Sustainable fisheries economic management strategy in Dumai City, Riau Province

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Abstract. Dumai City, located in Riau Province, is one of the regions in Indonesia with great potential in the capture fisheries sector. Capture fisheries in Dumai are not only the main source of income for local fishermen, but also contribute significantly to the local economy. The research on sustainable capture fisheries management in Dumai City was conducted in 2 research sites, namely Medang Kampai District and Sungai Sembilan District. This research aimed to analyze the sustainability level of the capture fisheries resource management and the sustainable capture fisheries management policy in Dumai City. Data analysis used the Rapfish method and multi-dimensional scaling. The results show that based on the Repfish analysis, the sustainability index values for each dimension are as follows: a) the ecological dimension is 19.89, b) the economic dimension is 41.55, and c) the social and institutional dimension is 37.57. This research concludes that, given the sustainability index value, the capture fisheries in Dumai City are unsustainable. Strategies that can be developed to improve the sustainability status of capture fisheries management in Dumai City include the environmental dimension (fishing regulations, ecological quality management, and fish stock monitoring), the economic dimension (diversification of higher value commodities, increasing market access, and increasing value-added), and the social and institutional dimension (increasing community participation, effective corporate social responsibility programs, and strengthening monitoring institutions).
Key Words: ecology, economics, capture fisheries, rafting, social and institutional.

Introduction. Dumai City is the center of economy and trade for the people of Riau Province. According to Hutapea et al (2019), Dumai City also plays a significant role in the fisheries sector. The abundance of fishery resources is an excellent opportunity for economic growth and for improving the welfare of fishermen (Zainal 2013). However, the large number of industrial zones around the coastal area of Dumai has impacted the capture fisheries sector. One of the effects of the proliferation of the industrial regions around the coast is a decrease in fish catches (Nufus 2018). Low production is also caused by damage to coastal ecosystems due to pollution (Ramadhan et al 2021). In addition to decreasing catches, some are unsuitable for sale and consumption because they have a foul odor. Such conditions have a significant impact on fishermen, as the majority of fishermen in Dumai City only use small fishing fleets with simple fishing gear (Hutapea et al 2019). This poses a severe challenge to the management of fisheries resources (Yulinda 2018). Of course, a strategy can be prepared by prioritizing sustainability principles from ecological, economic, social, and institutional perspectives (Sapanli et al 2022). Zulbainarni et al (2024) has also emphasized that sustainable fisheries have three critical dimensions: ecological, economic, and social. Based on the above issues, this study aimed at analyzing the level of sustainability of capture fisheries in Dumai City. This research collected data through Focus Group Discussion (FGD). The data obtained was then analyzed using the Rapfish method and Multi-Dimensional Scaling (MDS). Rapfish analysis determines the

sustainability level index for capturing fisheries activities from different dimensions. MDS is used to assess the sustainability of capture fisheries management in Dumai town.

Material and Method

Description of the study sites. This research was conducted in Dumai City, Riau Province. The data collection was conducted from February to March 2024. The research sites were in Lubuk Gaung Industrial Area, Sungai Sembilan District, and Dumai Industrial Area, Medang Kampai District, Dumai City. The determination of the research location was done purposefully (deliberately), taking into consideration: (1) the geographical location of Dumai City, which is very strategic because it borders the Melaka Strait, (2) the high sea transportation activity because it is an international shipping route that is often visited by large ships, (3) the accessibility on the mainland of Dumai is high because it has the largest oil industry company that uses Dumai waters as a means of sea transportation. Below is a map of the research site (Figure 1).

