Ecological sustainability status in mangrove conservation area of Gunung Anyar Sub-District, Surabaya

F Afifa and H Idajati

1 Urban and Regional Planning Department, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

E-mail: firdaafifa@gmail.com

Abstract. The mangrove conservation area in Gunung Anyar Sub-District has been directed to be one of the centers of mangrove education ecotourism in the city of Surabaya. In the process of managing coastal areas, it is necessary to approach various scientific disciplines, related to ecology, economics, social, institutional, and technology, to maintain the conservation of the coastal areas. Among these dimensions, the focus of researchers in the management of the mangrove conservation area of Gunung Anyar Sub-District is the ecological dimension, because ecology is a dimension of sustainability - the "outermost" - a foundation that forms the basis of everything. Therefore, this study was conducted to determine the status of ecological sustainability in Gunung Anyar Sub-District, Surabaya. The tool used to analyze is R Software in which three analysis processes take place, including; MDS (Multi Dimensional Scaling) analysis, Monte Carlo simulation, and Leverage analysis. From the results of the analysis, the ecological sustainability status of the mangrove conservation area of Gunung Anyar Sub-District is included in the unsustainable category with an average score of only 11.98988942. While the most influential variables are as follows: mangrove land pressure (2.134000151), mangrove conservation function (1.538443029), successful replanting (1.283040189), and surrounding population (1.23348515).

1. Introduction

The multi-objective, multi-stakeholder nature of coastal areas and the presence of various conflicts of interest resulting dilemmas in the decision making process [1]. Suaedi [1] explains, coastal areas have special characteristics that are more complex compared to land or sea due to interactions between ecosystems in coastal areas and also interactions of coastal communities that are very dynamic, both between communities themselves and interactions between communities and coastal ecosystems. This means that the focus of management on mangrove conservation areas in coastal areas is human activity in the utilization of coastal resources.

The mangrove conservation area in Gunung Anyar District has been determined to be one of the centers of mangrove education ecotourism in the Surabaya East Coast coastal area based on Surabaya City Regulation Number 3 of 2007 [2], which has been adjusted to the Surabaya City Regulation Number 12 of 2014 [3].

In the process of managing coastal areas, it is necessary to approach various scientific disciplines, both related directly to ecology, economics, social, institutional, technology, to defense and security in coastal areas and outside the coastal and marine areas. From these dimensions, the focus of researchers
in managing mangrove conservation areas in Gunung Anyar Sub-District is the ecological dimension, because ecology is a dimension of sustainability in the "outermost" - a foundation that forms the basis of everything, so it is important to preserve ecological processes in the long run which ultimately creates a guarantee for the future of humanity [4].

So that in this study, an analysis was conducted to determine the value of ecological sustainability status and which variables most affect the ecological sustainability status in the mangrove conservation area of Gunung Anyar District, Surabaya.

2. Methods

2.1. Research Approaches and Types

The approach used in this research is a rationalistic approach. This type of research in this research is descriptive using a case research model.

2.2. Research Variable

This research variable is based on the research of Afifa [5], where there are nine research variables that have been confirmed to expert stakeholders through Delphi analysis techniques as a basis for analyzing the status of ecological sustainability in the mangrove conservation area of Gunung Anyar Sub-District, Surabaya including; mangrove land pressure, coastal abrasion, water pollution, fishpond land use, tourism land use, coastal sedimentation, mangrove conservation function, surrounding population, and successful replanting.

2.2.1. Data Collection Methods

The data collection process is carried out through primary and secondary surveys. The method for collecting primary data is by structured interviews and closed questionnaires. While the method for collecting secondary data in this research is a literature survey.

2.2.2. Sampling Methods

The population used in this research is expert stakeholders who know and understand the management of mangrove areas. The method used in sampling in this research is the same as the sampling method used by Afifa [5], because this is a continuation research. So that the sample in this research was taken using a mixture of purposive sampling and snowballing methods. The purposive sampling technique was used to find the first key person, while the snowballing technique was used to explore other expert stakeholders from the first key person.

3. Result and explanation

3.1. Analysis of the Status of Ecological Sustainability in the Mangrove Conservation Area in Gunung Anyar Sub-District

The variables obtained from Afifa and Idajati (2020) were divided into two types, namely variables with purely opinion from expert stakeholders, including; waters pollution, fishpond land use, tourism land use, mangrove conservation function, and successful replanting. Meanwhile, variables with expert stakeholders opinion based on secondary data (data obtained from the field), including; mangrove land pressure, coastal abrasion, coastal sedimentation, and the surrounding population.

