Sustainability of small-scale fishing in the Zoning Plan of Coastal and Small Island (ZPCSI) of North Minahasa and its influencing factors

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Abstract. The sustainability of small-scale fisheries requires support from various fields, including ecological, human, physical, financial, social, economic, and institutional. The fishers of small-scale fishing in North Minahasa, North Sulawesi face various challenges, including the intersection of fishing zones resulting in shifting fishing areas and the emergence of utilization conflicts between fishers and other stakeholders. This causes economic loss and hardship for the fishers. In the face of threats and pressures, adaptation and the level of resilience of fishers are keys to minimizing risks and ensuring the sustainability of fishing businesses. This study aims to evaluate the sustainability of small-scale fishing in the Zoning Plan of Coastal and Small Islands (ZPCSI) of North Minahasa. The evaluation was conducted through the FLIRES Check, multidimensional approach, and the RAPFISH technique. Data collection was conducted in 8 coastal villages, namely Jayakarsa village; Paputungan village; Tarabitan village; Bahoi village; Munte village; Bulutui village; Likupang Dua village; and Likupang Kampung Ambon village. The results showed that there were 16 sensitive attributes of small-scale fisheries sustainability in North Minahasa (ZPCSI). Attributes that have the highest sensitivity value include coastal resources in terms of income, deep seaports, and assistance program. Coastal resources, the most sensitive attribute, act as a limiting factor for sustainability. Therefore, recommendations for fishing areas that are aligned with the characteristics of oceanographic parameters, water carrying capacity, and the installation of FADs need to be applied to support the sustainability of small-scale fishing in North Minahasa.
Key Words: attributes, FLIRES Check, RAPFISH, small-scale fishing, sustainability status.

Introduction. According to Law No. 27/2007 on the Management of Coastal Areas and Small Islands, the Coastal and Small Islands Zoning Plan (ZPCSI) is the direction of resource utilization in coastal areas and small islands of the provincial government and/or district/city government. The ZPCSI divides its areas into four categories: the general utilization area, conservation utilization area, specific national strategic area, and sea corridor area. The general utilization area categorizes capture fisheries areas alongside other zones. This triggers the issue of utilization conflicts between various interests involved in the utilization area.

Referring to the research results of Ibnusina et al (2023), North Minahasa Regency is one of the regencies in North Sulawesi Province with the largest population of fishers, reaching 2,168 fishers. Fishing activities use hand lines with a boat size of 3-5 GT. North Minahasa Regency is dominated by small-scale fishers with fishing fleets of equal or less than 5 GT. It is also stated by the Regional Marine and Fisheries Agency of North Sulawesi Province (2019) that fishing activities in North Sulawesi are dominated by small-scale fishers. The small-scale fishers are a group of fishers who have many limitations in terms of the fishing units used (type of boat or fishing gear), limited capital, limited travel time to sea, relatively short fishing distances, and the use of energy that

tends to be small (Manoppo 2013; Halim et al 2020). The development of small-scale fishing communities tends to be diverse, so the evaluation of small-scale fishers' problems has not been properly addressed, both in terms of resource management and from a global perspective of social and economic development (FAO 2015). Thus, monitoring and evaluation of small-scale capture fisheries needs to be considered on an ongoing basis as a source of coastal and island livelihoods (Barnes-Mauthe et al 2013).

The implementation of the ZPCSI in North Sulawesi Province has an impact on the sustainability of small-scale fishing businesses. According to the research of Ibnusina et al (2023), the fishing zone of small-scale fishers in North Minahasa intersects with other utilization zones such as aquaculture zones, tourism, conservation areas, biota migration routes, shipping routes, marine installation routes (submarine cables), and public facility zones. Overlapping utilization zones create opportunities for utilization conflicts in North Minahasa waters (Regional Marine and Fisheries Agency of North Sulawesi Province 2019; WCS 2021). The results of research by Ibnusina et al (2023) stated that small-scale fishers complained about the shift of fishing zones to more distant waters. This shift causes an increase in fuel consumption when conducting fishing operations. Fishing operations will be hampered if fuel, as an important operational supply, is not available in sufficient quantities (Sumaila et al 2008; Hamzah et al 2017). This causes small-scale fishers' expenses to increase, but inversely proportional to the income received. The fishers also stated that it was difficult to find mooring locations due to changes in the port structure. This is also emphasized in Dhoaly (2018) that the construction of high embankments on the coast has an impact on the difficulty of finding mooring areas during bad weather. Inappropriate mooring locations cause fishing boats to be damaged, thus disrupting fisher's operational activities. The existing conflict issues emphasize that small-scale fishing businesses are vulnerable. If left unchecked, small-scale fishers will be further disadvantaged and lose their right to conduct fishing activities safely and comfortably.

The fishers need to adapt to existing threats so that they become resilient as a way of facing the risks and challenges. Hapsoro & Buchori (2015) assert that human resilience can counteract the threat of vulnerability, thereby minimizing risks and optimizing capabilities (resilience). The level of resilience of small-scale fishers is closely related to the sustainability of fishing businesses. The sustainability of small-scale fishing businesses is related to the ability of fishers to adapt (Hardy et al 2017). Measuring the sustainability of fishing businesses can be done by comparing the adaptability of fishers in a particular community or sector. Measuring the level of sustainability of fishing businesses is done by identifying vulnerability attributes as factors that can encourage or hinder their fishing businesses (Mamauag et al 2013). The most robust fishing systems are those that exhibit high sustainability and low sensitivity, while the most vulnerable display low sustainability and high sensitivity (Allison & Ellis 2001).

Therefore, the purpose of this study is to evaluate the sustainability status of small-scale fishing businesses in the ZPCSI of North Minahasa and the factors that influence it. The evaluation of the sustainability of small-scale fishing businesses is measured in seven areas, namely natural, human, physical, financial, social, institutional, and economic. By applying the Fisheries Livelihoods Resilience Communities Check (FLIRES Check) instrument, Stanford et al (2017) developed a method that combines the Sustainable Livelihoods Analysis (SLA) approach with the Rapid Appraisal for Fisheries (RAPFISH) method.

Material and Method

Description of the study sites. The research site was located in North Minahasa Regency, North Sulawesi Province (Figure 1). In October 2023, the researchers conducted the data collection.

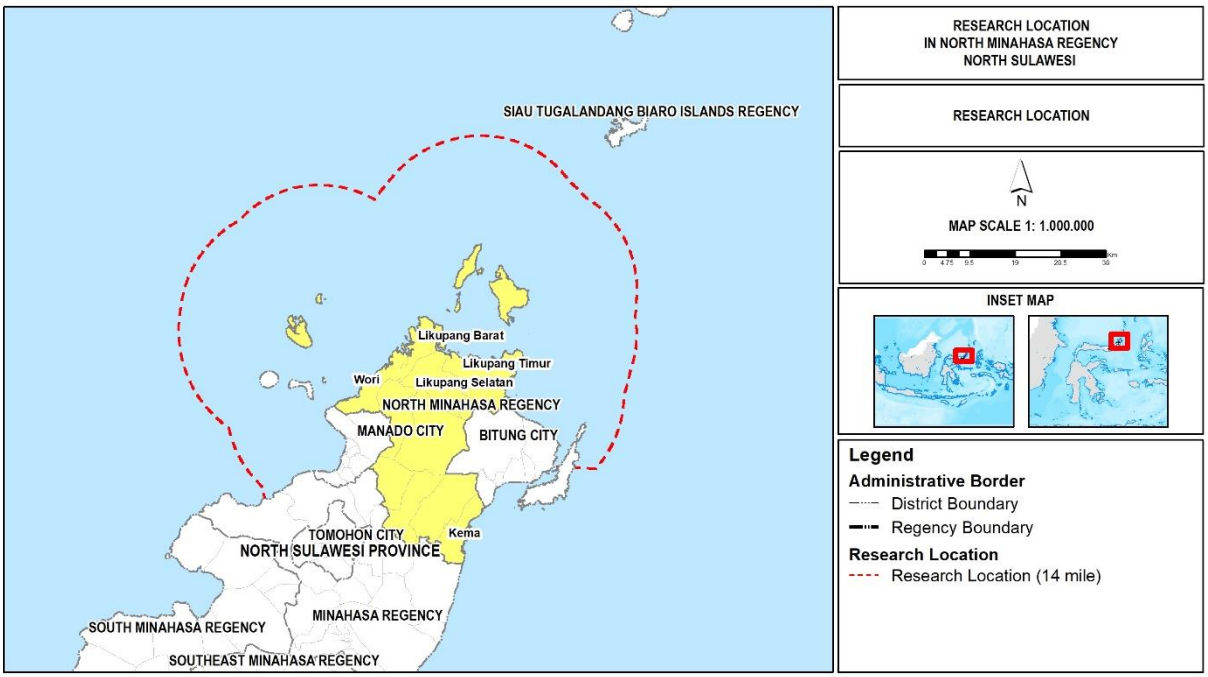


Figure 1. Research location: North Minahasa district, North Sulawesi.

Data collection. The types of data used in evaluating the sustainability status of small-scale fishing in North Minahasa are primary and secondary data. The primary data are data directly obtained from the original source and usually interpret the truth of information according to factual conditions (Pramiyati et al 2017). The types of primary data are categorized into seven fields, namely natural, human, physical, financial, social, institutional, and economic. The type of data used refers to Stanford et al (2014) research related to improving the living status of small-scale fishers in West Sumatra and Vatria (2019) research on evaluating the sustainability of small-scale fishers in North Kayong Regency.

The secondary data are data obtained through various literature sources to support the research studied. The use of secondary data is intended as additional information to support and clarify primary data (Pramiyati et al 2017). Secondary data in this research includes the results of literature studies in various journals or websites related to evaluating the sustainability of small-scale fishing businesses in the North Minahasa area. Secondary data sources can be obtained from local agencies such as the North Sulawesi Marine and Fisheries Agency, Central Bureau of Statistics reports, the Ministry of Marine Affairs and Fisheries, and scientific journals or various other supporting information.

