



Sustainability of mackerel (*Scomberomorus commerson*) capture fisheries in the waters of north Rupat district Bengkalis regency Riau province

Zulkarnaini, Trisla Warningsih, Rineta Khairunissa

Department of Fisheries Social Economics, Faculty of Fisheries and Marine, Riau University, Pekanbaru, Indonesia

Abstract

The waters of North Rupat Sub-district, Bengkalis Regency, Riau Province are based on five dimensions: ecological, economic, social, technological, and institutional. The approach used is Multi-Dimensional Scaling (MDS) with the Rapfish technique, and is complemented by leverage and Pareto analysis to identify sensitive attributes. The method used in this study used a survey method with direct interviews in the field using a questionnaire. The results showed that the overall sustainability status was in the "moderately sustainable" category with a multidimensional index value of 50.64. The index value for each dimension is ecological dimension 55.97 (moderately sustainable), economic dimension 53.20 (moderately sustainable), social dimension 37.25 (less sustainable), technological dimension 53.34 (moderately sustainable) and institutional dimension 53.44 (moderately sustainable). Attributes that are sensitive to the sustainability of mackerel capture fisheries in the waters of North Rupat District, Bengkalis Regency, Riau Province, include the size of the fish caught, the range of fishing areas, the collapse rate, boat ownership, the market, the price trend of mackerel in the last 3 years, the level of education of fishermen, environmental knowledge, the negative impact of fishing gear on habitat, the use of fishing aids, selectivity of fishing gear, institutional conflicts, and the role of fishermen in policy.

Keywords: Sustainability, mackerel, rapfish, north Rupat district

Introduction

The capture fisheries sector has an important and strategic role compared to aquaculture which can be seen from at least three roles, namely a source of economic growth, a source of food, especially animal protein, and a provider of employment ^[1]. Sustainable capture fisheries is the activity of capturing marine resources without disturbing the sustainability of organisms that are utilized so that fishing activities can continue ^[2]. According to Charles (2001) in ^[3] provides an explanation of the basic components of the sustainability of capture fisheries consisting of ecological, economic, social, technological and institutional sustainability. The first three sustainability components are the points in the sustainability triangle, while the fourth and fifth sustainability components will have an influence between them.

According to the Bengkalis Regency Fisheries Service (2022) the capture fisheries sector is a type of activity that has considerable potential with a utilization of 5,641.09 tons, one of which is in North Rupat District. Fishermen in North Rupat District have been catching fish using longline gear, gillnet, trammel net and bubu ^[4]. Of the 8 villages in North Rupat Sub-district, 5 villages where the majority of fishermen use gillnet fishing gear, namely Kadur Village, Puteri Sembilan Village, Teluk Rhu Village, Tanjung Medang Village and Titi Akar Village.

Based on UPT PPI Rupat Island, mackerel is the second main commodity after parang fish, where total production reaches 200 tons per year. This can also be seen from the level of mackerel production which fluctuates but tends to increase every year which until now has a total production of 200.87 tons. In 2014 mackerel production reached 98.78 tons, then experienced an increase in 2015 reaching 156.81 tons. In 2016 there was a decrease in production of 87.11 tons and an increase in 2017-2018 reaching 137.78 tons. In 2019 there was a decrease in production, namely 121.22

tons and in 2020-2023 there was an increase in catch production reaching 200.87 tons.

The increase in mackerel production in North Rupat sub-district indicates a high demand for this fish. On the other hand, increased exploitation without proper management can have a negative impact on the sustainability of mackerel resources. If overfishing continues, the mackerel population is at risk of declining, which in turn can disrupt the marine ecosystem and the sustainability of the fisheries sector in the future.

By paying attention to the characteristics of fisheries in the waters of North Rupat District, Bengkalis Regency, Riau Province, especially mackerel fishing activities and the sustainability assessment of several aspects of the sustainability dimension, namely the ecological dimension, economic dimension, social dimension, technological dimension and institutional dimension, it can determine the right development and management strategy so that the fishing business can still be sustainable without reducing its benefits in the present and future.