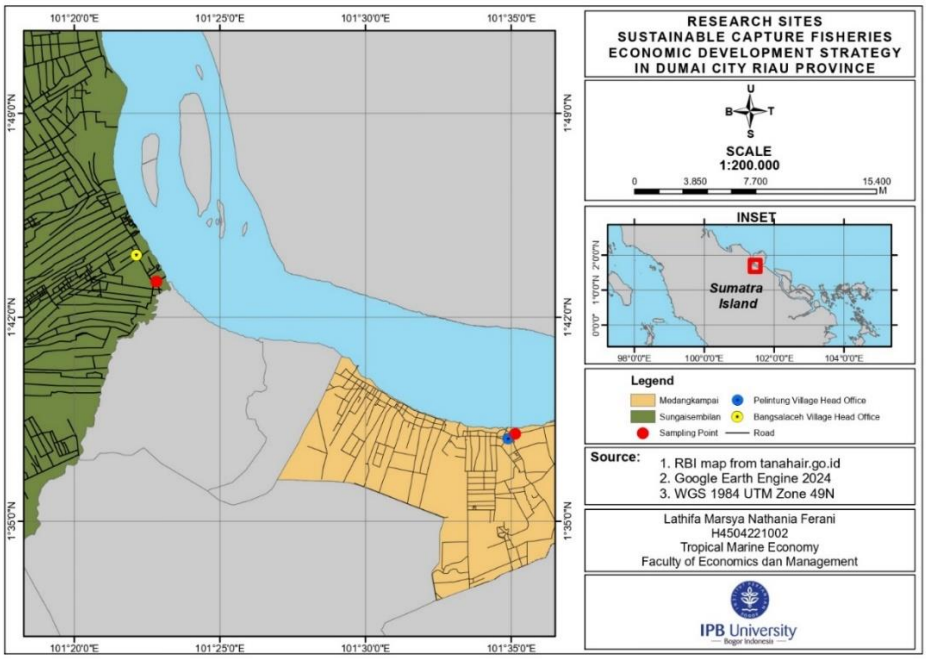

Figure 1. Research location map.

Data analysis procedures. This research uses the Rapid Appraisal for Fisheries (Rapfish) method to analyze fishing enterprises' sustainability levels. Rapfish uses multidimensional scaling (MDS) to explore the sustainability status (Sapanli et al 2022). At the beginning of the development of the Rapfish method, multidisciplinary perspectives such as capture fishery stocks, coral reef sustainability, clean water stocks, and so on could be measured when calculating the sustainability index of fisheries and marine resources. After data collection, the scoring is done to determine the sustainability status. This sustainability status can be grouped into three categories: not sustainable (index between 0-50), fairly sustainable (index between 51-75), and very sustainable (index between 76-100). Based on Firdaus et al (2021), the grouping of sustainability status scores can be seen in Table 1.

Table 1

Grouping of sustainability status scores

Number	*Dimension index value*	*Category*	*Information*
1	0.00-24.99	Bad	Not sustainable
2	25.00-49.99	Not enough	Less sustainable
3	50.00-74.99	Sufficient	Fairly sustainable
4	75.00-100.00	Good	Sustainable

Next, a sensitivity (leverage) analysis is performed to target sensitive attributes, having the most significant impact on changes in the sustainability index value; these can determine strategies to improve the sustainability status. Monte Carlo analysis measures the impact of the error variable in the model at a 95% confidence level. The results of the Monte Carlo analysis can determine (1) errors in creating rating categories for each attribute, (2) errors in assigning ratings due to differences of opinion, (3) errors in data entry, and (4) instability in data analysis (Sapanli et al 2022).

Results

Sustainability status of capture fishery business in Dumai City. This research uses three dimensions of sustainability and 24 attributes, which are divided into: (1) eight attributes in the ecological dimension; (2) eight attributes in the economic dimension; and (3) eight attributes in the social and institutional dimension. The index values of these three dimensions can be seen as a kite diagram (Figure 2).

