Sustainability status of bay management: case study in Jor Bay, East Lombok Regency, West Nusa Tenggara Province

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Abstract. Jor Bay in East Lombok - West Nusatenggara is a small bay system characterized by a common pool resource, in which found a contestation of utilization among resources users. Even though the bay has been managed by a local institution, namely Lembaga Pemangku Awiq-awiq Teluk Jor (LPATJ), the role and perform of institutions in managing the bay is still very low. To ensure the sustainability of the bay, the need to converge the different resource users’ interests by balancing utilization to accommodate economical, ecological and social dimensions. This study aimed to assess the sustainability status of bay management and design future sustainable bay management strategies. To measure the sustainability status, we used a sustainability index intended to develop to bay ecosystem form. The current sustainability status of Jor Bay management showed a moderate level. The institutional dimension provides the greatest sustainability value, while the lowest degree shows in the ecological dimension. The governability of Jor Bay management shows low institutional interaction, limited scale (local), minimal initiative and low willingness to cooperate among elements. For this reason, the ICM (integrated coastal management) based management mechanism needs to be strengthened to ensure the functioning of the Jor Bay management system.

Keywords: bay management; SES; sustainability

1. Introduction

Bay is a coastal complex system that plays important economic and ecological roles in regional socio-ecological systems, and their habitats link land to the ocean [1,2]. The complexity of coastal areas is increasingly problematic, degradation is increasing, and the characteristics of environmental problems are now generally caused by anthropogenic factors rather than natural phenomena [3] because all anthropogenic impacts lead to the sea. System variability in coastal areas, complex process interactions, and increasing pressures require interdisciplinary studies on a deeper understanding of processes and management scenario experiments carried out with model applications [4].

The current sustainability science approach is not about global biophysical systems or socio-economic-political systems only but also uses a location-based model that allows the study of human and environmental interactions [5]. The most appropriate analytical unit for sustainability...
studies is the socio-ecological system unit. This reason makes it increasingly important to understand the socio-ecological system (SES).

The concept of sustainability is defined as a dynamic balance in the process of interaction between the population and the carrying capacity of the environment in such a way that the population develops to express its full potential without negatively affecting the carrying capacity of the environment on which it depends [6]. What are the indicators and conditions for something to be said to be sustainable? The model for sustainable management of natural resources such as a bay has multi-criteria dimensions. As a marine resource typology, Bay resources play an important economic and ecological role in the regional socio-ecological system [2]. A special definition of sustainability in the bay's resources is required, with special characteristics in ecology and economic activity. To manage the bay ecologically, it is not only influenced by the conditions in the bay. However, it is also strongly influenced by the environment above it (upstream), such as the watershed (watershed) and urban systems [7]. In watersheds, urban and industrial areas reduce river water quality, and the best water quality is in upstream areas.

In addition to physical factors, social factors are very important. It was considering social capital [8, 9]. Social capital includes all non-object assets that exist in society, including knowledge, institutions, and rules established within the community and their belief system. In addition to the physical domain in the form of material, the domain of life and the spiritual domain in the form of human attitudes and behavior are also important in supporting the system's sustainability, including the sustainability of the resource management system [6]. The systems need to be considered in conservation management are knowledge system including knowledge, attitudes and behavior or practices.

Jor Bay as a complex system requires a comprehensive understanding of the system. To determine management options, it is necessary to evaluate the current status of the sustainability of its management, whether it is still sustainable or unsustainable, and it is also necessary to examine what factors and domains have the most role as determinants. Sustainability of its management can be recommended the choice of policies, strategies, and programs needed to achieve its sustainability. Several dynamic integral sustainability models were developed, which enable decision-makers to understand the main components of this socio-ecological system and their changes over time and the interactions between sustainability indicators and other factors in the system [10].

Sustainability status reveals conditions based on several indicators. Several indicators of economic, ecological and social dimensions have been developed [11]. Several experts have also developed a sustainability assessment framework, such as the Coastal Sustainability Index (CSI) [12], which is used to measure the sustainability of an estuary system, whose indicators focus on the natural system (ecology). This paper aims to analyze the sustainability status of Jor Bay management and formulate a sustainable bay management strategy.

2. Methodology

2.1. Time data collection

The research was conducted in the Jor Bay area, Jerowaru Sub District, East Lombok Regency, West Nusa Tenggara Province, including Jerowaru Village and Paremas Village. Data was carried out from December 2018 to December 2019. The data collected in primary and secondary data. Primary data were obtained based on field observations and interviews/discussions with respondents through questionnaires and a list of questions. Secondary data is obtained through literature studies from research results, regulations, and reports related to the research topic. Interviews with stakeholders, consist of community groups, administrators of management
institutions, government officials from the hamlet, village, sub-district, district and provincial levels.

