



Analysis of the sustainability of Fourfinger threadfin (*Eleutheronema tetradactylum*) catching in the waters of Pasir Limau Kapas subdistrict, Rokan Hilir Regency, Riau Province

Putri Febrianti, Zulkarnaini, Trisla Warningsih

Department of Fisheries Socio-Economics, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru, Indonesia

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Abstract

Analysis of the sustainability of fourfinger threadfin (*Eleutheronema tetradactylum*) capture fisheries in the waters of Pasir Limau Kapas Subdistrict, Rokan Hilir Regency, based on five dimensions: ecological, economic, social, technological, and institutional. The approach used was *Multi-Dimensional Scaling* (MDS) with the Rapfish technique, as well as leverage and pareto analyses to identify sensitive attributes. The method used in this study was a survey involving direct field interviews using a questionnaire. The results of the study indicate that the overall sustainability status falls into the “moderately sustainable” category with a multidimensional index value of 50.58. The index values for each dimension are as follows: ecological dimension 51.06 (moderately sustainable), economic dimension 52.13 (moderately sustainable), social dimension 52.12 (moderately sustainable), technological dimension 53.93 (moderately sustainable), and institutional dimension 43.66 (less sustainable). Attributes sensitive to the sustainability of fourfinger threadfin (*Eleutheronema tetradactylum*) capture fisheries in the waters of Pasir Limau Kapas Subdistrict, Rokan Hilir Regency, include changes in fishing grounds, catching fish before they reach marketable size, other sources of income, markets, fishing awareness campaigns, the influence of fishermen, conflict status, vessel size, sound navigation and ranging (SONAR), changes in catch capacity, illegal fishing, fishermen’s groups, and alternatives.

Keywords: Sustainability, fourfinger threadfin, Rapfish, Pasir Limau Kapas Subdistrict

Introduction

The capture fisheries sector plays an important and strategic role as a source of economic growth, a source of food particularly animal protein and a provider of jobs ^[1]. This potential must be managed sustainably so that resources can continue to be utilized without compromising ecological and economic sustainability or the well-being of local communities ^[2]. According to Charles in ^[3] the sustainability of capture fisheries consists of five components: ecological, economic, social, technological, and institutional sustainability. At the same time, the sustainability of capture fisheries also faces various pressures, such as price fluctuations, overfishing, overcapacity, and regional issues that can affect the livelihoods of fishermen ^[4].

The potential catch volume is 21,985.00 metric tons per year, with one of the main fishing areas located in Pasir Limau Kapas Subdistrict ^[5]. The Pasir Limau Kapas subdistrict covers an area of 670.63 km² and consists of eight villages, with the majority of the population earning a living as fishermen. This subdistrict is also a major center for capture fisheries, particularly in the villages of Panipahan, Panipahan Darat, Teluk Pulau, and the Panipahan urban village. Fishing activities in the area generally use gillnets with a mesh size of 3 inches and motorboats ranging from 0 to 5 GT ^[6].

One of the most widely utilized commodities in the Pasir Limau Kapas Subdistrict is the fourfinger threadfin (*Eleutheronema tetradactylum*). According to data from the Rokan Hilir Regency Central Statistics Agency (BPS), fourfinger threadfin production increased from 628.44 metric tons in 2020 to 885.41 metric tons in 2024. This increase indicates that the fourfinger threadfin plays a

significant role in the capture fisheries sector and the local economy. The economic value of the fourfinger threadfin also varies based on fish size, with selling prices at wholesalers and in markets reflecting differences in value based on the size classifications used by local sellers. Additionally, the fourfinger threadfin exhibits the biological characteristic of protandrous hermaphroditism a change in sex from male to female upon reaching maturity so the exploitation of large-sized fish must be carefully managed. Changes in fourfinger threadfin production indicate that resource utilization has evolved over time. Data from the Rokan Hilir Central Statistics Agency (BPS) show that production during the 2013–2015 period increased from 3,985.4 metric tons to 5,067.03 metric tons, then declined in 2016–2017 from 10,819 metric tons to 6,830.91 metric tons, and rose again during the 2020–2024 period. Although the use of gillnets with a 3-inch mesh size is selective based on fish size, field observations still reveal that small or juvenile fish are being caught. This situation, combined with heavy metal pollution and marine debris, can degrade the quality of fish habitats ^[7]. Fishermen’s dependence on middlemen, the weakness of fishermen’s cooperatives, the lack of regulations on minimum catch sizes, and low awareness of sustainable management indicate that the sustainability of the fourfinger threadfinery is under pressure from ecological, economic, social, and institutional perspectives. Given these conditions, an analysis of the sustainability of the senangin capture fishery in the waters of Pasir Limau Kapas Subdistrict, Rokan Hilir Regency, Riau Province is needed, taking into account the five dimensions of sustainability: ecological, economic, social, technological, and institutional. This analysis was conducted to determine the sustainability status of the fourfinger threadfin catch