Data collection was conducted in 8 (eight) coastal villages, namely Jayakarsa village (code A); Paputungan village (code B); Tarabitan village (code C); Bahoi village (code D); Bulutui village (code E); Munte village (code F); Likupang II village (code G); and Likupang Kampung Ambon village (code H) (Figure 2). The selection of villages as research samples was determined according to the level of fishing gear diversity operated by fishers with reference to data from the Wildlife Conservation Society (WCS) in 2021. The diversity of fishing gear was first grouped by gear type, followed by the determination of respondents. According to WCS (2021) data, small-scale fishers in North Minahasa predominantly use longlines to catch fish.

The determination of respondents used the purposive sampling method. The selected sample in accordance with the research objectives was determined through special considerations (Lenaini 2021; Prasetyono et al 2021). We determined the number of respondents from each village who were fishers using a fishing unit with a boat size of 5 GT and without a fishing boat. We determined the number of respondents proportionally, at 10%, from each research village.

Thus, the requirements of the fisher's respondents were fishers who live in the research villages and use fishing gear with a boat of 5 GT or without a boat. The total number of fisher respondents in each village was: Jayakarsa village 8 respondents, Paputungan village 8 respondents, Tarabitan village 20 respondents, Bahoi village 10 respondents, Bulutui village 30 respondents, Munte village 25 respondents, Likupang Dua village 100 respondents, and Likupang Ambon village 16 respondents.

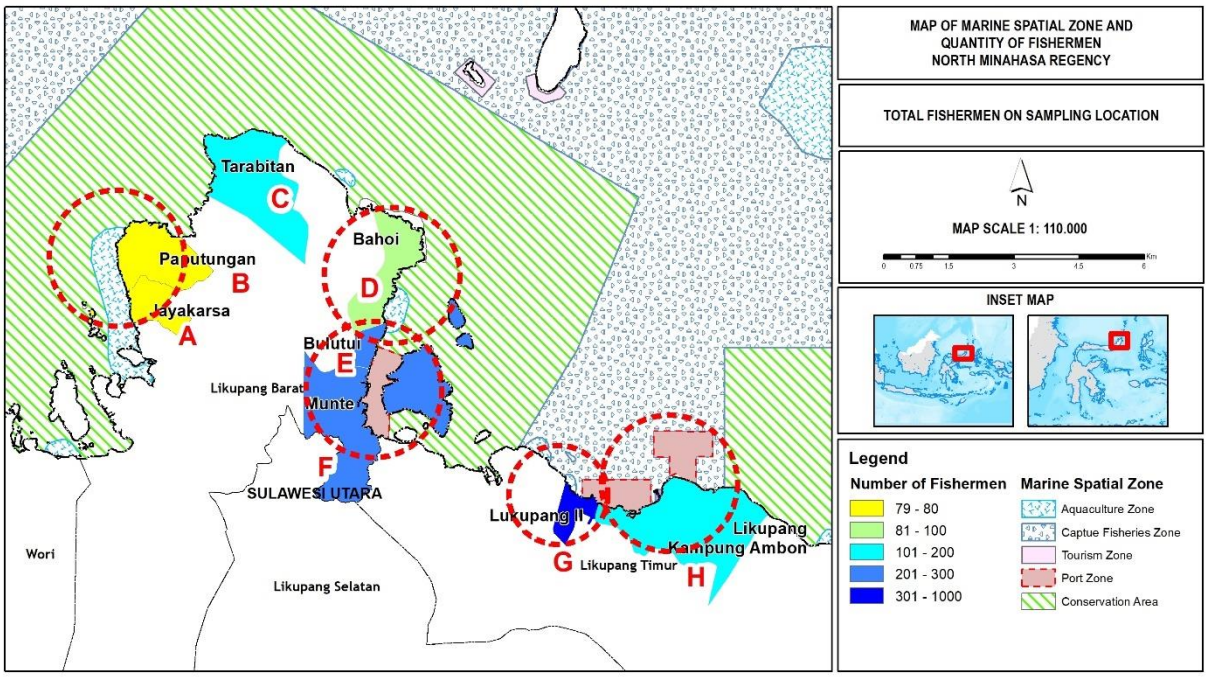


Figure 2. Sampling location of the study.

The researchers collected data using questionnaires that referenced to the FLIRES Check instrument. FLIRES Check is a guideline recommended by Stanford et al (2017) to measure and evaluate the strengths and weaknesses of small-scale fishing to realize the FLIRES Check sustainability of the fishing business. The researcher customizes the type of data used in each category through the FLIRES Check method. Table 1 presents the details of each attribute in each field.

Table 1

Types of data for evaluating the sustainability of small-scale fishing in North Minahasa

(1)

Field	*Attributes*	*Scores* *Poor (3) – Good (0)* *Poor (2) – Good (0)*
Nature	(1) Land resources;	3, or 2, or 1, or 0
	(2) Coastal resources;	3, or 2, or 1, or 0
	(3) Deep sea port;	3, or 2, or 1, or 0
	(4) Travel time to the provincial capital;	3, or 2, or 1, or 0
	(5) Natural hazards.	2, or 1, or 0
Physical	(1) Sale of caught fish;	3, or 2, or 1, or 0
	(2) Use of ice;	3, or 2, or 1, or 0
	(3) Catch;	3, or 2, or 1, or 0
	(4) Boat ownership;	3, or 2, or 1, or 0
	(5) Fishing gear;	2, or 1, or 0
	(6) Physical assets;	2, or 1, or 0
	(7) Family livelihood strategies;	2, or 1, or 0
Human	(1) Normal expenditure;	3, or 2, or 1, or 0
	(2) Minimum income;	3, or 2, or 1, or 0
	(3) Expectations of family education;	3, or 2, or 1, or 0

	(4) Family education;	3, or 2, or 1, or 0
	(5) Family members;	3, or 2, or 1, or 0
	(6) Loans;	3, or 2, or 1, or 0
	(7) Additional income;	3, or 2, or 1, or 0
	(8) Other work;	3, or 2, or 1, or 0
	(9) Sale of catch;	3, or 2, or 1, or 0
	(10) Savings;	3, or 2, or 1, or 0
	(11) Other family chores;	2, or 1, or 0
	(12) Old age provision;	2, or 1, or 0
Finance	(1) Savings for urgent needs	3, or 2, or 1, or 0
	(2) Loans;	3, or 2, or 1, or 0
	(3) Saving routine;	3, or 2, or 1, or 0
	(4) Collateral ownership;	3, or 2, or 1, or 0
	(5) Credit and payment;	2, or 1, or 0
	(6) Remittances from family members;	2, or 1, or 0
	(7) Other sources of income.	2, or 1, or 0
Social	(1) Help each other;	3, or 2, or 1, or 0
	(2) Utilizations of community funds;	2, or 1, or 0
	(3) The right to have a choice;	2, or 1, or 0
	(4) Helpful organizations and community leaders;	2, or 1, or 0
	(5) Fisher's groups;	2, or 1, or 0
	(6) Cooperative attitude.	2, or 1, or 0
Institution	(1) Assistance program;	3, or 2, or 1, or 0
	(2) Fishing business improvement program;	3, or 2, or 1, or 0
	(3) Capacity building training;	2, or 1, or 0
	(4) Proposal submission;	2, or 1, or 0
	(5) Extension officer.	2, or 1, or 0

Source: Stanford et al (2017)

(2)

Field	*Attributes*	*Scores* *Bad (0) – Good (3)* *Bad (0) – Good (3)*
Economy	(1) Average age of fishers;	0, or 1, or 2, or 3
	(2) Fisher's income in the last 5 years.	0, or 1, or 2, or 3
	(3) Operating costs in the last 5 years;	2, or 1, or 0
	(4) Saving rate;	2, or 1, or 0
	(5) Fuel increase;	2, or 1, or 0
	(6) Business diversification;	2, or 1, or 0
	(7) Boat ownership;	2, or 1, or 0
	(8) Fisher's welfare;	2, or 1, or 0
	(9) Number of fishers;	2, or 1, or 0
	(10) Comparison of fisher's income with the minimum wage.	2, or 1, or 0

Source: Stanford et al (2017), some attributes adjusted to the needs of this research.

Data analysis. The FLIRES Check by Stanford et al (2017) is a method that combines the Sustainable Livelihoods Analysis (SLA) approach with the Rapid Appraisal for Fisheries (RAPFISH) method. The SLA is a collection of average questionnaire attribute entries for each field in the villages using Microsoft Excel (Appendix 1). Furthermore, RAPFISH also uses questionnaires that have been filled in by respondents with reference to the FLIRES Check attributes and then checked, coded, and further categorized using Microsoft Excel. The categorized data was then processed to obtain a total score for each field, which was then saved in (*.csv*) format. Furthermore, the data were analyzed using RAPFISH software. The RAPFISH technique is an analytical technique to evaluate the sustainability status of small-scale fishing businesses (Hartono et al 2005; Pitcher et al 2013; Stanford et al 2014; Vatria 2019; Bawole & Apituley 2021; Chaliluddin et al 2023). You can operate the Rapfish software for free on the website (www.Rapfish.org/software) or download it and use it with R programming (www.r-project.org). The data were analyzed through multidimensional scaling (MDS) and leverage.

The result of the MDS analysis is the index value of the sustainability status of the study. If the sustainability index value is high, the study has a high level of livelihood or

resilience. A two-plane plot (scatter plot diagram) interprets the sustainability status index. The x-axis displays the position of each studied material, ranging from 0 (poor) to 100 (good). The y-axis explains that each study material has a different combination of scores for each attribute. The range of index values set as a reference determines the sustainability status. Index values in the range of 0.00-25.00 are categorized as unsustainable, the range of 25.10-50.00 as less sustainable, the range of 50.10-75.00 as moderately sustainable, and the range of 75.10-100.00 as highly sustainable.

The results of the leverage analysis through RAPFISH are used as a reference in determining sensitive attributes. Sensitive attributes can act as inhibiting factors or driving factors in the sustainability of small-scale fishing businesses (Stanford et al 2017). In addition, sensitive attributes can be used as evaluation and consideration materials to improve the sustainability status of small-scale fishing businesses. A bar chart displays the results of the leverage analysis, explaining the value of each attribute. Sorting attributes with a root mean square (RMS) change value greater than half the scale value on the x-axis determines which attributes are sensitive. Statistical parameter tests were conducted to validate the accuracy of the RAPFISH technique analysis results through stress values, coefficient of determination (R^2), and Monte Carlo. Using MDS (the relative position of fisheries management in a good fit or bad fit condition), we use the stress value to determine the accuracy of the analysis results. Modeling is considered good and accurate if it has a stress value of less than 0.25. Furthermore, the R^2 value for each dimension assesses the accuracy level of the RAPFISH analysis results. This aims to determine whether or not it is necessary to increase the number of attributes so that modelling achieves better accuracy. If the R^2 value is close to 1, it means that the number of attributes used to study a field is accurate. The Monte Carlo analysis results aim to estimate the possibility of error in the analysis results. If the comparison between MDS and Monte Carlo values tends to be small or less than 1, then the analysis results obtained have a relatively small chance of error.