Research Methodology

Time and Place

This research was conducted from January 04 to January 10, 2025 in North Rupat District.

Research Methods

The method used in this research is the survey method. This method is carried out by direct observation of objects in the field and collecting data through direct interviews with fishermen in North Rupat District and then all answers obtained by researchers are recorded, processed and analyzed.

Determination of Respondents

Responden dalam penelitian ini ditentukan dengan teknik purposive sampling dengan mempertimbangkan

karakteristik spesifik yang relevan dengan tujuan penelitian [5]. The criteria used were fishermen who caught mackerel with gillnet gear measuring 3.5 inches and using motorboats measuring 2 GT to 6 GT operating in North Rupert Waters, as well as experts (people who understand) and still have a relationship in the management of mackerel resources in the research location.

He number of respondents included 19 gillnet fishers from Tanjung Medang Village, 8 gillnet fishers from Teluk Rhu Village, 6 gillnet fishers from Putri Sembilan Village, 4 gillnet fishers from Kadur Village, and 12 gillnet fishers from Titi Akar Village. The criteria for experts selected in this study to fulfill primary and secondary data, namely the capture fisheries data/information section, namely, the head of the fishing group (1 person), community leaders (1 person), fisheries traders (1 person), village heads in each village (5 people). Riau Provincial Fisheries Service (1 person), and UPT PPI Rupert Island (1 person). So that in this study the total number of samples used as respondents amounted to 59 people.

Data Collection

The data collected in this research are primary data and secondary data. Primary data used in this study comes from mackerel fishermen and related parties obtained by conducting direct observations in the field and interviews. While secondary data is obtained from various sources such as books, reports, journals, and related agencies obtained from UPT PPI North Rupert District, in the form of times series data on mackerel catches from 2014-2023.

Table 1: Sustainability Status Index Categories

Index	Category
0-25	Poor (non sustainable)
>25-50	Less (less sustainable)
>50-75	Sufficient (sustainable enough)
>75-100	Good(very sustainable)

2. Leverage Analysis and Pareto Analysis

Determination of sensitive attributes that affect sustainability using a combination of leverage analysis and pareto analysis [12]. Leverage analysis aims to determine the relationship of each attribute to the sustainability status of mackerel. This analysis can show which attributes are considered to have the most good/bad effect on sustainability status. Determination of sensitive attributes is done based on the order of priority by looking at the Root Mean Square (RMS) value of ordination on the X axis. The greater the RMS value, the greater the role of attributes in sustainability status [13].

The Pareto concept called the 80-20 rule is that 80% of activities are caused by 20% of factors. By focusing on 20% of the factors, it will be able to overcome 80% of the problem [14]. The use of Pareto analysis in this study will be adjusted to the needs of the study and still refer to the sustainability index value in Table 1. The adoption of Pareto's Law in this study is not on the 80-20 rule, but on the 75-25 rule, namely attributes with a cumulative value limit of <75% are the most sensitive attributes that affect the value of the sustainability index [14].

Result and Discussion

Overview of the Research Location

North Rupert District is located in Bengkalis Regency, Riau Province and is the outermost island directly adjacent to

Data Analysis

The analysis used in this research is Multi-Dimensional Scalling (MDS) analysis, Leverage analysis, and Pareto analysis.