fishery and to identify the attributes that serve as sensitive factors in its sustainability. The results of the analysis are expected to serve as a basis for determining strategies for the development and management of the fourfinger threadfin catch fishery so that fishing activities can continue sustainably without diminishing their benefits to the community, both now and in the future.

Research Methodology,

Time and Place

This research was conducted from February 15 to February 21, 2026, in the Pasir Limau Kapas subdistrict.

Research Methods

The method used in this study was a survey. This method involved direct observation of the subjects in the field and data collection through face-to-face interviews with fishermen in the Pasir Limau Kapas subdistrict; subsequently, all responses obtained by the researcher were recorded, processed, and analyzed.

Determination of Respondents

The respondents in this study were selected using purposive sampling, a sampling technique based on specific criteria (considerations) of the population members ^[8]. The criteria used were fishermen who catch senangin using 3-inch gillnets and motorboats ranging from 0 GT to 5 GT operating in the waters of the Pasir Limau Kapas subdistrict, as well as experts (people with knowledge of the subject) who remain involved in the management of fourfinger threadfin resources in the study area..

The number of respondents included 22 gillnet fishermen from the four villages: Panipahan Village, Panipahan Subdistrict, Teluk Pulau Village, and Panipahan Darat Village. The expert criteria selected in this study to meet the needs for primary and secondary data—specifically regarding capture fisheries data and information—included community leaders (2 people), an academic (1 person), a fisheries extension officer (1 person), a fish merchant (1 person), a representative from the Rokan Hilir Regency Fisheries Office (1 person), and the village heads of each village (4 people). Thus, the total number of respondents in this study was 32 people.

Data Collection

The data collected in this study consists of primary and secondary data. The primary data used in this study were obtained from Fourfinger threadfinermen and relevant parties through direct field observations and interviews. Meanwhile, secondary data were obtained from various sources, such as books, reports, journals, and relevant agencies, including the Rokan Hilir Regency Fisheries Office, the Central Statistics Agency (BPS), and other data sources that support and are related to this study.

Data Analysis

The analyses used in this study were multidimensional scaling (MDS), leverage analysis, and Pareto analysis.

1. Multi-Dimensional Scaling (MDS) Analysis

Rapfish is one method for analyzing fisheries sustainability and represents a new approach to applying Multi-Dimensional Scaling in the field of fisheries ^[9]. The analysis was conducted in several stages, including the analysis of

fisheries data through the collection of fisheries statistics and literature. All attributes obtained from this study were analyzed multidimensionally. This multidimensional analysis was used to determine the positions of the points in the studied Rapfish relative to two reference points. These reference points are “good” and “bad,” where there are points that are very good and points that are very bad. In addition, using MDS analysis, the coefficient of determination (R^2) can be observed ^[10]. The Rapfish ordination results need to be tested using Monte Carlo analysis with the “scatter plot” method, which shows the ordination of each aspect ^[11].

Table 1: Sustainability Status Index Categories

Index	Category
0-25	Poor (unsustainable)
>25-50	Insufficient (not sustainable)
>50-75	Enough (sustainable enough)
>75-100	Good (very sustainable)

2. Leverage Analysis and Pareto Analysis

The leverage analysis aims to determine the relationship between each attribute and the sustainability status of the fourfinger threadfin. This analysis can reveal which attributes are considered to be has the greatest positive or negative impact on sustainability status. Sensitive attributes are identified based on priority, by examining the Root Mean Square (RMS) value of the ordinates on the X-axis. The higher the RMS value, the greater the attribute’s role in sustainability status ^[12].

The Pareto concept, known as the 80-20 rule, states that 80% of outcomes are caused by 20% of factors. By focusing on those 20% of factors, 80% of problems can be resolved. The use of Pareto analysis in this study will be tailored to the research needs while still referring to the sustainability index values in Table 1. The application of the Pareto principle in this study follows the 80-20 rule, where the attribute with a cumulative value threshold of 80% is the most sensitive attribute influencing the sustainability index value ^[10].

