Sustainable Fisheries Management of Flying Fish (*Decapterus* spp.) with Rapfish Analysis in Pasongsongan Waters, East Java, Indonesia

Akhmad Farid[*1], Rahma Dina Nunggal Ubaya[1], Apri Arisandi[1], Darmawan Soecahyo[2]
[1]Universitas Trunojoyo Madura, Indonesia
[2]Badan Riset dan Inovasi Daerah Provinsi Jawa Timur, Indonesia

*Corresponding Author: akhmadfarid@trunojoyo.ac.id

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ABSTRACT

This study aimed to determine the sustainability status offflying fish management in ecological, economic, technological, social and institutional dimensions with a multidimensional study of systems in the Pasongsongan waters. This research was carried out from September to October 2023 at the Coastal Fisheries Port Pasongsongan. The rapfish (Rapid Appraisal for Fisheries) method was applied to determine the condition of fisheries in an integrated manner and to evaluate the sustainability of fisheries in a multidisciplinary manner based on attributes and scores set. The sustainability index value of data processing was between 0 (bad) to 100 (good). The results of this study showed that the sustainability index of flying fish management in the ecological dimension fell within the sustainable category, with a value of 79.12. Similarly, in the economic dimension, the index was 81.19 and classified as sustainable. The technological dimension scored 76.9, placing it within the sustainable category as well. However, the social dimension recorded a value of 64.93, categorized as moderately sustainable, and the institutional dimension scored 55.31, also falling into the moderately sustainable category. The results of the rapfish analysis for the sustainability index of flying fish management in the multidimensional system obtained a value of 70.56, categorizing it as quite sustainable.

INTRODUCTION

Pasongsongan is one of the villages located in Pasongsongan District and includes the westernmost area of the north coast in Sumenep Regency, Madura. The majority of Pasongsongan people work as fishermen, the fishing gear used by Pasongsongan fishermen in general is gill nets, tonda fishing rods and purse seine (**Wahyudi *et al*., 2022**). Purse seine or ring trawl is an effective fishing gear for catching pelagic fish that are clustered and live near the surface of the water (**Fadli *et al*., 2020**). Purse seine in its processing uses rumpon fishing aids to increase catch during the day and uses light aids at night (**Aisyaroh & Zainuri, 2021**). Purse seine fishing gear is mostly used by Pasongsongan fishermen to catch pelagic fish.

Fishing in Pasongsongan waters is carried out every day with the main target being flying fish, but other types of fish are also caught, such as swordfish, selar bentong fish, mackerel, lemuru fish, anchovies and skipjack fish **(Aisyaroh & Zainuri, 2021)**. Flyfish are the main target in fishing due to their economic value and popularity for most people **(Mardiah *et al*., 2022)**. The people of Pasongsongan use kite fish both in fresh and processed form. Glider fish in fresh condition are directly marketed or distributed to Java, such as Semarang and Brondong, while in a processed form, they are turned into salted fish (klotok fish), petis and pindang.

Flying fish (*Decapterus* spp.) includes an important component of pelagic fisheries in Indonesia and usually lives in groups with other fish, such as *Sardinella sirm*, *Sardinella fimbriala*, *Sardinella perforala*, *Rastrelliger kanaguaa*, *Canax* sp., and *Caerio* sp. In Indonesian waters, there are 5 types that are commonly found, namely single *Decapterus*, *D. russelli*, *D. macrosoma*. *D. kurroides*, and *D. maruadsi*. The scientific name of the flying fish is *Decapterus* spp. which consists of two syllables, namely Deca means ten, and pteron that means wings. Hence, Decapterus means a fish that has ten wings. Flying fish is a type of fish that is able to move extremely fast in sea water. This Decapterus genus has a special mark, namely a finlet found behind the dorsal and anal fins; it it has an elongated rounded shape and on the back of the side line (lateral line) there are scales (lateral scute).

Pasongsongan is one of the largest flyfish production areas in East Java Province, which causes fishing intensity to increase due to large market demand. The availability of flying fish resources, which dominate the fisheries potential in Fisheries Management Area of the Republic of Indonesia 712 Java Sea, raises concerns about a decline in their availability in the water area some time in the future.

The utilization of fish resources in their management needs to be carefully executed to ensure an optimal utilization without exceeding the carrying capacity. Excessive utilization of fish resources can pose a threat to sustainability **(Wahyudi *et al*., 2022)**. The purpose of this study was to provide information on the sustainability status of glider fish resources using purse seine fishing gear at Coastal Fisheries Port (PPP) Pasongsongan through ecological, economic, social, technological and institutional dimension approaches with multidimensional system studies.