Analysis of the status of ecological sustainability in this study uses R software tools (measuring data qualitatively), in which three analysis processes take place, including; MDS (Multi Dimensional Scaling) analysis, Monte Carlo simulation, and Leverage Analysis.

Before being analyzed in R software, it takes a closed questionnaire in the form of scoring that contains selected variables that have been given parameters in the form of an ordinal scale and expert stakeholders responses to the choice of these parameters.
Table 1. Questionnaire score for the variable with purely opinion from expert stakeholders

| Variable                  | Expert stakeholders | Parameter                                                                 |
|---------------------------|---------------------|---------------------------------------------------------------------------|
|                           | ES1 | ES2 | ES3 | ES4 |                                                                 |
| Water pollution           | 1   | 1   | 2   | 2   | (0) Water color and aroma changed                                  |
|                           |     |     |     |     | (1) Water color or aroma changed                                     |
|                           |     |     |     |     | (2) Water color and aroma normal                                     |
|                           |     |     |     |     | (Adaptation results [6])                                             |
| Fishpond land use         | 1   | 1   | 1   | 1   | (0) Not appropriate                                                  |
|                           |     |     |     |     | (1) Appropriate                                                      |
|                           |     |     |     |     | (Adaptation results [6])                                             |
| Tourism land use          | 1   | 2   | 2   | 2   | (0) Not paying attention to conservation aspects                     |
|                           |     |     |     |     | (1) Paying attention to conservation aspects without paying attention |
|                           |     |     |     |     | to land capacity support                                             |
|                           |     |     |     |     | (2) Paying attention to conservation aspects and land capacity       |
|                           |     |     |     |     | support                                                                |
|                           |     |     |     |     | (Adaptation Results [6])                                             |
| Mangrove conservation function | 2   | 2   | 2   | 2   | (0) There is no conservation                                         |
|                           |     |     |     |     | (1) There is conservation but not well managed                       |
|                           |     |     |     |     | (2) There is conservation and well managed                           |
|                           |     |     |     |     | [6]                                                                    |
| Successful replanting     | 1   | 2   | 2   | 2   | (0) Mangroves experienced none of conditions (growing fertile, fresh |
|                           |     |     |     |     | green leaf, and sprout new leaf)                                     |
|                           |     |     |     |     | (1) Mangroves experience one / two conditions (growing fertile, fresh |
|                           |     |     |     |     | green leaf, and sprout new leaf)                                     |
|                           |     |     |     |     | (2) Mangroves experience all conditions (growing fertile, fresh green |
|                           |     |     |     |     | leaf, and sprout new leaf)                                           |
|                           |     |     |     |     | (Adaptation results [7])                                             |
### Table 2. Score results for variables with expert stakeholders opinion based on secondary data

| Variable                      | Expert stakeholders | Parameter                                                                 |
|-------------------------------|--------------------|--------------------------------------------------------------------------|
|                               | ES1    | ES2    | ES3    | ES4    |                                                             |
| Mangrove land pressure        | 0      | 0      | 0      | 0      | (0) Conversion of mangrove land occurs without regard to environmental functions (reduction of mangrove area is not natural) (1) Reduction of mangrove area occurs naturally (2) Mangrove land area remains (3) Mangrove area expansion (Adaptation results [6]) |
| Coastal abrasion              | 2      | 2      | 2      | 2      | (0) >5.0 m/year (High) (1) 1 – 4.9 m/year (Medium) (2) 0 – 0.9 m/year (Low) (Adaptation results [8]) |
| Coastal Sedimentation         | 0      | 0      | 0      | 0      | (0) Sedimentation has been increased significantly and affect the conditions waters (form delta formation and superficiality) (1) Sedimentation increases but not significantly influence water conditions (2) Sedimentation does not increases significantly (Adaptation results [6]) |
| Surrounding population        | 0      | 0      | 0      | 0      | (0) Population growth rates >2% and distribution patterns are getting closer to conservation areas (1) Population growth rates 1%-2% and distribution patterns start getting closer to conservation areas (2) Population growth rates <1% and distribution patterns are remains (Adaptation results [9]) |

**Expert Stakeholders:**
- **ES1**: Academics (AKADEMISI)
- **ES2**: Surabaya City Planning and Development Department (BAPPEKO)
- **ES3**: Surabaya City Food and Agriculture Department (DKPP)
- **ES4**: Surabaya City Environment Department (LH)

The range of scores allowed to be varied because all scores are normalized before the MDS ordination process, for example a scale of 0 to 2 on one variable and 0 to 3 on another variable. The scores of each of these variables will be normalized so that each variable has a uniform weight and the difference between measurement scales can be eliminated.
3.1.1. MDS Analysis (Multi Dimensional Scalling)

Figure 1. Distribution of stakeholder positions on the ecological sustainability status of mangrove conservation areas in Gunung Anyar Sub-District (based on MDS Analysis).