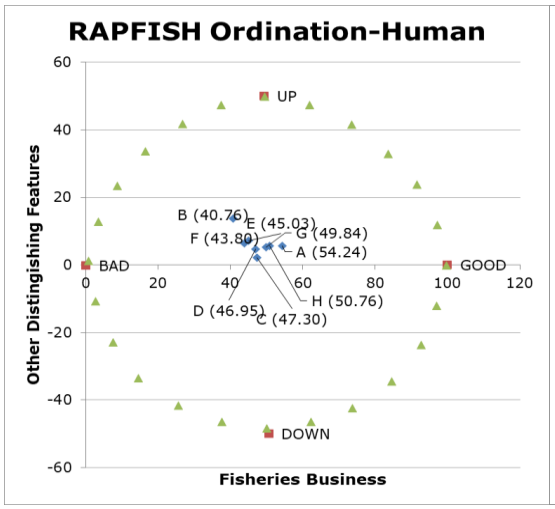
Results and Discussion

Sustainability status of small-scale fishing business. The results of the MDS analysis using the RAPFISH technique showed differences in the sustainability status of small-scale fishers for each field (natural, human, physical, financial, social, institutional, and economic) for each village in North Minahasa. A two-plane plot (scatter plot diagram) interprets the sustainability status in relation to each evaluated attribute in each area. The X-axis represents the position of each village in North Minahasa, while the Y-axis shows the different sustainability status of each village with different total scores for each sector. The position of the fishing business for each village is marked with a blue square symbol (Figure 3A-H).

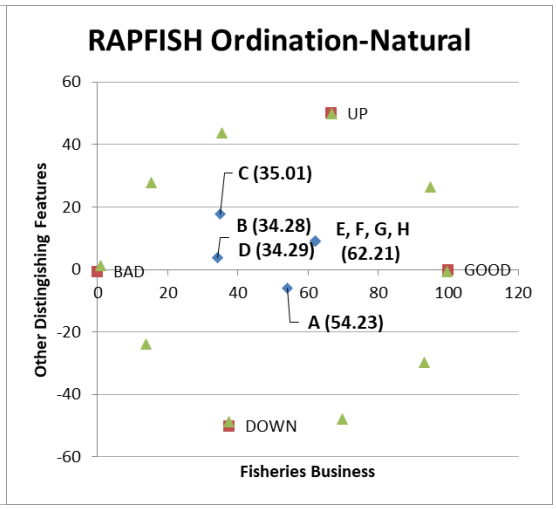
The results of the MDS analysis in the nature sector (Figure 3A) show that Bulutui village (E), Munte village (F), Likupang II village (G), and Likupang Ambon village (H) have the same sustainability position with the highest index value compared to other villages at 62.21. The village is categorized as moderately sustainable because it has an index value (50.00-75.00). Villages that have a less sustainable status with low index values in the range of 25.00 to 50.00 include Paputungan village (B), Bahoi village (D), and Tarabitan village (C).

Based on the results of the MDS analysis on the human sector (Figure 3B), it shows that the sustainability status for the eight (8) research villages is not much different. With an index value of 54.24, Jayakarsa village (A) has the highest sustainability status (moderately sustainable status), and Likupang Ambon village (H) is in the second position with an index value of 50.76. Other villages are in a less sustainable status but tend to lead to a fairly sustainable status, characterized by index values that are almost close to 50.00.

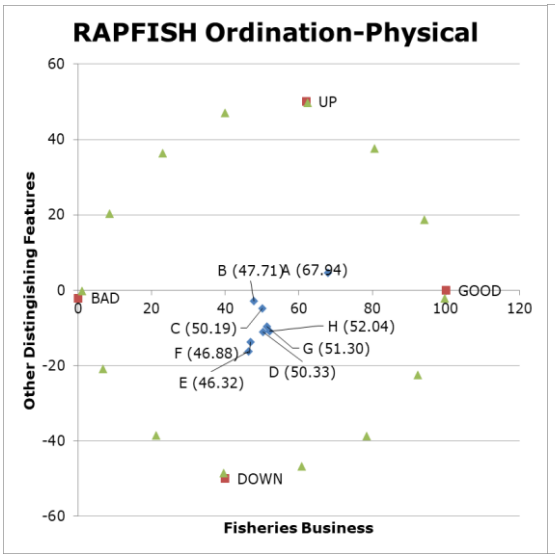
A


RAPFISH Ordination-Human
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
B (40.76)
E (45.03)
F (43.80)
G (49.84)
A (54.24)
H (50.76)
D (46.95)
C (47.30)

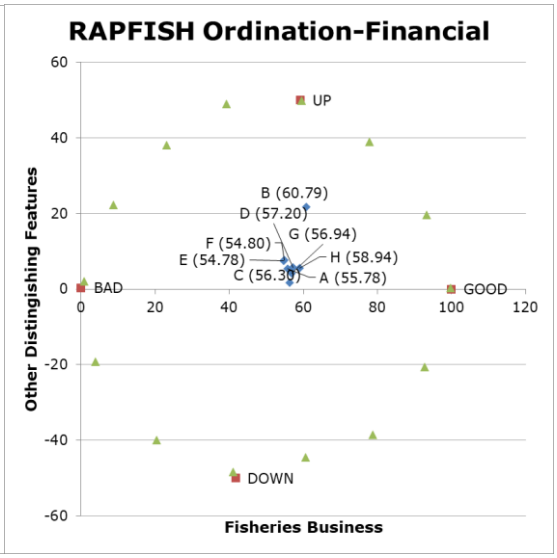
B


RAPFISH Ordination-Natural
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
C (35.01)
B (34.28)
D (34.29)
E, F, G, H
(62.21)
A (54.23)

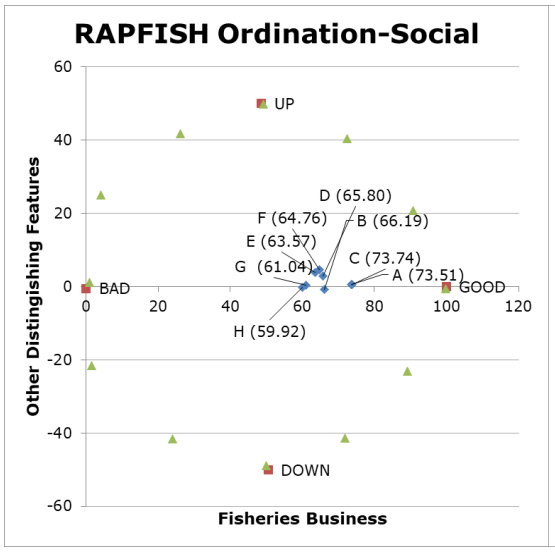
C


RAPFISH Ordination-Physical
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
B (47.71)
A (67.94)
C (50.19)
H (52.04)
F (46.88)
G (51.30)
E (46.32)
D (50.33)

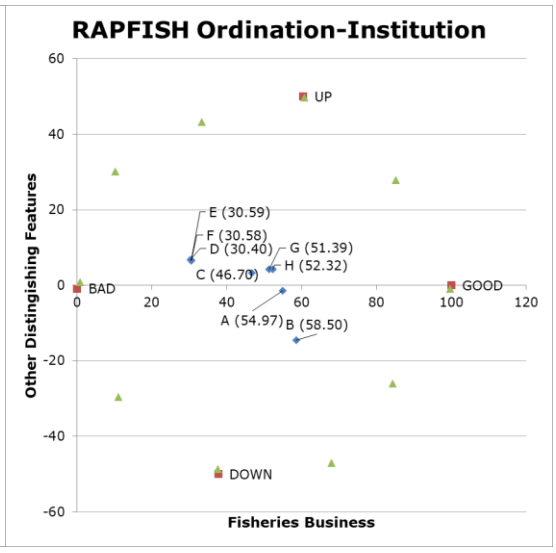
D


RAPFISH Ordination-Financial
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
B (60.79)
D (57.20)
F (54.80)
G (56.94)
E (54.78)
H (58.94)
C (56.39)
A (55.78)

E


RAPFISH Ordination-Social
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
D (65.80)
F (64.76)
B (66.19)
E (63.57)
C (73.74)
G (61.04)
A (73.51)
H (59.92)

F


RAPFISH Ordination-Institution
Other Distingishing Features
Fisheries Business
UP
DOWN
BAD
GOOD
E (30.59)
F (30.58)
D (30.40)
G (51.39)
C (46.70)
H (52.32)
A (54.97)
B (58.50)

G

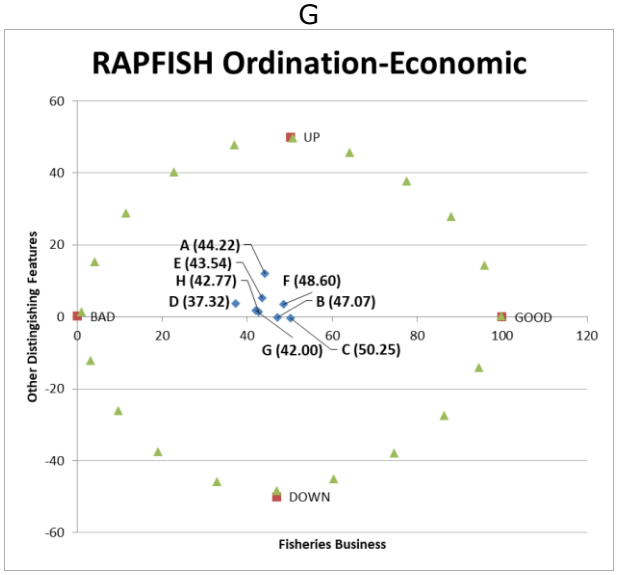


Figure 3. MDS score of small-scale fishers in each village in North Minahasa.