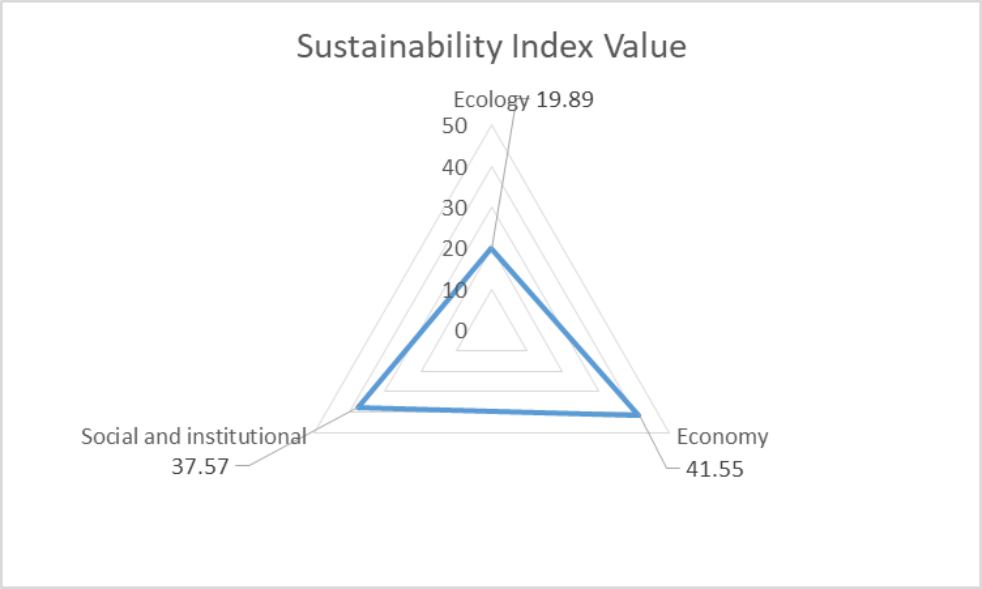

Figure 2. Dumai City capture fisheries sustainability index value.

Sustainability status of environmental dimensions. The sustainability index value of 19.89 is included in the unsustainable category (Figure 3). Based on the results of the leverage analysis in Figure 4, fish size, with a value of 7.6584, was the most sensitive attribute in the sustainability index of the ecological. The results of the Monte Carlo analysis for the ecological dimension show that the stress value obtained is 13.44%. This value is less than 25%, so it can be concluded that the studied attributes are appropriate and comply with the rules of scientific writing. The value of the coefficient of determination is 94.69%. This means that the variables included in the research can explain 94.69% of the variation in the ecological sustainability index value (Table 2).

Table 2

Stress value and squared correlation (RSQ) of ecological dimensions

Category	*Value*
Stress Value	13.44%
Squared Correlation (RSQ)	94.69%

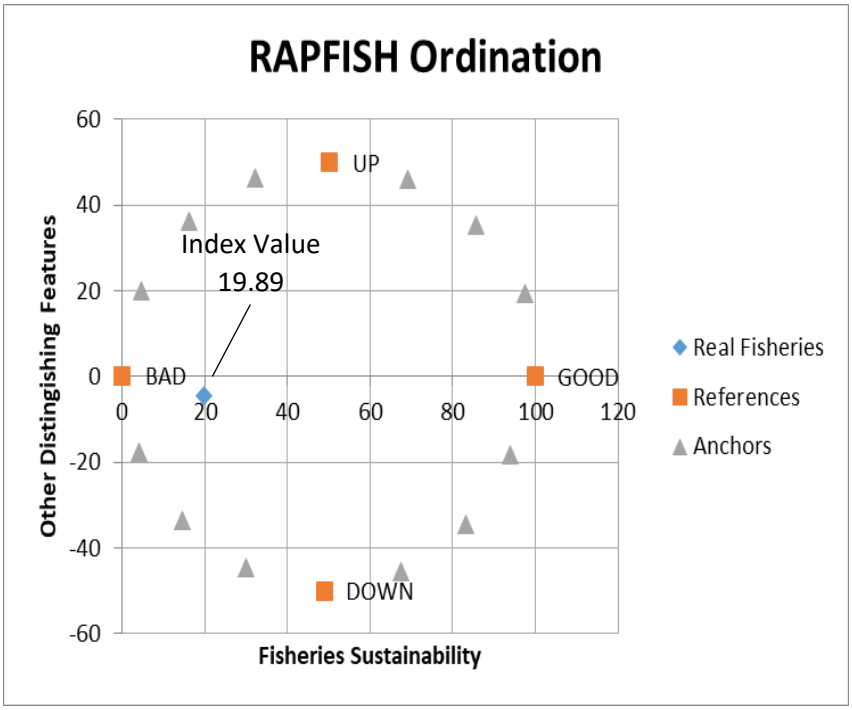

Figure 3. Ecological dimension sustainability index values.

