been utilized optimally and sustainably by the community. In addition, the problem is the lack of community participation in conservation water areas and sustainable management. The study aimed to determine the resource potential of brown seaweed Sargassum sp. in the location. In addition, it will evaluate the management and utilization, as well as the role of the community in sustainable management. Sustainability analysis was conducted using the Multi-Dimensional Scaling (MDS) technique through the RAPFISH (Rapid Appraisal for Fisheries) approach reinforced with Monte Carlo and Leverage analyses. The preparation of sustainability attributes is based on ecological, economic, social, and institutional dimensions. The results of this study showed that each dimension's value for the environmental dimension (66.15 entirely) is sustainable. The

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sustainability index value in the economic dimension (81.68) is sustainable. The results of the ordination analysis show that the sustainability index value in the social dimension (20.97) is not sustainable, institutional (31.92) with less sustainable status, so it needs to be a top priority for improvement on several sensitive attributes as leverage factors. In this case, the economic dimension is the value with the highest index, which aligns with the main livelihoods of the conservation area's people. As for the social and institutional dimensions, appropriate improvements still need to be made to support sustainable development. These results are expected to provide information and illustrations for stakeholders and the community in sustainable management efforts in formulating policy strategies.

Keywords: Sargassum sp; sustainable use; and management; RAPFISH; conservation; Ujung Kulon.

1. INTRODUCTION

The potential of seaweed resources in Indonesia has an essential economic value in the domestic and foreign markets because seaweed has many uses and benefits, both in the food and non-food fields. Looking at the economic value and benefits of seaweed, the level of utilization of seaweed resources in Indonesia is still largely unutilized, and in addition, there is still no synergy between the government and the community.

In Indonesia, there are 79 species and six variants of *Sargassum* species spread in various regions such as the Riau Islands, Bangka-Belitung, Pulau Seribu Islands, Karimunjawa, Sunda Strait, Southern Java coast, Bali, West Nusa Tenggara, East Nusa Tenggara, islands in Sulawesi and Maluku. *Sargassum* sp. *is* generally found in craggy coastal areas in the intertidal zone. *Sargassum* species that float on the sea surface in Indonesia are rarely seen. Areas with uneven or rocky shores are suitable habitats for *Sargassum* sp. because the *holdfast* can be firmly attached to the coral so that *Sargassum* sp. is not carried away by ocean currents [1]. Sargassum is the most extensively developed alginate, and its bioactive compounds, mainly phenolic compounds, are also known as florotanin. Florotanin, primarily found in brown seaweed, is known for its potent antioxidant activity. It also shows promising effects against cancer, allergies, diabetes, inflammation, and viral and microbial infections [2]. Seaweed is one of Indonesia's biological resources that have good potential to produce alginate, but it is necessary to find an appropriate alginate extraction method [3].

Sargassum sp. is a species of seaweed that is spatially variable, seasonal, and abundant [4]. Sargassum contains alginate, which can be utilized in food and non-food industries, as well as pharmaceutical and cosmetic industries. Alginate in brown algae is widely used in the cosmetics industry to make soap, cream, lotion, and shampoo. Cosmetic cream with *Sargassum* sp. extract has good texture, odor, and color. The extraction results show promising potential as an additive in cosmetics that functions as a preservative and antibacterial [5].

Ujung Kulon National Park, one of the conservation areas in Banten Province, holds many potential marine fisheries resources, such as brown seaweed *Sargassum* sp., that can be further developed. The existence of the brown seaweed species *Sargassum* sp. can be used as a potential resource for creation and production.

However, data on *Sargassum* sp. distributed around Ujung Kulon waters, catch volume data, and distribution data are still lacking. Similarly, data on its price and marketing area are also lacking. Thus, the existing potential has not been maximized, and management efforts have not been implemented effectively. The creation of sustainable management can be done by developing policy coherence. Development activities are usually sectoral and independent or separate. This means that if development in one sector succeeds or fails, the success or failure is highlighted, analyzed, and intervened only in the industry concerned. This sectoral perspective cannot be used from a sustainability perspective [6]. Looking at the economic value and benefits of seaweed, Indonesia's level of utilization of seaweed resources is still largely unutilized, and there is still no synergy between the government and the community. Management is a series of processes from planning, organizing, allocating resources, implementing, monitoring, and evaluating to achieve predetermined goals [7].

Conservation area management that provides space for community participation is management in which the process, method, or

management of conservation areas involves other related parties besides the government. The realization of the existence of local communities in conservation areas as an inseparable unit has led to paradigm and policy changes in the management of Indonesia's conservation areas, especially policies on community empowerment in conservation areas [8].

2. METHODS

The research was conducted in the waters of the Ujung Kulon National Park Conservation Area in May 2023 using descriptive and quantitative methods, namely by direct observation of the field to observe aspects that are the scope of the research to describe precisely the empirical conditions. Data that are quantified and expressed in numbers are also known as numerical data. This numerical data can be used for statistical analysis, both descriptive statistics and inferential statistics [9]. The data used in this study include primary data and secondary data. Primary data is valid and reliable because it is obtained directly from the source.

