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Multidimensional Scaling Approach For Evaluating The Sustainability Status Of Two Small Islands With Development Potential In The Banda Islands

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Abstract: Small islands will face a variety of very complex obstacles related to sustainable development. The Banda Islands are one of the areas that are likely to face these problems due to the high level of insularity. To avoid the problems that will be faced, various studies are needed in evaluating the status of small island sustainability on two Potential Islands as a priority for sustainable development carried out with the aim of knowing the sensitive factors that affect the development of Small Island Areas based on the dimensions of management as an improvement strategy. This research uses the Multidimensional Scaling (MDS) approach by determining five dimensions consisting of 56 Attributes. Based on the results of the study, Banda Neira Island has an average index value of 42.44 which is included in the Less Sustainable category and Banda Besar Island with an average index value of 43.91 which is included in the Less Sustainable category. From the sustainability status, it is known that sensitive factors in inhibiting sustainable development can be used as the main problems faced by the two potential islands and become a special concern in the planning process of the two potential islands.

Keywords: Sustainable, Sensitive Factors, Multidimensional Scaling, Planning, Small Island.

I. Introduction

The development of coastal areas and small islands is carried out as an effort to increase the capacity and efficiency of the region, which is expected to increase the development of small island areas and is directed at improving the quality of infrastructure, regional income, prosperity of community life and binding regulations in the country. This kind of theoretical generalization actually has very diverse potential from one place to another with different levels of exploitation. On the other hand, the development potential is still quite large, but in other places there is no development potential due to environmental damage and unsustainable utilization **(Rijanta, 2005)**. An important factor that is strongly suspected in determining the level of development of the Islands region is the level of regional insularity that varies between parts of the Islands region itself. The higher the level of insularity of the Islands region, the higher the problems it faces so that most areas with a high level of insularity tend to develop as underdeveloped areas **(Benedict dkk, 1999)**.

Theoretically, the development of an insularity region dominated by small islands will face a variety of very complex constraints. Understanding Islands in a way that makes sense to Islanders and in the context of specific island cultures, emphasizing epistemic diversity **(Nadarajah et al, 2022)**. To understand the dynamics of Islands, a deeper relational understanding between islands, regions, and cultures is needed, for example, islands that form new relational meanings and entities as a result of geopolitical developments with outlying islands **(Meng Qu et al, 2023)**. The Island space continues to hold a fascination that is difficult to define, through its paradoxical and ambivalent nature, the Island has its own interest from various fields as it is an element that triggers the imagination, offering successive modeling and redefinition as a vast and isolated space **(Potre A, 2017)**.

In the Maluku Islands, there is one group of small islands that is geographically surrounded by a vast sea and is far from the continental area and surrounding small islands, namely the Banda Islands, which administratively is the Banda District area with the capital Banda Neira, Central Maluku Regency, Maluku Province. Thus the Banda Islands Region is characterized as an insularity region, where a small island that is not connected to the continental region by permanent infrastructure such as tunnels or bridges, is at least 1 kilometer from the continental region and does not have a large city **(Euroisles, 2003)**. With the characteristics of the Banda Islands Region, it requires serious handling to anticipate development developments as other regions that cannot be separated from the problem of insularity that has its own challenges and can be an obstacle in regional development efforts in the Banda Islands. The problems faced by the insularity region itself include (1) connectivity of transportation access, (2) the existence of development disparities, (3) spatial planning of small island regions that are not yet organized, and (4) policies that are still partial and sectoral. On the other hand, the Banda Islands have regional potential in carrying out their functions and roles as sustainable competitive small island regions. The potential of the region which is then considered in several aspects of potential, namely Tourism, Plantations and Fisheries and Marine which can be marketed outside the Maluku region.

(Yaman G, 2015) in his research explains one of the strategies in regional development by determining growth centers as an effort to control regional development where areas that have such rapid growth that they are used as centers of development that affect other areas around them. There are 2 potential development islands as growth centers in the Banda Islands, namely Banda Neira

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Island and Banda Besar Island (Tuakora, 2023) with the existence of areas that are used as growth centers, it is hoped that the surrounding areas will also be affected and triggered to progress. For this reason, it is necessary to extract data to solve a problem in providing the necessary information, considering the basis of management related to regional development. Planning and sustainable regional development is carried out comparatively to describe the status of sustainability which produces sensitive factors as obstacles in the development of 2 potential islands in the Banda Islands by involving each domain and its relationship between each indicator used to achieve Social and Economic development goals.

II. Research Methods

The data used in this research are primary data and secondary data. Primary data was obtained and collected directly through field observations and in-depth interviews with stakeholders and respondents who became informants. Secondary data was obtained from statistical data covering the research area.

The method used in this research is the application of Multidimensional Scaling (MDS) techniques developed in a RapWIN application to determine the sustainability of small island development. This application is a modification of the Rapfish (Rapid Appraisal for Fisheries) program developed by the University of British Colombia-Canada to assess the sustainability of a system (Fauzi A and S. Anna, 2005).

The MDS technique maps two points or objects that are the same in one point that are close to each other. Conversely, different objects or points are depicted with points that are far apart. The score values for each attribute will form a matrix X (n x p), where n is the number of regions and reference points and p is the number of attributes used. The score value is then standardized for each attribute score value. So that each attribute has a uniform weight and differences between measurement scales can be eliminated. (Kavanagh et al, 2004) formulated the standardization method as follows:

$$X_{ik}sd = \frac{X_{ik} - X_k}{S_k} \quad (1)$$

Where to:

X_{ik}sd	:	standardized score value of the i-th region (including its reference point) = 1.2...n. on the ke-k attribute = 1.2...p
X_{ik}	:	Initial score value of the region (including its reference points) i = 1.2...n. on each ke-k attribute = 1.2....p
X_k	:	The center value of the score on each ke-k attribute = 1.2...p
S_k	:	Standard deviation of scores at each ke-k attribute = 1.2...p

