The Status of Sustainability of Anchovy Resources in the Labuhanbatu Territorial Waters, North Sumatra Province

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Abstract. This research was conducted in August 2017 to analyze the sustainability status of anchovy resources in the Labuhanbatu territorial waters. This study used a method of secondary data analysis and surveys with samples. The data were analyzed following Multi Dimensional Scaling (MDS) method through the RAPFISH (Rapid Assessment Technique for Fisheries) approach. The results indicate that the resources management in Labuhanbatu waters is less sustainable with the index value of 42.76 (<50)

Keywords: Sustainability, Labuhanbatu District, Anchovy

1. Introduction

One of the potential areas in North Sumatra rich of anchovy is the Labuhanbatu territorial waters, located on the East Coast of North Sumatra with an area of 2,561.38 km2 facing the Malacca Strait. The area has 2 (two) watersheds, Barumun and Bilah, making it a considerable area for the capture of fishes.

Anchovy in Labuhanbatu territorial waters is mainly captured using trawls with one fishing fleet consisting of two 20 GT motorboats equipped with a 3 GT outboard motorboat. One single trip to capture anchovy usually lasts for two days and one night. The amount of anchovy caught in Labuhanbatu territorial waters is declining per year along with the decreasing effort of the fishermen [1]. This is allegedly due to the ban on the operation of trawls based on the regulation of the Minister of Maritime Affairs and Fisheries of Indonesia (PERMEN KP: 18 /PERMEN-KP/ 2013) [2] and massive exploitation.

If the decline is not immediately dealt with, the anchovy might be unsustainable. Sustaining the resources requires appropriate management, where the fish resources are maximally deployed without neglecting their sustainability. The fishery development, therefore, must be seen from various aspects as the activities only prioritizing one aspect while ignoring another can damage the ecosystem and eventually threaten the sustainability of resources. There are four sustainability aspects that should be taken into account: ecological sustainability (maintaining stocks/biomass and increasing ecosystem capacity and quality), socio-economic sustainability (the welfare of fishermen and related parties at the individual level), community sustainability (the welfare of community), and institutional sustainability (the sustainable and efficient administration) [3] [4].

A good fishery management is, therefore, necessary to maintain the sustainability of anchovy resources. This is to ensure abundant resources for sustainable fishery [5]. For this reason, a sustainability analysis of anchovy resources is needed to determine the sustainability status of anchovy in terms of ecological, economic, social, technological and institutional aspects by means of sustainability analysis (Rapfish).

This study aims to find out the index value and the sustainability status of Anchovy resources in Labuhanbatu Regency waters based on five dimensions of sustainability (ecology, economics, social, technological and institutional).
2. Materials And Methods

2.1 Location and Time of Research
The research was conducted in August 2017 in the Labuhanbatu territorial waters, North Sumatra. Questionnaires were used to collect primary and secondary data. In addition, stationery and mobile phone were employed to record respondents during interviews, while camera was used to take pictures of the research field. Finally, the researchers used laptop to analyze the data.

2.2 Research Procedure
In this study, the results from secondary data analysis and surveys were examined. The primary and secondary data are related to the attributes of sustainability dimensions, namely: ecological dimensions (5 attributes), economics (6 attributes), social (8 attributes), technology (8 attributes) and institutions (6 attributes). The primary data were obtained from field observation and the results of interviews with 11 respondents selected using the following sampling formula [6][7].

\[ n = \frac{NZ^2P(1-P)}{Nd^2 + Z^2P(1-P)} \]

In addition to respondents, institutions related to capture fisheries, including the Department of Marine and Fisheries of Labuhanbatu District, were also considered as the key informant in this study. The secondary data were obtained from relevant agencies such as the Central Bureau of Statistics (BPS), the Central Department of Marine and Fisheries, and the results from other related studies.

2.3 Data Analysis
The data were analyzed using the Rapfish (Rapid Assessment Technique for Fisheries) technique developed by Fisheries Center, University of British Colombia [8][9][10][11]. Below are the steps of analysis according to Rapfish:
1) Evaluating and determining attributes of the five dimensions.
2) Analyzing the fisheries data of Labuhanbatu territorial waters through statistics.
3) Analyzing the data from field observation and literature studies.
4) Scoring the sustainability of anchovy resources in Labuhanbatu waters.