Results and Discussion

Overview of the Research Location

The Pasir Limau Kapas Subdistrict is located in Rokan Hilir Regency, Riau Province, and is a coastal area characterized by a coastline and fairly extensive waters. Pasir Limau Kapas Subdistrict is situated at coordinates 2°15’ – 2°28’ North Latitude (NL) and 100°18’ – 100°28’ East Longitude (EL). The total area of Pasir Limau Kapas Subdistrict is 516.91 km², with the largest village being Pasir Limau Kapas Village at 217.17 km² and the smallest being Panipahan Village at 1.01 km².

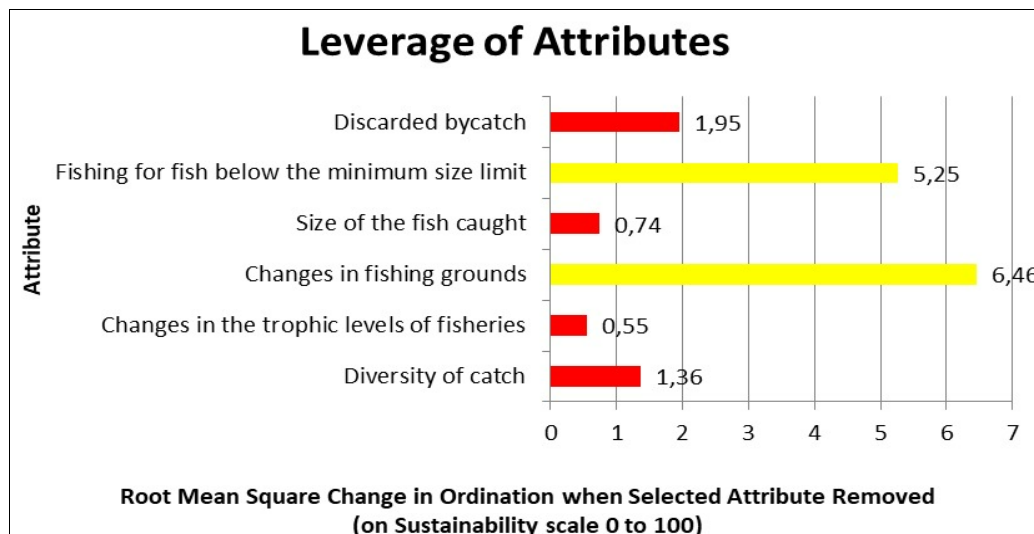
Sustainability Status of Senangin Capture Fisheries in the Waters of Pasir Limau Kapas Subdistrict

Ecological Dimension

Based on the results of the Rapfish analysis of the ecological dimension, the sustainability index value was 51.06, which falls into the “moderately sustainable” category (>50–75). This indicates that the ecological aspects of the capture fishery remain at a relatively good level, although they are not yet fully optimal. This condition is influenced by several favorable attributes, such as the absence of a collapse in the fishing range, slow-occurring

changes in trophic levels, and the presence of several target fish species such as senangin, mackerel, and gulama. However, there are still several limiting factors, namely the

harvesting of fish before they reach marketable size, a downward trend in fish size, and the continued discarding of bycatch.



Gambar 1: Sensitivity of the Ecological Dimension

To identify sensitive attributes, leverage and Pareto analyses were used with a cumulative percentage of 80%. The results of the analysis showed that the sensitive attributes in the ecological dimension were changes in fishing grounds and the catching of fish before they reached marketable size. Changes in fishing areas became a sensitive attribute because fishermen began fishing in more distant areas due to indications of a decline in fish stock availability; furthermore, the influx of fishermen from outside the region and the open-access nature of the waters contributed to increased fishing pressure. The greater the distance traveled to fishing areas, the more evident it becomes that fish stocks in the previous areas are beginning to decline.

This situation can be exacerbated by the use of a large fleet, which allows for the expansion of fishing operations. This is also consistent with what was stated by ^[13] that increased fishing activity and uncontrolled fishing pressure can lead to a decline in fish stocks and encourage fishermen to expand their fishing grounds to more distant areas. Therefore, it is necessary to regulate fishing zones, monitor fishing activities, and strengthen fishermen's institutions.

The issue of catching fish before they reach marketable size has become a critical concern due to the still-high proportion of fish caught before they reach maturity or before they have a chance to reproduce. Based on field observations, more than 60% of the fish caught have not yet reached marketable size, which can disrupt the natural regeneration process of fish stocks. This situation is influenced by the use of fishing gear such as gillnets with relatively small mesh sizes, which result in the capture of small fish, as well as high fishing pressure and a lack of monitoring regarding the size of fish that may be caught. This is also consistent with what was stated by ^[14] excessive and sustained fishing can reduce the ability of fish stocks to recover naturally. Therefore, it is necessary to regulate mesh

sizes, establish minimum sizes for fish that may be caught, and increase oversight of fishing activities.