(Kavanagh et al, 2004) mentioned that the MDS technique in Rapfish is done by calculating the closest Euclidian distance based on equation (2):

$$d_{12} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (2)$$

The Euclidean distance between the two points (d_{12}) is then projected into a two-dimensional Euclidean distance (D_{12}) and e is the error value. Formulated in equation (3):

$$d_{12} = a + bD_{12} + e \quad (3)$$

In Rapfish, the regression process uses the ALSCAL algorithm with the principle of making repetition (interaction) of the regression process so as to produce the smallest error value. According to **(Kavanagh et al, 2004)** the ALSCAL algorithm in Rapfish forces the intercept value in the equation to be equal to zero (a = 0) so that equation (3) becomes equation (4) below:

$$d_{12} = bD_{12} + e \quad (4)$$

The repetition process is stopped. If the stress value is smaller than 0.25. the stress value is obtained based on equation (5).

$$Stress = \sqrt{\frac{1}{m}\sum_{k=1}^{m}\left[\frac{\sum i \sum j \left(D_{ijk} - d_{ijk}\right)2}{\sum i \sum j d_{ijk}^2}\right]} \quad (5)$$

The effect of error will appear in MDS analysis caused by various things, such as: (1) Errors in scoring due to misunderstanding of attributes or imperfect conditions of the research location, (2) Variations in values due to differences in opinion or judgment by researchers, (3) Data entry errors or missing data and (4) high Stress values. Stress value <25% is an acceptable stress value. Evaluation of the effect of error in the process of estimating the sustainability ordination value can be done using Monte Carlo analysis. **(Kavanagh et al, 2004)** mentioned that the goodness of fit in MDS is reflected in the value of S (stress) and R^2 . A good model is indicated by the value of S which is smaller than 0.25 and R^2 which is close to 1. The scale of the system sustainability index studied has an interval of 0-100 percent.

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Table 1. Sustainability Index Value

No	Value Index	Sustainability Status
1	0,00 – 25,00	Unsustainable
2	25,01 – 50,00	Less Sustainable
3	50,01 – 75,00	Sustainable Enough
4	75,01 – 100,00	Sustainable

Source : Suwarno, et al., 2011

The stages in the MDS sustainability analysis are carried out through three stages, namely: (1) Determination of Dimensions and Attributes that include 5 Dimensions and 56 Attributes; (2) Evaluation of Attributes on an ordinal scale (scoring) based on the sustainability criteria of each dimension; (3) Determination of Sustainability Status through ordination analysis through the values assessed both multidimensionally and in each dimension, Sensitive Analysis (Leverage) to determine variables that sensitively affect sustainability and Anomaly Analysis (Monte Carlo) to take into account aspects of uncertainty **(Schaduw, 2015)**.