Monte Carlo analysis should carried out and replicated 25 times following the RAPFISH method to find the error value [8]. The Leverage analysis was done to find out any attributes sensitive to each dimension of sustainability employed in this study. In this analysis, the most sensitive attribute in each dimension was re-analyzed in a multidimensional manner to determine the sustainability status. The Stress value is able to measure how close the two-dimensional distance value is to the multidimensional one. The Stress value, symbolized by S, and the coefficient of determination (R2) were used in measuring the goodness of fit. A good analysis is indicated with low Stress value (S < 0.25) and high R2 values [12]. The assessment of the overall attributes of each dimension of sustainability in the management of anchovy in Labuhanbatu waters is categorized into good, good enough, not good enough, and bad. Clear details of each category can be seen in Table 1.

| No | Dimension | Index Value       | Category       | Description       |
|----|-----------|-------------------|----------------|-------------------|
| 1  | 0.00 – 24.99 | Bad               | Not sustainable|
| 2  | 25.00 – 49.99 | Not good enough  | Less sustainable|
| 3  | 50.00 – 74.99 | Good enough       | Quite sustainable|
| 4  | 75.00 – 100.00 | Good              | Sustainable     |
3. **Results And Discussion**

### 3.1 Ecological Dimension

The score of each attribute in the ecological dimension of anchovy resources can be seen in Table 2.

| No | Indicator                      | Good | Bad | Score | Assessment Basis       |
|----|--------------------------------|------|-----|-------|-------------------------|
| 1  | Exploitation level             | 0    | 2   | 2     | Bio-economic analysis   |
| 2  | Collapse level                 | 0    | 2   | 2     | Modus value             |
| 3  | Size of captured fish          | 0    | 2   | 1     | Modus value             |
| 4  | Percentage of fish discards    | 0    | 2   | 1     | Modus value             |
| 5  | Pressure to utilize waters     | 0    | 2   | 2     | Modus value             |

RAPFISH analysis on ecological dimension can be seen in Figure 1.

![Figure 1](image1.png)

Figure 1. Results of RAPFISH Analysis of Ecological Dimension

The results of the *Leverage* analysis on the ecological dimension is outlined in Figure 2.

![Figure 2](image2.png)

Figure 2. Results of Leverage Analysis on the Ecological Dimension

Table 2 shows that Labuhanbatu territorial waters as a strategic coastal area located on the east coast of North Sumatra are the gateways of marine economic activity towards the Tanjung Balai Asahan and Belawan port in Medan. This means that the pressure of utilization of Labuhanbatu territorial waters is
undeniably high, not only due to the marine nature of the area, but also because of the great volume of economic activities originating from the mainland of Labuhanbatu district. The waters of Labuhanbatu district are densely packed with all economic activities, from being the site for fisheries, transportation, and industry to a place where waste is disposed from the land. This condition has direct implications for capturing fisheries activities as the fishing area is declining significantly, resulting in the lower volume of sea creatures being captured.

Furthermore, the restriction on the operation of trawls as regulated by the Minister of Maritime Affairs and Fisheries of Indonesia (PERMEN KP: 18/PERMEN-KP/2013) makes it even harder for fishermen to catch anchovy. Meanwhile, bio-economic analysis of anchovy resources shows that the percentage of actual effort compared to the level of effort in the MSY condition is 101.97 percent. The percentage over one hundred percent indicates that the actual value is greater than the optimal value of resources to be exploited. This means there has been more input (fishing trips) than what is deemed normal that directly impact on the output (the falling production of anchovy). It indicates that the exploitation of anchovy resources in Labuhanbatu territorial waters has exceeded the maximum sustainable potential (MSY), known as biological overfishing. Moreover, the addition of inputs does not align with the increase in output, signaling fishing inefficiency of anchovy in the territory. In other words, anchovy has been overexploited. The size of captured anchovies is also getting smaller than they were in the last ten years, and there was a significant reduction in fishing area in Labuhanbatu territorial waters due to the increasing waste disposal flowing from the mainland to the waters, which was also caused by the regulation of the Minister of Maritime Affairs and Fisheries of Indonesia (PERMEN KP: 18/PERMEN-KP/2013).

Figure 1 exhibits that the anchovy resources in Labuhanbatu waters are ecologically less sustainable (index value 29.68). In addition, Figure 2 explains three of the most sensitive attributes: the reduction rate of fishing area, the proportion of fish discarded, and the changes in the size of caught fish in the last 10 years.

3.2 Economic Dimension

Table 3 shows the results of assessment on each attribute within economic dimension for anchovy resources in the Labuhanbatu territorial waters.

| No | Indicator                        | Good | Bad | Score | Assessment Basis                                    |
|----|----------------------------------|------|-----|-------|----------------------------------------------------|
| 1  | Profit                           | 4    | 0   | 4     | Bio-economic analysis                              |
| 2  | The fishery contribution towards PDRB | 2    | 0   | 1     | Percentage of PDRB fishery in comparison to the total of PDRB (BPS) |
| 3  | Ownership                        | 2    | 0   | 1     | Modus value                                        |
| 4  | Other income                     | 0    | 3   | 3     | Modus value                                        |
| 5  | Market orientation               | 0    | 2   | 0     | Modus value                                        |
| 6  | Employment                       | 0    | 2   | 1     | BPS Kabupaten Labuhanbatu                          |

The results of RAPFISH analysis are laid out in Figure 3.
Meanwhile, the results of leverage show that ‘Other income’ is the most sensitive attribute, as seen in Figure 4.