The MDS analysis in the physical sector (Figure 3C) shows that the eight research villages' sustainability levels tend to change, with values that cannot be pinned down. Jayakarsa village (A) is the village that has the highest sustainability index value, with a value of 67.94. Thus, Jayakarsa village (A) has a moderate sustainability status with an index value of 50.00-75.00. The other villages' sustainability index values are much different from Jayakarsa village (A), only falling within the range of 40.00-50.00, with a status of less sustainable to moderately sustainable. Bulutui (E) is the village with the lowest sustainability index value for the physical sector, at 46.32.

The results of the MDS analysis in the financial sector (Figure 3D) represent that the overall position of the research villages is fairly sustainable, with a range of values of 50.00-75.00. Paputungan village (B), is the village with the highest sustainability index value, with a value of 60.79, followed by Likupang Kampung Ambon village (H) with a value of 58.94, and Likupang II village (G) with a value of 56.94. Bulutui village (E) had the lowest sustainability index value at 54.78. This value is not much different from Munte village (F), which has a value of 54.80.

The results of the MDS analysis in the social sector (Figure 3E) show that the sustainability status of all research villages is fairly sustainable, with an index value of 50.00-75.00. The sustainability index of each research village in the social sector tends to be higher than in other sectors. The village with the highest sustainability index value of 73.74 is Tarabitan village (C), while Likupang II village (G) is the village with the lowest sustainability index value of 61.74.

Based on the results of the MDS analysis on the institution sector (Figure 3F), it shows that many villages are in a less sustainable status with index values of 25.00-50.00. In addition, the institution sector tends to have the lowest distribution of sustainability index values compared to other villages. The lowest sustainability index with a less sustainable status was in Bahoi village (D) at 30.40, Munte village (F) with a value of 30.58, and Bulutui village (E) at 30.59. Paputungan village (B) has the highest sustainability index in the institution sector, with a value of 58.50.

The results of the MDS analysis in the economic sector (Figure 3G) show that the sustainability position of the research villages is predominantly lower than in the institutional sector. Tarabitan village (C) is the only one with a moderately sustainable status, with an index value of 50.25. Other research villages have a range of index values (25.00-50.00) with a less sustainable status. Bahoi village (D) is the village with the lowest index value of only 37.32.

Factors affecting the sustainability of small-scale fishing businesses. Leverage analysis is one of the results of RAPFISH processing that is able to identify factors that

affect the sustainability status of small-scale fishing. Sensitive attributes obtained through leverage analysis can be a reference in determining the limiting factors (inhibitors) or driving factors in determining the sustainability status of small-scale fishing. Referring to the results of Stanford et al (2017), the results of the RAPFISH analysis were combined with the FLIRES Check total score assessment. The determination of sensitive attributes as factors inhibiting or driving the sustainability of small-scale fishing in North Minahasa is based on the results of the leverage analysis validated through the FLIRES check. The sensitive attributes analysed can be used as evaluation materials as well as considerations in decision-making in order to maintain the sustainability of small-scale fishing in North Minahasa (Vatria 2020).

Leverage analysis results are presented in the form of a bar graph showing the value of the attributes in each analysed field. The determination of sensitive attributes is known by sorting attributes that have changes in Root Mean Square (RMS) values of more than half the scale of the x-axis value on the bar graph. The results of the leverage analysis of the natural, human, physical, financial, social, institutional, and economic fields are shown in Figures 4-10.

The results of the analysis on the nature plane show that the changes in RMS values for the 5 attributes range from 3.53 to 10.68 (Figure 4).

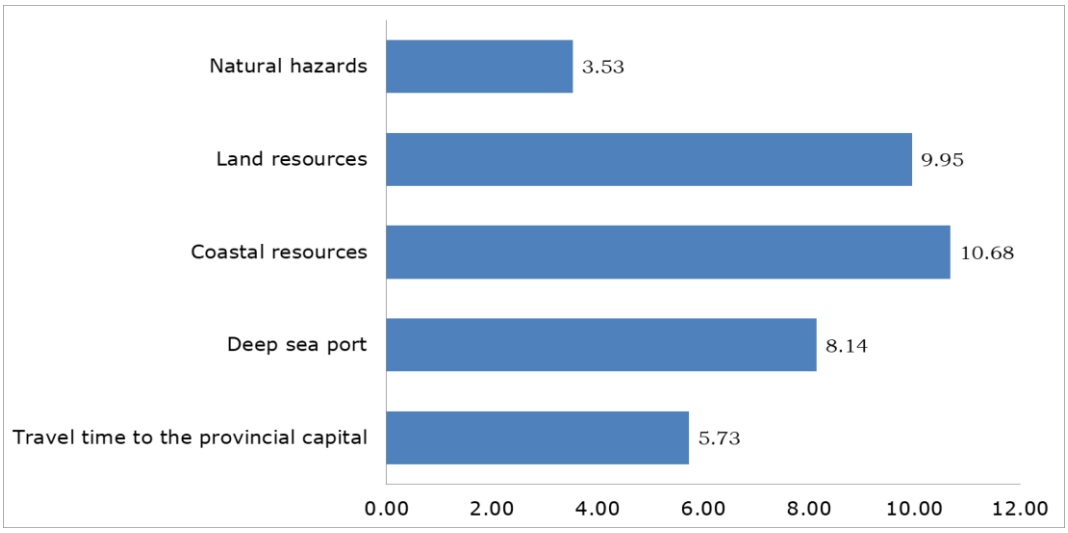


Figure 4. Leverage analysis in the nature field.

The sensitive attributes identified through the leverage analysis are coastal resources (revenue), land resources and deep sea ports. Referring to the average FLIRES check score, the attributes of land resources, coastal resources and deep sea ports have the highest values of 17.11, 16.22 and 11.00 (Appendix 1). This indicates that the attributes of land resources, coastal resources (income), and deep-sea ports act as limiting factors in the sustainability of small-scale fishing in North Minahasa. In the sensitive attribute of land resources, the average respondent believes that they do not own land or even have land, but it is not well managed. Land ownership affects the welfare of fishers. Fishers who have the understanding to manage their land have the potential to increase their income as a side business. Furthermore, respondents also stated that the income earned was much less than the previous income for coastal resource attributes (income). The issue of utilization conflicts, between fishers and other stakeholders, contributes to the decline in income. In line with the research results of Ibnusina et al (2023), the conflict of shifting the fishing zone to a more distant location causes a decrease in income for small-scale fishers. In addition, respondents stated that fishing boats are mostly placed in coastal areas for deep sea port attributes. As cited in Dhoaly (2018), North Sulawesi fishers often have difficulty finding mooring locations due to other activities in the coastal area. In addition, the construction of barriers on the beach is one of the factors in the difficulty of finding additional mooring locations. Therefore, local governments should pay

more attention to the condition of coastal areas so that the sustainability and rights of small-scale fishers can be fulfilled and not hampered.

The results of the leverage analysis in the human sector state that there are 2 sensitive attributes out of a total of 12 attributes analysed, namely the loan attribute and other family work (Figure 5). The FLIRES check results explain that the loan and other family work attributes are the limiting attributes because they have the highest value scores, namely 19.81 for loans and 13.71 for other family work (Appendix 1). On the loan attribute, respondents explained that fishers tend to never try entrepreneurship because they are unwilling to take risks. Fishers even have a tendency to not want to make loans even to build their own businesses. In Wantah (2017) research, fishers tend to focus on one type of fishing business, namely catching fish, without thinking about the possibility of business diversification other than fishing. Another sensitive attribute is the employment of other family members, in this case, fisher's wives. Respondents stated that other family members, especially wives, do not have jobs and only carry out the role of housewife. This is also expressed in Stanford et al (2014) and Vatria (2019), where wives tend to spend time taking care of households, children, and husbands when preparing to go to sea and returning from fishing activities. According to Zuraidah & Lario Saunabella (2018), fisher wives make an important contribution to increasing household income. Wives' participation will help lift family welfare because they get additional income. The form of work that wives can do is entrepreneurship through the utilization of fish catches obtained by their husbands and processing them into various types of food to increase the added value of these products (Putri & Eriyanti 2019).

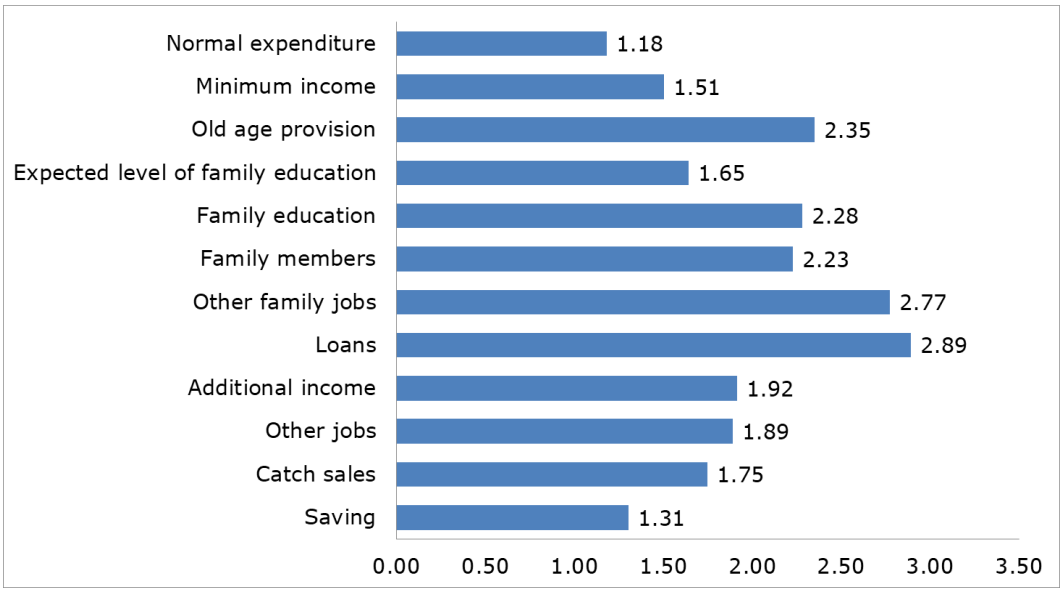


Figure 5. Leverage analysis on the human field.