In the MDS analysis, the results of ecological sustainability status are on the X axis (Y axis is not used because the values of Good and Bad are on the X axis), where the sustainability index is assessed on a scale of 0 to 100.

Based on the results of MDS ordination, the value of the ecological dimension of the sustainability index in the mangrove conservation area of Gunung Anyar District shows the score as in the following table:

| Expert stakeholder                                           | Ecological Sustainability Status Index |
|--------------------------------------------------------------|----------------------------------------|
| Academics (AKADEMISI)                                       | 9,05027                                |
| Surabaya City Planning and Development Department (BAPPEKO)  | 11,01513                               |
| Surabaya City Food and Agriculture Department (DKPP)         | 12,23795                               |
| Surabaya City Environment Department (LH)                    | 12,23795                               |
| Average Value                                                | 11,13532                               |

The category of sustainability status is divided into four [10], where a score of 0-25 indicates ecological sustainability in the mangrove conservation area of Gunung Anyar Sub-District is included in the unsustainabe category status.

3.1.2. Monte Carlo Simulation

Monte Carlo simulation is used to test the confidence level of the MDS index value. This simulation is very helpful in the analysis of sustainability indices to see the effect of scoring errors on each variable caused by procedural errors or understanding of variables, variations in scoring due to differences in
opinion or differences in judgment by expert stakeholders, stability of the MDS analysis process, errors in entering data if there are missing data [6]. There are two outputs of the Monte Carlo simulation, namely the data distribution graph and the simulation value. The following is a graph of the data distribution of ecological sustainability status in the mangrove conservation area of Gunung Anyar Sub-District:

![Graph of the distribution of ecological sustainability status data in the mangrove conservation area of Gunung Anyar District](image)

**Figure 2.** Graph of the distribution of ecological sustainability status data in the mangrove conservation area of Gunung Anyar District

On the other hand, Monte Carlo simulation values are recommended to have a difference of <1 with the MDS score index to ensure the accuracy of the data. The following table shows the difference in MDS index values against Monte Carlo simulations

| Expert stakeholder                                      | MDS result | Monte Carlo Result | Deviation |
|---------------------------------------------------------|------------|--------------------|-----------|
| Academics (AKADEMISI)                                  | 12,238     | 10,406             | 1,832     |
| Surabaya City Planning and Development Department (BAPPEKO) | 12,238     | 10,415             | 1,823     |
| Surabaya City Food and Agriculture Department (DKPP)    | 9,050      | 9,764              | -0,714    |
| Surabaya City Environment Department (LH)               | 11,015     | 10,077             | 0,938     |
| Average Value                                           | 11,135     | 10,165             | 0,970     |

**3.1.3. Leverage Analysis**

Leverage Analysis aims to find out which sensitive attributes contribute to the sustainability index (the most influential). The most sensitive attributes will contribute to sustainability in the form of changes to Root Mean Square (RMS). The greater the value of RMS changes, the greater the role of these attributes in the formation of the sustainability index value on the scale of sustainability or the more
sensitive these attributes in determining the ecological sustainability of mangroves in the research location.

Based on Leverage analysis results, the ecological sustainability of mangrove conservation areas in Gunung Anyar Sub-District has four variables that have high sensitivity because they have an RMS value above the median/middle value of 1.201978927. These variables include; mangrove land pressure (2.134000151), mangrove conservation function (1.538443029), successful replanting (1.283040189), and surrounding population (1.23348515). This means the four variables greatly affect the ecological sustainability status of mangrove conservation areas in Gunung Anyar Sub-District. While the beach sedimentation variable is right on the RMS threshold with a leverage value of 1.201978927.

![Leverage Graphic](image)

**Figure 3.** Leverage analysis graphic, = sensitive variable

4. Conclusions
Based on the results and discussions that have been carried out, the conclusions from this research can be drawn including:

1) The results of the analysis on R software related to determine the status of ecological sustainability in Gunung Anyar Sub-District shows that the ecological sustainability status index in the research area has the lowest index score of 9.05027, the highest of 12.23795, and an average score of only 11.13532 so it is included in the *unsustainable* category.

2) Meanwhile, according to the results of leverage analysis, the most sensitive or most influential variable on the ecological sustainability status of mangrove conservation areas in Gunung Anyar Sub-District is the mangrove land pressure (2.134000151), mangrove conservation function (1.538443029), successful replanting (1.283040189), and the surrounding population (1.23348515).

5. References
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