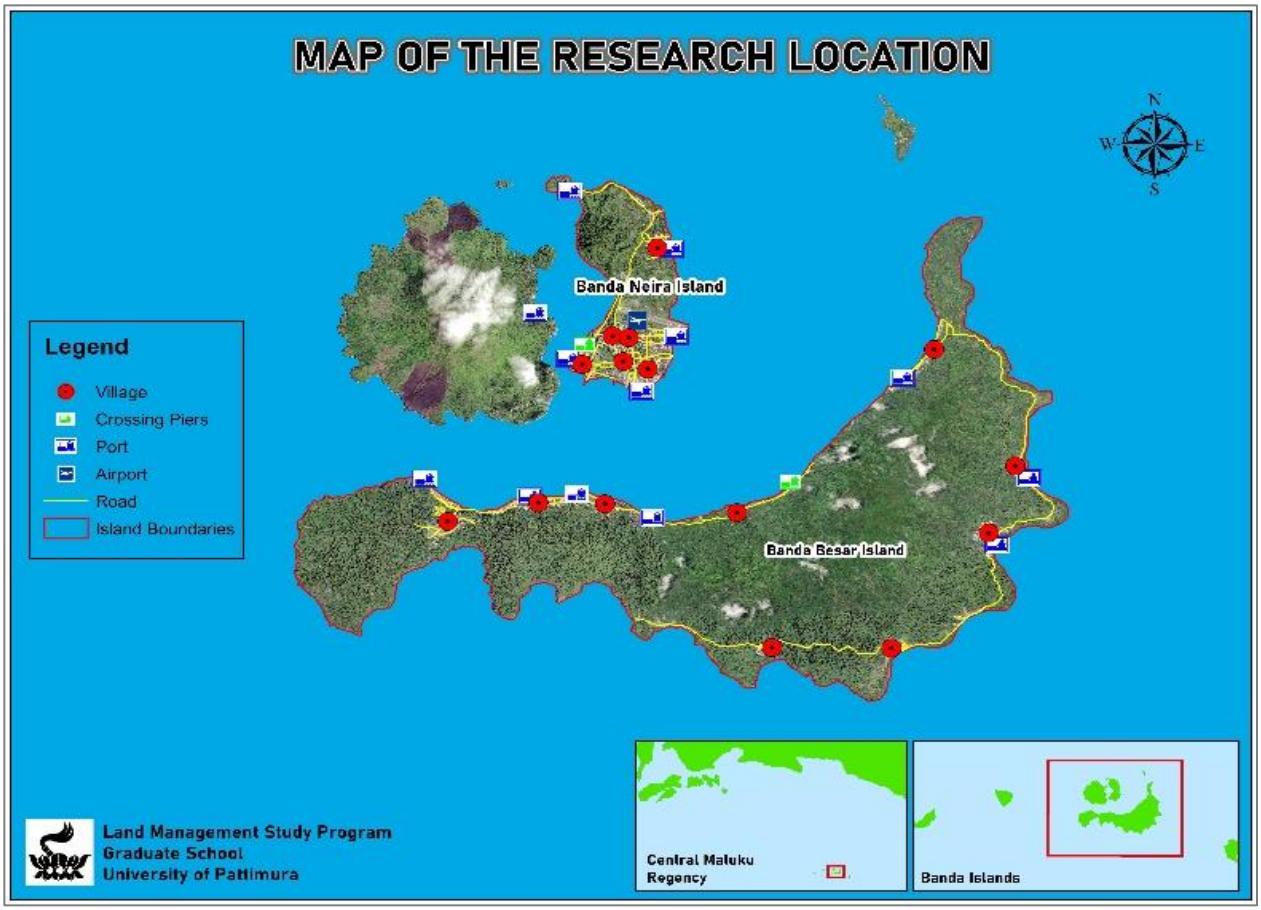

Fig 1. Map of the Research Location

III. Results and Discussion

Evaluation of Sustainability Status

Sustainability Analysis on the Infrastructure Dimension

The results of the analysis of the sustainability of Regional Development for the Infrastructure Facilities dimension show that the sustainability status on the two Potential Islands has a value between 50.01 - 75.00 which indicates a fairly sustainable status position, namely for Banda Neira Island 53.72 and Banda Besar Island 51.56. based on the results of this analysis, the condition of the two potential islands needs special attention to restore the dimensions of infrastructure facilities on the condition of Banda Neira Island and Banda Besar Island with a fairly sustainable status in order to achieve sustainable status.

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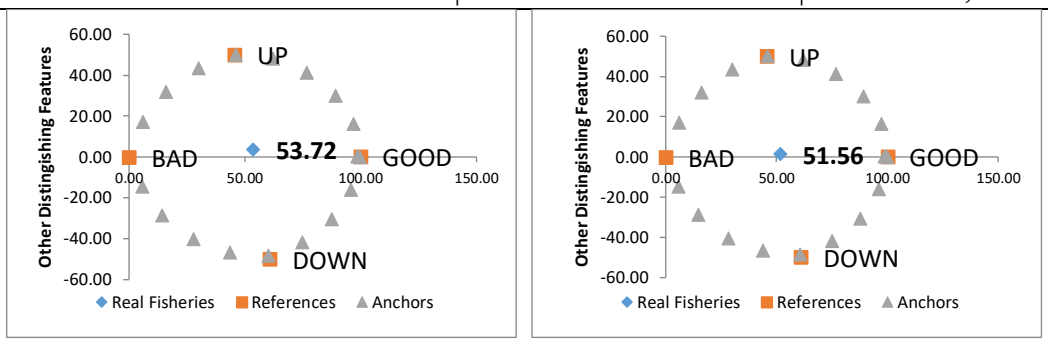
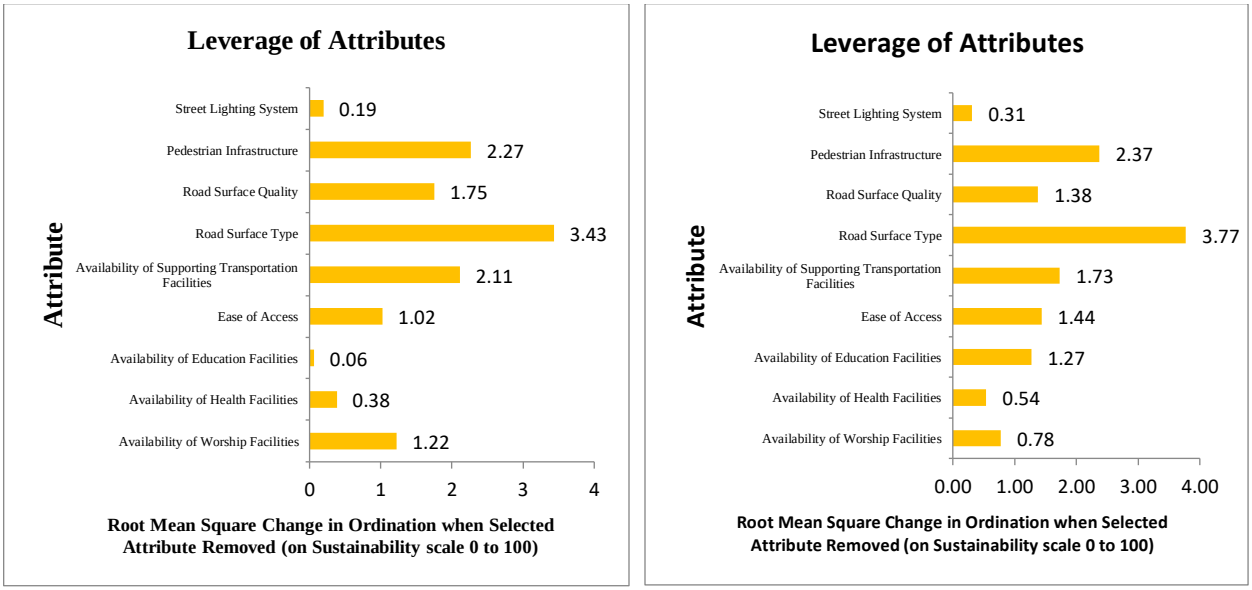


(a) (b)

Fig 2. Sustainability Status of Infrastructure Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Assessment of the status of sustainability in the Infrastructure dimension is carried out based on the leverage attributes that have been analyzed. Based on the results of the leverage analysis as shown in **Fig 3**, of the 9 attributes analyzed, there is 1 attribute that positively affects the value of the sustainability index of the infrastructure facilities dimension, namely the Type of Road Surface on Banda Neira Island with a value of 3.43 and Banda Besar Island 3.77. This attribute needs special attention by making better road improvements so that it can increase the value of a better sustainability status in the future.



