A technique of assessing the status of sustainability of resources

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Abstract. The sustainability of natural resources must be maintained, and the millennial generation must be responsible for that. Stakeholders play an important role in determining fisheries management practices, to assess fisheries sustainability indicators. Rapfish (rapid appraisal for fisheries) as an indicator-based tool will be able to evaluate the sustainability of fishery resources. The procedure for validating rapfish in this study has been applied, which is an evaluation tool based on multidisciplinary indicators (ecological, economic, social, and ethical aspects) to measure the sustainability of fisheries resources. Sustainability indicators are subject to the validation process based on feedback from resource owners, users, and experts. Using multi-criteria analysis such as the excellent weighting model and following the rules of the FAO-Code of Conduct. Based on the results of validation, suggestions have been made to improve the methodology and its practical application. Rapfish as a multidisciplinary tool, in this paper, shows that it has sufficient potential to evaluate the sustainability of fisheries resources.

1. Introduction

Natural resources can be categorized as renewable natural resources and non-renewable natural resources. The millennium generation must have a concern for the sustainability of natural resources. One example of renewable natural resources is in the field of marine fisheries. To manage marine fisheries and adjacent waters, specific management is required with a specific approach [1, 2, 3, 4].

Rapfish (Rapid Appraisal for Fisheries) is known as a relatively recent technique developed by the University of British Columbia, Canada, which is an analysis to evaluate sustainability and fisheries in a multidisciplinary way. In principle rapfish works in the form of ordination techniques (ie through the placement of something based on the order of attributes measurably) with multidimensional scaling (MDS). MDS is a statistical technique through experiments by means of multidimensional transformation at lower dimensions. The general dimensions of rapfish include aspects of ecological, economic, social, and ethical sustainability. The five dimensions of the rapfish have each attribute or indicator with a linkage to sustainability, following the rules of the FAO-Code of Conduct [5, 6].

Some rules in rapfish analysis begin by reviewing the attributes and definitions of fisheries activities to be analyzed (e.g. ship size, capture area, and time period), followed by scoring, based on the rule of thumb rapfish rules. The next provision performed MDS stage to obtain the relative state of fisheries to good and bad ordination. The next step carried out Monte Carlo and Leverage analysis to obtain aspects of uncertainty and anomaly based on attributes that have been analyzed [6].

2. Literature review

The reasons for the determination of MDS were used in Rapfish analysis, with the findings of other multivariate analysis methods such as analytical factors and Multi-Attribute Utility Theory (MAUT), did not produce a stable response [7]. Another rule with the use of MDS, the observed object or point is mapped into two or three-dimensional space, so that the object or point can be adjacent from its original point. In other words, two points or the same object are mapped to a point that is close together. On the contrary objects or points are not the same depicted with distant points. The ordination technique (distance determination) within MDS is based on Euclidian Distance based on space and dimension n can be presented like this:

$$d = \sqrt{(|x_1 - x_2|^2 + |y_1 - y_2|^2 + |z_1 - z_2|^2 + \cdots)}$$

The configuration may also be called an ordination and is related to the object point relating to the MDS and then approximates by regression activity to the Euclidian distance (d_{ij}) from point i to point j based on the origin point ij as presented here:

$$d_{ij} = a + bd_{ij} + e$$

In general, there are three techniques used to regress the above equation, the least square method (KRYST), the least squared alternating method based on the root of the Euclidian Distance (squared distance) or the ALSCAL method, and the method based on Maximum Likelihood. Of the three methods, the ALSCAL Algorithm is the most appropriate method for Rapfish and is readily available on almost every statistical software (SPSS, SAS, and R) [8].

The ALSCAL method optimizes squared distance (squared distance = d_{ijk}) to quadratic data (origin = o_{ijk}), which in three dimensions (i, j, k) is written in a formula called S-stress as follows:

$$S = \sqrt{\frac{1}{m}\sum_{k=1}^{m}\left[\frac{\sum_i \sum_j (d_{ijk}^2 - o_{ijk}^2)^2}{\sum_i \sum_j o_{ijk}^4}\right]}$$

Where the squared distance is a weighted Euclidean distance or written:

$$d_{ijk}^2 = \sum_{a=1}^{r} w_{kn}(x_{ia} - x_{ja})^2$$

In each measurement of a metric the goodness of fit, the distance of the point of expectation with the point of origin becomes very important. The goodness of fit in MDS is nothing more than measuring how well the configuration of a point can reflect the original data. The Goodness of fit in MDS is reflected in the amount of S-stress value calculated based on the value of S above. A low-stress score indicates good fit, while a high S value indicates otherwise. In Rapfish, a good model is shown a value of stress smaller than 0.25 (S <0.25).

3. Methods

The aspect of sustainable aquatic fisheries in waters is analyzed through an ordination process using the Rapfish algorithm (the rapid appraisal of the status of fisheries). Rapfish (Rapid Appraisal for Fisheries) is a new technique developed by the University of British Columbia, Canada, which is an analysis to evaluate the sustainability of a multidisciplinary fishery. The use of MDS obtained the relative position of sustainability of fisheries management on two reference points that a good point (bad) and bad point (bad).

Rapfish analysis is done through several stages:

- Analysis of aquatic fish fisheries data through the collection of fishery statistical data, literature studies, and field observations.

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- Scoring the ecological, social, economic, technological, and ethical dimensions of rapfish refers to [7, 8, 9, 10].
- Perform MDS analysis with R software to determine ordination and stress value through the ALSCAL Algorithm.
- Conducting "rotation" to determine fishery position in bad ordination and good with software R.
- Conducting sensitivity analysis (leverage analysis) and Monte Carlo analysis to take into account aspects of uncertainty.