1. Analisis Multi-Dimensional Scalling (MDS)

Rapfish is one of the methods in analyzing fisheries sustainability and is new to the application of Multi-Dimensional Scalling in fisheries [6]. This method combines semi-quantitative assessment with qualitative information to evaluate fisheries sustainability in a multidisciplinary manner [7]. The analysis was conducted through several stages, including fisheries data analysis through the collection of fisheries statistics and literature [8]. All attributes obtained from the results of this study were analyzed multidimensionally. This multidimensional analysis was used to determine the points in the Rapfish studied relative to two reference points. The reference points are good and bad, where there are extreme good points and extreme bad points. In addition, by using MDS analysis, the stress coefficient of determination (R²) can be seen [9]. Rapfish ordination results need to be tested with Monte Carlo analysis with the "scatter plot" method to determine the impact of random error from the ordination results [10]. The data validation test on Rapfish using the Monte carlo value is acceptable if the difference between the Monte carlo value and the ordination value is quite small wich is about [11]

Malaysia. The beach that stretches in North Rupert is called Pasir Panjang beach, because its shape extends about 11 kilometers. North Rupert sub-district is located at coordinates 0°55'24"-2°7'41" LU-101°25'43 East-101°47'14° East. The total area of North Rupert Sub-district is 628.50 km², with the largest village being Titi Akar Village with an area of 184 km²and the smallest village being Puteri Sembilan Village which is a new village expansion from Kadur Village with an area of 45 km². The village with the largest distance to the capital of North Rupert Sub-district is Titi Akar village with a straight distance of 25 km. The closest distance is Tanjung Medang Village as the capital of North Rupert Sub-district.

Sustainability Status of Mackerel Fishing in the Waters of North Rupert District

Ecological Dimension

Ecological sustainability related to maintaining ecosystem integrity, maintaining the carrying capacity of the aquatic environment, and increasing the capacity and quality of the aquatic ecosystem are the main concerns [15]. The better condition of the aquatic ecosystem will affect the success of the sustainable ecological dimension [16]. The results of the ecological dimension analysis obtained a sustainability index value of 55.97 which can be said to have a fairly sustainable position, because it is seen that the exploitation status has not been overfished. Exploitation status that has

not been overfished does not rule out the possibility that this status will decrease. Because if the exploitation of mackerel

is carried out excessively, it will cause the availability of fish mackerel in waters will decrease [17].

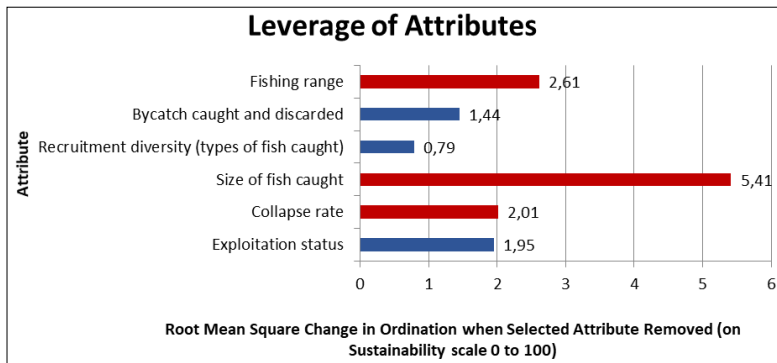


Fig 1: Sensitivity of the Ecological Dimension

To identify sensitive attributes, leverage analysis and Pareto analysis are used. The RMS values in the leverage analysis results are sorted from largest to smallest, then accumulated by looking at the cumulative percentage results <75%. So it can be seen that the sensitive attributes in the sustainability of mackerel capture fisheries in the waters of North Rupa District in the ecological dimension are the attributes of the size of the fish caught, fishing range, and collapse rate.

The size of the fish caught is a sensitive attribute because if the fish caught are small or sexually immature, this means that they have not had time to reproduce. This will reduce the number of individuals that can continue the next generation. Changes in the size of fish caught are influenced by several factors. The type of fish and its age certainly determine the size, with young fish being smaller. Environmental conditions such as temperature, water quality, and food availability also affect their growth. This is also the same as stated by [18] which states that differences in the number and size of fish in one body of water are caused by several factors including the entry of new individuals in existing populations. There are differences in growth patterns, differences in gonad maturity rates and differences in life span.