(a) (b)

Fig 3. Sensitive Factors affecting the Sustainability of Regional Development in the Infrastructure Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Sustainability Analysis on the Population and Social Conditions Dimension

The results of the analysis of the sustainability of Regional Development for the dimensions of Population and Social Conditions show that the sustainability status of the two Potential Islands has a value between 50.01 - 75.00 which indicates a fairly sustainable status position, namely for Banda Neira Island 64.64 and Banda Besar Island 60.72. based on the results of this analysis, the conditions of the two potential islands need special attention to restore the dimensions of Population and Social Conditions on the conditions of Banda Neira Island and Banda Besar Island with a fairly sustainable status in order to achieve sustainable status.

Assessment of the status of sustainability in the Population and Social Conditions dimension is carried out based on the leverage attributes that have been analyzed. Based on the results of the leverage analysis as shown in **Fig 5**, of the 13 attributes analyzed, there is 1 attribute that positively affects the value of the sustainability index of the Population and Social Conditions dimension, namely the Waste Disposal Process on Banda Neira Island with a value of 2.70 and the use of defecation facilities on Banda Besar Island with a value of 2.76. these attributes need special attention by improving better management so as to increase the value of sustainability status.

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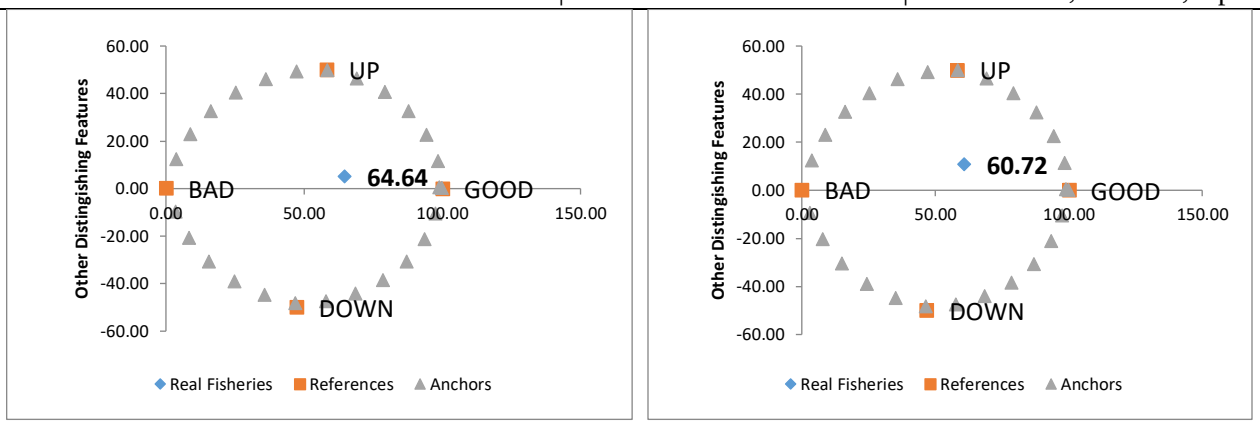
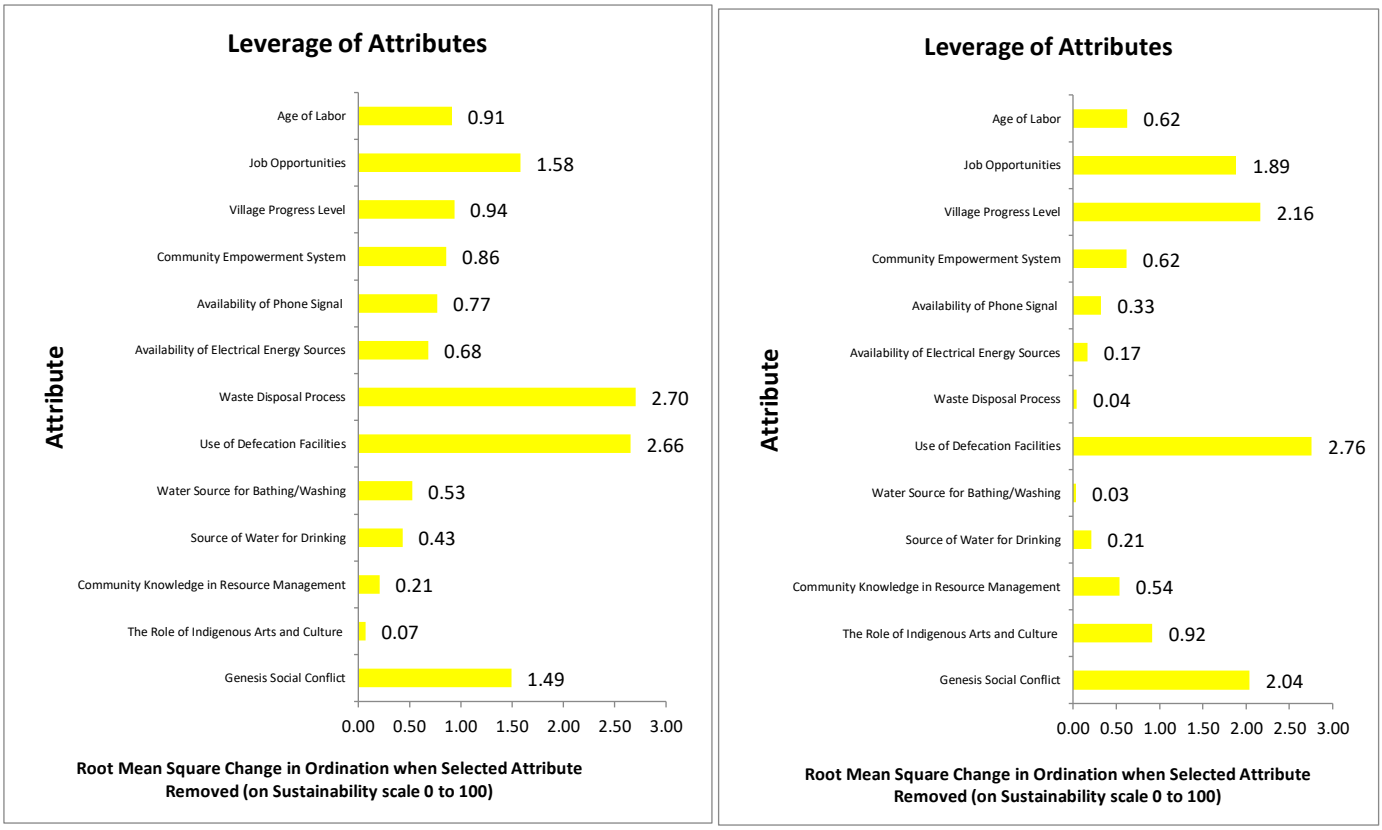