Meanwhile, secondary data is not obtained directly from the source or collected by researchers themselves but is compiled by others and published so that it can be accessed by the public [10]. The sampling method used is the purposive sampling method. States that purposive sampling is a sampling technique with specific considerations. This means sampling is based on certain considerations or criteria formulated in advance by the researcher [11]. The number of respondents was 20, who were interviewed and filled out questionnaires divided into two groups: experts and the general public. Extracting information from *experts* (*Expert survey*) is done through *in-depth interview* techniques. The participants or informants interviewed were people who met the criteria of being part of the decision making process with regard to the management of the nature reserve. The number of interviewees was in accordance with the actual conditions in the field. The list of participants/informants interviewed is as follows 5 officials of the national park, 15 seaweed harvesters. An *in-depth interview* is a face-to-face interview technique with a relatively long duration to explore more detailed and in-depth information. The aim is to understand better the perspective of the subject's thinking or the concept being investigated or developed [12]. In-depth interviews aim to establish indicators and provide scores on each sustainability indicator. Respondents in this study consisted of key stakeholders and community leaders. Secondary data is in the form of data and information related to the dimensions of sustainability. Sustainability analysis was conducted using the *Multi-Dimensional Scaling* (MDS) technique through the RAPFISH (*Rapid Appraisal for Fisheries*) approach reinforced with *Monte Carlo and Leverage analyses*. RAPFISH is a rapid appraisal technique multidisciplinary and objective to evaluate fisheries sustainability [13]. The development of sustainability attributes is based on ecological, economic, social, and institutional dimensions. Rapfish analysis uses the *Monte Carlo* method, *Laverage*, and *Pareto Analysis*. *Monte Carlo* analysis is used to determine the stability of the *RAPFISH* ordination results. In principle, *MDS- RAPFISH* tools are sustainability analysis tools to assess the status (level) and leverage attributes of the sustainability of management or development. *Laverage* analysis determines which attributes are sensitive from all dimensions used. Sensitivity analysis (*Leverage*) in this study was conducted to see which attributes are dominant or susceptible to affect sustainability compared to other attributes [14]. Monte Carlo analysis was used to evaluate the impact of random error on all dimensions in estimating the value of ordination [15]. Leveraging is the analysis feature in RAPFISH besides ordination. *Leveraging* detects the dominant attribute and looks at the change in ordination (*bad-good* position) when that attribute is removed individually. The *leverage* value ranges from 2% to 6% as measured by the *Root Mean Square* (RMS) change. If the change in RMS value is more significant, the sensitivity of the attribute is higher in influencing sustainability [16].

3. RESULTS AND DISCUSSION

In analyzing the sustainability of this research, the *RAPFISH* technique is used, namely analysis using the *Multi-Dimensional Scaling* (MDS) method with four (4) ecological, economic, social, and institutional dimensions.

3.1 Ecological Dimension

The results of *RAPFISH* ordination*, Leverage* analysis*,* and *Pareto* analysis on each attribute of the ecological dimension can be seen in Figs. 1, 2, and 3.