Based on bio-economic analysis as outlined in Table 3, the profit of anchovy business in actual condition is Rp. 447,805,860, while the profit at the time of MSY is Rp. 466,751,51 million. Looking at the contribution of the fisheries sector to the total GDP of Labuhanbatu district, which is very small and with a tendency to decline every year, the government of Labuhanbatu clearly does not consider marine and fisheries sector to be a priority in the overall development of the region. Based on data of Fisheries Households – the number of households employed in fishery sector – from 2007 to 2016 (10 years) as issued by the Central Statistics Agency of Labuhanbatu district, anchovy fisheries only contributed an average of 0.18% to the employment in Labuhanbatu District. It is also known that the fishing facilities for anchovy fishermen are mostly owned by local owners. Being fishermen is the main job of the people in the area. All anchovies are sold in the local market to meet the needs of people in Labuhanbatu.

Figure 3 shows that the economic dimension has a fairly sustainable status with an index value of 52.07. In addition, the most sensitive attribute after the Leverage analysis as shown in Figure 4 is ‘Other income’.

Figure 3. Results of the RAPFISH Analysis of Economic Dimension

Figure 4. Results of Leverage Analysis on Economic Dimension
3.3 Social Dimension

Table 4 shows the results of assessment on each attribute within social dimension for anchovy resources in the Labuhanbatu territorial waters.

| No | Indicator                                                                 | Good | Bad | Score | Assessment Basis                  |
|----|---------------------------------------------------------------------------|------|-----|-------|-----------------------------------|
| 1  | The growth rate of the number of fishermen in 10 years                     | 0    | 2   | 0     | BPS Labuhanbatu District          |
| 2  | Knowledge                                                                 | 2    | 0   | 0.5   | Modus value                       |
| 3  | Fishermen’s level of education                                            | 2    | 0   | 0     | Modus value                       |
| 4  | Status and conflict frequency                                             | 0    | 2   | 1     | Modus value                       |
| 5  | Family participation                                                       | 1    | 0   | 0     | Modus value                       |
| 6  | Socialization of fishing                                                   | 2    | 0   | 1     | Modus value                       |
| 7  | Socialization frequency                                                    | 3    | 0   | 2     | Modus value                       |
| 8  | Fishermen’s influence                                                      | 2    | 0   | 0     | Modus value                       |

The results of the RAPFISH and Leverage analysis on the social dimension are outlined in Figure 5 and Figure 6.

![RAPFISH Ordination](image_url)

**Figure 5.** Results of RAPFISH Analysis of Social Dimension
Data from the Central Statistics Agency of Labuhanbatu District show that the average growth rate of anchovy fishermen for the past ten years is -0.056. The smaller the number of people engages in fisheries, the smaller the need for fisheries resources (thus minimizing the sustainability of fisheries in the region [14]. Moreover, most fishermen only pass elementary school level. The low level of education is the primary cause of their limited understanding of environmental issues. It is rare for conflicts between locals or between locals and migrants to occur. Unfortunately, in most instances, almost none of family members involve in the anchovy business – most fishermen do not want children to follow their career. It is also uncommon for the anchovy fishermen to have meetings as most of them have formed a local joint business group (KUB).

The results of the analysis in Figure 5 show that the sustainability index value is 36.78 (categorized ‘less sustainable’), while Figure 6 demonstrates three dominant attributes: family participation in fisheries resource utilization, fisherman level of education, and frequency of conflict status.

3.4 Technological Dimension
The results of assessment for each technological dimension attribute of anchovy resources are presented in Table 5.

Table 5. Results of assessment of each attribute of technological sustainability dimension of anchovy resources

| No | Indicator                                      | Good | Bad | Score | Assessment Basis   |
|----|------------------------------------------------|------|-----|-------|--------------------|
| 1  | Places where to land captured fish             | 0    | 2   | 0     | Direct observation |
| 2  | Length of fishing trip                         | 0    | 2   | 1     | Modus value        |
| 3  | Types of fishing tools                         | 0    | 2   | 2     | Modus value        |
| 4  | Selectivity of fishing tools                   | 2    | 0   | 2     | Modus value        |
| 5  | Handling in vessel before fish being landed   | 3    | 0   | 2     | Modus value        |
| 6  | Size of fishing vessel                         | 0    | 2   | 2     | Modus value        |
| 7  | The usage of destructive fishing tools         | 0    | 2   | 0     | Modus value        |
| 8  | Change in capture power                        | 0    | 2   | 2     | Modus value        |