(a) (b)

Fig 4. Sustainability status of population dimension and social conditions

(a) Banda Neira Island, (b) Banda Besar Island



(a) (b)

Fig 5. Sensitive Factors Affecting the Sustainability of Regional Development in the Dimension of Population and Social Conditions

(a) Banda Neira Island, (b) Banda Besar Island

Sustainability Analysis on Economic Dimension

The results of the analysis of the sustainability of regional development for the economic dimension show that the sustainability status of the two potential islands has a value between 0.00 - 25.00 which indicates the position of the status of sustainability is not sustainable, namely for Banda Neira Island 17.56 and Banda Besar Island 17.13. based on the results of this analysis, the condition of the two potential islands needs special attention to restore the economic dimension in the condition of Banda Neira Island and Banda Besar Island with unsustainable status in order to reach the status above quite sustainable or even sustainable.

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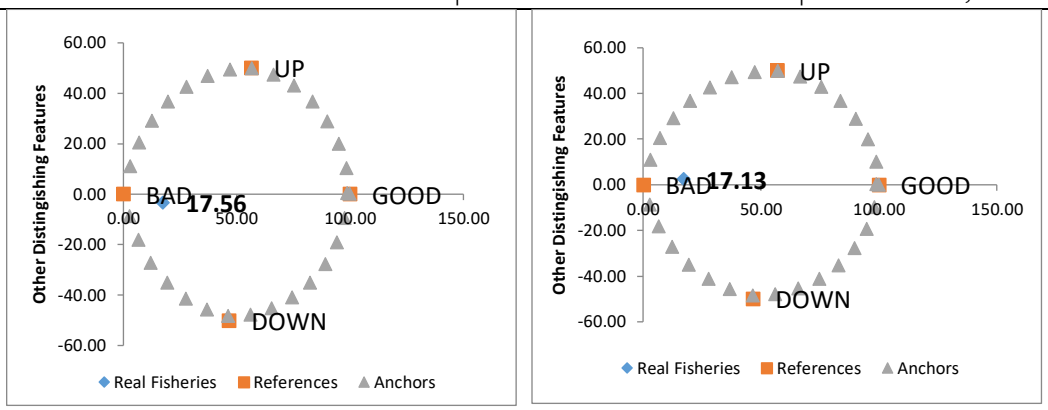
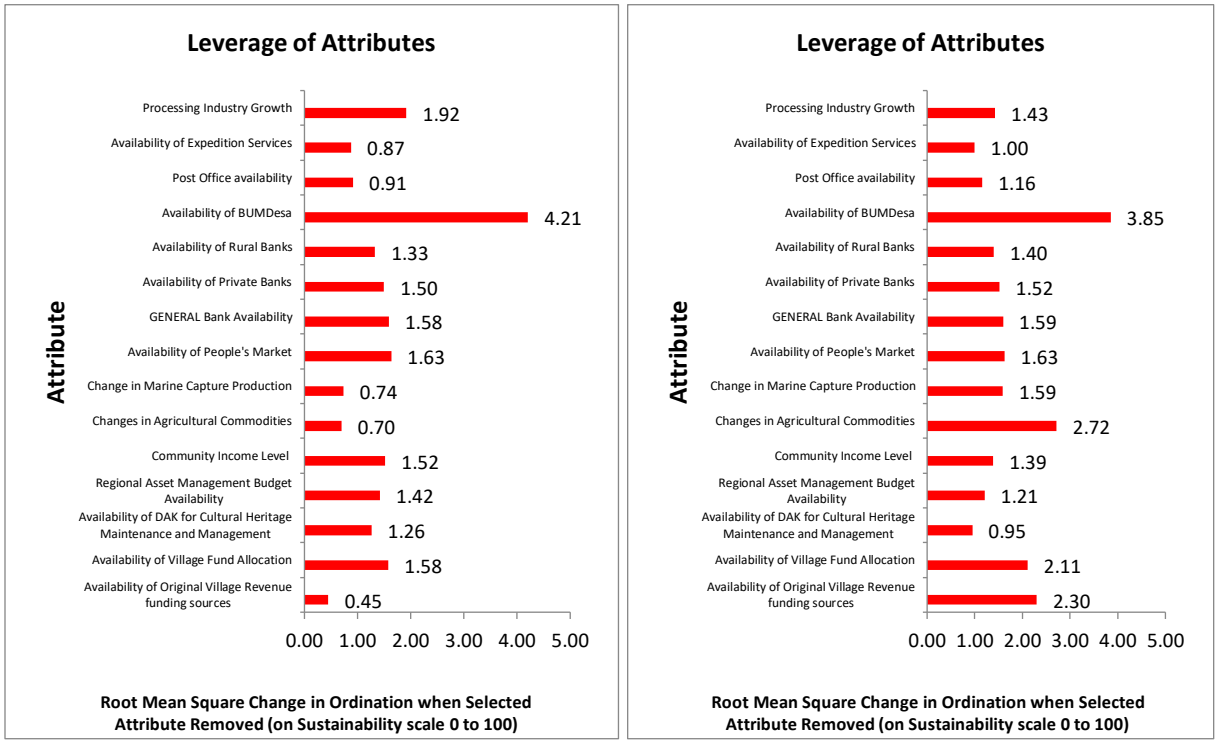


(a) (b)

Fig 6. Sustainability Status of Economic dimension

(a) Banda Neira Island, (b) Banda Besar Island

Assessment of the status of sustainability in the economic dimension is carried out based on the leverage attributes that have been analyzed. Based on the results of the leverage analysis as shown in **Fig 7**, of the 15 attributes analyzed, there is 1 attribute that positively affects the value of the economic dimension sustainability index, namely the availability of BUMDesa on Banda Neira Island with a value of 4.21 and Banda Besar Island with a value of 3.85. This attribute needs special attention by making better improvements so that it can increase the value of sustainability status.