The leverage analysis on the physical field revealed that there are 2 sensitive attributes out of a total of 7 attributes that impact the sustainability status of small-scale fishing in North Minahasa (Figure 6). The sensitive attributes identified are physical assets and ice use. The FLIRES check results interpreted the physical assets attribute as a limiting factor in the sustainability of small-scale fishing because it has a high score value of 13.16 (Appendix 1). The attribute of using ice as a driving factor towards the sustainability of small-scale fishing has a low score value of 5.02 (Appendix 1). On average, respondents were of the opinion that fishers do not have physical assets to generate additional income other than fishing activities. Examples of useful assets for small-scale fishers include land, livestock, or vehicles. Asset ownership is a way of strengthening the fishing business profile of small-scale fishers (Trijayanti & Muta'Ali 2017). Regarding the attribute of ice use, respondents stated that North Minahasa fishers never lack ice as a supply material due to the location of the ice provider near the market, where it is easily accessible. Adequate ice availability is a sensitive attribute that needs to be maintained.

Fishers have an understanding and awareness of the importance of maintaining the quality of fish so that its quality is maintained (Vatria 2020).

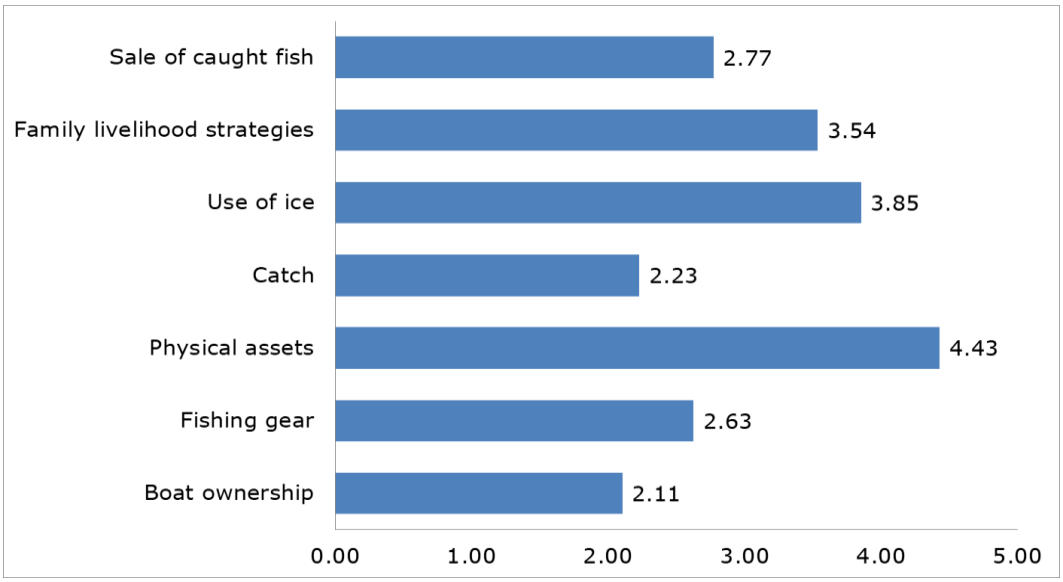


Figure 6. Leverage analysis on the physical field.

The results of the leverage analysis in the financial sector show that from a total of 7 attributes analysed, there are 2 sensitive attributes that affect the sustainability of small-scale fishing in North Minahasa (Figure 7). The sensitive attributes identified are loans and credit and their repayment. The FLIRES check results explain that the loan attribute is a limiting factor for fishing businesses because it has a high score of 19.92 (Appendix 1). The credit and payment attribute is a supporting factor for fishing business sustainability, as it has a low score of 1.74 (Appendix 1). On average, respondents stated that fishers tend to never be able to take out loans. Furthermore, the average respondent was also of the opinion that credit and payments can be repaid in a timely manner or payments can still be made despite late payments.

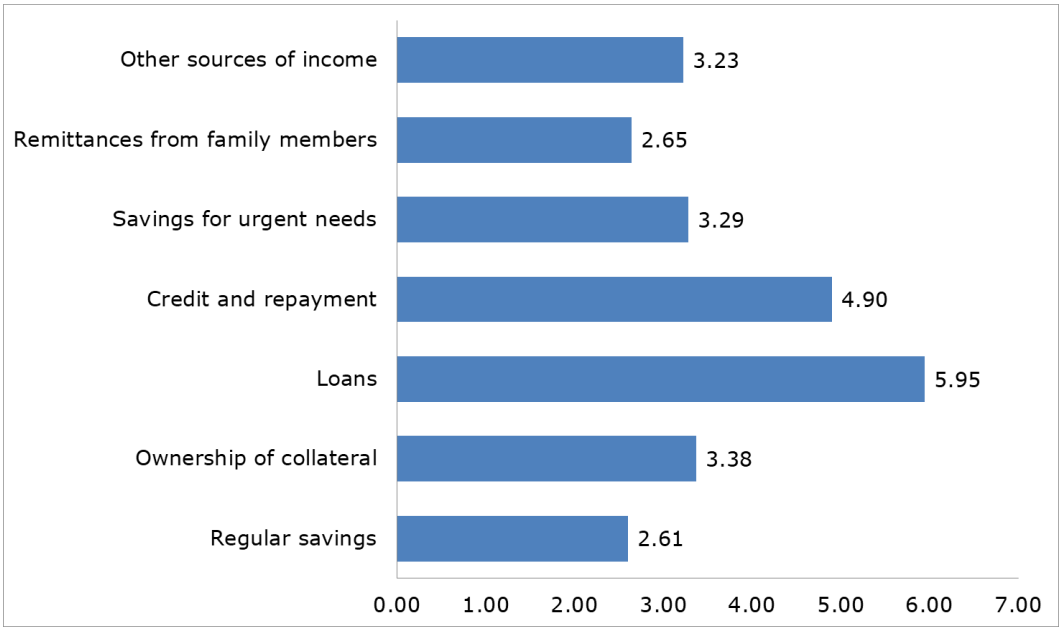


Figure 7. Leverage analysis in finance.

The results of the analysis in the social sector show that the change in RMS values for 5 attributes is in the range of 2.92-6.99 (Figure 8). The sensitive attributes identified

through the leverage analysis are the figures or institutions that help and the attributes that help each other. The FLIRES check results suggest that the helpful figures, institutions, and mutual help attributes are among the drivers of fishing business sustainability, as they have low scores of 5.06 and 3.17 respectively (Appendix 1). Respondents were of the opinion that leaders or community leaders have worked and actively supported the actions of all community members. The contribution of community leaders is key to the success of community-based fisheries management (Sutton & Rudd 2015). A similar opinion was also expressed in a study by Banon et al (2011), that increasing active participation from the community can support sustainable development. In addition, community involvement does not only come from community leaders but also from all components, including local communities, NGOs, the private sector, universities, and other researchers (Kusnandar & Mulyani 2015). Furthermore, in the attribute of mutual help, respondents also said that they were often helped by many parties, including family when they were in trouble. Fishers have a tendency to have a high sense of family or unity. The sense of togetherness that has been nurtured since the parents' era until the sense of common fate causes fishers not to hesitate to help each other (Kandou et al 2022). According to the results of research by Mailangkay et al (2022) conducted in Jayakarsa village, the social life of the community is very close; when there are residents who experience a disaster, the community will come voluntarily to assist. This shows that a sense of togetherness, mutual help, and support from the community and community leaders need to be maintained or even improved as a form of maintaining the sustainability of small-scale fishers in North Minahasa.

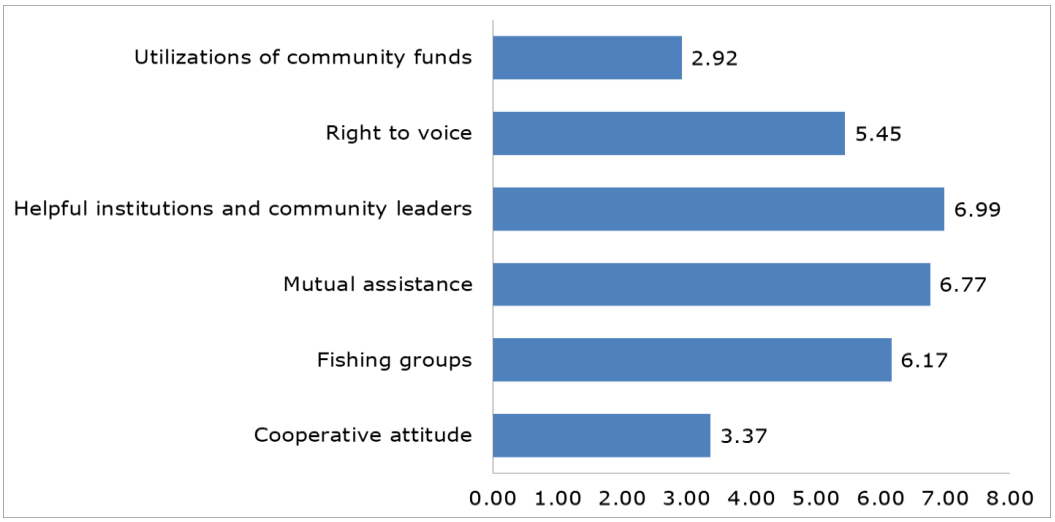


Figure 8. Leverage analysis of the social field.

The institutional field was analysed according to five attributes, with changes in RMS values ranging from 3.81 to 9.30 (Figure 9). The sensitive attributes revealed through the leverage analysis are the assistance program and the fishing business improvement program. Referring to the total FLIRES check score, the aid program sensitive attribute has a value of 0.88 and the fishing business improvement program sensitive attribute has a very high value of 18.89 (Appendix 1). Therefore, the assistance program attribute acts as a driving factor for sustainability as it has a low FLIRES check score and the fishing business improvement program attribute acts as a limiting factor for fishing business sustainability as it has a high FLIRES check score. Respondents stated that the community has received short- to long-term benefits from the assistance programs provided by the government. The assistance programs that have been provided to small-scale fishers in North Minahasa are assistance for boats, outboard engines, procurement of seawater aquaculture infrastructure, procurement of freshwater infrastructure, procurement of environmentally friendly fishing gear, procurement of fishing gear (Cool Box), and provision of grants for infrastructure assistance in the fisheries and marine

sectors. The ongoing assistance program needs to be maintained and improved so that the sustainability index of small-scale fishers in North Minahasa will increase.