2.2 Data analysis

2.2.1. Sustainability analysis of bay management. The analysis was carried out using a Multi-Dimensional Scaling (MDS) approach using RAPFISH (Rapid Assessment Techniques for Fisheries), which can be modified dimensions and attributes according to the evaluated aspects [13-15]. The indicators for the sustainability of Jor Bay management are determined based on criteria that can represent the complexity of Jor Bay management. This study formulates five dimensions as the basic elements of sustainability: 1) ecology dimension, 2) economy dimension, 3) social dimension, 4) knowledge system dimension, and 5) institutional dimension. Each dimension contains indicators, each of which determines the status of sustainability which explain in table 1 – table 5. The arrangement of attributes and criteria on the five dimensions was compiled referring to several previous studies [16-20] and then adjusted to the characteristics and conditions of the resources studied. The Best-Worst Scaling (BWS) model was used. BWS was conducted to collect data on priority sustainability indicators for each dimension [21]. Attributes and scoring criteria for each dimension are presented in tables 1 to table 4.

Table 1. Ecological dimension attribute criteria.

| No. | Ecological Attributes                          | Score and rating | Assessment Criteria                                      |
|-----|----------------------------------------------|------------------|----------------------------------------------------------|
|     |                                              | Rating range     | Good | Bad | The better (2); fixed (1); decrease (0) |
| 1   | Biodiversity of fisheries resources           | 0-2              | 2    | 0   |                                             |
| 2   | Utilization of bay water for mariculture      | 0-2              | 2    | 0   | Under carrying capacity (2); according to carrying capacity (1); overcapacity (0) |

Figure 1. Application stages of using the RAPFISH method in assessing the sustainability of bay management.
| No. | Ecological Attributes                                      | Score and rating | Assessment Criteria                                                                                                                                 |
|-----|-----------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
|     |                                                           | Rating range     | Good | Bad |                                                                                                          |
| 3   | The width and quality of the mangrove ecosystem          | 0-3              | 3    | 0   | The greater (3), the more (2); getting a little smaller, partially protected (1); keep decreasing (0) |
| 4   | The width and quality of the coral reef ecosystem        | 0-3              | 3    | 0   | The greater (3), the more (2); getting a little smaller, partially protected (1); keep decreasing (0) |
| 5   | The width and quality of seagrass ecosystem              | 0-3              | 3    | 0   | The greater (3), the more (2); getting a little smaller, partially protected (1); keep decreasing (0) |
| 6   | Fish landing distance to the fishing ground              | 0-3              | 3    | 0   | The farther away (0); far outside the region (1); out of the bay (2); in the bay (3)                   |
| 7   | Presence of conservation areas (protected zones)         | 0-3              | 3    | 0   | None (0); newly initiated (1); exists but not yet effective (2); running well (3)                      |
| 8   | Aquatic environmental quality                            | 0-2              | 2    | 0   | > 3 parameters exceed the quality standard/optimum value (0); > 3-5 parameters according to quality standards (1); all parameters according to quality standard/optimum value (2) |
|     | A. Total suspended solids (TSS)                          | 0-1              | 1    | 0   | Exceeding the quality standard/optimum value (0); according to quality standard/optimum value (1)     |
|     | B. Organic material (BOD)                               | 0-1              | 1    | 0   |                                                                                                        |
|     | C. Salinity                                             | 0-1              | 1    | 0   |                                                                                                        |
|     | D. pH                                                   | 0-1              | 1    | 0   |                                                                                                        |
|     | E. Dissolved Oxigen                                      | 0-1              | 1    | 0   |                                                                                                        |
|     | F. Ammonium Content                                     | 0-1              | 1    | 0   |                                                                                                        |
|     | G. Water Residence time                                 | 0-1              | 1    | 0   | Long time (0); short while (1)                                                                         |
| 9   | The quantity of pollutant from human activities flows into bay | 0-3              | 3    | 0   | The bigger (0), bigger (1); slightly smaller (2); small (3)                                           |
| 10  | Control over the input of organic matter, pollutants and sediments into bay | 0-3              | 3    | 0   | Fully controlled (3), mostly controlled (2); slightly restrained (1); out of control (0)                 |
| 11  | Inut fresh water into the bay water                      | 0-3              | 3    | 0   | More and bigger (3), still (2); slightly smaller (1); small (0)                                        |
| 12  | Efforts to conserve resources by rehabilitation / restocking | 0-3              | 3    | 0   | Intensive (3), constant (2); less (1); None (0)                                                        |

A. Total suspended solids (TSS)  
B. Organic material (BOD)  
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I. Control over the input of organic matter, pollutants and sediments into bay  
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K. Efforts to conserve resources by rehabilitation / restocking
| No. | Ecological Attributes                                                                 | Score and rating | Assessment Criteria                                                                 |
|-----|----------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------|
|     |                                                                                        | Rating range     | Good | Bad                                                                                     |
| 14  | Landscape/seascape changes                                                             | 0-2              | 2    | 0                                                                                       | Extensive (0), exist but less (1); none (2) |