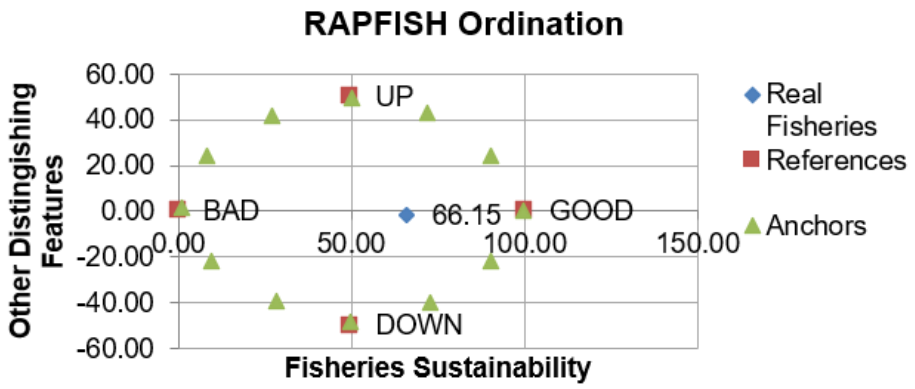

Fig. 1. Results of rapfish ordination on the ecological dimension

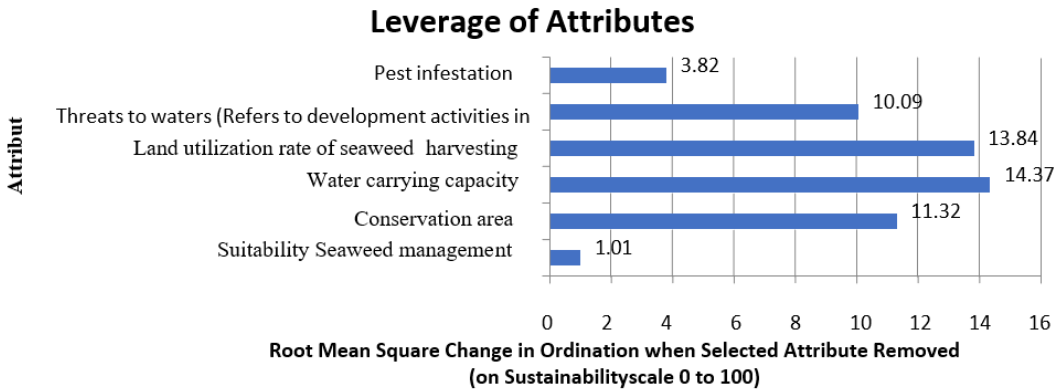

Fig. 2. Results of *leverage* analysis on the ecological dimension

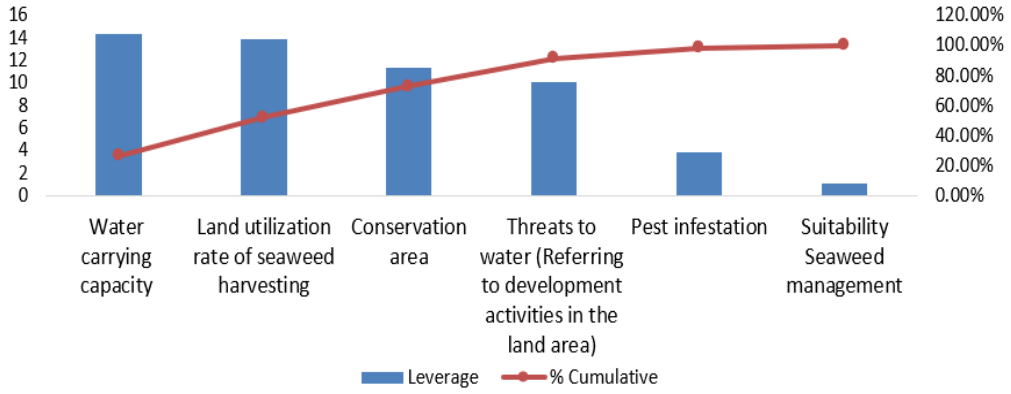

Fig. 3. *Pareto* diagram on the ecological dimension

The value of this ecological dimension is then analyzed using *RAPFISH*, where the results are obtained through the *Multi-Dimensional Scaling* (MDS) method, which will show the value of the sustainability index in the ecological dimension. Fig 1 shows the results of the *RAPFISH* analysis that illustrate the condition or status of the sustainability of seaweed utilization in conservation zones in the environmental dimension.

The results of the ordination analysis showed that the sustainability index value of the utilization and management of brown seaweed

Sargassum sp. in the ecological dimension was 66.15. Based on sustainability criteria, this value is in the *quite sustainable* category. The results of the *RAPFISH* analysis also obtained the *Stress* value and the *Squared Correlation* (RSQ) or R-value. The *stress* value obtained in the ecological dimension is 0.1453, which shows the *goodness of fit.* The analysis results are pretty good because the value of *stress is* 0.1453.

Stress is still below 0.25 or S < 25%. The coefficient of determination (confidence interval) or R value^2 is 92.35%, which means the model using the current variables already explains 92.35% of the existing model. This shows that the value of the squared correlation is close to 1 or less than 100%, which means that the entire attribute can be trusted. The results of the leverage analysis can be seen in Fig 2.

Based on the *leverage* analysis (sensitivity) results in the ecological dimension, it is known that there are 4 (four) attributes in the dominant environmental dimension. This can be seen in the overall value of more than eight percent. To determine the sensitive attributes, *Pareto* analysis is performed by drawing a line of 80% on the x-axis and y-axis. The x-axis point separates the essential causes on the left and less important ones on the right, so based on *Pareto* analysis obtained 3 (three) sensitive attributes, namely: 1) Water carrying capacity (RMS-14.37); 2) Land utilization rate for seaweed harvesting (RMS-13.84); 3) Conservation area (RMS-11.32): Changes to these three *leverage* factors will easily affect the increase or decrease of the sustainability index. Fig 3 shows *Pareto* diagram on ecological dimension.

The level of sustainability in the ecological dimension is in the moderately sustainable category, with a value score of 66.15. based on *Pareto* analysis, obtained 3 (three) sensitive attributes, namely: 1) Water carrying capacity (RMS-14.37); 2) Seaweed harvesting land utilization rate (RMS- 13.84); 3) Conservation area (RMS-11.32). Changes to these three *leverage* factors will easily affect the increase or decrease of the sustainability index. These conditions indicate that the level of management in the ecological dimension is relatively good. Water conditions significantly affect the ecosystem; the carrying capacity of the waters is the determining factor that affects the condition of the waters. The value or concentration of the water determines it.

Water quality parameters. Water quality can be broadly defined as physical and chemical factors that directly or indirectly affect the lives of fish and other aquatic organisms [17]. The level of seaweed land utilization used by the community around Ujung Kulon National Park, a conservation area, if carried out without supervision, will cause ecosystem damage caused by excessive exploitation without considering how management and conservation are carried out. It is feared that this could lead to ecosystem damage in the future, considering that seaweed is currently the primary source of livelihood for the community by taking seaweed from nature. Economic *resource valuation* can be used as a policy tool to help government planners strengthen the management of conservation areas by considering the economic value of various alternative land use options, including conservation areas [18]. Determining the boundaries of areas that can be utilized is essential to save the ecosystem. The management of conservation areas is often faced with various interests of individuals and groups in utilizing natural resources, often leading to social conflicts [19].

3.2 Economic Dimension

The results of *RAPFISH* ordination*, Leverage* analysis*,* and *Pareto* analysis on each economic dimension attribute can be seen in Figs. 4, 5 and 6.

Fig. 4 shows the results of the *RAPFISH* analysis that describes the condition or status of the sustainability of the utilization and management of brown seaweed *Sargassum* sp. in the economic dimension.

The results of the ordination analysis showed that the sustainability index value of the utilization and management of brown seaweed *Sargassum* sp. in the economic dimension was 81.68. Based on sustainability criteria, this value is in the *sustainable* category. The stress value obtained in the economic dimension is 0.1541, which shows *goodness of fit* or the results of the analysis obtained are pretty good because the *stress* value is still below 0.25 or S < 25%. The coefficient of determination (confidence interval) or R value^2 is 90.62%, which means that the model using the current variables has explained 90.62% of the existing model.