Economic Dimension

Economic sustainability in the capture fisheries sector relates to the sector's ability to generate income and support the well-being of fishermen on a sustainable basis. Fishermen's livelihoods are heavily influenced by catch conditions, fish prices, operating costs, and market access. Based on Rapfish's analysis of the economic dimension, a sustainability index value of 52.13 was obtained, which falls into the "moderately sustainable" category (>50–75). This result is supported by relatively stable and rising prices for fourfinger threadfin, as well as the existence of a market capable of absorbing fishermen's catches. However, fishermen's income remains below the minimum wage for the Pasir Limau Kapas subdistrict; most fishermen do not yet have alternative sources of income; market access remains limited and dependent on middlemen; and rising operational costs may reduce fishermen's net income. Therefore, efforts are needed to improve market access, develop alternative sources of income, increase operational cost efficiency, and strengthen fishermen's economic institutions.

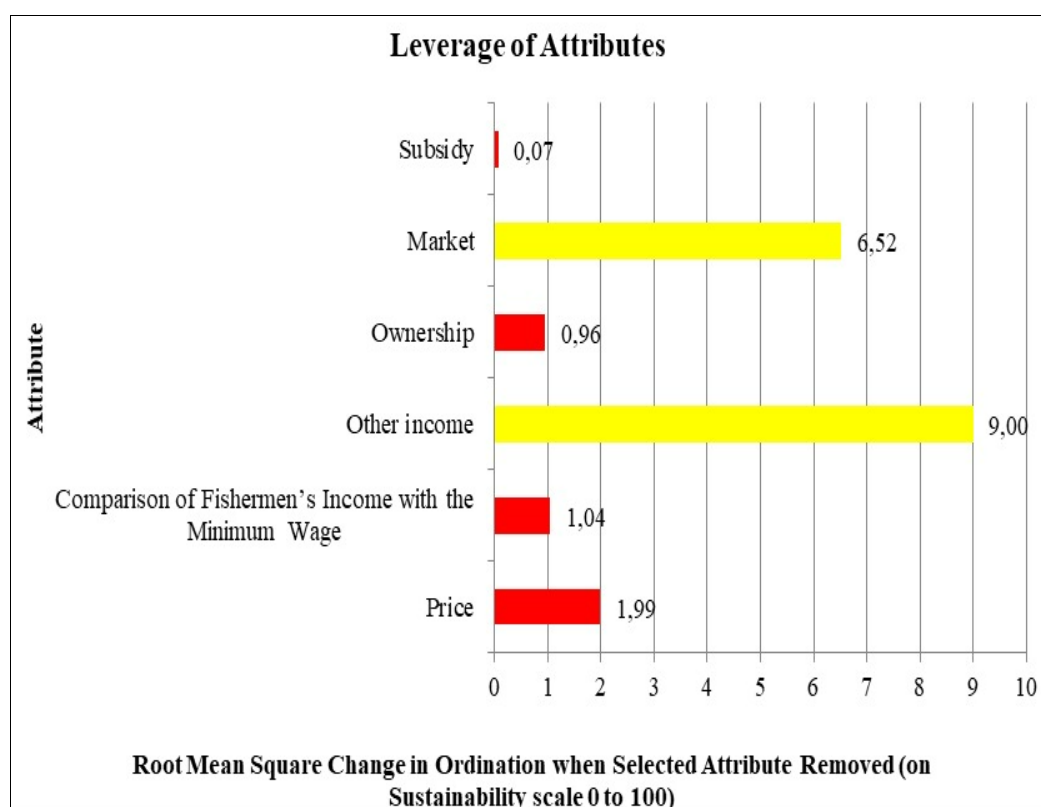
Other sources of income are a sensitive issue because most fishermen still rely on a single primary source of income: capture fisheries. Based on conditions on the ground, the majority of fishermen work full-time as fishermen and do not yet have alternative sources of income outside the fisheries sector. This situation makes fishermen's household economies vulnerable to fluctuations in catch volumes, adverse weather, or declines in fish prices. Limited employment opportunities in coastal areas, a lack of non-fishing business skills, and limited access to capital are also factors contributing to the low level of livelihood diversification among fishermen. Therefore, there is a need for livelihood diversification, the development of alternative businesses, skills training, and support for economic