However, respondents also stated the opposite of the attributes of the assistance program. Respondents contended that while the community had indeed welcomed the assistance program and the enhancement of fishing businesses, socialization did not follow. This causes the program to fail or even not be on target. Referring to Stanford et al (2017), empowerment needs to be done ideally so that fishers as actors who will implement the program, have an understanding and are ready to implement it.

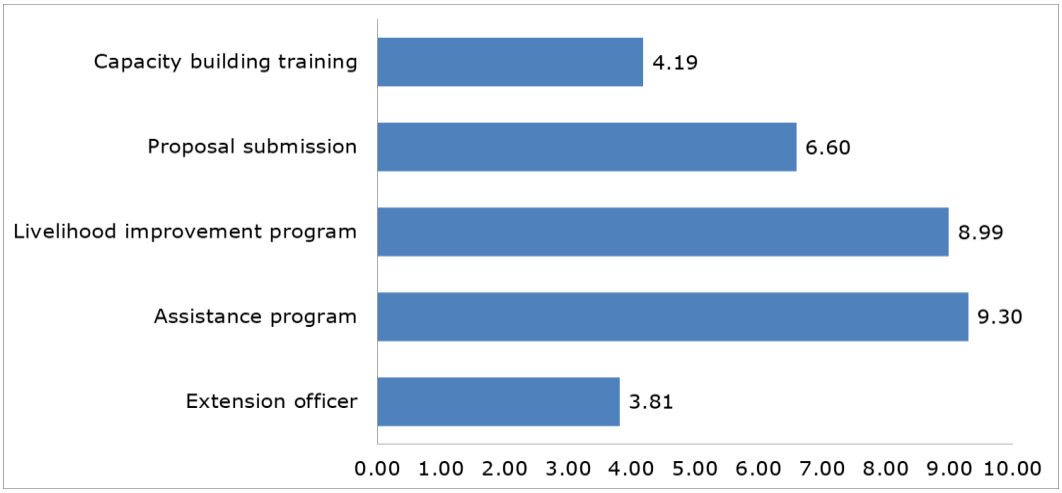


Figure 9. Leverage analysis of the institutional field.

The economic leverage analysis revealed that out of a total of 10 attributes, there are 3 sensitive attributes that impact the sustainability status of small-scale fishing businesses in North Minahasa (Figure 10). The sensitive attributes identified are the ratio of fishers' income to the minimum wage; boat ownership; and fuel increase. The FLIRES check results stated that the fuel increase attribute is a limiting factor in the sustainability of small-scale fishers' fishing businesses because it has a low total score with a value of 1.21. The attributes of fishers' income with the minimum wage and boat ownership are the driving factors in the sustainability of fishing businesses, with high scores of 10.81 and 11.07 respectively (Appendix 1).

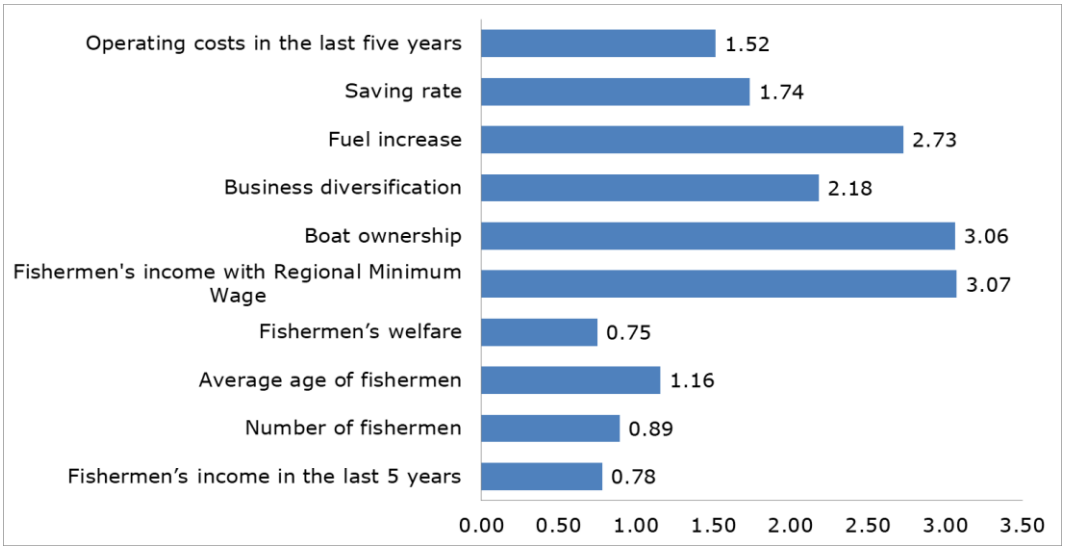


Figure 10. Leverage analysis in economics.

Respondents believed that the increase in fuel greatly affected the operational costs incurred by fishers. In Wantah (2017), high fuel prices for fishing are a problem faced by coastal fishers, especially traditional fishers in North Minahasa Regency. In line with the

results of Ibnusina et al (2023), more fishing areas are outside the research location, as far as 14 km. The long distance from the fishing location will have an impact on the use of more fuel. Furthermore, respondents also stated that the income earned was still above the minimum wage. Referring to the results of Wantah (2017), the northern Minahasa community has a high consumptive behaviour problem. Consumptive behaviour occurs when fishers have more income from fishing, which tends to be spent on less important needs. The community does not save for the famine period, considering that the fishing business depends on seasonal changes. Therefore, for this attribute to be maintained as a driving factor for sustainability, it should be balanced with an adequate understanding of financial literacy. Finally, for boat ownership, fishers stated that the boats used are generally owned or group-owned.

Stress and Monte Carlo values. Stress and Monte Carlo values are other outputs from MDS analysis. The indicators of Stress (S) value and R^2 correlation of each field towards the sustainability status of small-scale fishers in North Minahasa are shown in Table 2. The results of the MDS analysis show that the attributes studied are quite accurate, with an $S < 0.25$ value in each field. Although the S value in the nature field approaches the 0.25 index, it remains an accurate result. The R^2 correlation value for almost all fields is close to 1, except the economy field that has the lowest value of 0.3. This confirms that the number of attributes used in each field is accurate enough to explain the sustainability status of small-scale fishers in North Minahasa.

Table 2

Indicators of stress and RSQ values in the results of MDS analysis of each field

Field	*Stress value (S)*	*R^2 (squared correlation)*
Nature	0.167	0.904
Human	0.177	0.929
Physical	0.205	0.926
Finance	0.189	0.932
Social	0.159	0.915
Institution	0.196	0.911
Economy	0.184	0.300

The Monte Carlo analysis further strengthened the results of the RAPFISH analysis for each field. The Monte Carlo analysis results suggest that the resulting RAPFISH analysis is suitable for use. The comparison between the Monte Carlo value and the MDS value interprets the level of error in the analysis process. If the difference in index values tends to be small, it indicates that the random errors that occur tend to be small as well. The results of the Monte Carlo analysis of the sustainability status of small-scale fishers in North Minahasa are presented in Table 3. We can still categorize the analysis as having relatively small random errors because the difference between MDS and Monte Carlo values tends not to be too far.

Sustainability index of all fields in small-scale fishing businesses. Figure 11 illustrates a scatter diagram that presents the results of the MDS analysis using the RAPFISH technique. The presentation of the diagram is to determine the average score of each field analysed. The position of each village is represented by coloured lines that form a pattern according to the MDS value in each field.

Figure 11 shows the relative position of the scores for each dimension. The sector with the highest sustainability score is the social sector, with an average score of 66.07. The lowest sustainability score is in the economic sector, with an average score of 44.47. When viewed from the average value of each dimension, it is known that the human dimension, institutional dimension, and economic dimension are of poor status, while the natural dimension, physical dimension, financial dimension, and social dimension are of sufficient status. Complete data on the results of the calculation of sustainability values based on location and field of study can be seen in Table 4.

Table 3

Comparison of Monte Carlo and MDS scores on the sustainability status of small-scale fishers in North Minahasa

Field	*AMDS*	*MC*	*BMDS*	*MC*	*CMDS*	*MC*	*DMDS*	*MC*	*EMDS*	*MC*	*FMDS*	*MC*	*GMDS*	*MC*	*HMDS*	*MC*
Nature	54.23	53.41	34.28	35.33	35.01	35.63	34.29	36.15	62.21	60.87	62.21	61.00	62.21	61.31	62.21	61.01
Human	54.24	53.82	40.76	41.81	47.30	47.08	46.95	47.08	45.03	45.27	43.80	44.00	49.84	49.85	50.76	50.76
Physical	67.94	67.58	47.71	47.60	50.19	50.00	50.33	50.50	46.32	46.05	46.88	46.93	51.30	51.55	52.04	52.17
Finance	55.78	56.03	60.79	55.74	56.30	56.27	57.20	52.79	54.78	54.51	54.80	50.05	56.94	57.31	58.94	54.71
Social	73.51	73.17	66.19	64.39	73.74	73.02	65.80	65.51	63.57	63.65	64.76	64.26	61.04	61.77	59.92	60.75
Institution	54.97	55.77	58.50	58.00	46.70	46.22	30.40	31.88	30.59	31.47	30.58	32.58	51.39	51.75	52.32	52.41
Economy	44.22	44.07	47.07	47.20	50.25	50.31	37.32	37.22	43.54	44.00	48.60	48.85	42.00	41.72	42.77	42.75

Note: MC = Monte Carlo; AMDS = multidimensional scaling for Jayakarsa village (code A); BMDS = multidimensional scaling for Paputungan village (code B); CMDS = multidimensional scaling for Tarabitan village (code C); DMDS = multidimensional scaling for Bahoi village (code D); EMDS = multidimensional scaling for Bulutui village (code E); FMDS = multidimensional scaling for Munte village (code F); GMDS = multidimensional scaling for Likupang II village (code G); HDMS = multidimensional scaling for Likupang Kampung Ambon village (code H).