MATERIALS AND METHODS

Location and time of research

This research was conducted from September to October 2023. The research location is located in Fisheries Management Area of the Republic of Indonesia 712 as the northern part of the Java Sea of Sumenep Regency. Data collection was carried out in this study at Coastal Fisheries Port Pasongsongan (PPP), Sumenep. The technical Implementation Unit (UPT) Coastal Fisheries Port (PPP) Pasongsongan serves as a loading and unloading point for fishing boat catches. The map of the research location is presented in Fig. (1).
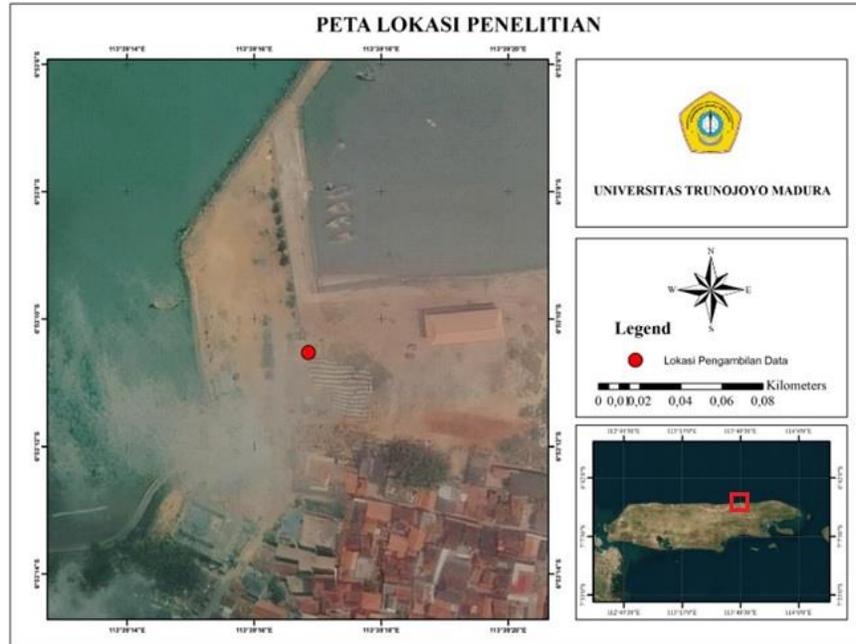
Fig. 1. Pasongsongan water research site

Data collection

The data collected in this study were obtained through observation and interviews using questionnaires administered to 20 respondents, including purse seine fishermen and employees of the Technical Implementation Unit (UPT), PPP Pasongsongan. The data included records on ecological, economic, social, technological and institutional aspects. This study also used Pasongsongan PPP fisheries statistics data from 2014- 2023, where these data were about flying fish catches, the number of fishing gear, and the annual report of PPP Pasongsongan.

Data analysis methods

This study used a multi dimensional scaling (MDS) approach with a popular tool called rapfish (Rapid Appraisal for Fisheries). The rapfish method is an analytical approach used to determine the condition of fisheries in an integrated manner and as a guideline to evaluate the sustainability of fishing businesses. Rapfish analysis was used in determining each measurable indicator using Microsoft Excel software. This method has several aspects of approach, namely ecological, economic, social, technological and institutional aspects **(Triyanto *et al*., 2021)**. The analysis procedure with the rapfish technique was carried out in several stages as follows:

1. Analyzing fisheries statistical data at the study site;
2. Scoring every aspect used;
3. Performing MDS analysis with templates in Microsoft Excel;
4. Rotating to determine the position of fisheries in bad and good ordinations, and
5. Performing a laverage analysis to determine the level of sensitivity

The value of the sustainability index used was between 0 (bad) & 100 (good) and was divided into four categories, namely 0- 25 (unsustainable), 26- 50 (less sustainable), 51- 75 (moderately sustainable) and 76- 100 (sustainable). Leverage analysis is a sensitivity analysis that shows changes within attributes in the bad-good ordination. A longer "bar" indicates a lower score/ value and an attribute rating. This implies that the attribute has a more dominant impact on sustainability. Sensitive attributes are issues that can affect the sustainability status of fisheries resource management so that they can be used as a reference in choosing an election strategy **(Hidayah *et al*., 2020)**.
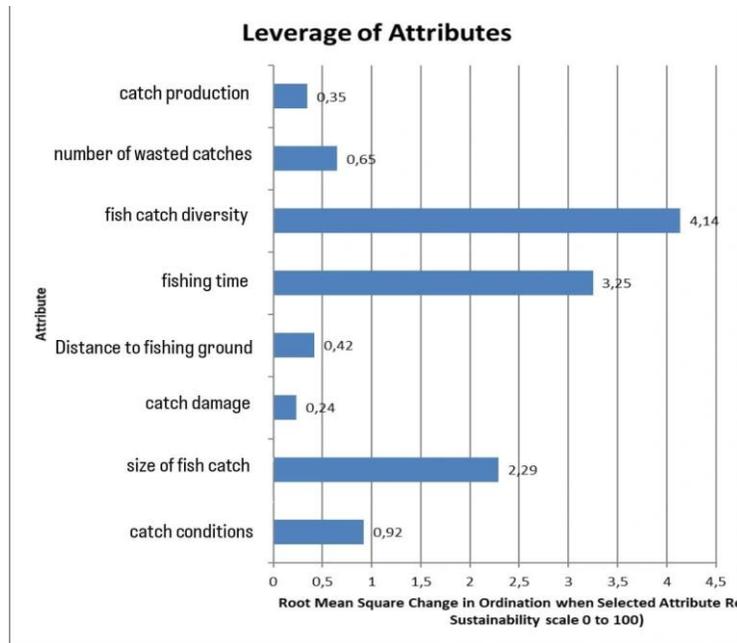
RESULTS