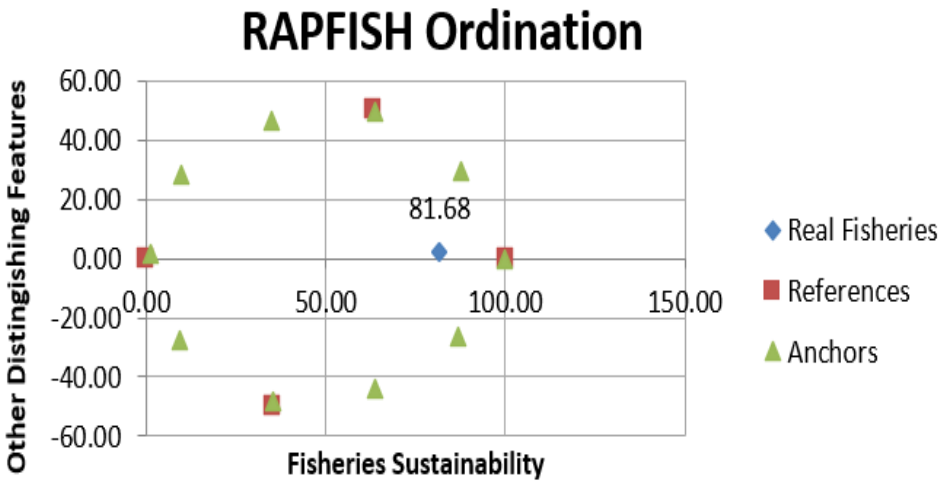

Fig. 4. Results of *RAPFISH* ordination on the economic dimension

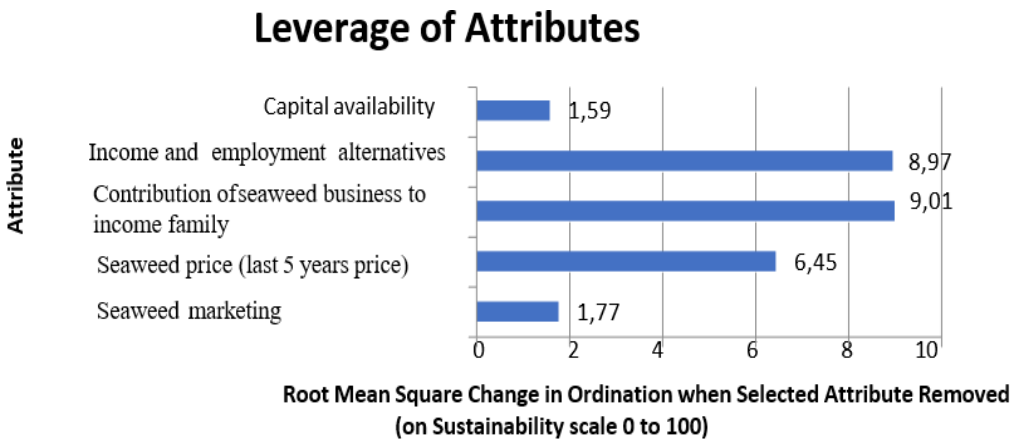

Fig. 5. Results of *Leverage* analysis on the economic dimension

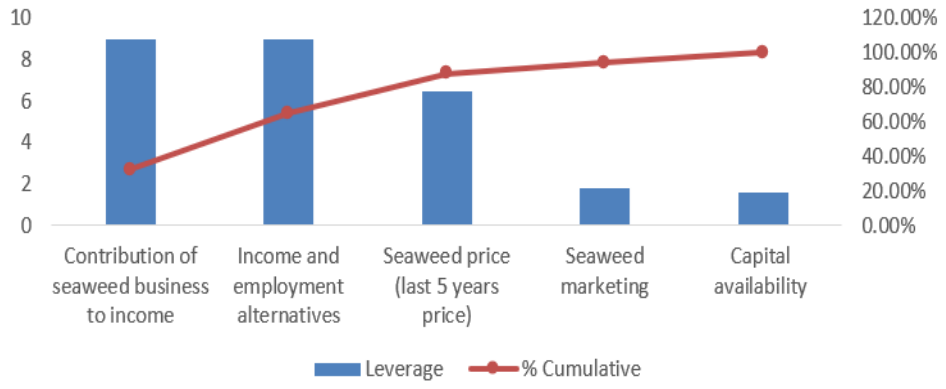

Fig. 6. *Pareto* diagram on economic dimension

Based on the results of the *Leverage* (sensitivity) analysis on the economic dimension, it is known that there are two attributes in the dominant economic dimension, which can be seen in the overall value of more than eight percent (8%). To determine the sensitive attributes then, *Pareto* analysis so obtained 2 (two) sensitive attributes, namely: 1) alternative income and employment

(RMS-9.01) and 2) contribution of seaweed business to family income (RMS-8.97). Changes to these two *leverage* factors will easily affect the increase or decrease in the sustainability index. Fig 6 shows the *Pareto* diagram for the economic dimension.

The results of the MDS analysis on the economic dimension amounted to 81.68. Based on sustainability criteria, this value is in the *sustainable* category. Based on *Pareto* analysis, 2 (two) sensitive attributes were obtained, namely: 1) alternative income and employment (RMS-9.01) and 2) contribution of seaweed business to family income (RMS-8.97). Changes to these 2 *Leverage* factors will easily affect the increase or decrease in the sustainability index.

Based on observations and interviews when conducting research, several important points were obtained; namely, the seaweed business is the main livelihood carried out by the surrounding community, which is the biggest supporter of the wheels of life community's economy. However, this factor is a problem that occurs and is related to ecology, which is feared to threaten ecological damage. For this reason, it is necessary to carry out integrated and sustainable management from stakeholders. Community income is one of the main factors influencing human activities, including using seaweed resources. Some efforts can be made for this, including creating a systematic work management system where a seaweed collection scheduling system can be applied. Another effort can be made to seek alternative jobs for the community based on market interests and the condition of natural resources and human resources so that the seaweed business is no longer the main livelihood to support the economy. The blue economy offers opportunities to coastal communities by developing a national blue economy to coastal communities by creating new jobs and financial opportunities, increasing income from the sea. The blue economy leads to subsidies and investments towards the environmental and social pillars of the blue economy, improved infrastructure, advanced technology, access to information and energy, and other services to activity sites with co-benefits, including climate change adaptation, increased cultural value, and infrastructure to enhance ecosystem restoration and protection for national sovereignty [20].