The dimension index value is expressed on the worst (bad) scale 0% up to (good) 100%. Index value> 50% can be stated that the system under review is continuous, otherwise <50% of the system is not yet or unsustainable. The sustainability index is divided into several categories as listed in Table 1 [11].

Table 1. Category Sustainability Index

No	The Value of Sustainability Index	Sustainability Status
1	0.00-25.00	Not sustainable
2	25.01-50.00	Less sustainable
3	50.01-75.00	Sustained
4	75.01-100.00	Highly sustainable

Source: [11]

4. Discussion

Rapfish analysis in sustainable fish resource management research can use 5 (five) dimensions as indicators of sustainable catch fisheries that are ecology, technology, economy, social, and ethics. The determination of attributes and scores analysis of these ecological, economic, technological, social, and ethical dimensions refers to those developed by [7, 8, 9, 10] and then adjusted to existing conditions in the field.

4.1. The determination of attributes and analysis of ecological dimension score

In this analysis, it is known that attribute influence from the ecology dimension and water area. This dimension is a reflection of the good and bad quality of the environment and capture fisheries resources and natural processes in it [9].

The attributes analyzed in the ecological dimensions of fisheries management in sustainable waters include exploitation status, size of fish caught, catch species, catch per unit effort (CPUE), side catch (discharge bycatch), size of fish caught before maturity (catch before maturity) and species on the same geographical. The scores used to assign attribute values and ecological dimensions vary depending on the classification of attribute support for the ecological environment.

4.2. Determination of attributes and analysis of economic dimension score

In this analysis, the attribute of the economic dimension of catching fishery management in the waters area in the form of financial benefit for the fishers and its contribution in improving the economic condition of the community and the surrounding area. These economic dimensions include the product and quality of the marketed catch.

The economic condition of the community and the surrounding area can be seen from the profitability, average wage, other income, ownership transfer, fishery sector employment, market, and subsidy. The scores used to assign attribute values and economic dimensions vary depending on the classification of attribute support for economic activity.

4.3. Determination of attributes and scoring analysis of technology dimensions

This analysis is conducted to determine the suitability of the attributes of technological dimensions related to the management of capture fisheries in water areas. This dimension is a reflection of the

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degree of utilization of capture fisheries resources using a technology. Good technology is a technology that is increasingly able to support in the long run and continuously every economic activity in the fishing sector [9].

The attributes used to analyze technology dimensions in the management of fish resources include trip length, landing sites, onboard handling, pre-sale processing, gear, selective gear, FADs, vessel size, the capability of catching power and gear side effects. The scores are given for each attribute and the technological dimension in sustainable fish resource management vary depending on the classification of attribute support for the technological factor.

4.4. The determination of attribute and social dimension score analysis

This analysis is conducted to determine the suitability of the social and environmental dimensions of fisheries management in water areas. This dimension is a reflection of how human social systems (catching fishing societies that occur and can / cannot support long-term and sustainable fishing development [9].

Attributes used for the analysis of aspects of the social environment include the use of labor, the number of new fishers in the last 5 years (new entrance into the fishery), the amount of labor absorbed in the fishery sector (fishery sector), knowledge of fishers to the environment knowledge, education level, conflict status, fisher influence, fishing income, family participation (kin participation). The scores used to assign attribute values and the dimensions of this social environment vary according to the classification of attribute support for their social environment.

e. The determination of attribute and ethical dimension score analysis

This analysis was conducted to determine the suitability of the attributes of the ethical dimension in the management of capture fisheries in the waters area. This dimension is a reflection of how the management system and fishing communities that occur and can/cannot support the ongoing development of long-term and sustainable capture fisheries [9].

The attributes used for this ethical aspect analysis include the proximity of access to resources, alternative employment, equity utilizing resources, rules of management, the influence of ethical formats, the mitigation of habitat destruction, the mitigation of ecosystem degradation, illegal arrest, and waste. The scores used to assign attribute values and ethical dimensions vary depending on the classification of attribute support for ethics.

5. Conclusion

The improvement scenarios for sensitive attributes for the preparation of sustainable fish resource management strategies in waters are attributes that have high sensitivity and adversely affect the status of sustainability are prioritized for improvement, especially those that allow for improvement or intervention. Interventions are conducted with rational considerations, available human resources, financial capabilities, and can be technically implemented. However, apart from dimensions that have such poor sustainability status, then the attributes and other dimensions, which provide a large sensitivity value and affect the value of the sustainability index remain a priority for improvement. While attributes that have low sensitivity and positively affect the value of the status index is maintained and enhanced when possible.

Based on these considerations, the attributes and the four dimensions are then arranged in order of priority with the root mean square (RMS) indicator. Priority sequences at start and attributes that have the largest root mean square (RMS) value. Furthermore, the strategy undertaken is the interaction of each attribute which is arranged inaction based on the priority of the time period, that is the short term and the medium term. Determination of the time span, for a short-term 1-5 year while long-term 5-10 year. The consideration is based on the length of the leadership of the regional head.

The attribute change requirement is for the interfered attribute increases one scale for short-term priority and 2 scales or maximum for medium-term priority. Intervention or improvement is a strategy that will be done in the form of operational policies that may be done and adjusted with consideration of rationality, availability of costs, availability of human resources and can be easily applied.

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From the scoring and determination of the implementation period, operational policy scenarios will be followed in the form of short and medium-term programs. Furthermore, for each scenario is evaluated the multidimensional index changes by using Rapfish analysis.

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