Ecological dimensions

The results of the rapfish analysis of the sustainability index of flyfish management in Pasongsongan waters on the ecological dimension with 8 attributes showed a value of 79.12 (Fig. 2). The index value on the ecological dimension was included in the sustainable category since the sustainable index value is between 76- 100 **(Triyanto *et al*., 2021)**. The resulting squared correlation (R^2) value was 92%, while the stress value was 0.1326 which describes goodness of fit. A low stress value means having a small analysis error, while a high stress value can be concluded that the data are not suitable for use in the analysis process **(Nawangsari & Ismaili, 2022)**.

The results of the sustainability laverage analysis on the ecological dimension can be seen in Fig. (3) to determine the attributes that have a major influence on the sustainability index value of flyfish management in Pasongsongan waters, where the largest attribute value indicates that these attributes have high sensitivity. The results of the analysis at the research location showed 2 main attributes with a high sensitivity, namely the diversity of fish catches with a laverage of atributess value of 4.14, and fishing time with a laverage of atributess value of 3.25. The determination of sensitive attributes graphically can be seen from the length of the bars on the attributes that have been evaluated **(Mahida *et al*., 2019)**.
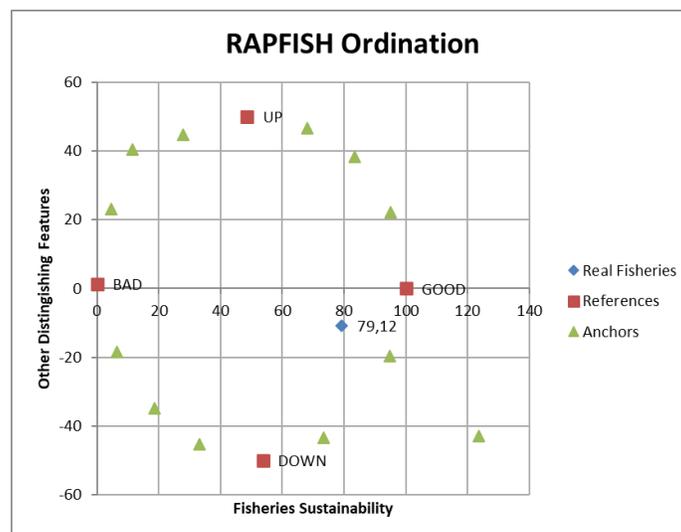
Fig. 2. Rapfish analysis of ecological dimensions of Pasongsongan Waters

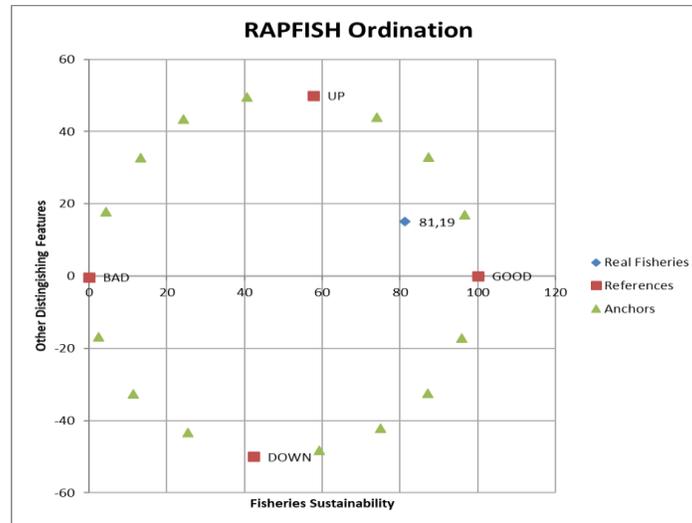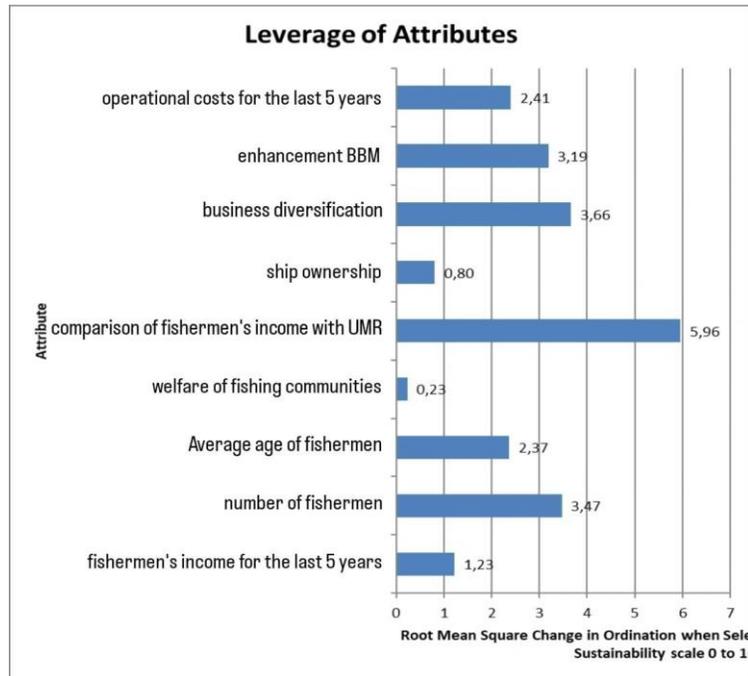**Fig. 3.** Leverage analysis of ecological dimensions of Pasongsongan waters