**Table 2.** Economical dimension attribute criteria.

| No. | Ecological Attribute                                                                 | Score and rating | Assessment Criteria                                                                 |
|-----|----------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------|
|     |                                                                                        | Rating range     | Good | Bad                                                                                     |
| 1   | Types of ecosystem services provided by the bay                                        | 0;1;2            | 2    | 0                                                                                       | The more (2); stayed (1); decrease (0)     |
| 2   | Natural Resources Production Level (catch, aquaculture and non-fishery)                | 0;1;2            | 2    | 0                                                                                       | The more (2); stayed (1); decrease (0)     |
| 3   | The value of production of bay Community                                               | 0;1;2            | 2    | 0                                                                                       | Mostly dependent/very high (3); many/ high (2); little/ low (1); very little / very low (0) |
| 4   | The development of new types of business/economic activities                           | 0;1;2;3          | 3    | 0                                                                                       | Highly developed and diverse (3); sufficiently developed (2); slightly developed (1); not growing (0) |
| 5   | The market follows the market for other products (2); temporal market (1); no market (0) | 0;1;2;3          | 3    | 0                                                                                       | Specially formed markets (3); The market follows the market for other products (2); temporal market (1); no market (0) |
| 7   | Product marketing outreach                                                             | 0;1;2;3          | 3    | 0                                                                                       | Export (3); National (2) local (1), Limited market (0) |
| 8   | Access to sources of financing/investment                                              | 0;1;2            | 2    | 0                                                                                       | Easily accessible (2); available but not easy to access (1); not available (0) |
| 9   | Types of livelihoods based on resource bay                                             | 0;1;2;3          | 3    | 0                                                                                       | Very diverse > 6 (3); quite diverse (3-6); (2), slightly < 3 (1); only fishermen and fish farmers (0) |
| 10  | Community basic need fulfilment                                                        | 0;1;2;3          | 3    | 0                                                                                       | Fulfilled mostly from within (3); Balanced from inside and outside (2); mostly met from outside (1); completely from outside (0) |
| 11  | Absorption of labor from activities in the bay                                         | 0;1;2;3          | 3    | 0                                                                                       | Greatly increased (3); increase (2); constant (1); decrease (0) |
| No. | Ecological Attribute                          | Score and rating | Assessment Criteria                                                                 |
|-----|----------------------------------------------|------------------|--------------------------------------------------------------------------------------|
|     |                                              | Rating range     | Good | Bad       |                                                                  |
| 12  | Economic Infrastructure                       | 0;1;2            | 2    | 0         | Completely (2); available but incomplete (1); not available (0) |
| 13  | Community income                             | 0;1;2            | 2    | 0         | Below the minimum wage (0); Same (1); higher (2)                |
| 14  | Contribution to government revenue           | 0;1;2;3          | 3    | 0         | Height (3); medium (2); low (1); none yet (0)                   |
|     |                                              |                  |      |           | Distributed to most communities (3); fishermen, cultivators, collectors, traders, processors and distributors (2); fishermen, cultivators, traders (1); fishermen and cultivators only (0); |
| 15  | Distribution of income from bay resources    | 0;1;2;3          | 3    | 0         |                                                                   |

**Tabel 3. Social dimension attribute criteria.**

| No. | Social Attribute                          | Score and rating | Assessment Criteria                                                                 |
|-----|------------------------------------------|------------------|--------------------------------------------------------------------------------------|
|     |                                          | Rating range     | Good | Bad       |                                                                  |
| 1   | Formal leadership                         | 0;1;2;3          | 3    | 0         | Very good (3); good (2); low (1); none (0)                      |
| 2   | Informal leadership (religion and customary) | 0;1;2;3          | 3    | 0         | Very good and very effective (3); good (2); less effective (1); ineffective (0) |
| 3   | Community participation in development planning | 0;1;2;3          | 3    | 0         | Doesn't want to get involved (0); low (1); quite high (2); very high (3) |
| 4   | Community participation in bay management | 0;1;2;3          | 3    | 0         | Doesn't want to get involved (0); low (1); quite high (2); very high (3) |
| 5   | Community involvement in conflict resolution | 0;1;2;3          | 3    | 0         | Doesn't want to get involved (0); low (1); quite high (2); very high (3) |
| 6   | Conflict in utilize spatial and resources of bay Number of direct users | 0;1;2;3          | 3    | 0         | Very low (3), low (2), moderate (1); height (0) |
| 7   | Number of direct users                    | 0;1;2;3          | 3    | 0         | Decrease (0); constant (1); slightly increased (2); greatly improved (3) |
| 8   | Number of indirect users                  | 0;1;2;3          | 3    | 0         | Decrease (0); constant (1); slightly increased (2); greatly improved (3) |
| 9   | Number of non-fisheries users             | 0;1;2;3          | 3    | 0         | Decrease (0); constant (1); slightly increased (2); greatly improved (3) |
| 10  | Inisiative program from community         | 0;1;2;3          | 3    | 0         | None (0); very few (1); exists and persists (2); increasing (3) |
| No. | Social Attribute                                      | Score and rating | Assessment Criteria                                                                 |
|-----|------------------------------------------------------|------------------|--------------------------------------------------------------------------------------|
| 11  | Community communication channel                      | 0;1;2;3 3 0      | Very good and very effective (3); good (2); less effective (1); obstructed (0)       |
| 12  | Preparedness for emergencies (crisis, or disaster)   | 0;1;2;3 3 0      | Ready and highly effective (3); Exist and effective (2); not good (1); none (0)      |
| 13  | Community vulnerability                             | 0;1;2;3 3 0      | Not vulnerable (3); quite vulnerable (2); vulnerable (1); very vulnerable (0)        |
| 14  | Community resilience (self-organizational ability)   | 0;1;2 2 0        | Very Resilient (2); quite Resilient (1); Not Resilient (0)                          |
| 15  | Social networking                                   | 0;1;2;3 3 0      | Strong and functional (3); medium (2); weak (1); Not working (0)                     |