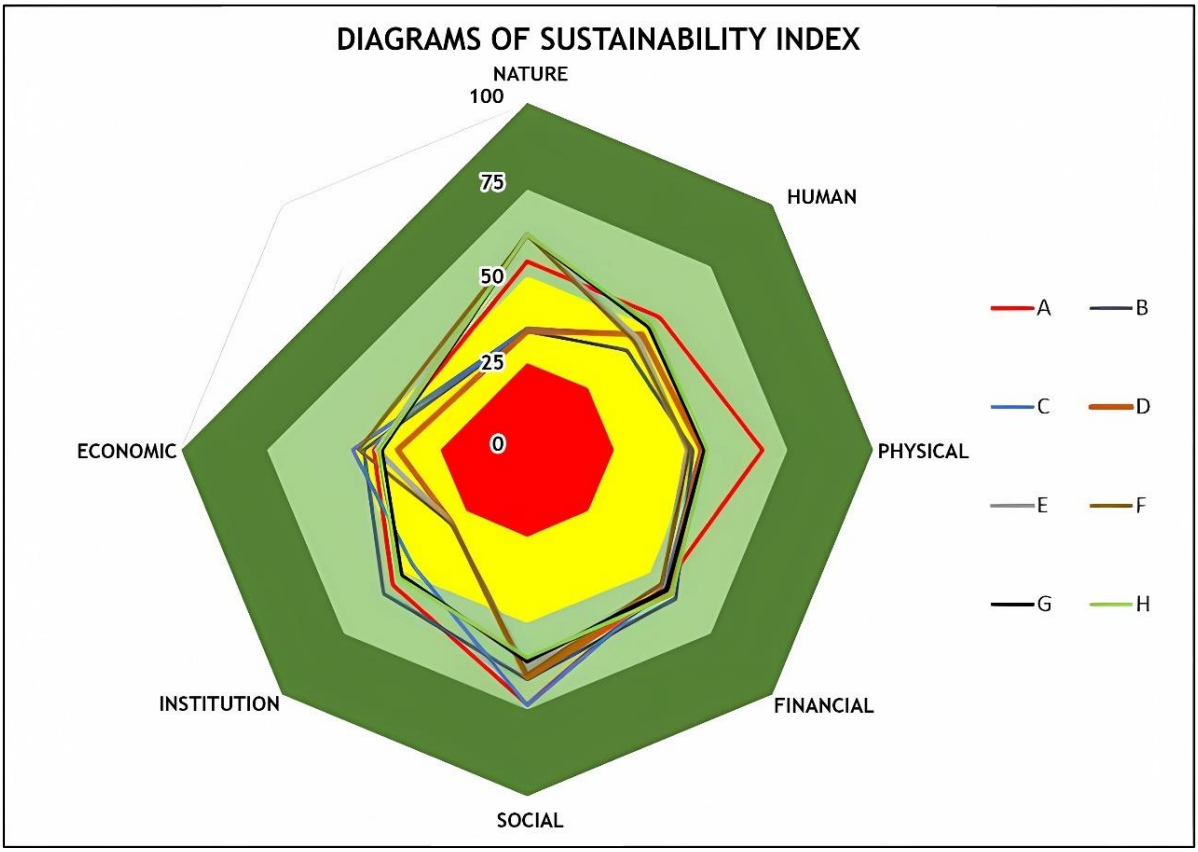


Figure 11. Diagram of sustainability status index values for all areas based on RAPFISH analysis of small-scale fishing in North Minahasa.

Table 4

Sustainability index value of small-scale fishing businesses at each research location

No.	*Location*	*Field*						
		Nature	*Human*	*Physical*	*Finance*	*Social*	*Institution*	*Economy*
1	A	54.23	54.24	67.94	55.78	73.51	54.97	44.22
2	B	34.28	40.76	47.71	60.79	66.19	58.50	47.07
3	C	35.01	47.30	50.19	56.30	73.74	46.70	50.25
4	D	34.29	46.95	50.33	57.20	65.80	30.40	37.32
5	E	62.21	45.03	46.32	54.78	63.57	30.59	43.54
6	F	62.21	43.80	46.88	54.80	64.76	30.58	48.60
7	G	62.21	49.84	51.30	56.94	61.04	51.39	42.00
8	H	62.21	50.76	52.04	58.94	59.92	52.92	42.77
Average by field		50.83	47.33	51.59	56.94	66.07	44.43	44.47

Description:

Index value	*Category*
0-25	Bad
26-50	Less
51-75	Simply
76-100	Good

The fields indicated with less sustainability status are the institutional field (44.43) followed by the economic and human fields (44.47) and (47.33) (Table 2). Other sectors identified as moderately sustainable (index value 50.00-75.00) are the natural, physical, financial, and social sectors. The institutional sector includes the provision of extension programs, empowerment, and skills training to improve human resource capacity. This shows that the institutional sector acts as a link between the small-scale fisher sector and large-scale institutions to support the sustainability of fisher's lives.

Institutions are dynamic as a link between the fishing community and the wider society as a direction in making decisions to allocate resources. Institutional engagement is an important process to achieve the sustainability status of small-scale fishing that tends to form heterogeneous groups in fishing practices (Baiju et al 2022; Garcia-Lorenzo et al 2023). Institutional, human, and economic fields are interrelated and form a domino effect if one of them is in a less sustainable status. The lack of extension activities, empowerment, and assistance programs provided by institutions has an impact on weakening the quality of human resources. The limited quality of human resources will affect the ability of fishers to optimize fishing activities, resulting in an unstable economy (Allison & Ellis 2001; Stanford et al 2014; Vatria 2020). Therefore, evaluations and improvements to each area need to be implemented to realize sustainability in small-scale fishing businesses in North Minahasa.

Recommendations for the sustainability of small-scale fishing in the North Minahasa ZPCSI area. Sensitive attributes of small-scale fishing sustainability in North Minahasa reached 16 attributes from 7 total fields studied (natural, physical, human, financial, social, institutional, and economic fields). Attributes that have the highest sensitivity value include coastal resources in terms of income, land resources, assistance programs, fishing business improvement programs, and deep seaports. The attribute of coastal resources in terms of income is the most influential attribute due to the establishment of the North Sulawesi ZPCSI (Figure 12).

Coastal resource attributes in terms of income are a limiting factor in the sustainability of small-scale fishers in North Minahasa. The decline in income for small-scale fishers is in line with the conflict issue of shifting fishing grounds due to the intersection of fishing zones with other utilization zones in the ZPCSI. The shifting of fishing grounds will increase fuel consumption and increase the cost of fishing operations. In addition, shifting fishing grounds will cause fishers' income to decrease (Muchlisin 2012; Limbong et al 2022). Small-scale fishers, as a community that is often marginalized, are particularly affected by increases in fuel consumption (Maryono et al 2020).

Evaluation of the fishing area mapping needs to be done to support the strengthening of small-scale fishers' fishing businesses. Fishing area mapping needs to be adjusted to the distance that small-scale fishers can travel and the characteristics of the fishing gear used. In the research results of Ibnusina et al (2023), the recommendation for fishing areas in the ZPCSI area of North Minahasa waters not only involves global fishing area information but also adjusts the characteristics of oceanographic parameters and the carrying capacity of existing waters. In addition, based on data from WCS (2021), small-scale fishers in North Minahasa predominantly use longlines as fishing gear. Longline fishers usually use fish aggregating devices (FADs) as auxiliary fishing equipment. Therefore, the location of FADs aligns with recommendations for mapping fishing areas. FADs are expected to increase the chances of catching fish as well as the certainty of fishing grounds for small-scale fishers (Forget et al 2015; Cao et al 2023). In terms of economics, the certainty of the fishing area makes it easier for fishers to estimate the distance travelled and the use of fuel to minimize fuel consumption in fishing activities. Thus, the installation of FADs in North Minahasa waters that are adjusted to the ecological considerations of the waters can encourage the sustainability of small-scale fishing businesses in the area.

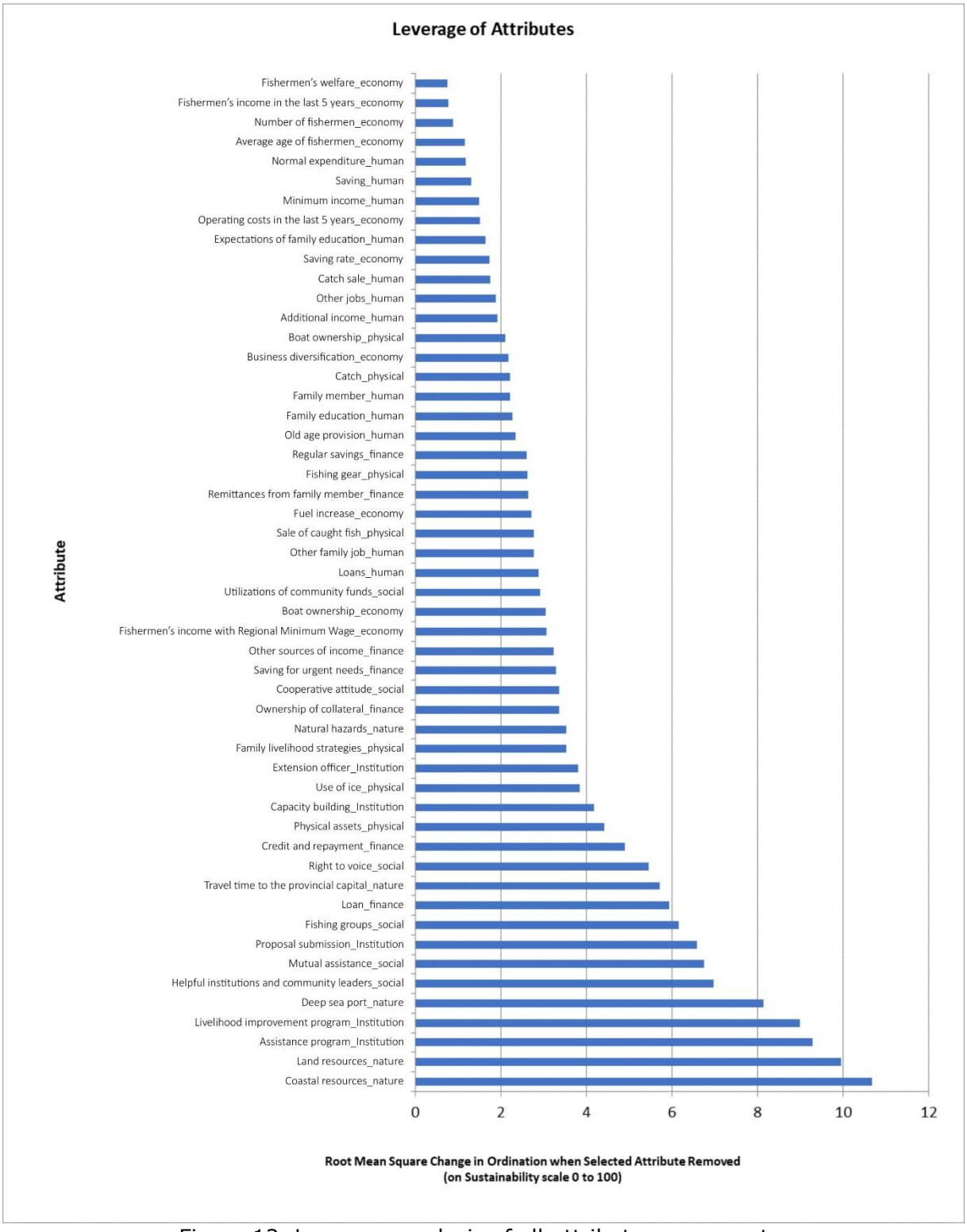


Figure 12. Leverage analysis of all attribute components.