empowerment programs for fishing communities. This is also in line with what was stated by ^[15] small-scale fishermen who rely solely on the fisheries sector are highly economically vulnerable to changes in the environment, catch levels, and market conditions. Diversifying income sources is essential for enhancing the economic resilience of fishing households and reducing risks stemming from uncertainty in the fisheries sector. Consequently, other income attributes become critical, as they reflect the extent of fishermen's economic dependence on the fisheries sector. The market is a critical factor because market access significantly influences the selling price of the catch and the income received by fishermen. Based on conditions on the ground, most fishermen still sell their catch through middlemen and therefore do not yet have direct access to broader markets. This situation weakens fishermen's bargaining power in determining fish prices. Limitations in distribution networks, storage facilities for catches, market price information, and fishermen's economic institutions also affect marketing conditions. Therefore, it is necessary to strengthen fishermen's cooperatives, improve access to market information, develop distribution systems for fishery products, and expand marketing networks so that fishermen can obtain more competitive selling prices. This is also in

line with what was stated by ^[16] limited market access and low economic diversification result in small-scale fishermen having weak bargaining power and being vulnerable to price fluctuations and economic pressures. Strengthening market access and diversifying livelihoods can enhance the economic resilience of fishing communities. Thus, market conditions are critical because they affect the stability of fishermen's incomes and well-being.

Social Dimension

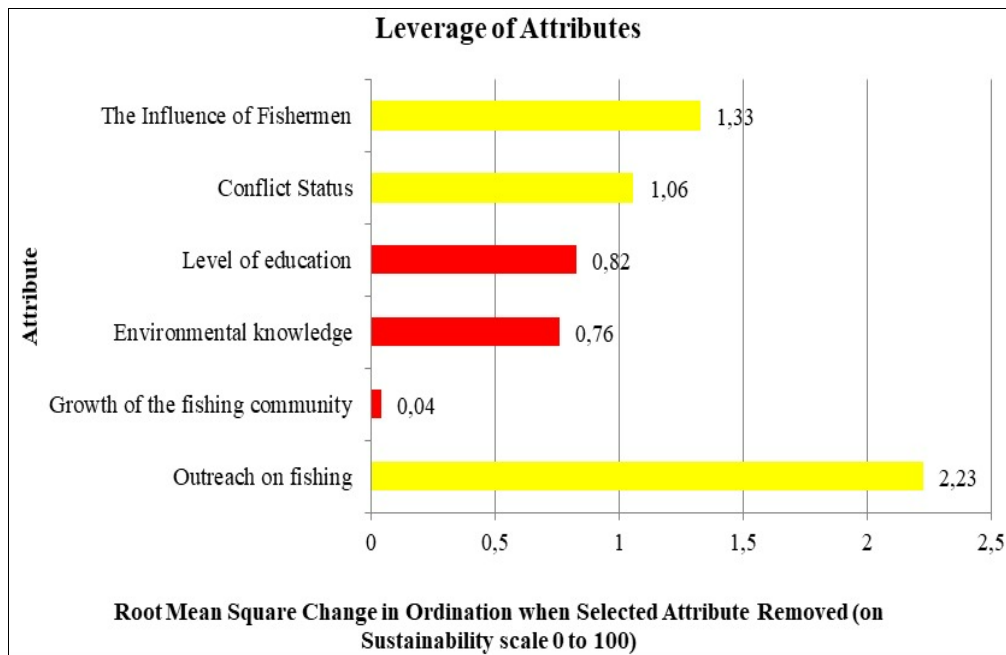
The social dimension of capture fisheries sustainability relates to communication, participation, and relationships among fishermen in the use of fishery resources. Based on the results of the Rapfish analysis, the sustainability index value for the social dimension is 52.12, which falls into the "moderately sustainable" category (>50–75). This condition is supported by outreach efforts regarding fishing practices through fishermen's groups and the relatively stable growth of the fishing community. However, there are still limitations in environmental knowledge, educational levels, fishermen's involvement in decision-making, and conflicts within fishing activities. Therefore, there is a need to increase outreach, strengthen the institutional capacity of fishermen's groups, and enhance fishermen's participation.