3.3 Social Dimension

The results of *RAPFISH* ordination*, Monte Carlo* analysis*, Leverage* analysis, and *Pareto* analysis on each social dimension attribute can be seen in Figs 7, 8, and 9.

Fig 7 shows the results of the *RAPFISH* analysis that describes the condition or status of the sustainability of the utilization and management of brown seaweed *Sargassum* sp. in the social dimension.

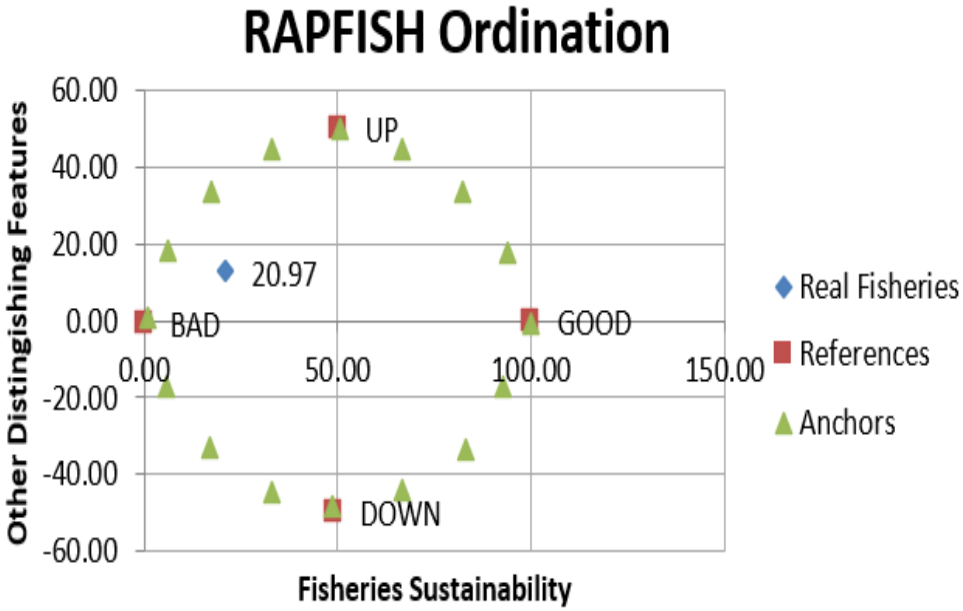

Fig. 7. *RAPFISH* ordination results on the social dimension

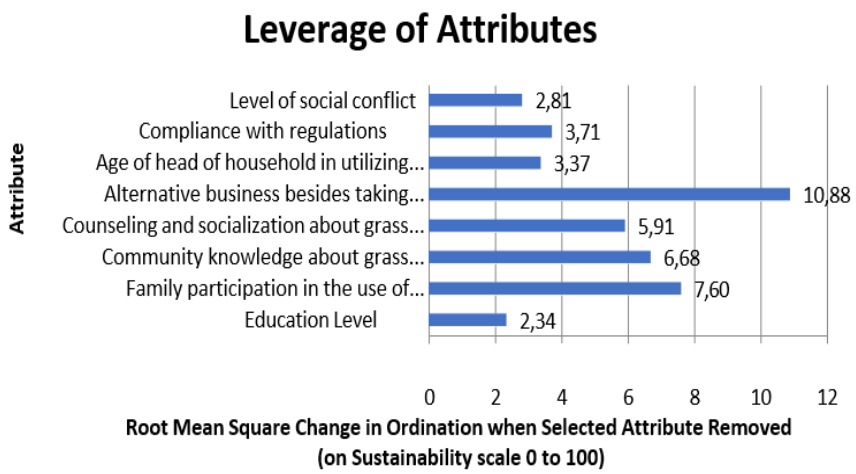

Fig. 8. *Leverage* analysis results on the social dimension

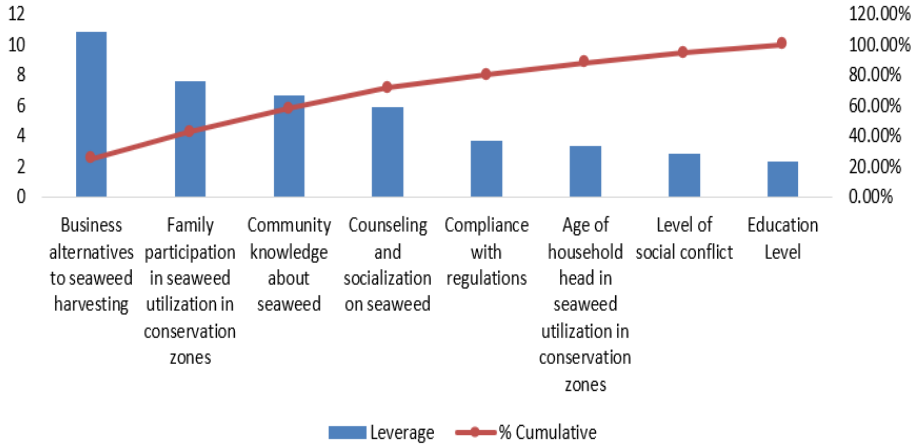

Fig. 9. *Pareto* diagram of the social dimension

The results of the ordination analysis showed that the sustainability index value of the utilization and management of brown seaweed *Sargassum* sp. in the social dimension was 20.97. Based on sustainability criteria, this value is in the *less sustainable* category. The *stress* value obtained in the social dimension is 0.1396, which shows *goodness of fit* or the results of the analysis obtained are pretty good because the *stress* value is still below 0.25 or S < 25%. The coefficient of determination (confidence interval) or R value^2 is 92.97%, which means that the model using the current variables has explained 92.97% of the existing model. This shows that the value of the squared correlation is close to 1 or less than 100%, which means that the entire attribute can be trusted.