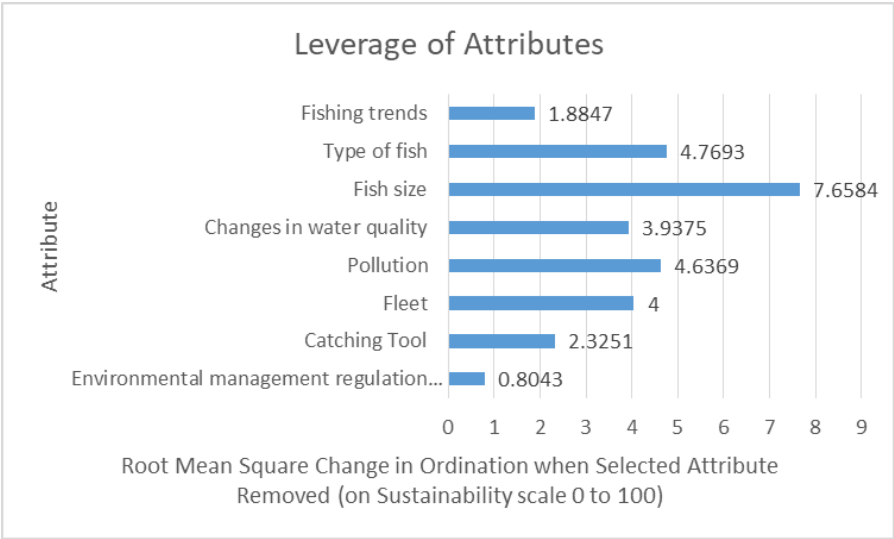

Figure 4. Leverage of attributes in the ecological dimension.

From the environmental dimension's perspective, compliance could be more substantial. Illegal or underreported fishing activities can contribute to low levels of sustainability. In Dumai City, a significant amount of fishing is done by foreign vessels that do not belong to Dumai City fishermen. This is due to weak monitoring and enforcement of fisheries laws, which allow foreign vessels to continue unsustainable practices. Using non-selective or destructive fishing gear can also destroy the seabed habitat and disrupt the ecosystem. It is often found that some fishermen which are not part of a fishing group still use destructive fishing gear, such as trawls. Such high-volume fishing damages the seabed habitat and also results in small or unwanted fish being caught. The large number of fish caught that are small or have not yet reached the mature size for reproduction will indicate a long-term decline in fish populations. Even if this population decline occurred in a few key species, it could affect the entire marine ecosystem, reducing the stability and function of the ecosystem.

The lack of access to fishing fleet technology and facilities to support fishing operations and fish management also contributes to the low sustainability status of capture

fisheries in Dumai City. According to the Marine and Fisheries Service-Riau Province (2019), the fleet size used by fishers is between 1 and 2GT and needs to be supported by sophisticated and adequate fishing tools. According to Aini et al (2015), several large industries with international capacity are located in the coastal area of Dumai, such as the Pertamina Dumai oil refinery, PT. Chevron Indonesia, a palm oil processing company, and wood raw material processing, as well as port activities for the loading and unloading goods and people. These activities discharge industrial waste into the sea, affecting fish habitat and water quality. This can be seen from the increase of industrial companies established around the coastal areas of Dumai City, which will directly or indirectly affect fishermen's catches (Nedi 2010). According to Ramadhan et al (2021), the capture fishery products in the waters of Dumai City tend to decrease. The flow of industrial waste may also cause a decrease in water quality in Dumai waters. Erlangga (2007) emphasized that the introduction of pollutants into water bodies can affect water quality. Of course, this will also affect the fish's habitat, affecting their growth and reproduction. This is also confirmed by Arkham et al (2021), the production value of fishermen's catch in Dumai City tends to decrease yearly. An increase in fishing efforts indicates that Dumai waters are in the overfishing category.