Gambar 2: Sensitivity of the Economic Dimension

Leverage analysis was used to examine the influence of each attribute on the sustainability value of the economic dimension. To identify attributes with high sensitivity, a Pareto analysis was conducted using a cumulative percentage of 80%. The results of the analysis showed that the "other income" attribute had the highest leverage value, followed by the

"market" attribute. Based on the cumulative percentage, these two attributes are sensitive to the economic sustainability of the Senangin capture fishery. Meanwhile, the attributes of price, the ratio of fishermen's income to the minimum wage, ownership, and subsidies have exceeded the 80% cumulative percentage threshold and are therefore not considered sensitive attributes.



Gambar 3: Sensitivity to Social Dimensions

Leverage and Pareto analyses with a cumulative percentage of 80% indicate that the attributes of fishing socialization, fishermen's influence, and conflict status are sensitive attributes within the social dimension. The attribute of fishing socialization is sensitive because it plays a role in enhancing fishermen's understanding of regulations, fishing techniques, and sustainable resource management. Based on conditions in the field, outreach has been conducted through fishermen's groups and extension programs, but it has not yet reached all fishermen equally. This is also consistent with what was stated by ^[17] that fisheries extension and outreach programs influence fishermen's understanding, participation, and behavior regarding fisheries resource management.

The influence of fishermen is a sensitive issue because their involvement in decision-making remains limited. This situation may affect the alignment of policies with the needs of fishermen on the ground. Therefore, institutional strengthening and increased opportunities for fishermen's participation are needed. This is also in line with what was stated by ^[18] that the involvement of fishing communities in fisheries management is essential to ensuring the success of co-management and the sustainability of fisheries.

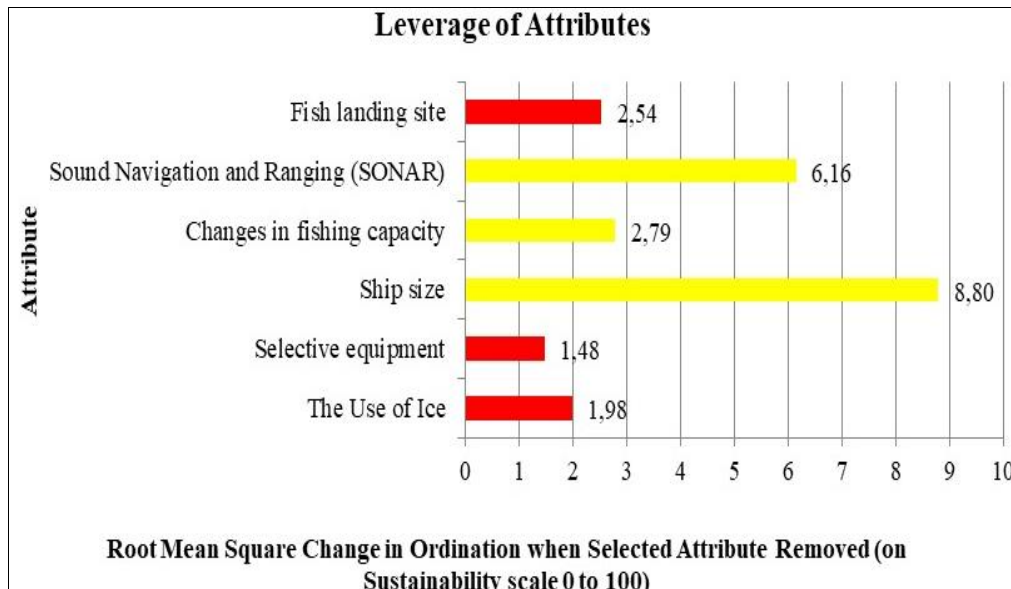
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fisheries management is essential to ensuring the success of co-management and the sustainability of fisheries.

Conflict-related factors are a sensitive issue because there is still competition over fishing grounds, differences in the use of fishing gear, and the influx of fishermen from outside the region. Unmanaged conflicts can disrupt social relations and fishing activities. Therefore, it is necessary to strengthen regulations, enforcement, and conflict resolution through fishermen's groups. This is also in line with what was stated by ^[19] conflicts over the use of fishery resources can be influenced by conflicting interests, unequal access to resources, and weak regulations. Therefore, conflict management and increased community participation are necessary to support the sustainability of capture fisheries.

Technology Dimension

The technology dimension describes the application of technology in fishing activities and the handling of the catch. The Rapfish analysis yielded a sustainability index value of 53.93, placing it in the "moderately sustainable" category (>50–75). This finding is supported by the use of vessels capable of reaching wider fishing areas, the availability of several fish landing sites, and the fact that some fishermen have adopted the use of ice and fishing gear with a certain level of selectivity. However, the application of technology is not yet fully optimized because the use of ice and selective fishing gear is not yet widespread, catch volumes continue to fluctuate, and the majority of fishermen have not yet adopted modern navigation technology.