Fishing range is a sensitive attribute in the ecological dimension because some water areas play an important role in fish life cycles and ecosystem balance. It is necessary to establish protection zones or conservation areas that prohibit fishing in areas that have high ecological value, such as spawning grounds or important habitats for fish. This is also the same as stated by [19] that regulating the range of fishing areas can be done by determining the zoning of fishing.

Collapse rates can be very sensitive to the sustainability of capture fisheries because excessive declines in fish stocks

can worsen the condition of marine ecosystems and make it more difficult to recover. If fisheries are conducted without regard to ecosystem balance, such as overfishing, the regeneration process of fish stocks is disrupted. Therefore, it is necessary to control the number of fleets so that the catch does not increase excessively which can lead to a decrease in future catches. This is also the same as stated by [20] that the way to control the number of fishing fleets by determining the number of fishing fleets operating in these waters so that the amount of catch obtained does not exceed the amount of fish catch allowed.

Economic Dimension

Economic sustainability requires the meaning that a development activity must be able to create economic growth, maintain capacity, and use resources and investment efficiently. Fishermen's economies are vulnerable to the influence of external factors, including fish commodity prices, market conditions and other variables that affect operational costs [21]. The results of the economic dimension analysis obtained a sustainability index value of 53.20 which can be said to have a fairly sustainable position, because the condition of fishermen's income in the last 5 years is in a stagnant position even though it is below the minimum wage, the price of mackerel shows an increase in the conditions of the last 3 years, and the mackerel market has reached the international market.

Factors affecting fishermen's income are the availability of fish stocks, operational costs such as fuel, boat maintenance, fishing gear, and fluctuating fish market prices that greatly affect fishermen's income. Fluctuations in fuel prices that affect the operational costs of fishing are also a leverage factor [21]

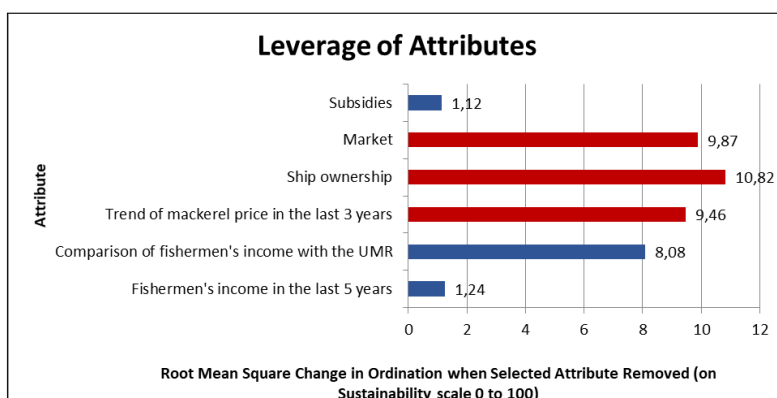


Fig 2 : Sensitivity of the Economic Dimension

To identify sensitive attributes, leverage analysis and Pareto analysis are used. The RMS values in the leverage analysis results are sorted from largest to smallest, then accumulated by looking at the cumulative percentage < 75%. So it can be seen that sensitive attributes in the sustainability of mackerel capture fisheries in the waters of North Rupa District in the economic dimension are the attributes of ship ownership, trend of mackerel price in the last 3 years, and market.

Ship ownership is a sensitive attribute because fishermen who own boats tend to have a more collective orientation and pay more attention to resource sustainability. This is also the same stated by [22] who stated that by owning their own boats, fishermen have more control over the business they run. Fishermen can set their own fishing schedules, determine fishing locations, and manage their own boat operations. This gives fishermen freedom and flexibility in running their fishing business, potentially increasing their daily income.