Sustainability status of economic dimensions. The sustainability index value of 41.55 is included in the unsustainable category (Figure 5). Based on the results of the leverage analysis in Figure 6, an attribute sensitive, in the economic dimension of the sustainability index, is obtained, namely the share of income from fishing, with a value of 8.9236. The results of the Monte Carlo analysis for the economic dimension show that the stress value obtained is 13.83%. This value is less than 25%, so it can be concluded that the attributes studied are appropriate and comply with the rules of scientific writing. The value of the coefficient of determination is 94.04%. This means that the variables included in the research can explain 94.04% of the variation in the economic sustainability index value (Table 3).

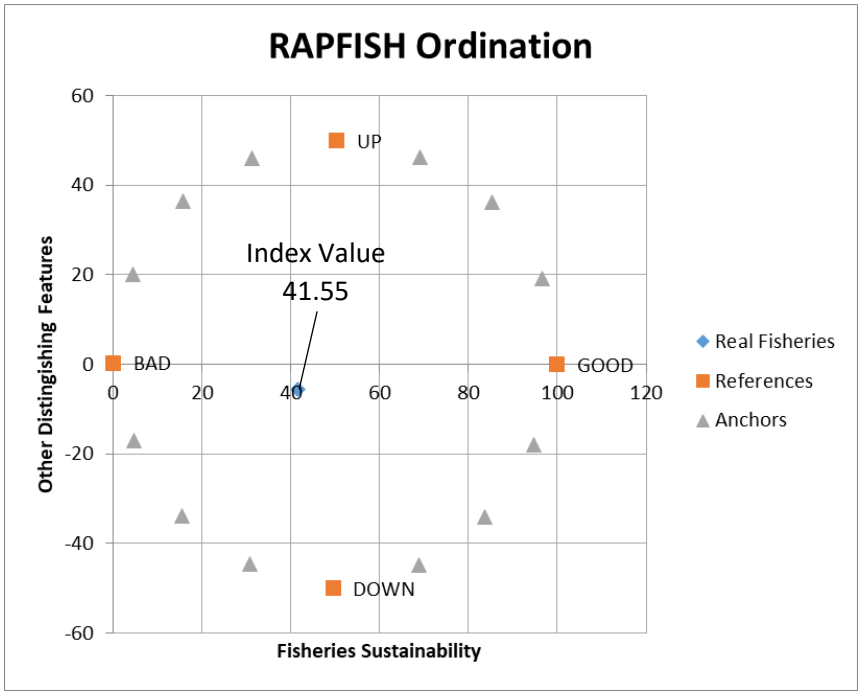

Figure 5. Economic dimension sustainability index values.

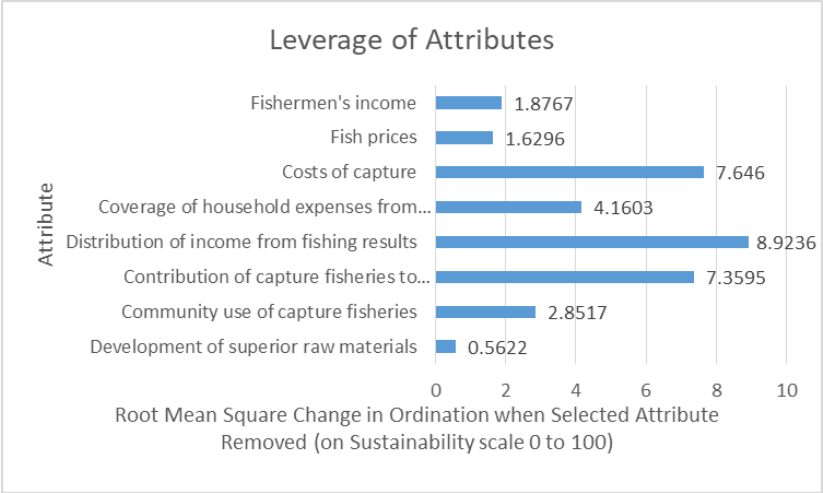

Figure 6. Leverage of the attributes in the economic dimension.