Economic dimension

The results of the rapfish analysis of the sustainability index of flyfish management in the Pasongsongan waters on the economic dimension with 9 attributes showed a value of 81.19 (Fig. 4). The index value on the economic dimension was included in the unsustainable category since the sustainable index value is between 76- 100 (**Triyanto *et al*., 2021**). The resulting squared correlation (R2) value of 94% indicates that the sustainability index estimation model is accurate to use since the squared correlation (R2) value is more than 80% (**Kavanagh & Pitcher, 2004**). The resulting stress value of 0.1320, which illustrates the accuracy (goodness of fit) in the category, is quite good since it is less than 0.25 (**Alvi *et al*., 2018**).

The results of the laverage sustainability analysis on the economic dimension are displayed in Fig. (5) showing 3 main attributes that have a high sensitivity value, namely the comparison of fishermen's income with regional minimum salary (UMR) having a laverage of atributess value of 5.96, business diversification with a laverage of atributess value of 3.66, and the number of fishermen with a laverage of attributes value of 3.47. These main attributes are used to determine those with a major influence on the sustainability index value of flyfish management in the Pasongsongan waters. Sensitive attributes are problems with each attribute to the formation of sustainability values in a dimension so that they can be used as a reference in choosing management strategies (**Hidayah *et al*., 2020**).

Fig. 4. Rapfish analysis of economic dimensions of Pasongsongan Waters

Fig. 5. Leverage analysis of economic dimensions of Pasongsongan waters

Technology dimensions

The results of rapfish analysis of the sustainability index of flyfish in the Pasongsongan waters on the technological dimension with 9 attributes showed a value of 76.90 (Fig. 6). The index value on the technology dimension was included in the sustainable categorysince the sustainable index value is between 76- 100 (**Triyanto** *et al.***, 2021**). The squared correlation (R2) value produced was 92%, while the resulting stress value was 0.1395, which describes the accuracy (goodness of fit). A stress value close to

zero indicates that the output produced is more similar to the actual state and means that the lower the stress value, the better the model **(Andi *et al*., 2022)**.

The results of the sustainability laverage analysis on the technology dimension can be seen in Fig. (7) to determine the attributes that have a major influence on the sustainability value of flyfish management in the Pasongsongan waters, where the largest attribute value shows that these attributes have high sensitivity. The results of the analysis in the research location showed 3 main attributes with a high sensitivity, namely the use of fishing ground information with a laverage of atributess value of 5.96, the use of tools with a laverage of atributess value of 3.66, and the post-harvest handling with a laverage of atributess value of 3.47.
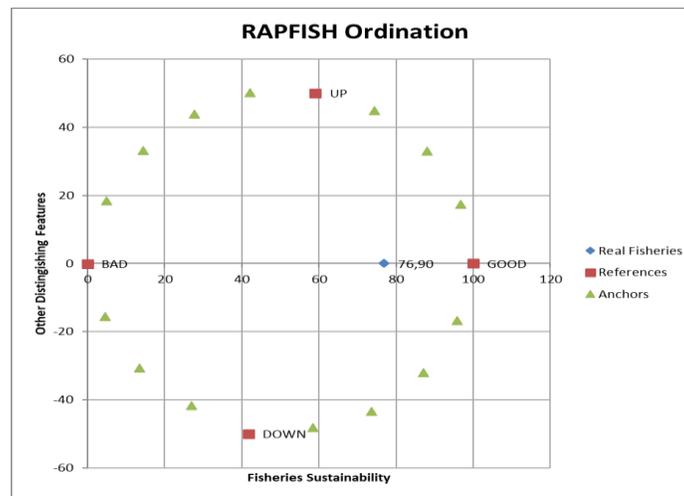