Social Dimension

Social sustainability requires that a development should be able to create equitable distribution of development results, social mobility, social cohesion, community participation, community empowerment, social identity, events that affect demand and supply and relationships between economic actors [15]. The results of the social dimension analysis obtained a sustainability index value of 37.25, which can be said to be less sustainable because it still faces various challenges such as low levels of education, uneven training and counseling activities, and conflicts between fishing

groups. Although the growth of the fishing community has increased, it has also increased competition in resource utilization. The participation of fishing families in fishing remains important, but there is a need to increase their involvement in resource management and broader decision-making.

Fishers have new commitments and knowledge to avoid destructive fishing and avoid catching prohibited organisms [23]. The development of fishermen through counseling and training is the main key to national fisheries development through strengthening and fostering coastal communities to improve knowledge and skills related to fishing businesses, so that they have high bargaining power in line with the statement to improve the quality of fishermen [17].

Fishers have new commitments and knowledge to avoid destructive fishing and avoid catching prohibited organisms. The formation of both formal and informal groups is based on various reasons, including needs, closeness, interests, goals, and economics. Thus, it can be said that the formation of fishing groups is driven by the similarity of socio-economic backgrounds as fishermen [24]. These groups not only share information with each other, but also solve common problems faced in fisheries management.

The less established economic level due to the low level of education of fishermen, resulting in a lack of public awareness to protect the coastal environment from damage. Therefore, the community must be given an understanding of the importance of the concept of sustainability in the utilization of coastal resources to ensure that no further damage occurs in their area [21].

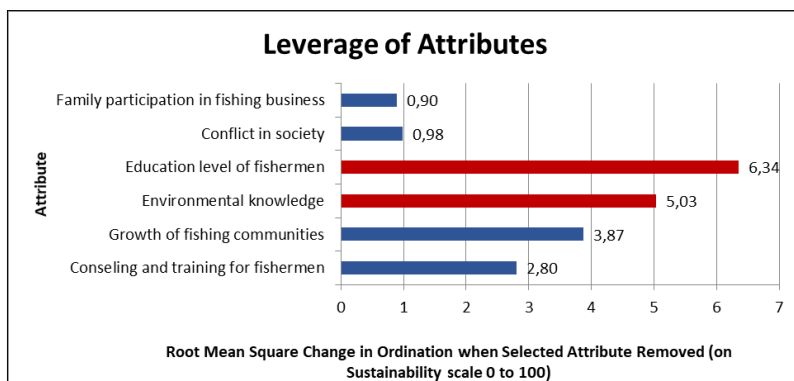


Fig 3 : Sensitivity of the Social Dimension

To identify sensitive attributes, leverage analysis and Pareto analysis are used. The RMS values in the leverage analysis results are sorted from largest to smallest, then accumulated by looking at the cumulative percentage < 75%. So it can be seen that sensitive attributes in the sustainability of mackerel capture fisheries in the waters of North Rupa District in the social dimension are the attributes of education level of fishermen and environmental knowledge. Education level is one of the attributes sensitive to the sustainability of capture fisheries in the social dimension. Education plays an important role in influencing fishers' behavior, understanding, and awareness of the importance of fisheries sustainability, as well as their ability to adopt environmentally and economically friendly fisheries practices. This is also the same as stated by [25] that the education level attribute has the most dominant level of sensitivity or leverage, because the level of education

greatly influences a person's mindset both in attitude and behavior.

Environmental knowledge plays a particularly sensitive role to the sustainability of capture fisheries in the social dimension as it relates directly to how fishers understand and manage marine ecosystems as well as the impact of their activities on them natural resources. This is also the same as stated by [25] that low levels of knowledge and weak understanding of resources will result in destructive behaviors that can threaten the sustainability and conservation of these resources.

Technology Dimension

The technological aspect used in fisheries is highly dependent on the type of technology that is allowed or not allowed which will have a negative impact on the aquatic environment. The results of the technology dimension

analysis obtained a sustainability index value of 53.34 which can be said to have a fairly sustainable position, because gillnet fishermen in North Rupa use fishing gear that is very efficient and environmentally friendly. Selective fishing gear aims to minimize waste, non-target catches of

both fish and non-fish species, and other impacts associated with the catch. A fishing gear is said to have high selectivity if it catches less than 3 species and with almost the same size [26]. Good vessel size indicates that the technology supports fishing operations in a stable and effective manner.