**Table 4. Knowledge system dimension attribute criteria.**

| No. | Knowledge System Attribute                          | Score and rating | Assessment Criteria                                                                 |
|-----|-----------------------------------------------------|------------------|--------------------------------------------------------------------------------------|
| 1   | The community value and belief as a knowledge base on natural resources | 0;1;2;3 3 0      | None (0); Exist and not awake (1); Yes, just believe (2); Yes, believed and implemented (3) |
| 2   | The level of community knowledge of resources       | 0;1;2;3 3 0      | Low (0); not good (1); good (2); Very good / high (3)                                |
| 3   | Attitudes/Behavior of the community towards bay management | 0;1;2;3 3 0    | Negative/Don't care (0); care less (1); care enough (2); very caring (3)             |
| 4   | Practices in bay management                         | 0;1;2;3 3 0      | Ignore/Don't want to do (0); less willing to do (1); want to do if there is a chance (2); always act (3) |
| 5   | Innovation in resource utilization/management       | 0;1;2;3 3 0      | Widely developed and implemented (3); Apply by adoption (2); Very few (1); none (0) |
| 6   | Capacity building program                           | 0;1;2;3 3 0      | Greatly increased (3); increase (2); fixed (1); decrease (0)                         |
| 7   | Channels of transformation / dissemination of information to the public | 0;1;2;3 3 0    | Exist and run well (3); exist and run less well (2); exist but not working (1); none (0) |
| 8   | Involvement of educational institutions,             | 0;1;2;2 0        | Exist and active (2); exist but not working (1); none (0)                           |
| No. | Knowledge System Attribute | Score and rating | Rating range | Good | Bad | Assessment Criteria |
|-----|-----------------------------|------------------|--------------|------|-----|---------------------|
| 9   | research and human resource development | | 0;1;2;3 | 3   | 0   | Greatly increased (3); increase (2); constant (1); decrease (0) |

**Table 5.** Institutional dimension attribute criteria.

| No. | Institutional Attribute | Score and rating | Rating range | Good | Bad | Assessment criteria |
|-----|-------------------------|------------------|--------------|------|-----|---------------------|
| 1   | Boundaries of management | | 0;1;2;3 | 2   | 0   | None yet (0), exists but still not agreed (1), exists and has been determined (2) |
| 2   | Zoning (bay spatial plan), including the protection zone | | 0;1;2;3 | 3   | 0   | Not yet establish (0), initiation of formulation (1), exists and has not been determined (2); exists and determined (3) |
| 3   | Multi-stakeholder co-management strategies and plans | | 0;1;2;3 | 3   | 0   | Not yet establish (0), initiation of formulation (1), exists and has not been determined (2); exists and determined (3) |
| 4   | Availability of binding rules | | 0;1;2 | 2   | 0   | Not yet available (0), exists but has not been determined (1), exists but has not been effectively implemented (2) exists and has been effectively implemented (3) |
| 5   | Existence of management institution (legal) | | 0;1;2;3 | 3   | 0   | None (0); exists but has not been fully recognized (1); there is enough community recognition (2); highly recognized (3) |
| 6   | Effective performance of managers in carrying out roles and functions | | 0;1;2;3 | 3   | 0   | Ineffective (0); less effective (1); effective (2); very effective (3) |
| 7   | Program attention and support from the government to management institutions | | 0;1;2;3 | 3   | 0   | None (0); less (1); exists and sufficient (2); very big (3) |
| 8   | Collaboration with institutions outside the village | | 0;1;2;3 | 3   | 0   | None (0); exist a few (1); exist and enough (2); many (3) |
An Ordination assessment was carried out to determine a point that reflected the relative position of management activities in Teluk Jor with respect to two main reference points: the good point and the bad point. In the MDS analysis, the ordination technique is carried out by determining the distance based on the Euclidian Distance, which in n-dimensional space can be written as follows [17]:

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

(1)

Configuration/ordination of an object or point in MDS analysis is approximated by regressing Euclidian distance \( d_{ij} \) from point \( i \) to point \( j \) with origin \( \delta_{ij} \) as the following equation [17] :

\[
d_{ij} = \alpha + \beta \delta_{ij} + \varepsilon
\]

(2)