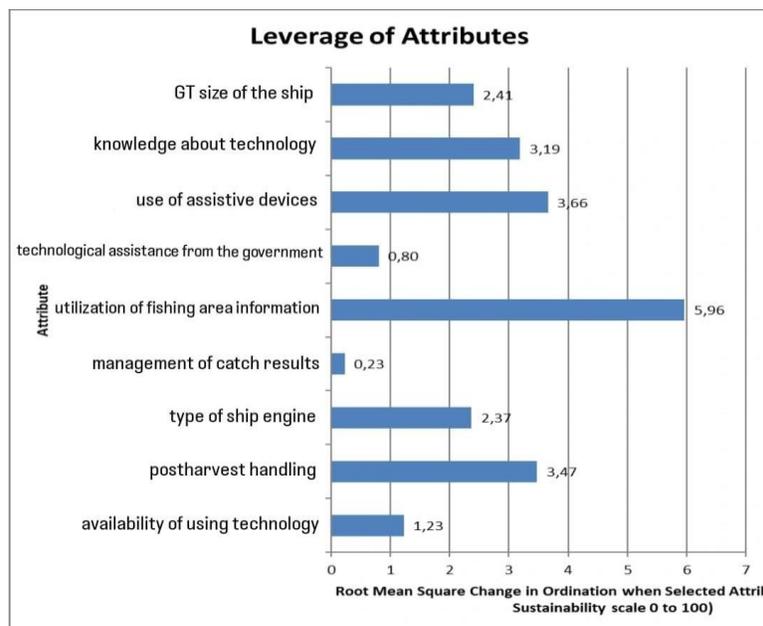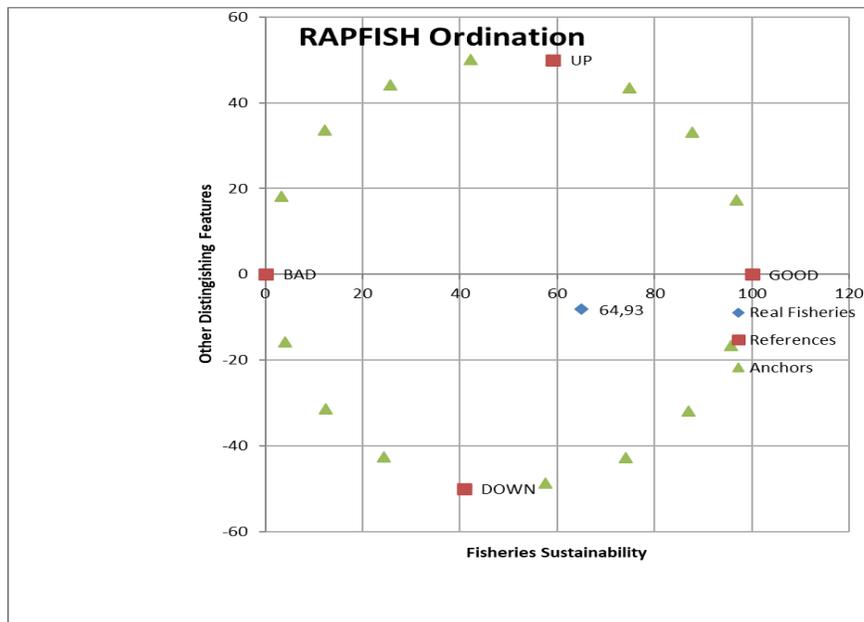**Fig. 6.** Rap analysis of technology dimensions of Pasongsongan waters

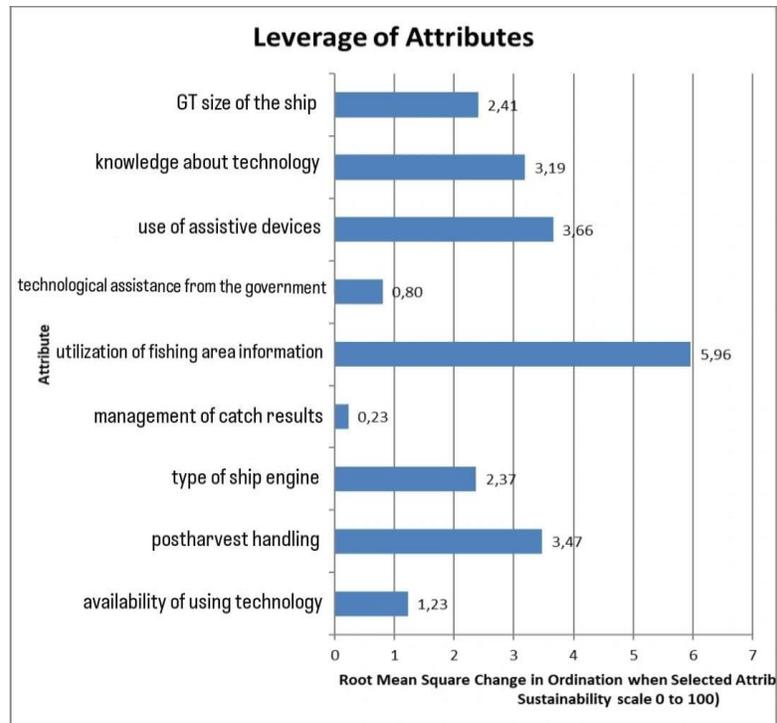**Fig. 7.** Laverage analysis of technology dimensions of Pasongsongan waters

Social dimension

The results of rapfish analysis of the sustainability index of flyfish in the Pasongsongan waters on the social dimension with 9 attributes showed a value of 64.93 (Fig. 8). The index value on the social dimension was included in the sufficient category since the continuous index value is between 51- 75 (**Triyanto *et al*., 2021**). The resulting squared correlation (R^2) value was 94%, meaning that the estimated proportion of various data that can be explained by this analysis technique is identified as adequate since the squared correlation value is >90% (**Alvi *et al*., 2018**). The resulting stress value of 0.1333 which describes the accuracy (goodness of fit) shows a fairly good value since it is classified as a fair criterion, which is between 10- 20% (**Reza *et al*., 2021**).