Conclusions. The results of the MDS analysis in determining the sustainability status of small-scale fishing in North Minahasa showed that the factors affecting sustainability have the highest index in the social sector (66.07) and the financial sector (56.94). The lowest sustainability index was in the institutional (44.43) and economic (44.47) sectors. In order to improve the sustainability status of small-scale fishing, improvements need to be made in all areas.

Sensitive attributes of small-scale fishing sustainability in North Minahasa reached 16 attributes from 7 total fields used (natural, physical, human, financial, social,

institutional, and economic fields). The attributes that have the highest sensitivity value include coastal resources in terms of income, assistance programs, and deep seaports.

The coastal resource attribute in terms of income was the most influential sustainability-limiting attribute due to the Coastal and Small Islands Zoning Plan (ZPCSI). Recommendations for fishing areas that are harmonized with the characteristics of oceanographic parameters, water carrying capacity, and FAD installation need to be applied to encourage the sustainability of small-scaled fishing in North Minahasa.

Acknowledgements. We appreciate and thank the Secretary General of the Ministry of Marine Affairs and Fisheries, the Directorate General of Marine Spatial Management, the Directorate General of Capture Fisheries of the Ministry of Marine Affairs and Fisheries, the Republic of Indonesia, and the Marine and Fisheries Agency of North Sulawesi Province for providing access to the data.

Conflict of interest. The authors declare that there is no conflict of interest.

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Received: 29 March 2024. Accepted: 31 May 2024. Published online: 30 August 2024.
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How to cite this article:
Ibnusina F., Purbayanto A., Wiryawan B., Novita Y., Yulianto I., 2024 Sustainability of small-scale fishing in the Zoning Plan of Coastal and Small Island (ZPCSI) of North Minahasa and its influencing factors. AACL Bioflux 17(4):1776-1802.

Appendix 1

Total flires check score for each field in each research village

Field/village name	*Jayakarsa village*	*Paputungan village*	*Tarabitan village*	*Bahoi village*	*Bulutui village*	*Munte village*	*Likupang II village*	*Likupang Ambon village*	*Total score*
				Nature field					
How long does it take by car to reach the provincial capital?	0.00	0.0	0.00	0	0	0	0	0	0.00
Deep sea port	2.00	3.0	3.00	3	0	0	0	0	11.00
State of coastal resources (income)	2.22	2.0	2.00	2	2	2	2	2	16.22
Regional Land resources	1.11	3.0	2.00	3	2	2	2	2	17.11
Natural hazards (shocks) that threaten prosperity (e.g. erosion, flooding)	0.00	0.0	2.00	0	0	0	0	0	2.00
				Human field					
Are you saving money? Where? Do you buy gold, livestock? How often?	0.89	0	0.2	0.85	0.87	0.88	0.26	0.25	4.20
Where do you sell your catch? Do you know the price of the provincial capital?	0.78	0	2.15	0.15	0	0	0.77	0.625	4.47
Please describe your working day. What potential is there for you to do additional catching business?	0.78	0	1.5	1.95	2.1	2.12	1.16	1	10.61
Have you ever had an additional income besides fishing?	1.22	3	1.4	1.6	1.63	1.8	1.55	1.5	13.71

Have you ever tried starting your own source of extra income? Are you willing to borrow money to start your own business?	1.33	3	2.95	2.65	2.73	2.84	2.12	2.19	19.81
What type of fishing business does your wife do?	0.78	2	0.7	1.6	1.53	1.64	1.27	1.188	10.71
How many children do you have?	0.33	1	2.05	0.95	1.23	1.2	1.48	1.5	9.75
Is education something important to your family? What do you hope your children will graduate from?	1.44	1	0.85	1.1	1	1	0.82	0.69	7.90
Given your current economic situation, what level of education can you realistically provide for your children?	1.33	1	1.05	1.05	1.1	1.2	1.04	1.125	8.90
Have you made provisions for when you are too old to go to sea?	1.67	2	1.85	1.9	2	2	1.65	1.44	14.50
What is the minimum income you need to keep your family out of debt?	2.11	3	1.8	1.4	1.9	1.76	2.17	2.25	16.39
What is your normal spending per day on consumables (smoking, coffee)?	1.67	1	1.8	2.8	2.97	2.96	2.03	2	17.22
				Physical field					
Do you have a fishing boat?	1.22	1.44	1.25	2	1.8	1.4	1.69	1.81	12.62

What fishing gear do you have and what does it allow you to catch?	0.22	1	0.85	0.65	1.63	1.64	1.31	1.44	8.74
Besides fishing, what physical assets do you have?	0.44	2	1.6	2	2	2	1.62	1.5	13.16
Did you or your family process the catch? How?	0.56	2	2	2	2	2	1.76	1.625	13.94
Do you use ice to maintain the quality of your catch? Is there enough?	0.44	0	1.35	0.85	0.7	0.68	0.56	0.4375	5.02
Does your home enhance or hinder your family's livelihood strategy?	0.33	1	0.55	0.25	0.36	0.4	0.35	0.375	3.63
Where is your catch sold?	2	2	0.4	0.75	0.63	0.68	0.85	0.8125	8.13
				Finance					
Do you regularly set aside a portion of your income?	0.78	0	0.6	0.9	0.73	0.8	1.16	1	5.97
Do you have anything (such as a land certificate) that can be used as collateral for formal borrowing?	0.444	0	1	0.35	0.57	0.48	0.27	0.25	3.36
Have you taken out a loan? From where /who?	1.56	3	2.6	2.8	2.77	2.76	2.5	1.9375	19.92
Have you ever taken out credit for goods (e.g. television, refrigerator, motorcycle)? Were you able to make the repayments?	0.56	0	0.2	0.2	0.17	0.2	0.23	0.1875	1.74

If there is a need (such as a family member needing surgery or a wedding) do you have savings/ gold/assets that can be used to pay for it?	1	1	0.4	0.35	0.53	0.56	0.45	0.4375	4.73
Do you have household members who are economic migrants? Do they send remittances?	0.78	1	0.7	1	1.13	1.12	1.03	1.125	7.89
Do you have a source of income other than fishing?	1.67	2	1.75	1.75	1.87	1.88	1.57	1.4375	13.92
Social field									
Do people in this community have a cooperative attitude? How is this evident?	1	1	2	1.9	2	2	1.49	1.5625	12.95
Can the people here be trusted - would you form a fishing group/ cooperative with the people? Why?	0	0	0.05	0.15	0.1	0	0.12	0.25	0.67
What do community leaders do to help/ serve the community? Do they do a good job? Why?	0.22	2	0.15	0.2	0.233	0.24	1.08	0.9375	5.06
If you have a problem (such as your boat being washed out to sea/house being damaged in an earthquake) who in the community will help you?	0	0	0.4	0.6	0.7	0.76	0.33	0.375	3.17

For the future of this village, does everyone here have equal rights to contribute their views? Can you protest/complain if something unfair happens?	0.44	0	0.25	0.45	0.6	0.56	0.22	0.25	2.77
If you have a community fund and the fund manager misuses it, what happened?	0.89	2	2	2	2	2	2	2	14.89
				Institutional field					
Do you have an extension officer helping you with your catching business here? How?	0.89	2	1.6	2	1.93	1.92	1.2	1.125	12.67
Tell us about the types of programs/assistance that have been provided to this community? Please give examples?	0.44	0	0	0	0.2	0.24	0	0	0.88
Have you ever received fishing business improvement assistance/programs? Please give an example?	2	2	2.4	3	3	3	1.8	1.6875	18.89
If you have a proposal for your fishing business or for the community to whom can you submit the proposal?	0.44	0	0.8	1	1.07	1.08	1	1	6.39

Have you ever been part of a fishing business improvement/ capacity building training?	0.78	1	1.6	2	2	2	1.2	1.125	11.70
				Economic field					
Fishermen's income in the last 5 years	1	0.44	1.45	0.6	0.8	0.8	0.26	0.25	5.60
Number of fishermen	1	0.78	0.1	0.65	0.43	1.04	0.86	0.875	5.74
Average age of fishermen (number of fishermen per age group)	0.44	1.22	1.05	1.1	0.97	0.92	0.94	1.125	7.77
Welfare of fishing communities (FAO standard)	1	0.67	1.05	0.6	0.87	0.8	0.88	0.8125	6.68
Comparison of fishermen's income with UMR (comparison with UMR)	2	1.55	1.7	0.6	1.6	1.64	0.9	0.8125	10.81
Ship/boat ownership	1.78	1.55	1.6	0.8	1.2	1.64	1.31	1.1875	11.07
Business diversification (other businesses)	0	0.89	1.05	0.75	1.03	1.12	0.88	1.125	6.85
Fuel increase (effect of fuel on operational costs)	0	0.11	0.75	0.1	0.13	0.12	0	0	1.21
Saving rate (EAFM standard saving ability)	0.22	0.89	0.47	0.45	0.13	0.8	0.26	0.8125	4.04
Operating costs for the last 5 years (upward trend in operating costs)	0.56	0.89	1.6	0.1	0.13	0.16	0.87	0.0625	4.37