Gambar 4: Sensitivity of the Technology Dimension

Leverage and Pareto analyses indicate that three attributes are particularly sensitive to the sustainability of the technology dimension: vessel size, Sound Navigation and Ranging (SONAR), and changes in catch volume. These three attributes account for a cumulative 80%, while fish landing sites, ice usage, and selective gear fall below the sensitivity threshold.

Vessel size is a sensitive factor because it relates to fleet capacity, fishing range, and the ability to transport the catch. Field observations indicate that some fishermen use vessels ranging from 8 to 17 meters in length, which allow them to fish in more distant waters. A larger fleet capacity can increase fishing capacity but also has the potential to increase pressure on fish stocks if not balanced by sound management. This is also consistent with what was stated by ^[20] that an increase in fleet capacity must be accompanied by controls on fishing activities so that pressure on fish stocks remains under control.

The use of SONAR is a sensitive issue because this technology is linked to fishermen's ability to locate fishing grounds more quickly and efficiently. Fishermen in the Pasir Limau Kapas subdistrict generally still rely on experience, natural conditions, and local knowledge, so the use of modern navigation technology remains low. These conditions indicate an opportunity to improve efficiency through technology, but its use must still be aligned with resource management. This is also in line with what was stated by ^[21] that fishing support technologies can improve effectiveness and efficiency, but must be balanced with sound management to avoid increasing pressure on fish stocks.

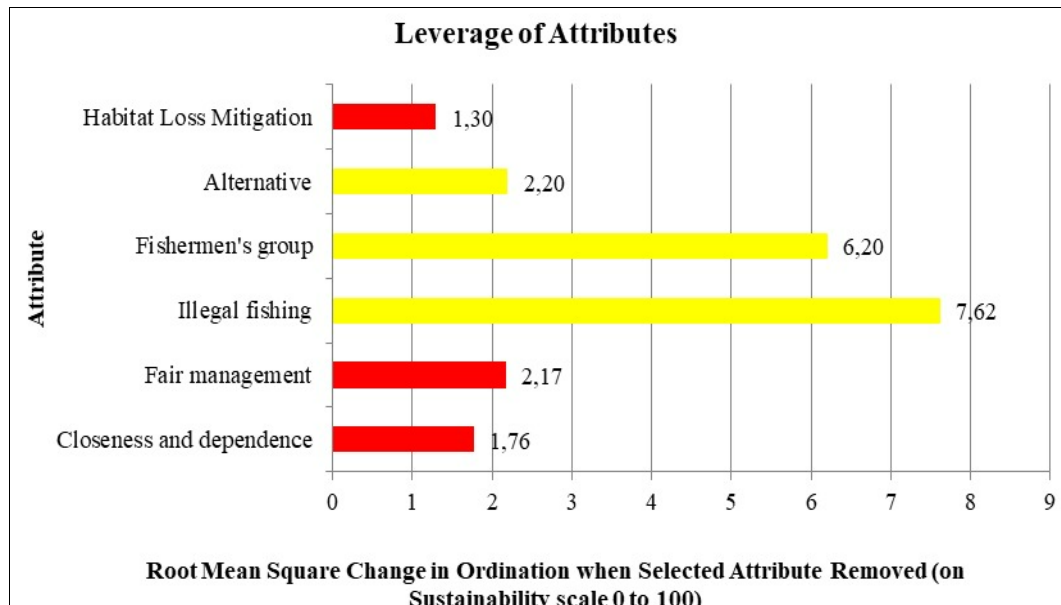
Changes in catch volume are a sensitive indicator because

they reflect changes in the productivity of fishing activities over time. Interview results indicate that fishermen experience fluctuations in catch yields influenced by the season, weather, water conditions, and fishing activities. These changes can serve as an indicator of fisheries productivity and must be monitored to prevent them from leading to a long-term decline in catch yields. This is also consistent with what was stated by ^[22] that changes in catch levels are influenced by environmental conditions, seasons, and fishing activities, and therefore must be taken into account in sustainable fisheries management.

Thus, efforts to improve sustainability in the technological dimension should focus on controlling fleet capacity, the appropriate use of fishing technologies, and monitoring changes in catch levels so that fishing efficiency can be improved without increasing pressure on fish stocks.