Based on the results of the *Leverage* (sensitivity) analysis on the social dimension, it is known that there is one attribute in the social dimension that is dominant, namely alternative businesses other than seaweed harvesting; this can be seen at a value of more than eight percent (8%). To determine the sensitive attributes then conducted *Pareto* analysis, so based on *Pareto* analysis obtained 4 (four) sensitive attributes, namely: 1) alternative businesses other than seaweed harvesting (RMS-10.88); 2) family participation in seaweed utilization in conservation zones (RMS-7.60); 3) community knowledge about seaweed (RMS-6.68); 4) counseling and socialization about seaweed (RMS-5.91). Changes to these four *leverage* factors will easily affect the increase or decrease of the sustainability index. Fig 9 shows the *Pareto* diagram for the social dimension.

The level of sustainability in the social dimension is in the unsustainable category, with a score of

20.97. Based on sustainability criteria, this value is in the *less sustainable* category. Based on *Pareto* analysis, 4 (four) sensitive attributes were obtained, namely: 1) alternative business besides seaweed harvesting (RMS-10.88); 2) family participation in seaweed utilization in conservation zones (RMS-7.60); 3) community knowledge about seaweed (RMS-6.68); 4) counseling and socialization about seaweed (RMS-5.91). Changes to these four *Leverage* factors will easily affect the increase or decrease of the sustainability index.

Alternative businesses other than seaweed harvesting are essential parameters that need special attention; of course, in this case, the existence of family participation plays a role in seaweed harvesting in conservation zones. For this reason, supervision and data collection are needed because the data and information related to how many family members use seaweed is minimal. Efforts that can be made at this time certainly need to collaborate with the village government to accommodate and assist in managing the conservation area ecosystem. Improving the economy of coastal communities can be determined by ecological sustainability. Health, education, rules, and social relations are determined by economic status. Therefore, the role and awareness of the community in maintaining biological resources is needed. Biological and non-biological components interact with each other, and if there is a change in one, it will affect the entire system, both in functional structure and balance. In addition, the leverage factor in the social dimension is community knowledge about seaweed [21]. Based on direct observations in the field, it can be concluded that community knowledge about seaweed is still minimal, hindering sustainability. It is hoped that there will be empowerment efforts for the surrounding community about seaweed, such as ecosystem management, characteristics, and product diversification. This can undoubtedly facilitate the improvement of technology, innovation, and entrepreneurship to improve the community's sustainable economy. Increasing community knowledge through counseling will enable the community to actively participate in developing marine ecotourism and seaweed cultivation in conservation areas. The extension is expected to boost community knowledge about using sustainable fisheries and ecotourism zones as locations for marine ecotourism and seaweed cultivation [22]. This can increase income and change the community's negative perception of conservation.

3.4 Institutional Dimension

The results of *RAPFISH* ordination, *Leverage* analysis, and *Pareto* analysis on each institutional dimension attribute can be seen in Figs 10, 11, and 12.

Fig 10 shows the results of the *RAPFISH* analysis that describes the condition or status of the sustainability of the utilization and management of brown seaweed *Sargassum* sp. in the institutional dimension.