Table 3

Stress value and squared correlation (RSQ) of economic dimensions

Category	*Value*
Stress value	13.83%
Squared correlation (RSQ)	94.04%

In developing value-added products, the Dumai fishing community depends on a small number of fish species that are vulnerable to stocks and market fluctuations. As a result, the diversification of fishery products in Dumai City can be considered very poor. Dumai fishermen also need more innovation in developing high-value-added fishery products. In addition, there is little community involvement in the management and utilization of capture fisheries, resulting in a lack of community ownership and responsibility in maintaining the sustainability of the resource. According to Kusnandar (2008), natural resource utilization activities should significantly contribute to the economy of the community, region, and country. However, in Dumai City, capture fisheries make relatively low contributions to locally generated revenue due to a lack of effective management and resource optimization. The fisheries sector's tax and fee management system is also not working well. This, of course, can reduce the potential for regional revenue. In addition, the fishermen in Dumai City are only small-scale fishermen who receive a much smaller share of the income. This is because some fishermen sell their catch to middlemen, where most profits go to a few individuals. This has resulted in unequal welfare for the fishing community. The fishing community in Dumai City is highly dependent on the capture fisheries sector (Hutapea et al 2019). Fishing activities are fishermen's primary income source, which can increase pressure on fish resources. The income earned by fishermen from fishing operations cannot meet the needs of fishing households, forcing them to look for additional sources of revenue.

The type of fishing fleet and fishing gear used by the fishing community in Dumai City are still basic (Arief et al 2014), which leads to a low efficiency in fishing operations and is considered ineffective. According to Marlianingrum et al (2021), capture fisheries can be developed by supporting adequate fishing facilities and infrastructure, such as fishing technology, shipyards, fishing ports, and cold storage at the fish auction places (TPI). Operating costs, such as fuel, vessel maintenance, and fishing gear, are high. In addition, the fishermen's fishing areas are becoming increasingly remote due to the damage to the coastal ecosystem, which also reduces the profit margins of the fishermen. According to Ramadhan et al (2016), fishing in new fishing locations is also a challenge for fishermen. Fishermen find it difficult to reach new fishing areas because the sea distances are getting longer, while the size of the vessels used does not support it. This results in an increase in the cost of going to sea. As a result, fishermen's incomes are unstable and often low due to various factors, including fluctuations in fish stocks, high fishing costs, and low

fish prices. This low economic well-being of fishers can undoubtedly lead to social problems such as low levels of education and poor health.

Sustainability status of social and institutional dimensions. The sustainability index value of 37.57 is included in the less sustainable category. Based on the results of the leverage analysis in Figure 7, an attribute that is sensitive, in the sustainability index of the social and institutional dimension, is obtained, namely the availability of non-formal rules in the management of capture fisheries with a value of 8.5218. The results of the Monte Carlo analysis for the social and institutional dimension show that the stress value obtained is 13.36%. This value is less than 25%, so it can be concluded that the studied attributes are appropriate and comply with the rules of scientific writing. The value of the coefficient of determination is 94.51%. This means that the variables included in the research can explain 94.51% of the variation in the social sustainability index value (Table 4).

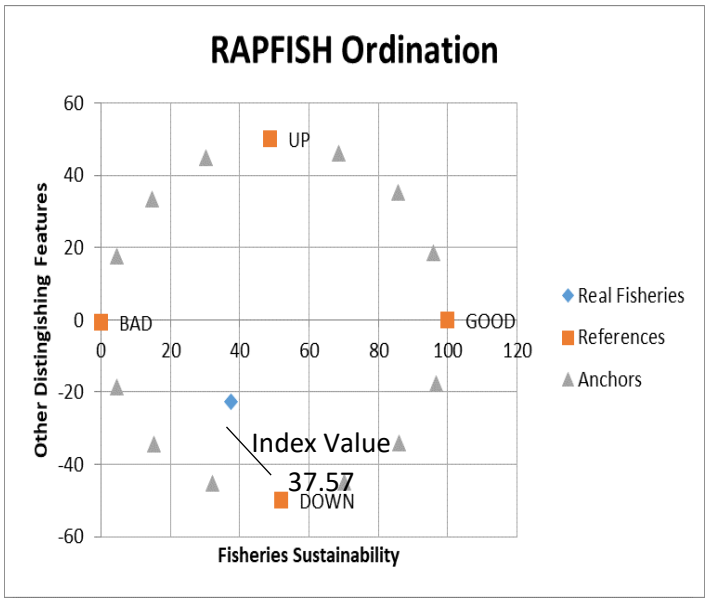

Figure 7. Social dimensions of institutions dimension sustainability index values.