ALSCAL algorithm is used to regress in Rapfish, using SPSS software. The ALSCAL method optimizes the squared distance (square distance = \( d_{ijk} \)) to square (origin = \( O_{ijk} \)), in three dimension \((i, j, k)\) expressed in a formula called S-Stress as follows:
The squared distance is the Euclidean distance breached or expressed as follows:

\[
d_{ijk}^2 = \sum_{\alpha=1}^{r} W_{\alpha} (x_{i\alpha} - x_{j\alpha})^2
\]

Where the squared distance is the Euclidean distance breached or expressed as follows:

\[
Stress = \sqrt{\frac{\sum_{i}^{n} \left[ \sum_{j}^{m} \sum_{\alpha}^{r} (d_{i\alpha} - d_{j\alpha})^2 \right]}{\sum_{i}^{n} \sum_{j}^{m} d_{i\alpha}^2}}
\]

(3)

A low-stress value indicates a good fit, while a high S value indicates otherwise. The analysis results of a good RAPFISH method will show a stress value that is smaller than 0.25 (S < 0.25). Determination of sustainability status with RAPFISH refers to an index with an interval between 0-100, which refers to four levels as in table 6.

The next stages of RAPFISH analysis are Monte Carlo analysis and Laverage analysis. The Monte Carlo analysis was repeated 25 times using the scatter plot method to determine the stability of the RAPFISH ordinance results. Laverage analysis is carried out to find out what attributes are sensitive from all dimensions of sustainability. The most sensitive attribute will contribute to sustainability change in Root Mean Square (RMS) on the x-axis (sustainability scale). The greater value of the change in RMS, the greater the role of the attribute and the more sensitive it is in the value of sustainability.

Management prospective analysis. The prospective analysis is a follow-up analysis in the RAPFISH method based on the importance value that influences and depends on sensitive attributes. Management prospective analysis was carried out based on the PPA (Participatory Prospective Analysis) method [23]. This analysis is to synthesize information in comparative policy formulation. The stages are as follows:

1) Identify and define important attributes in bay management.
2) Assess the direct or indirect influence between attributes. If there is no effect between the attributes being compared, then the value is zero (0); if the effect is small, then it is given a value of one (1); if the effect is moderate, then it is given a score of two (2); and if the effect is very large or strong, then it is given a score of three (3).
3) Putting attribute positions in four (4) quadrants (figure 2). Quadrant I is a determining factor (driving variables), contains attributes that have a strong influence, but the dependence is not strong. Factors in this quadrant are important factors or drivers included

![Figure 2. Grouping of resource management attributes in a prospective analysis diagram [24.]]
Quadrant II is a connecting factor (leverage variables), which shows the strong influence and strong dependence between factors. Quadrant III is a dependent factor (output variables) representing small influence but strong dependence. Quadrant IV is an independent factor (marginal variable) with a small influence and low dependence so that this factor is independent in the system [25].

4) Develop management policies based on prospective analysis. The main priority policy is based on the attributes located in quadrant I (driving variable). The policy and strategies have a strong level of influence and a low level of dependence. Supporting policies are set on attributes located in quadrants II and III, while attributes located in quadrant IV can be ignored.

3. Results and discussion

3.1. Jor Bay management sustainability status

Based on the RAPFISH analysis results on five dimensions, the general status of management sustainability in Teluk Jor shows a Quite Sustainable. This status is obtained from the average value of the Jor Bay Management sustainability status index in the aggregate of 57.72 for Jerowaru Village and 54.74 for Paremas Village, with a stress value of 12.95-14.95% and an R² value of 94.78-95.26%, an acceptable result at a 95% confidence level. This is indicated by the low-stress value and the high R² value from the average analysis. Sustainability index values, stress values and R² for each sustainability dimension are presented in table 7.

| Sustainability Dimension | Sustainability Value Jerowaru | Sustainability Value Paremas | Stress Value (%) | R² (%) | Sustainability Status |
|---------------------------|-------------------------------|-------------------------------|-----------------|--------|-----------------------|
| Ecology                   | 51.03                         | 47.42                         | 14.21           | 95.18  | Medium -Less           |
| Economy                   | 59.95                         | 57.87                         | 13.73           | 95.23  | Medium - Medium        |
| Social                    | 58.14                         | 50.94                         | 12.95           | 95.26  | Medium - Medium        |
| Knowledge System          | 56.51                         | 51.72                         | 14.75           | 94.92  | Medium - Medium        |
| Institutional             | 62.95                         | 65.77                         | 14.26           | 94.78  | Medium (QUITE SUSTAINABLE) |
| Average                   | 57.72                         | 54.74                         |                 |        |                       |

Figure 3. Comparison of sustainability index values between dimensions in Jerowaru Village.

Figure 4. Comparison of sustainability index values between dimensions in Paremas Village.
The largest dimension contributing to the sustainability status of bay management in the two villages is the institutional dimension. Each has a value of 62.95 in Jerowaru Village and 65.77 in Paremas Village. While the lowest dimension of the degree of sustainability is the ecological dimension, each of which is 51.03 in Jerowaru Village and 47.42 in Paremas Village. Comparison of sustainability index values between dimensions in two villages as shown in figure 3 and figure 4.