(a) (b)

Fig 7. Sensitive Factors Affecting the Sustainability of Regional Development in the Economic Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Sustainability Analysis on the Tourism Dimension

The results of the analysis of the sustainability of Regional Development for the Tourism dimension show that the sustainability status on the two Potential Islands has a value between 25.01 - 50.00 which indicates the position of a less sustainable status, namely for Banda Neira Island 48.04 and Banda Besar Island 40.16. based on the results of this analysis, the condition of the two potential islands needs special attention to restore the Tourism dimension in the condition of Banda Neira Island and Banda Besar Island with a less sustainable status in order to achieve a status above moderately sustainable or even sustainable.

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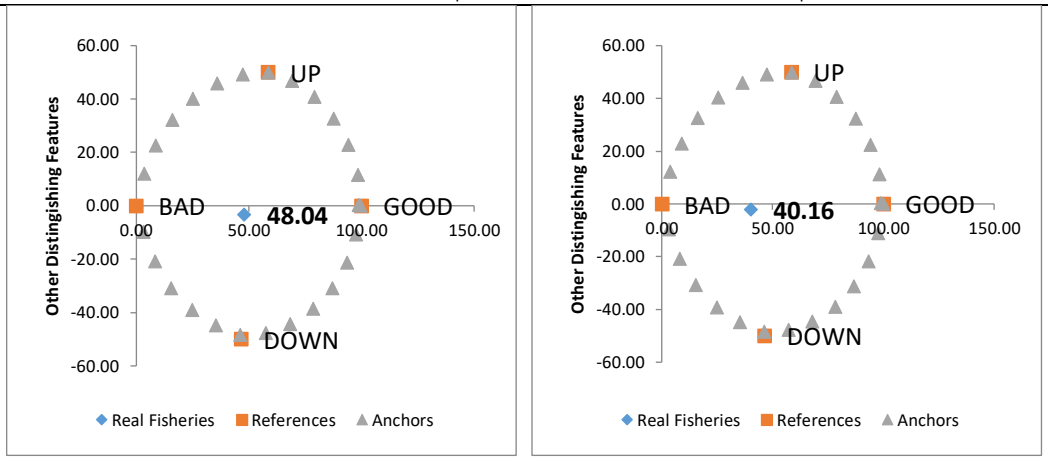
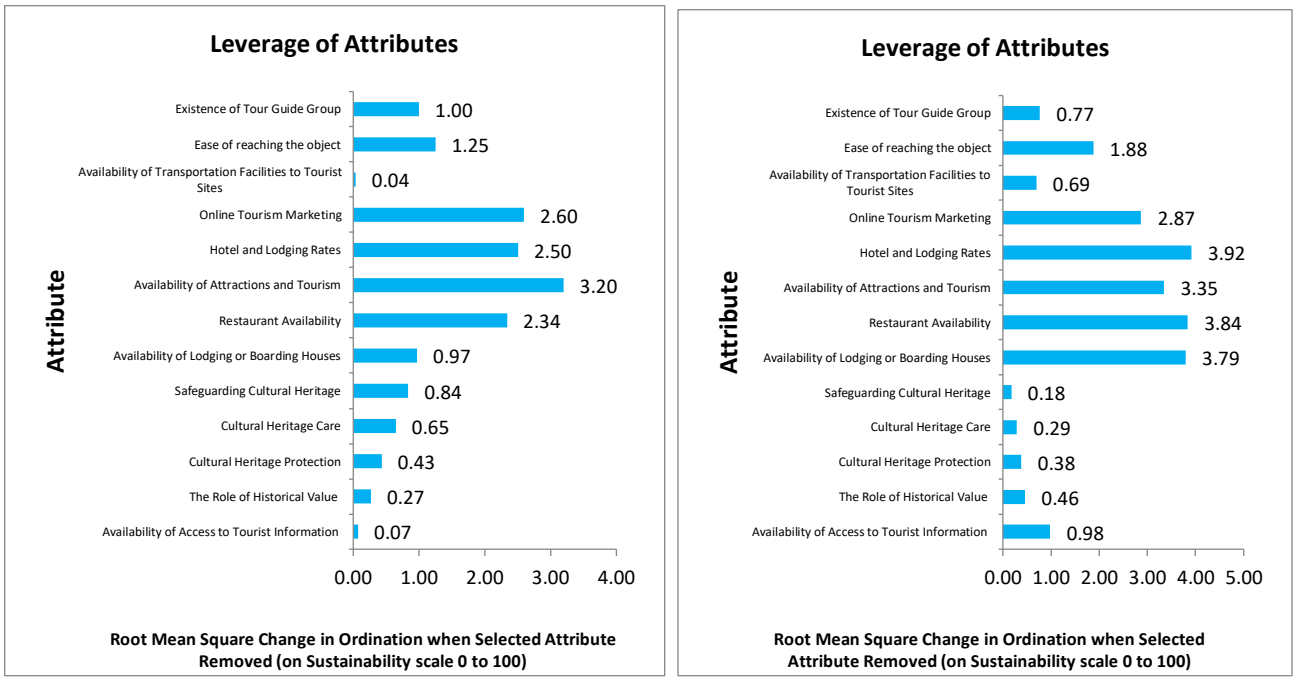


(a) (b)

Fig 8. Sustainability Status of Tourism Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Assessment of the status of sustainability in the Tourism dimension is carried out based on the leverage attributes that have been analyzed. Based on the results of the leverage analysis as shown in **Fig 9**, of the 13 attributes analyzed, there is 1 attribute that positively affects the value of the sustainability index of the Tourism dimension, namely the availability of tourist attractions on Banda Neira Island with a value of 3.20 and the availability of hotels and lodging on Banda Besar Island with a value of 3.92. these attributes need to get special attention by making better improvements so that they can increase the value of sustainability status.