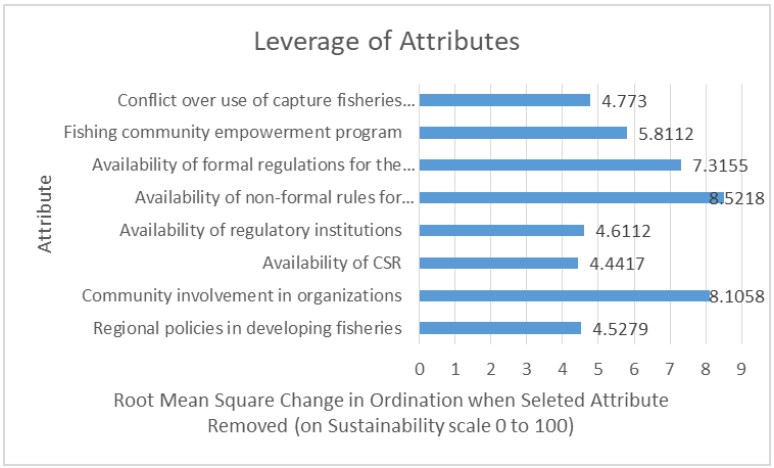

Figure 8. Leverage attribute social dimensions of institutions.

Regional policies for the development of the coastal area of Dumai City have not been optimal in integrating sustainability issues. Poor management can lead to the degradation of coastal ecosystems vital for fisheries. According to Nedi (2010), the large amount of ecological pressure in water areas can lead to the degradation of the coastal regions of Dumai City. Policy implementation is often weak and inconsistent, preventing coastal areas from being managed sustainably. This is also a result of the low participation of communities, especially fishermen, in organizations or groups that manage fishery

resources. Fishing communities are often uninvolved in decision-making and fisheries management, their sense of ownership and responsibility for the resources is considered low.

Table 4

Stress value and squared correlation (RSQ) of social and institutional dimensions

Category	*Value*
Stress value	13.83%
Squared correlation (RSQ)	94.04%

The city of Dumai is known as a port city that is increasingly developing, resulting in increasing environmental impacts and pressures (Siregar & Edward 2010). Companies are carrying out many industrial activities in Dumai's coastal area. These activities include hydrocrackers, palm oil refineries, ship docking, and various port activities, which are potentially significant sources (point sources) of pollution in the Dumai coastal area. Because of these multiple activities, the fishing community in Dumai City feels that the companies' involvement in CSR programs to support fisheries sustainability is still limited. Existing CSR programs focus less on empowering fishermen and managing fishery resources. In addition, the lack of oversight by regulatory agencies means that enforcement of fisheries regulations is still low. Non-formal rules in the form of local customs or traditions are not found in the Dumai fishing community. However, there are formal rules that are used to regulate fishermen's fishing activities. The level of compliance with formal rules is considered low because law enforcement is not effective and consistent. In addition to enforcing formal regulations for fishermen, the relevant government is quite active in providing empowerment programs for fishing communities and fisherwomen. The aim is to generate additional income for fishing families. However, fishermen are still trapped in a cycle of poverty because they do not practice the training and education provided due to a lack of capital to continue these activities.