The results of the sustainability laverage analysis on the social dimension can be seen in Fig. (9) showing 3 main attributes that have high sensitivity values. These main attributes have a major influence on the sustainability index value of flyfish management in the Pasongsongan waters, namely fisheries extension with a laverage of atributess value of 5.96, the existence of fishermen groups with a laverage of atributess value of 3.66 and social conflicts with a laverage of atributess value of 3.47. The existence of sensitivity attributes can affect the increase or decrease in sustainability status (**Pratama & Umar, 2020**).

**Fig. 8.** Rapfish Analysis of social dimensions of Pasongsongan waters

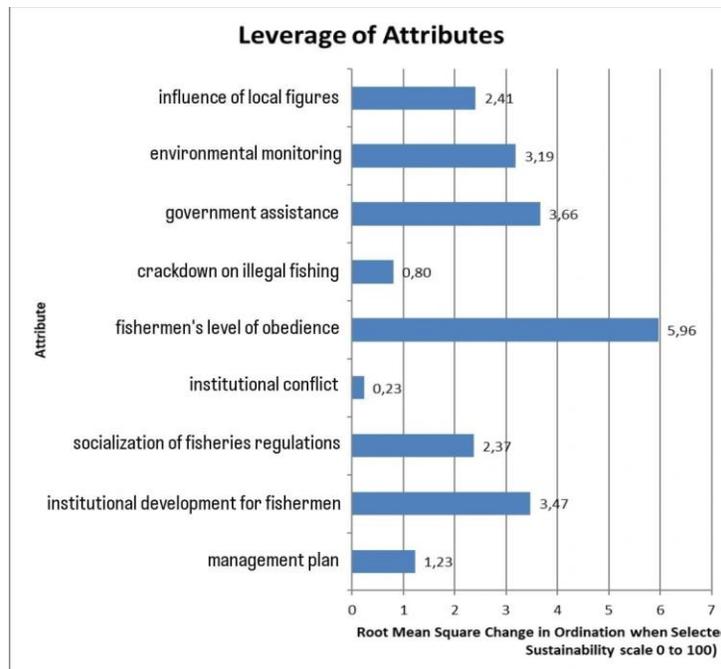**Fig. 9.** Leverage analysis of social dimensions of Pasongsongan waters

Dimensions of institutionality

The results of the rapfish analysis of the sustainability index of flyfish in the Pasongsongan waters on the institutional dimension with 9 attributes showed a value of 55.31 (Fig. 10). The index value on the institutional dimenssion was included in the category of quite sustainable since the index value is between 51-75 (**Triyanto *et al*., 2021**). The resulting squared correlation (R2) value of 95% indicates that the sustainability index estimation model is accurate to use since the squared correlation (R2) value is more than 80% according to **Kavanagh and Pitcher (2004)**. The resulting stress value of 0.1337 illustrates the goodness of fit. A stress values that is close to zero indicates that the output produced is more similar to the actual situation and means that the lower the stress value, the better the model (**Andi *et al*., 2022**).

The results of the sustainability laverage analysis on the institutional dimension can be observed in Fig. (11) to determine the attributes that have a major influence on the sustainability value of flyfish management in the Pasongsongan waters, where the largest attribute value shows that these attributes have a high sensitivity. The determination of sensitive attributes graphically can be detected from the length of the bars on the evacuated attributes (**Mahida *et al*., 2019**). The results of the analysis for the research location showed 3 main attributes that had high sensitivity, namely the level of fishermen's obedience with a laverage of atributess value of 5.96, government assistance with a laverage of atributess value of 3.66 and institutional guidance for fishermen with a laverage of atributes value of 3.47.
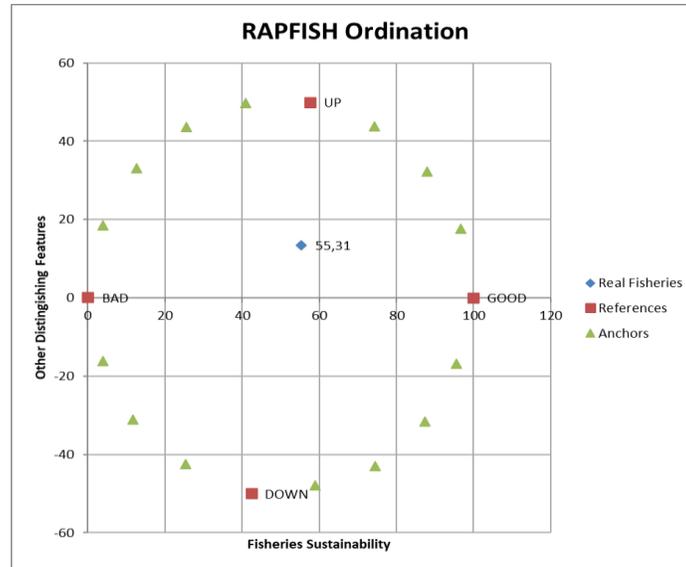
Fig. 10. Rap Analsyis of insititutional dimensions of Pasongsongan waters

Fig. 11. Laverage Analsyis of insitutional dimensions of Pasongsongan waters

DISCUSSION

Ecological dimensions

The diversity of fish catches found in the study location is very low, the fishing gear used by fishermen is purse seine. Purse seine operations in Pasongsongan waters that are the main target of fishing are flying fish. Types of fish caught other than flying fish include swordfish, cuttlefish, mackerel, lemuru fish, anchovies, and skipjack fish.