(a) (b)

Fig 9. Sensitive Factors Affecting the Sustainability of Regional Development in the Tourism Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Sustainability Analysis on the Institutional Dimension

The results of the analysis of the sustainability of Regional Development for the Institutional dimension show that the sustainability status of the two Potential Islands has a value between 25.01 - 50.00 which indicates the position of a less sustainable status, namely for Banda Neira Island 39.50 and Banda Besar Island 49.99. based on the results of this analysis, the condition of the two potential islands needs special attention to restore the Institutional dimension in the condition of Banda Neira Island and Banda Besar Island with a less sustainable status in order to achieve a status above moderately sustainable or even sustainable.

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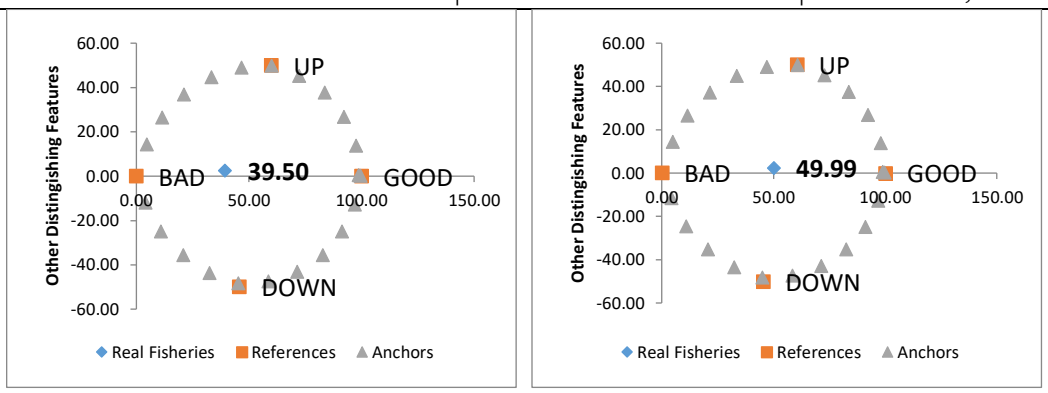
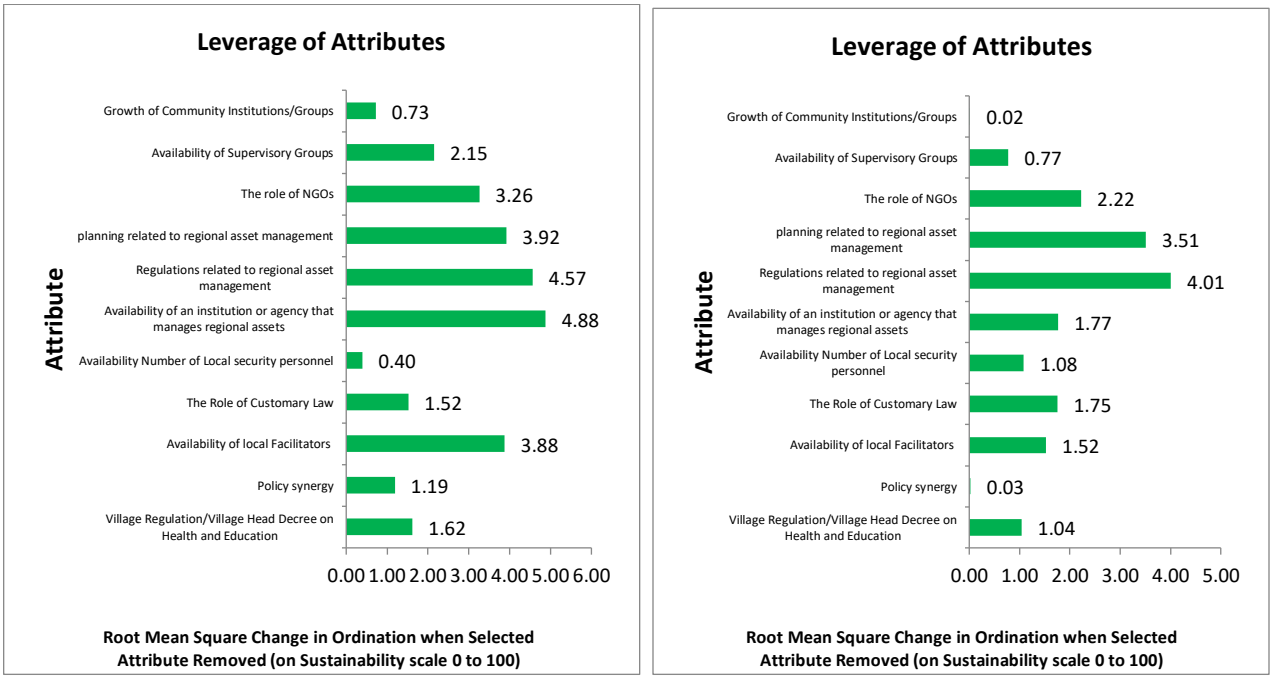


(a) (b)

Fig 10. Sustainability Status of Institutional dimension

(a) Banda Neira Island, (b) Banda Besar Island

Assessment of the status of sustainability in the institutional dimension is carried out based on the leverage attributes that have been analyzed. Based on the results of the leverage analysis as shown in **Fig 11** of the 11 attributes analyzed, there is 1 attribute that positively affects the value of the institutional dimension sustainability index, namely the availability of institutions or agencies that manage regional assets on Banda Neira Island with a value of 4.88 and policies in managing the assets of the Banda Besar Island area with a value of 4.01. these attributes need special attention by making better improvements so that they can increase the value of sustainability status.