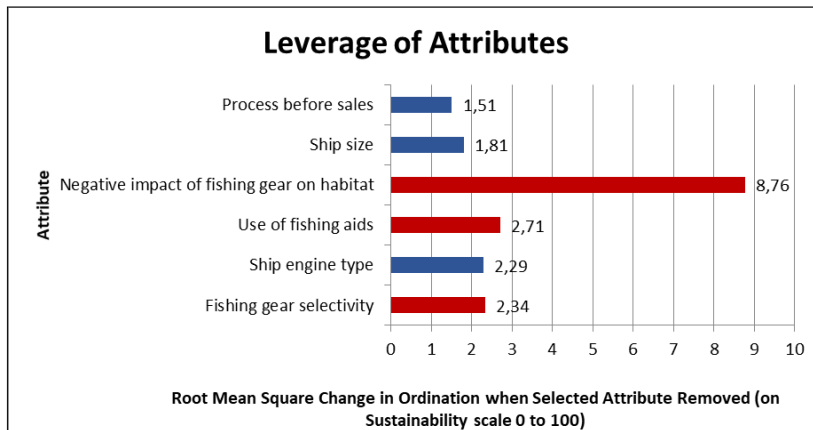


Fig 4 : Sensitivity of the Technology Dimension

To identify sensitive attributes, leverage analysis and Pareto analysis were used. The RMS values in the leverage analysis results are sorted from largest to smallest, then accumulated by looking at the cumulative percentage < 75%. So it can be seen that the sensitive attributes in the sustainability of mackerel capture fisheries in the waters of the North Rupa District in the technological dimension are the attributes of the negative impact of fishing gear on habitat, the use of fishing aids, and fishing gear selectivity.

Fishing aids are a sensitive attribute because the use of these technologies can affect the sustainability of marine resources and ecosystems as a whole. Fishing gear selectivity is a sensitive attribute of fisheries sustainability because it is directly related to the ability of the gear to efficiently catch fish without damaging the ecosystem or catching species that are undesirable.

The attribute of negative impact of fishing gear on habitat is sensitive to the technological dimension of the sustainability of capture fisheries because the use of fishing gear that is not environmentally friendly can damage marine habitats and ecosystems where fish and other marine biota live. Therefore, the use of fishing gear must pay attention to balance and minimize negative impacts on other biota. This is important to consider considering the loss of biota in the ecosystem structure will affect the entire ecosystem [27]. The development and utilization of fisheries resources must pay attention to the nature of these fisheries activities which must be environmentally friendly, and have a variety of fishing gear that can support the sustainability of fisheries resource utilization [28].

Institutional Dimension

The institutional dimension is an aspect directed at measuring management capabilities and rule enforcement capabilities. The results of the institutional dimension analysis obtained a sustainability index value of 53.44, which can be said to have a fairly sustainable position, because with illegal fishing practices now rarely occur even though further supervision is needed. There is no conflict between community institutions and fishermen, but fishermen feel less involved in making policies that affect them. Existing institutions are considered less effective and fisheries regulations are considered less useful and inefficient in improving the welfare of fishermen. To achieve more optimal sustainability, improvements are needed in fisher empowerment, institutional effectiveness, and the relevance of existing regulations.