This research was done in September and October during the swallowfish seaso; therefore, the bycatch or the amount of diversity of fish caught was very low. The number of high and low main catches of fish obtained by fishermen is one of the indicators in the selectivity of fishing gear **(Aisyaroh & Zainuri, 2021)**.

Based on the results of the interview, it is known that the fishing time at the research site is divided into 3 seasons, viz.the peak season, the oncoran season, and the famine season. The peak season or poshake season occurs from July to October, during which fishermen depart at 11.00 Western Indonesia Time (WIB) or 13.00 WIB and come the next day at 09.00 Western Indonesia Time (WIB) or 11.00 Western Indonesia Time (WIB). The oncoran season occurs from November to December; fishermen depart at 14.00 WIB or 16.00 Western Indonesia Time (WIB) and come the next day at 04.00 Western Indonesia Time (WIB) or 06.00 Western Indonesia Time (WIB). The famine season occurs from January to March, when fishermen do not work since they experience westerly winds.

Economic dimensions

The comparison of fishermen's income with regional minimum salary (UMR) is one attribute that has a high level of sensitivity at the study site. Fishermen's income is influenced by fishing results, including the season and the type of fishing gear used **(Yusup *et al*., 2022)**. The statement is in accordance with the conditions of the research site that the kite fish season is from June to September and the fishing gear used by Pasongsongan fishermen is the purse seine. This purse seine fishing gear has a fairly high effectiveness in catching large pelagic fish and small pelagic fish with large sizes and numbers **(Amura & Pirhel, 2021)**.

The second attribute in the economic dimension that has a high laverage value at the research location is business diversification with a laverage of atributess value of 3.66. Based on the results of the interview, it is known that there are Pasongsongan people who have a business processing the catch of kite fish, consisting of petis, salted fish or klotok, and pindang fish. The number of fishermen included the third attribute that had a high laverage value at the study site. Based on the results of an interview, Mr. Rasidi, who has been a local fisherman for 10 years, stated that the number of fishermen is increasing every year, based on data on the number of fishermen data and the number of purse seine boats at UPT Pasongsongan Beach Fishing Port.

Technology dimensions

Based on the results of interviews with fishermen and UPT employees at Pasongsongan Beach Fishing Port, Mr. Rudy mentioned that in operating the purse seine, it is necessary to use fishing aids to collect fish. The tools used during the peak season, precisely from July to October, are rumpon with a fishing ground area of 30 to 35 miles, while in the oncoran season, precisely from November to December, the fishing aids used by fishermen are lights with a fishing ground area of 12 to 18 miles.

Post-harvest handling at UPT Pasongsongan Beach Fishing Port is one of the dimensions of technology that has a high average value of 3.47. At the research site, handling of swallowfish after being unloaded from the ship involves immediately placing them into boxes with additional ice cubes and salt. This ensures that the fish remain fresh and durable during distribution by fishermen. Good and correct handling involves

applying a cold chain, which aims to keep fish in low temperature conditions to inhibit the process of fish meat decay **(Anggraini, 2021)**. Post-harvest handling of fish must be considered since it can affect the quality of the fish.

Social dimensions

With respect to the results of interviews at the fisheries extension research location at UPT Pasongsongan Beach Fishing Port, it was found that the operations runs well every month. Fisheries extension is an attribute with a high sensitivity value on the social dimension with a laverage of atributess value of 5.96. Fisheries counseling in the research location is carried out once a month with 3 socialization topics, viz. the socialization of ship document service facilities, socialization of improving work safety, and socialization of ports. The second attribute that has a high sensitivity value is the presence of a group of fishermen with a laverage of atributess value of 3.66. At the research site, there has been no formation about a fishing group; therefore, it can be concluded that there is no purse seine fishing group.

Social conflict is the third attribute with a high sensitivity value, where this value can affect the sustainability of flyfish management in the Pasongsongan waters. Social conflicts at the research site have occurred, not from the local fishermen but from the migrant fishermen from Sampang who sail in Pasongsongan waters. The conflict occurred because the fishing gear used by Sampang fishermen is cantrang, where the fishing gear is operated to the bottom of the waters. The impact that occurred was that the Pasongsongan fishermen's aids (rumpon) stocked on the surface of the water were trapped with cantrang fishing gear, so that the incident became a social conflict.