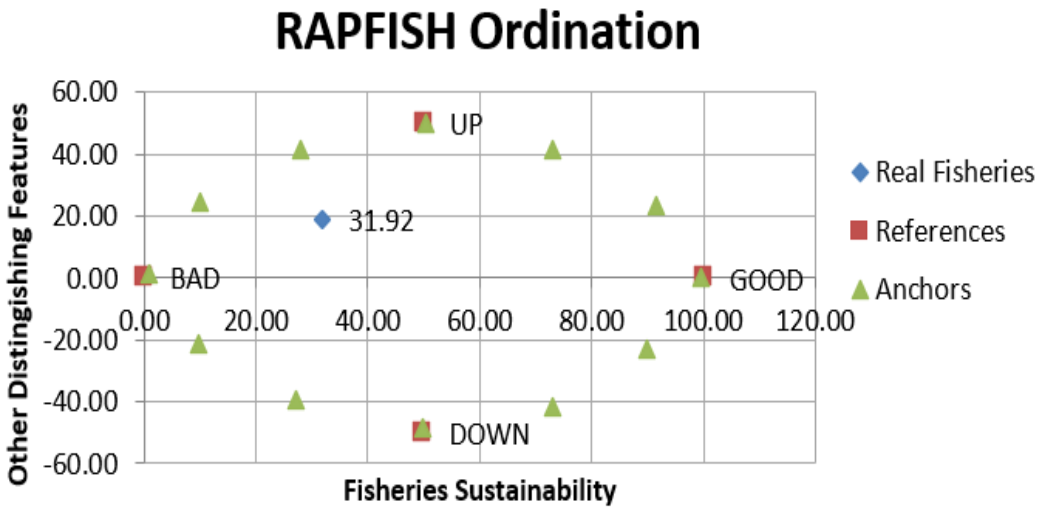

Fig. 10. Rapfish ordination results on the institutional dimension

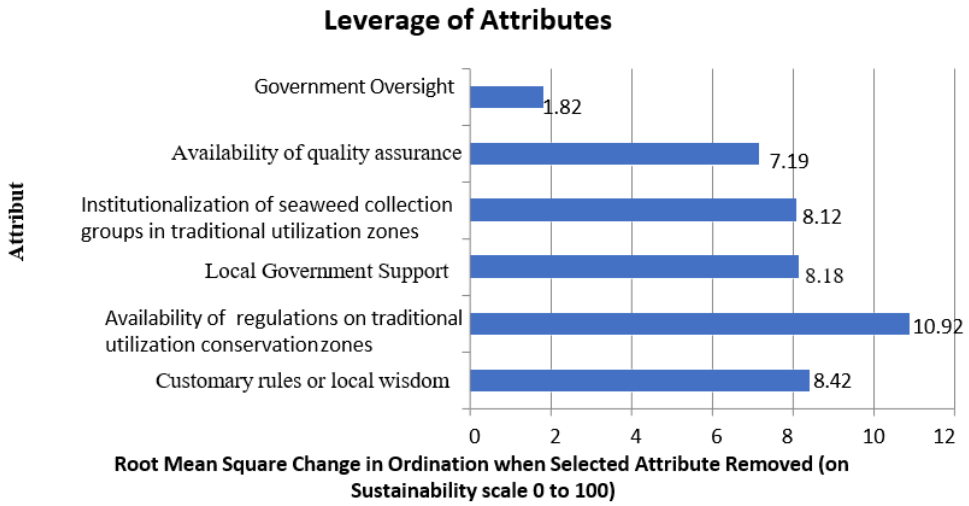

Fig. 11. Results of *Leverage* analysis on the institutional dimension

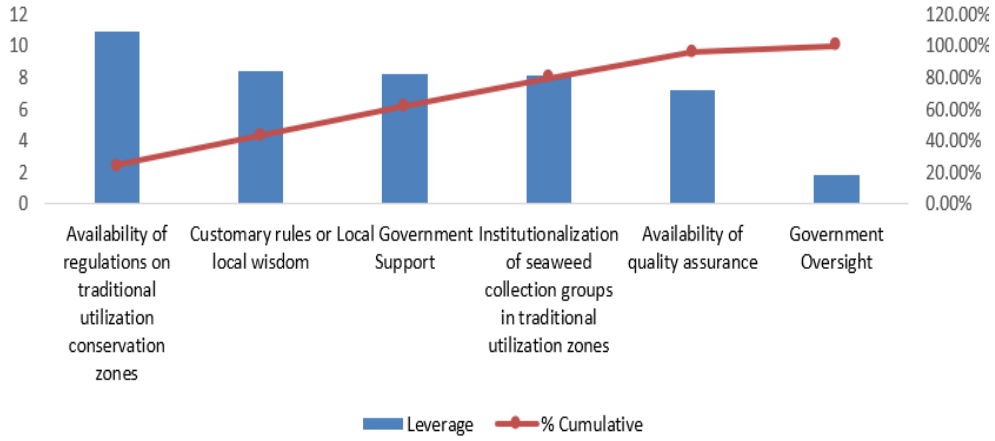

Fig. 12. *Pareto* diagram on the institutional dimension

The results of the ordination analysis showed that the index value of the level of utilization and management of seaweed in the institutional dimension was 31.92. Based on sustainability criteria, this value is in the *less sustainable* category.

The stress value obtained in the institutional dimension is 0.1431, which shows the *goodness of fit* or the analysis results are pretty good because the *stress* value is still below 0.25 or S < 25%. The coefficient of determination (confidence interval) or R value^2 is 94.06%, which means that the model using the current variables has explained 94.06% of the existing model. This shows that the value of the squared correlation is close to 1 or less than 100%, which means that the entire attribute can be trusted.

Based on the results of *Leverage* (sensitivity) analysis on the institutional dimension, it is known that there are 4 (four) attributes in the dominant institutional dimension; this can be seen in the overall value of more than eight percent (>8%). To determine the sensitive attributes, *Pareto* analysis was conducted so that four sensitive attributes were obtained, namely: 1) availability of quality assurance (RMS-7.19); 2) institutionalization of seaweed collection groups in traditional utilization zones (RMS-8.12). Changes to these two *leverage* factors will easily affect the increase or decrease of the sustainability index. Fig 12 shows the *Pareto* diagram of the institutional dimension.

The result of the MDS analysis on the institutional dimension is 31.92. Based on sustainability criteria, this value is in the *less sustainable* category. 1) Availability of quality

assurance (RMS-7.19); 2) Institutionalization of seaweed collection groups in traditional utilization zones (RMS-8.12); 3) Local government support (RMS-8.18); 4) Availability of regulations on traditional utilization conservation zones (RMS-8.12); 5) Customary regulations or local wisdom (RMS-8.12). Changes to these five *leverage* factors will easily affect the increase or decrease of the sustainability index.

The availability of capital in a business is a determining factor in the movement of the economy towards a sustainable development paradigm, which requires cooperation between institutions as a driver of economic development. Coordination between *stakeholders* in ecosystem management in an area is an essential factor. The involvement of many parties in developing or utilizing coastal area resources (including seaweed) requires a shared vision for ecosystem conservation. Therefore, coordination and good partnerships need to be realized to improve the performance of policies that have been made. In addition, each sector understands and understands each main task and function well. Management objectives can be considered achieved or successful if the outcomes and results are the following eight *good governance* indicators: *the rule of law*, accountability, transparency, responsiveness, inclusive & equitable, consensus, participatory, efficient, and effective [23].