(a) (b)

Fig 11. Sensitive Factors Affecting the Sustainability of Regional Development in the Institutional Dimension

(a) Banda Neira Island, (b) Banda Besar Island

Multidimensional Scaling Analysis and Validation of Sustainability

The results of the identification of the sustainability status that has been carried out in each dimension can be combined and compared as a whole in the form of Multidimensional Scaling Analysis (MDS). **Table 2**, shows the Sustainability Status of Infrastructure, Population and Social Conditions, Economy, Tourism and Institutions on the two islands of potential regional development. The average value of the sustainability status of each dimension on the two Potential Development Islands is in the range of sustainability index values 25.01 - 50.00 which indicates a less sustainable status so that special attention needs to be paid to improving the sustainability status of the Economic dimension on the two Islands because of the smallest ordination value compared to other dimensions.

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Table 2. Sustainability Status Score for each Dimension

No	Dimensions	Potential Island	
		Banda Neira	**Banda Besar**
1	Infrastructure Facilities	53.72	51.56
2	Population and Social Conditions	64.64	60.72
3	Economy	17.56	17.13
4	Tourism	48.04	40.16
5	Institutional	39.50	49.99
Average		42.44	43.91

Fig 12, shows a kite diagram of the position of sustainability status between potential islands in each dimension. Banda Neira Island has the highest sustainability status in the dimensions of Tourism, Population and Social Conditions and Infrastructure Facilities compared to Banda Besar Island which is only prominent in the Institutional dimension.

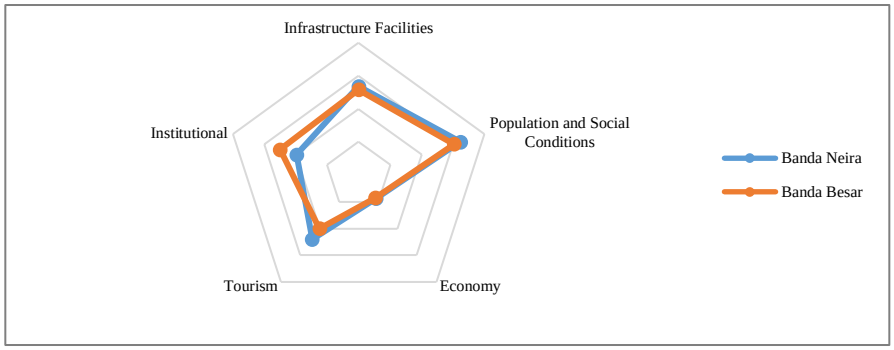

Fig 12. Kite Diagram of Sustainability Status Index Analysis

Validation of the results of the MDS analysis can be analyzed based on the value of statistical parameters issued by the Insularity Rap-Region model, namely based on the value of "S-Stress and the Coefficient of Determination (R^2). The model output results as shown in **Table 3**, show the S-Stress value <0.25, meaning that the model output is quite significant. Likewise, the coefficient of determination generated at the 95% confidence interval level obtained a significant coefficient value close to 1 for each dimension.

Another test of the results is to compare the results of the MDS analysis with the results of the Monte Carlo analysis, as can be seen in **Table 4**. The results obtained indicate that the difference in results between the MDS and Monte Carlo values at the 95% confidence interval does not experience much difference with a difference of 1. The small difference in the value of the sustainability index between the results of the analysis of the two methods indicates that (1) The error in making the score of each attribute is relatively small, (2) Relativ small differences in opinion are given, (3) The model iteration process is relatively stable. The relatively small difference of less than 1 between the MDS and Monte Carlo simulation results indicates that the system studied has a high level of confidence.

Table 3. Statistical Parameters (Goodness of fit) Sustainability Index Analysis

No	Dimensions	Potential Island			
		Banda Neira		**Banda Besar**	
Parameter Statistik		**S Stress**	**R2**	**S Stress**	**R2**
1	Infrastructure Facilities	0.14	0.95	0.14	0.95
2	Population and Social Conditions	0.14	0.95	0.14	0.95
3	Economy	0.13	0.96	0.13	0.96
4	Tourism	0.14	0.95	0.13	0.95
5	Institutional	0.13	0.95	0.14	0.95

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Table 4. MDS and Monte Carlo Comparison Analysis Results

No	Dimensions	Potential Island					
		Banda Neira			**Banda Besar**		
Parameter Statistik		**Hasil MDS**	**Hasil Monte Carlo**	**Selisih**	**Hasil MDS**	**Hasil Monte Carlo**	**Selisih**
1	Infrastructure Facilities	53.72	53.48	0.24	51.56	51.34	0.22
2	Population and Social Conditions	64.64	63.89	0.75	60.72	60.38	0.34
3	Economy	17.56	17.33	0.23	17.13	16.94	0.19
4	Tourism	48.04	47.76	0.28	40.16	39.78	0.38
5	Institutional	39.50	39.20	0.30	49.99	49.92	0.07

IV. Conclusion

The index value of the sustainability of the development of the insularity area for each Potential Island is 42, 44 and 43.91 which is obtained from the average of the total index on the dimensions analyzed, meaning that the status of the sustainability of the development of the insularity area is included in the Less sustainable category for both Potential Islands. Two of the five sustainable dimensions have a fairly sustainable status, while there are two dimensions that have a less sustainable status, namely the Tourism and institutional dimensions and one dimension that has an unsustainable status, namely the economic dimension.

Planning fund policy strategies need to be carried out by managing attributes that have a sensitive effect or as a major problem in the development of insularity areas. Sensitive attributes are basic services in supporting tourism activities which will have an impact on the economy and regulations are needed in the planning stages to run according to the needs and procedures that apply to the creation of mature and targeted planning. This will prevent effects that will later have an impact on other aspects / dimensions and worsen the sustainability status of the development of the insularity area.

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