The results of RAPFISH and Leverage analysis on the technological dimension can be seen in Figure 7 and Figure 8.
The fishing tool actively used to capture anchovy is trawls, using 10 GT and 20 GT vessels and equipped with a 3 GT vessel. A single fishing trip lasts for two days and one night since fisheries activities in Labuhanbatu territorial waters are dominated by small-scale fishing businesses. Moreover, the usage of destructive auxiliary fishing tools is less common. Most fishermen sell anchovy the day after going back from the sea. The fish sold are dried anchovy because after being caught, the fish are cleaned, boiled using salt, drained and dried on the roof of fishing boats.

The results of the RAPFISH analysis on the technological dimensions outlined in Figure 7 show a sustainability index value of 52.27, which is in a fairly sustainable status. The most sensitive attributes based on the leverage analysis shown in Figure 8 are fishing vessel size, the selectivity of fishing tools, and kinds of fishing tools.

### 3.5 Institutional Dimension

Surveys and interviews with key informants reveal that the government of Labuhanbatu has sufficient formal regulations in fisheries management. The regulations, however, come from the Minister of Maritime Affairs and Fisheries Ministry so that fishermen have no position in the management of fisheries (just management). Meanwhile, illegal fishing sometimes occurs in Labuhanbatu territorial waters. The fishermen are also geographically and historically not close to one another in fisheries.
management. Some fishermen have side jobs, such as selling groceries. Meanwhile, there have been formal institutions supporting fisheries resource management, but their influence is still minimal.

The results of analysis in Figure 9 show the index value of 42.99 (less sustainable status), while the results of leverage analysis in Figure 10 reveal that the three most influential attributes are: the position of fishermen in fisheries business, other jobs outside fisheries, and illegal fishing. Table 6 details the assessment of attributes of institutional dimension.

| No | Indicator                                      | Good | Bad | Score | Assessment Basis                                      |
|----|------------------------------------------------|------|-----|-------|-------------------------------------------------------|
| 1  | The presence of formal regulation of fishery management | 2    | 0   | 1     | Secondary data, modus value from interviews with respondents |
| 2  | Just management                                 | 4    | 0   | 0     | Modus value                                            |
| 3  | Illegal fishing                                 | 0    | 2   | 1     | Modus value                                            |
| 4  | Adjacency and reliance                          | 3    | 0   | 1     | Direct observation, modus value                        |
| 5  | Alternatives                                    | 2    | 0   | 1     | Modus value                                            |
| 6  | Formal Institutional Role (DKP)                 | 3    | 0   | 1     | Direct observation, modus value                        |

Figure 9 and Figure 10 detail the results of RAPFISH and Leverage analysis on the social dimension.
3.6 Results of Monte Carlo Analysis

The comparison between the sustainability index of MDS results and the results of Monte Carlo analysis is presented in Table 7.

**Table 7. The Comparison between MDS Sustainable Indices and Monte Carlo Analysis (Reliability Interval of 95%) of Anchovy Resources**

| Dimension | MDS  | Monte Carlo | Difference |
|-----------|------|-------------|------------|
| Ecology   | 29.68| 31.80       | 2.12       |
| Economy   | 52.07| 52.39       | 0.32       |
| Social    | 36.78| 37.78       | 1.00       |
| Technology| 52.27| 52.24       | 0.03       |
| Institution| 42.99| 43.40       | 0.41       |

Table 7 indicates that the sustainability index values obtained in each dimension show small differences. The small difference indicates that (1) the error in scoring each attribute is relatively small, (2) the variety of scores due to differences in opinion is relatively small, (3) the analysis process is repeated in a stable manner, and (4) error in data entry and lost data can be avoided. Thus, the results of the sustainability analysis carried out with the Rapfish technique for anchovy resources are highly credible.

3.7 The Sustainability Status of Anchovy Resources

The kite diagram below is created based on the index values of each dimension of sustainability as shown in Figure 11.

![Kite Diagram for Anchovy Resources](image)

From all index values from the five dimension as detailed in Figure 11, the sustainability index value for anchovy resources in Labuhanbaru territorial waters is 42.76 (<50), meaning that the resources are less sustainable.

4. Conclusions

Based on the findings of this study, it can be concluded that all assessment basis demonstrates that the sustainability index of anchovy resources in terms of the five sustainability dimensions is 42.76 (<50), categorized as less sustainable.

Considering the results of this study, the researchers propose some suggestions as follows:
1) The use of Rapfish analysis as a method in this study can answer the problems offered, but future studies should employ other attributes in each dimension in the assessment.
2) The government needs to issue policies to regulate overexploitation to ensure sustainability of anchovy resources.
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