The comparison of the difference between the MDS values and the results of the Monte Carlo analysis on each sustainability dimension shows a varied value. However, the value is low (<1) (table 8). The small difference in values indicates that the error in scoring each attribute is relatively small, the variance of scoring for each attribute is relatively small, the analysis process carried out repeatedly is stable, and data entry errors can be avoided.

### Table 8. Comparison of MDS values from analysis and Monte Carlo results.

| Dimension        | MDS Jerowaru | MDS Paremas | Monte Carlo Jerowaru | Monte Carlo Paremas | Difference Jerowaru | Difference Paremas |
|------------------|--------------|-------------|----------------------|---------------------|---------------------|--------------------|
| Ecology          | 51.03        | 47.42       | 50.21                | 47.14               | 0.82                | 0.28               |
| Economy          | 59.95        | 57.87       | 59.22                | 57.65               | 0.73                | 0.22               |
| Social           | 56.51        | 51.72       | 56.45                | 51.7                | 0.06                | 0.02               |
| Knowledge System | 62.95        | 65.77       | 62.13                | 63.73               | 0.82                | **2.04**           |
| Institutional    | 58.14        | 50.94       | 56.35                | 49.85               | **1.79**            | **1.09**           |

**Figure 5.** The results of the ordinance value of the ecological dimension of the sustainability index.

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The comparison of the difference between the MDS values and the results of the Monte Carlo analysis on each sustainability dimension shows a varied value. However, the value is low (<1) (table 8). The small difference in values indicates that the error in scoring each attribute is relatively small, the variance of scoring for each attribute is relatively small, the analysis process carried out repeatedly is stable, and data entry errors can be avoided.

### 3.1.1. Ecological sustainability. The ecological dimension index value is 47.38 in Paremas Village (less sustainable) and 50.99 in Jerowaru Village (quite sustainable). In Jerorawu Village, the ecological sustainability status is better than in Paremas Village. The results of the Rapfish analysis can be accepted with an R² value of 95.17% and a stress level of 14.21%. The results are considered very well because they meet the statistical criteria (goodness of fit). The stress value <25% and the R² value close to 1 (100%) indicates the MDS (multidimensional scaling) model produced has good accuracy [16, 17]. If the R² (r-squared) value is greater than 80%, the MDS model results are categorized as good [23]. The ordinance value of the ecological dimensions is
In the bay management, the sustainability of the ecological dimension is influenced by indicator attributes that have a high leverage factor value (figure 6). Only three of the fourteen attributes/indicators on the ecological dimension, which are quite sensitive and are considered to affect this dimension which is water residence time (2.27), freshwater input (1.34) and the quality of mangrove ecosystems (1.42). Based on this fact, the sustainability of Jor Bay management on the ecological dimension is strongly influenced by the

![Figure 6](image_url)

**Figure 6.** The value of leverage on the ecological dimension of sustainability attributes.

![Figure 7](image_url)

**Figure 7.** Ordination results of the sustainability index on the economic dimension.

presented in figure 5. In the bay management, the sustainability of the ecological dimension is influenced by indicator attributes that have a high leverage factor value (figure 6).

Only three of the fourteen attributes/indicators on the ecological dimension, which are quite sensitive and are considered to affect this dimension which is water residence time (2.27), freshwater input (1.34) and the quality of mangrove ecosystems (1.42). Based on this fact, the sustainability of Jor Bay management on the ecological dimension is strongly influenced by the
time required for the exchange of seawater masses in the bay, the existence of mangrove ecosystems and freshwater input from upland.

3.1.2. Economic sustainability. The economic dimension value of the sustainability index is 58.36 (sufficiently sustainable) in Jerowaru Village and 56.90 (moderately sustainable) in Paremas Village. Jerowaru Village got slightly better than Paremas Village. The results can be accepted with an R² value of 94.93% with a stress value of 14.04%. The results are considered very well because they meet the statistical criteria (goodness of fit). Stress values <25% and R² values close to 1 (100%) also indicate that the MDS model produced in the analysis has good accuracy. The

![Figure 8. The value of sustainability attribute on the economic.](image)

![Figure 9. The results of the ordinance of the social dimension.](image)
The results of the ordination of sustainable management on the economic dimension are presented in Figure 7. The sustainability status on the economic dimension is influenced by attributes that have high leverage values (Figure 8). Three of the fifteen attributes are sensitive indicators and affect this dimension, which is the ability to fulfil basic needs (1.86), access to financing/investment (1.62), and marketing distribution reach (1.58). The factors that most influence economic sustainability in management as sensitive attributes are: (1) the ability of the bay to fulfil basic needs, (3) access to financing or investment and (3) marketing distribution reach. Three indicators are currently contributing the most in boosting the economy of Jor Bay.