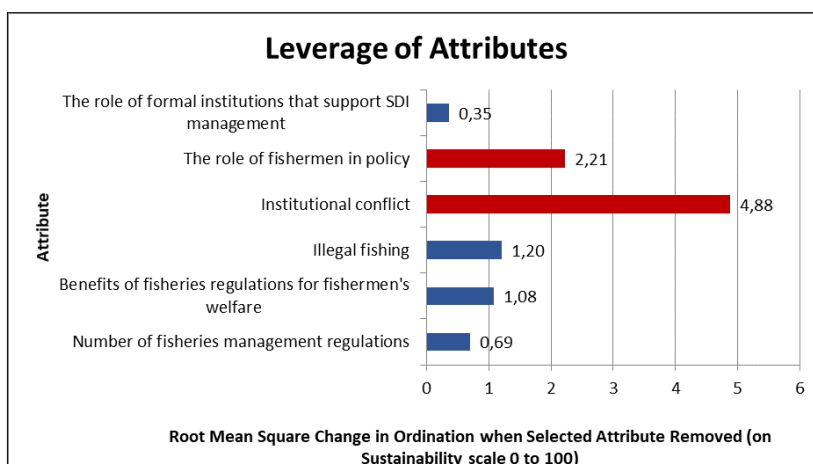


Fig 5: Sensitivity of the Institutional Dimension

To identify sensitive attributes, leverage analysis and Pareto analysis are used. The RMS values in the leverage analysis results are sorted from largest to smallest, then accumulated by looking at the cumulative percentage < 75%. So it can be seen that the sensitive attributes in the sustainability of mackerel capture fisheries in the waters of North Rupa Sub-district in the institutional dimension are the attributes of institutional conflict and the role of fishermen in policy.

Sensitive attributes in conflicts between fishing community institutions refer to factors that influence how such conflicts arise, develop, and potentially affect the sustainability and stability of the fisheries sector. The underlying factors driving the conflict have not received much attention and are used as the basis for resolution. One of the factors causing conflict is juridical factor, namely the existence of rules and regulations governing the utilization of fisheries resources that are not in accordance with regional

characteristics and the prevailing value system in the community [29].

The role of fishermen in policy is very important because they are the parties directly involved in the utilization of marine natural resources. Community participation should arise through increased awareness and understanding of the importance of having a sense of responsibility.

Responsibility together with the government and other parties to achieve optimal and sustainable resource utilization, according to carrying capacity and environmental sustainability responsibility together with the government and other parties to achieve optimal and sustainable resource utilization, according to carrying capacity and environmental sustainability [30].

Goodness of Fit

Table 2: Stress dan R-Square Values

No	Dimensions	Stress Value	R ²
1	Ecological Dimension	0,15	0,94
2	Economic Dimension	0,14	0,94
3	Social Dimension	0,15	0,94
4	Tehnology Dimension	0,15	0,93
5	Institutional Dimension	0,16	0,94

In Table 2, the stress values obtained from 5 dimensions, namely the ecological, economic, social, technological and institutional dimensions are smaller than 0,25. Meanwhile, the R-Square value of the 5 dimensions shows a value close to 1 or > 90%. A good analysis is indicated by a low stress value (S< 0,25) and R2 value above 95% confidence or close to a value of 1 (100%) which means that the currently selected attributes can explain close to 100% of the existing model, so the quality of the Multi-Dimensional Scalling (MDS) analysis can be accounted for [9].

Conclusion

The sustainability status of mackerel (*Scomberomorus commerson*) capture fisheries in the waters of North Rupa District is in the moderately sustainable category of 50.64. Ecological dimension 55.97 (moderately sustainable), economic dimension 53.20 (moderately sustainable), social dimension 37.25 (less sustainable), technological dimension 53.34 (moderately sustainable), and institutional dimension 53.44 (moderately sustainable). Sensitive attributes in the sustainability of mackerel (*Scomberomorus commerson*) capture fisheries in the waters of North Rupa District are the attributes of the size of the fish caught, the range of fishing areas, the level of collapse, ship ownership, the market, the price trend of mackerel in the last 3 years, the level of education of fishermen, environmental knowledge, the negative impact of fishing gear on habitat, the use of fishing aids, selectivity of fishing gear, institutional conflicts, and the role of fishermen in policy.

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