Institutional Dimension

The institutional dimension describes the role of regulations, oversight, and fishermen's organizations in supporting the sustainability of capture fisheries. The results of the Rapfish analysis show a sustainability index value of 43.66, placing it in the "less sustainable" category (>25–50). This indicates that fisheries institutions in Pasir Limau Kapas Subdistrict are not yet functioning optimally. Several institutional structures have been established, such as fishermen's groups and relationships between fishermen and fish collectors, but challenges remain, including dependence on certain parties, insufficient involvement of fishermen in decision-making, fishermen's groups that are not regularly active, and the continued occurrence of fishing practices that do not comply with regulations.



Gambar 5: Sensitivity of the Institutional Dimension

Thus, efforts to enhance the sustainability of the institutional dimension should focus on strengthening oversight and compliance with regulations, increasing the active participation of fisher groups, and developing alternative livelihoods to reduce dependence on fishing activities.

Goodness of Fit

Tabel 2: Stress Value and R-Square

No	Dimensions	Stress Value	R ²
1.	Ecological Dimensions	0,15	0,93
2.	Economic Dimensions	0,14	0,93
3.	Social Dimension	0,16	0,93
4.	Dimensions of Technology	0,14	0,93
5.	Dimensi Kelembagaan	0,15	0,93

In Table 2, the stress values obtained from the five dimensions ecological, economic, social, technological, and institutional are less than 0.25. Meanwhile, the R-squared values for these five dimensions are close to 1 or greater than 90%. A good analysis is characterized by low stress values ($S < 0.25$) and an R^2 value above the 95% confidence level or close to 1 (100%), which means that the currently selected attributes can explain nearly 100% of the existing model, thus ensuring the reliability of the Multi-Dimensional Scaling (MDS) analysis ^[10].

Leverage and Pareto analyses reveal three attributes that are sensitive to the sustainability of the institutional dimension: illegal fishing, fisher groups, and alternative livelihoods. These three attributes account for a cumulative percentage approaching 80%, while equitable management, proximity and dependence, and habitat loss mitigation fall below the sensitivity threshold.

Illegal fishing is the most sensitive issue because it relates to compliance with regulations and pressure on fish stocks. Conditions on the ground indicate that fishing practices that do not comply with regulations still exist, while enforcement has not yet been fully optimized. If this continues, it could increase pressure on fish stocks and undermine the sustainability of the fishing industry. This is also consistent with what was stated by ^[23] that illegal

fishing can have ecological and economic impacts due to the increased exploitation of fishery resources.

Fishermen's groups are a sensitive issue because they serve as a forum for cooperation, information exchange, capacity building, and the articulation of fishermen's interests. Fishermen's groups in Pasir Limau Kapas Subdistrict already exist, but their activities have not yet been conducted on a regular and optimal basis. This situation has prevented the institutional functions of these groups from being fully utilized. This is also consistent with what was stated by ^[24] that fishermen's groups can support the development of skills, cooperation, and the well-being of coastal communities if their activities and the involvement of their members are carried out effectively.

Alternative sources of livelihood are a sensitive issue because they relate to the extent to which fishermen depend on fishing activities. Most fishermen in Pasir Limau Kapas Subdistrict still rely on capture fisheries as their primary source of income, while alternative jobs or businesses remain limited. This situation can increase the vulnerability of fishing households when catch levels decline or fishing activities are disrupted. This is also consistent with what was stated by ^[25] that the development of alternative livelihoods can help reduce fishermen's dependence on catch yields and help them cope with the uncertainties of the fishing industry.

Conclusion

The sustainability status of the Fourfinger threadfin (*Eleutheronema tetradactylum*) capture fishery in the waters of Pasir Limau Kapas Subdistrict, Rokan Hilir Regency, Riau Province, is classified as "moderately sustainable," with an index value of 50.58. The ecological dimension scored 51.06 (moderately sustainable), the economic dimension 52.13 (moderately sustainable), the social dimension 52.12 (moderately sustainable), the technological dimension 53.93 (moderately sustainable), and the institutional dimension 43.66 (less sustainable). Sensitive attributes that influence the sustainability of Fourfinger threadfin (*Eleutheronema tetradactylum*) capture fisheries in the waters of Pasir Limau Kapas Subdistrict, Rokan Hilir Regency, Riau Province, include changes in fishing grounds

and the catch of fish below the minimum legal size, alternative sources of income and markets, public awareness campaigns regarding fishing, the influence of fishermen, and conflict status, vessel size, sonar, and changes in catch capacity, as well as illegal fishing, fisher groups, and alternatives.

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