3.1.3 Social sustainability
The results of the RAPFISH analysis on the social dimension show that the social sustainability status in Jerowaru Village has an index score of 55.48 (quite sustainable), while in Paremas.
Village it is 50.39 (entirely sustainable). Although both are quite sustainable, Jerowaru Village scores better than Paremas Village. The results can be accepted with an $R^2$ value of 94.67% with a stress value of 14.64%. These results show very good results because they meet the statistical criteria (goodness of fit). The stress value <25% and the $R^2$ value close to 1 (100%) indicate the MDS model produced has good accuracy. The results of the ordination of social dimensions are presented in figure 9.

The social dimension is influenced by attributes with a fairly high leverage value in determining the achievement of sustainability (Figure 10). However, only two of the 15 attributes in social dimensions are the most sensitive and affect this dimension: (1) the independent program initiative from the community (1.55) and (2) the number of users of the bay for non-fishing activities (1.47). The social dimension is influenced by the two most sensitive attributes, it is also found that other attributes, although their influence is small, can be encouraged to make a greater

**Figure 12.** Leverage value of the knowledge system attribute in sustainability.

**Figure 13.** The results of the institutional dimension of the sustainability index.
contribution, namely community involvement in planning, smooth communication channels, traditional and religious leadership that is still quite strong. This social dimension is related to the contribution, role and perception of the community around Teluk Jor and other stakeholders needed to support this sustainability.

3.1.4. Knowledge system sustainability. The knowledge system dimension shows that the value is quite sustainable in both villages. The index value obtained is 66.03 for Paremas Village (fairly sustainable), and 62.94 for Jerowaru Village (moderately sustainable) (Figure 11). The results can be accepted with an $R^2$ value of 94.61% with a stress value of 14.22%. The results are considered very well because they meet the statistical criteria (goodness of fit). A stress value of <25% and an $R^2$ value close to 1 (100%) indicates that the MDS model produced in the analysis has good accuracy.

Attributes influence sustainability status on the knowledge system dimension as knowledge indicators with a high leverage value (figure 12). There are three attributes of the nine attributes that are sensitive and affect this dimension: the attributes of innovation and community initiatives (4.02), community attitudes (3.69), and capacity building programs (3.58).

- The power of innovation and community initiative
- The attitude of the community around Jor Bay, which is generally pro-conservation and shows support for the sustainability of the bay. This attribute is also related to an
adequate understanding of the resources because attitudes are formed from their knowledge and experiences.

c. Capacity building program, such as training, counseling and coaching programs that have been carried out for the Jor Bay communities by various parties such as government, non-government institutions and universities.

3.1.5. Sustainability of institutional dimension. The sustainability analysis using RAPFISH on the institutional dimension shows that the sustainability status of Jerowaru Village has an index value of 57.56 (quite sustainable, while Paremas Village has an index of 50.18 (less sustainable). The results can be accepted with an $R^2$ value of 95.17% with a stress value of 13.02%. This result is considered very good because it meets the statistical criteria (goodness of fit), where the stress value is <25%, and the $R^2$ value is close to 1 (100%), indicating the MDS model has good accuracy. The results of the ordination of the dimensions of economic sustainability are presented in figure 13.

Attributes with a high leverage value influence the status of management sustainability on the institutional dimension. There are three of nine attributes as indicators as the most sensitive indicator: regulatory attributes as binding management rules (4.69), bay management organizations/institutions (2.72), and sustainable financing schemes (2.60). The results of the analysis of the leverage of each attribute on the institutional dimension are presented in figure 14. Three attributes control this difference in achievement as the most sensitive indicator and the most influencing this dimension. These three indicators play an important role so that they also determine the current institutional condition of Teluk Jor management. Based on the results of the leverage analysis on each dimension, the three most sensitive and influential attributes on each dimension need to be cross-tested against the attributes of other dimensions. For this reason, sensitive attributes in each dimension of sustainability need to be analyzed further. Attributes that are sensitive to each of these dimensions are presented in table 9.

Figure 15. Attribute placement in quadrants I-IV as a prospective basis for management.
The prospective analysis is a continuation of the RAPFISH analysis as an effort to develop management policies. Sensitive attributes are input in the prospective analysis, based on the value of influence and dependence on each attribute, as shown in Table 10. While the results of the prospective analysis are as shown in figure 15.

3.2. Prospective of Jor Bay management

The prospective analysis is a continuation of the RAPFISH analysis as an effort to develop management policies. Sensitive attributes are input in the prospective analysis, based on the value of influence and dependence on each attribute, as shown in Table 10. While the results of the prospective analysis are as shown in figure 15.

Based on the results of the prospective analysis above, the main programs prioritized in the management of Jor Bay are in quadrant I due to the determining factors: (1) mangrove ecosystem; (2) fulfillment of basic needs; (3) access to finance and investment; (4) marketing outreach; (5) water residence time; (6) independent programs/community initiatives; (7) non-fisheries users; and (8) freshwater input. In quadrant II which functions as a connecting factor, there are no attributes that enter into it. In Quadrant III, which functions as a binding factor, there are five attributes, namely (1) sustainability financing; (2) management organization; (3) binding regulations; (4) capacity building programs; and (5) the attitude of the community. In quadrant IV, as a major factor, there are no attributes influence on management.