Discussion. In this study, the results show that the sustainability index in all three dimensions, namely environmental, economic, social and institutional, is in the less sustainable category. This indicates that there are significant challenges that need to be overcome to achieve better sustainability. The following is a detailed assessment and recommendations that can be the first step towards improvement. The research results show that the environmental dimension is less sustainable. This can be caused by various factors such as excessive use of natural resources, environmental pollution, and climate change. To improve environmental sustainability, steps that can be taken include: sustainable natural resource management, by ensuring that the use of natural resources is done efficiently and sustainably; pollution control, by implementing strict policies to reduce emissions and waste that pollute the environment; and environmental awareness, by educating the public about the importance of protecting the environment and practical ways to contribute to the environmental sustainability. In the economic dimension, a low economic sustainability score reflects an imbalance in economic growth, wealth distribution and economic stability. Some recommendations to improve the economic dimension include: economic diversification by reducing the dependence on one sector of the economy and promoting the development of other sectors; economic inclusion by ensuring that all levels of society, including vulnerable groups, benefit from economic growth; and increasing productivity by promoting innovation and efficiency in different sectors of the economy to increase productivity and competitiveness. Finally, the social and institutional dimensions have a less sustainable status, indicating problems in social welfare, inclusion and equality. Some of the steps that can be taken to improve social sustainability include: strengthening social security by developing a social security system that can protect society from economic and social risks; promoting equality by overcoming social and economic disparities by ensuring fair access to education, health, employment opportunities and participation; empowering the community by increasing its active participation to decision-making processes that affect their lives; strengthening governance by developing an effective, transparent and accountable governance system; enhancing institutional

capacity by providing training and capacity development for institutions involved in sustainability management; and promoting cooperation and coordination by encouraging collaboration among different stakeholders to ensure that sustainability efforts are carried out in an integrated and synergistic manner.

Achieving better sustainability requires integrated efforts that address multiple dimensions of sustainability. The steps suggested above can be a starting point for improving the conditions for environmental, economic, social and institutional sustainability. With the commitment and cooperation of all stakeholders, improved sustainability can be achieved for the benefit of present and future generations.

Conclusions. Based on the ecological dimension, strategies that can be implemented in the development of capture fisheries in Dumai City are (1) strengthening the enforcement of environmental regulations and educating the fishing communities about sustainable fishing; (2) promoting the use of selective and environmentally friendly fishing gear; (3) modernizing the fishing fleet to increase the efficiency and reduce the environmental impact; (3) modernizing the fishing fleet to increase the efficiency and reduce the environmental impact; (4) implementing strict pollution control policies and strong monitoring; (5) routinely monitoring and improving the water quality; (6) implementing regulations on the minimum size of fish that can be caught; (7) diversifying the species caught; and (8) using scientific data to set catch quotas and recommend adaptive management of fish stocks. From the economic dimension, several strategies need to be developed, namely: (1) developing superior raw materials and products with high added value; (2) increasing community involvement and participation in fisheries management; (3) optimizing the management of taxes and levies from the fisheries sector; (4) increasing equitable income distribution among fishermen; (5) providing financial and technical support to increase the efficiency and reduce the operating costs; (6) increasingly stable market access to reduce price fluctuations, and (7) improving fishermen's welfare through integrated social and economic programs. Based on the social and institutional dimensions, several strategies can be implemented, namely: (1) strengthening regional and central policies by integrating sustainability principles; (2) increasing community participation and active role in empowerment; (3) encouraging the private sector to contribute more to fisheries sustainability through CSR programs; (4) strengthening appropriate monitoring institutions and strict legal oversight; (5) supporting and enforcing non-formal rules based on local customs and traditions; (6) ensuring that formal rules can be implemented effectively and consistently; (7) developing a comprehensive program for the empowerment of fishing communities; (8) mediating and resolving conflicts among stakeholders to create cooperation in the resource management.

Acknowledgements. The authors would like to express their gratitude for the research funding provided by the Indonesian Endowment Fund for Education (LPDP) through the Equity Program (DAPT), specifically under the national research collaboration scheme/Riset Kolaborasi Nasional (Ri-Na) (Grant No: 524/IT3.D10/PT.01.03/P/B/2023).

Conflict of interest. The authors declare no conflict of interest.

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Received: 10 July 2024. Accepted: 25 November 2024. Published online: 12 December 2024.
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How to cite this article:
Novindra, Sapanli K., Rosanti N., Ramadona T., Ferani L. M. N., Maulina I., 2024 Sustainable fisheries economic management strategy in Dumai City, Riau Province. AACL Bioflux 17(6):2876-2885.