Regarding the availability of regulations on conservation zones, these regulations have not been appropriately implemented due to the lack/absence of cooperation and unformed institutions. Existing local wisdom, which relates to community norms and beliefs, still applies to a strong culture. For example, some days are used as a prohibition to fish and go to sea on certain days. The current problem is that no institutions are running, so sustainable development cannot be carried out optimally. Efforts that can be made to cover the current weaknesses include the need to develop an institutional system immediately because it will facilitate the preparation of policies, strategies, planning, and management. Efforts towards a sustainable economy for all stakeholders require understanding the three pillars of sustainability: social, economic, and environmental. Customary regulations and local wisdom are local community beliefs about going to sea and catching fish on certain days [24]. Managing water areas by conservation is a form of wisdom in management. Wisdom in caring nature has been a characteristic of the Indonesian people since immemorial. This is indicated by various local wisdom in different regions of the country, a legacy of several layers of previous generations that are still sustainable today [25].

The sustainability index values for each dimension are depicted in the form of a *kite* diagram, which is shown in Fig 13.

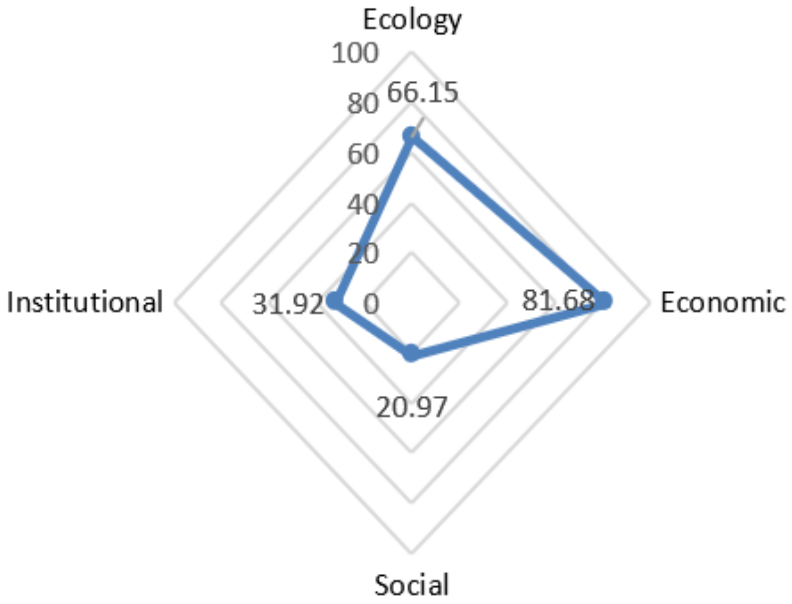

Fig. 13. 4th Dimension sustainability status flyer diagram

Table 1. Difference in sustainability Index values between MDS analysis and Monte Carlo

Analysis. Dimension	MDS Analysis	*Monte Carlo* Analysis
Ecology	66,15	64,35
Economy	81,68	77,91
Social	20,97	24,37
Institutional	31,92	33,23

Source: Data analysis results, 2023

Table 2. MDS accuracy test results on each dimension

Dimensions	Rap Analysis with MDS	Iterations	Stress	Coefficient of Determination n $(R)^2$
Ecology	66,15	2	0,1453	0,9235
Economics	81,68	2	0,1541	0,9062
Social	20,97	2	0,1396	0,9297
Institutional	31,92	2	0,1431	0,9406

Source: Data analysis results, 2023

The results of the ordination analysis on the four dimensions are that the social dimension has a score of 20.97 (unsustainable), the institutional dimension 31.92 (less sustainable), the ecological dimension 66.15 (moderately sustainable), and the economic dimension 81.68 (sustainable). Dimensions with low scores need to be a top priority to improve some sensitive attributes as leverage factors. The economic dimension has the highest score, while the social dimension has the lowest score. This shows that the economic condition of the conservation water area is in good condition. This is following what happens in communities where seaweed collection is the main livelihood to improve the economy of coastal communities around conservation water areas.

Regarding social and economic aspects, we need to pay attention to the limited ability of the community to utilize resources. This will affect sustainable utilization and management and is also related to the ecology in the waters of the conservation area. So, some efforts that can be made include improving the ability of human resources through alternative livelihood development strategies, innovation, and technology development. So that all interrelated aspects can synergize with each other in sustainable development.

3.5 Validity Test (*Monte Carlo*) and Precision Test of *Multi-Dimensional Scaling*

Based on the results obtained by the MDS ordination analysis process, errors can occur, so it is necessary to evaluate the effect of errors on the process through *Monte Carlo analysis* as a validity test. A comparison of the sustainability index value of MDS analysis with *Monte Carlo* analysis can be seen in Table 1.

Based on *Monte Carlo's* analysis of all dimensions, there is no significant difference, and the data is considered valid. The results of the MDS accuracy test on the four dimensions can be seen in Table 2.

MDS analysis is needed to determine the condition of the sustainability status of the dimensions that have been selected so that the imbalance between dimensions is known. A good model is indicated by the *S-Stress* value, which is smaller than 0.25, and RSQ, which is close to 1, so it can be said that the MDS results are a good model and can present the problem being discussed, or the data is usually distributed. From the analysis, the coefficient of determination is obtained with an interval between 0.9062 and 0.9406, which means that the model using the attributes used can explain 90.62% - 94.0% of the existing model. The *stress* value obtained results between 0.1541 and 0.1431 with a difference of 0.01.

4. CONCLUSION

In this study, the results of the value of each dimension for the ecological dimension (66.15) are *Sufficiently Sustainable*. The sustainability index value in the economic dimension (81.68) is sustainable. The results of the ordination analysis show that the sustainability index value in the social dimension (20.97) is not

sustainable/unsustainable, institutional (31.92) with the status of less sustainable / *Less sustainable,* so it needs to be a top priority for improvement on several sensitive attributes as a leverage factor. In this case, the economic dimension is the value with the highest index, which is in line with the main livelihoods of the people living in the conservation area. Meanwhile, the social and institutional dimensions still need to be improved accordingly to support sustainable development.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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