Table 10. The results of the assessment of the level of influence and dependence of each attribute.

| Management Attribute | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|----------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Water Residence Time | 2 | 3 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 2 | 1 | 1 | 1 |
| B. Mangrove ecosystem | 3 | 2 | 1 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| C. Fresh water input | 1 | 1 | - | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| D. Community basic need fulfilment | 3 | 3 | 3 | 2 | 3 | 1 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| E. Access to Finance/Investment | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| F. Market outreach | 3 | 3 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| G. Community self-initiative Program | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| H. Non-fisheries user | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| I. Innovation and Community initiative | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| J. Attitude | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| K. Capacity building Program | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| L. Binding regulations | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| M. Bay Management Body | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| N. Sustainable financing | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Information: A-N is a management attribute, value 0 = no effect, value 1 = small effect, value 2 = moderate effect, value 3 = very large/strong effect.
The prospective analysis resulted that the attributes being perfectly clustered in quadrants I and III. It shows that the relationship between attributes occurs without any connecting attribute, only the determining factor (quadrant I) and the dependent factor (quadrant III). The study concludes that the indicators that determine the sustainability of Jor Bay are 8 attributes: (1) mangrove ecosystem, (2) fulfilment of basic community needs, (3) access to finance and investment, (4) Table 11. Policies and strategic recommendations to strengthen sustainability of Jor Bay management.

| No | Policy                        | Strategies                                                                 |
|----|-------------------------------|---------------------------------------------------------------------------|
| 1. | Ecosystem/Habitat Protection  | a. Determination of conservation zone (marine protected area)              |
|    |                               | b. Control the carrying capacity of land and water                          |
|    |                               | c. Pollution load and pollutant sources control                            |
|    |                               | d. Develop eco-friendly tools and methods for utilizing resources          |
|    |                               | e. Handling of waste from the settlement                                   |
|    |                               | f. Handling of Waste from activities at sea                                |
|    |                               | g. Rehabilitation of ecosystems (mangroves, seagrass and TK)               |
|    |                               | h. Habitat quality improvement                                            |
|    |                               | i. Restocking                                                              |
| 2. | Socio-economic strengthen      | a. Local labor absorption                                                  |
|    |                               | b. Livelihood Development                                                  |
|    |                               | c. Source of community income/Alternative livelihood                       |
|    |                               | d. Increased use of sustainable ecosystem services                         |
|    |                               | e. Development of tourism activities                                       |
| 3. | Institutional strengthen       | a. Organizational reform                                                   |
|    |                               | b. Improving bay management organization performance                        |
|    |                               | c. Improving management strategies                                         |
|    |                               | d. Enhancement of awiq-awiq enforcement                                    |
|    |                               | e. Strengthening management organization capacity                           |
| 4. | Community Capacity Building   | a. Sustainable capacity building Program                                   |
|    |                               | b. Encourage community initiative                                          |
|    |                               | c. Self-initiative community based Program                                 |
|    |                               | d. Community innovation and creativity incentives                          |
| 5. | Bay Zoning Plan               | a. Mapping of land use around the bay                                       |
|    |                               | b. Establishing bay Zoning Plan                                            |
|    |                               | c. Monitoring and surveillance                                              |
|    |                               | d. Optimizing land productivity                                            |
|    |                               | e. Carrying capacity of water control                                      |
|    |                               | f. Monitoring the decline in land productivity and water quality           |

3.3. **Sustainable bay management strategy**

The prospective analysis resulted that the attributes being perfectly clustered in quadrants I and III. It shows that the relationship between attributes occurs without any connecting attribute, only the determining factor (quadrant I) and the dependent factor (quadrant III). The study concludes that the indicators that determine the sustainability of Jor Bay are 8 attributes: (1) mangrove ecosystem, (2) fulfilment of basic community needs, (3) access to finance and investment, (4)
marketing outreach, (5) water residence time, (6) independent programs/community initiatives; (7) non-fishing bay users, (8) freshwater input.

Five factors function as binding factors, as well as can be the main support for successful management: (1) sustainable financing; (2) the performance of the management organization; (3) binding regulations; (4) capacity building programs; and (5) the attitude of the community. In quadrant IV, as a major factor, there were no attributes that had less influence on management. The recommendation policies and strategies that need to be implemented to strengthen Jor Bay's management to ensure its sustainability are described in table 11.

4. Conclusion
The current status of management sustainability in Jor Bay are QUITE SUSTAINABLE. The institutional dimension provides the greatest sustainability value, while the lowest sustainability value dimension is the ecological dimension. The level of sustainability in the two villages shows different results, where each show quite sustainable in Jerowaru Village and less sustainable in Paremas Village. Recommendations needs to improving the sustainability level of Jor Bay management, are implement some basic policies and strategies: (1) maintain the existence of mangrove ecosystems; (2) Encouraging access to finance and investment; (3) Expanding the marketing outreach of ecosystem services; (4) Strictly regulate the mariculture activity based on carrying capacity in the bay; (5) Encouraging self-management programs; (6) Encouraging non-fishing activities/businesses as an alternative livelihood.

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