Institutional dimensions

The level of fishermen's obedience is one of the attributes that has a high level of sensitivity to the institutional dimension of sustainability of flying fish management in Pasongsongan waters with a value of 5.96. Based on the results of interviews with UPT employees at Pasongsongan Beach Fishing Port, purse seine fishermen have sufficiently complied with the existing regulations from the completeness of ship documents, departure and arrival report letters, port area cleaning service levies, anchorage mooring restribution, and the use of environmentally friendly fishing gear. The perception of purse seine fishermen in Pasongsongan toward environmentally friendly fishing gear has been applied for a long time, and they never used fishing gear that damages aquatic ecosystems, in fact fishermen strongly support sustainable fisheries.

The second attribute that has a high sensitivity value on the institutional dimension with a value of 3.66 is the governmental assistance. At the research site, government's assistance provided at UPT Pasongsongan Beach Fishing Port includes grants of goods such as cool boxes and fish baskets. On the other hand, the 3rd attribute that has a high sensitivity value in the institutional dimension with a value of 3.47 is the institutional coaching. Institutional development for purse seine fishermen at UPT Pasongsongan Beach Fishing Port has been running well once a month. Institutional development (socialization) for fishermsen is carried out as an evaluation every month, so as to increase fishermen's compliance in supporting sustainable fisheries optimally. Socialization of fishermen can increase the self-capacity, abilities, knowledge, skills, and attitudes of fishermen **(Nababan & Wiyono, 2017)**.
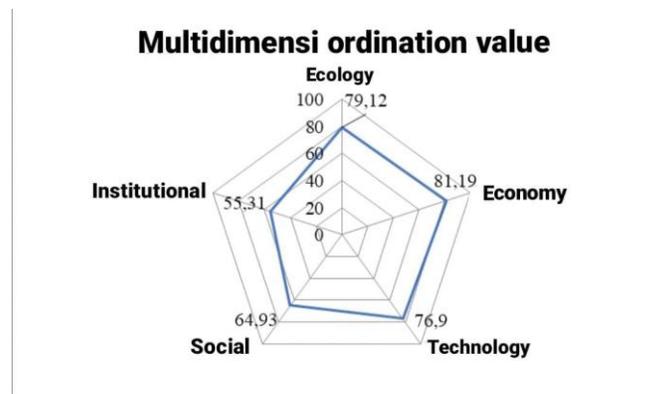
Multidimensional system

The results of multidimensional rapfish analysis using ordination techniques through the MDS (Multidimensional scaling) method resulted in a value of 70.56, with a fairly sustainable category (included in the index 51- 75). The value in this study was obtained based on an assessment of 44 attributes consisting of 8 attributes of the ecological dimension, 9 attributes of the economic dimension, 9 attributes of the technological dimension, 9 attributes of the social dimension and 9 attributes of the institutional dimension. The results of the multidimensional analysis can be seen in Fig. (12).
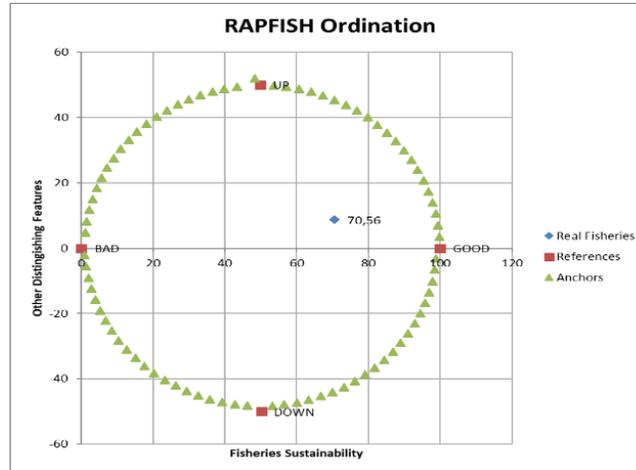
Fig. 12. Multidimensional Rapfish analisyis of Pasongsongan waters

The results of rapfish analysis on each dimension can also be seen in the kite diagram (Fig. 13). The results of the kite diagram on 5 dimensions show that the dimension that the institutional dimension recorded the lowest index value with a value of 55.31, followed by the social dimension with a value of 64.93, the technological dimension at 76.9, the ecological dimension at 79.12, and the economic dimension which had the highest index value at 81.19.

Fig. 13. Pasongsongan waters multidimensional kite diagram

CONCLUSION

The results of the rapfish analysis on the sustainability index of flying fish management in the ecological dimension fell within the sustainable category, with a value of 79.12. Similarly, in the economic dimension, the index was 81.19, aslo classified as sustainable. The technological dimension scored 76.9, placing it within the sustainable category as well. However, the social dimension recorded a value of 64.93, categorized as moderately sustainable.

The results of the rapfish analysis indicate that the sustainability index of flying fish management in the multidimensional system obtained a value of 70.56, falling within the category of moderately sustainable. Among the dimensions analyzed, the institutional dimension had the lowest index value at 55.31, followed by the social dimension at 64.93, the technological dimension at 76.9, and the ecological dimension at 79.12. The economic dimension had the highest index value at 81.19.

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