The Use of MDS (Multidimensional Scaling) Method to Analyze the Level of Sustainability of Fisheries Resources Management in Thousand Islands, Indonesia

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Abstract This paper will discuss the sustainability of fisheries resources in the Thousand Islands by five main indicators, which are (1) ecology, (2) economic, (3) socio-cultural, (4) legal & institutional and (5) technology & infrastructure, by using the MDS (multidimensional scaling) analysis. By ordinal scoring on each attribute 0 (the lowest) and 3 (the highest) of each indicator, and with the support of Rapfish, it can be seen the similarity or dissimilarity of each indicator that are grouped in a space based on euclidian distance. By using the scale of the sustainability index, it can be known the level of sustainability of each indicator. Besides, it can also be known the attribute’s level that should get the attention based on the percentage’s sequence of ordination root mean square (RMS) change on the X axis. And the evaluation of the error’s effect is using Monte Carlo. The results shows there are 2 indicators in the sufficient category of sustainable which are economic and social culture indicators with each sustainability index value stated 55.44% and 56.54%, while for ecology, legal and institutional as well as technology and infrastructure, the indicators are in the less sustainability category, amounting each sustainability index value of 48.63%, 43.73% and 34.17%.

Keywords Thousand Islands; Coastal pollution; Sustainability indicators; Sustainability index; MDS; RMS

Introduction

Thousand Islands is the coastal and marine areas in the north of Jakarta and it is part of the Special Region of Jakarta consisting of 105 groups of small islands, with a land area of 897.7 hectares and 6,997.50 km² of water area. This area was built by coral reef ecosystems which become major ecosystems. Thousand islands have great potential for economic development, especially for industry, fisheries, and as marine tourism which becomes as an attractive recreational area for domestic tourists, especially from Jakarta. This mean that Thousand Islands has a very essential function, namely economic and social (Regulation No. 6 of 1999). According to the Minister of Marine Fisheries Regulation No. 45 Year 2011, Thousand Islands including WPP (Regional Fisheries Management) is part of the Java Sea. The fish resource potential in the Java Sea is estimated at 836 600 tonnes, 21.74% of them (about 181 876 tonnes) are in the Thousand Islands.

As the area of fisheries for fishermen, there are several types of fishing gear used by them, among others: gill nets, longlines, dogol tool and fishing pole. The fishing fleet at the present time comprises 1,289 with the largely is motor boats (899 units) and the other consisted of outboard motors, sailboats, and canoes / boats (370 units). (Fisheries & Marine Department of the Special Region of Jakarta, 2012). During the period 2008 - 2011 the number of fishing gear, especially gill nets chart and drift boat had an increasing of 13.2% while the other gear has decreased about 10%.

Over the past 10 years, the development has been showing that this region is risk from various problems, both concerning physical, biological social, economic and cultural aspects (Ian and Dichmont, 2010). The number of fishermen in the Thousand Islands region is expected to reach 68,360 people, but later began to decline due to environmental degradation, caused by the pollution of sea water due to accumulation of犯tes, heavy metals and other pollutant sources, which came from 13 river streams in Jakarta (Ministry
of Maritime Affairs and Fisheries, 2011). Estimated the number of incoming waste reaching 678 cubic meters covering 54% of plastic waste, 24% wood, 14% plants and foliages and the remaining are glasses, cans and others (Thousand Islands Management Board, 2013). One of the indicators of the environmental degradation can be seen from the coral cover which is only around 24-26% (Gluseppa, et al, 2010).

Fishing activities undertaken by the fishermen in this region tend not to be controlled so give the result of over fishing, this is indicated by the size of the fish caught in the last few years become smaller (Diniah and Septiawan, 2009 and Harmiyati, 2009). During the period 2008-2011 the area of thousand islands had faced serious problem of water pollution and deterioration to 29% (Ian and Dicmont, 2010). Water pollution in Jakarta coastal area is very serious, every day hundreds of tons of waste brought through 13 rivers flowing into the sea of Jakarta, consequently not only decrease the production of fish but also affect the tourism activities (BPLHD: Regional Environment Management Agency, 2012). As the marine tourism destination, thousand islands attract tourists and every week around 5000-7000 tourists, mostly domestic tourists come to the region, some activities are undertaken including diving, swimming, cycling, and beach volleyball (Syarifudin, 2012).

Due to the environmental degradation in the Thousand Islands region, either because of the build up of trash and over fishing, the area is currently facing a serious problem, which threatened the sustainability of the economic and social function. This study aims to determine the level of sustainability of thousand islands based on 5 (five) key indicators, i.e. ecological, economic, socio-cultural, legal and institutional, as well as infrastructure and technology by using MDS (Multidimensional Scaling).

Literature Review

Fishery resources consist of fish resources, environmental resources, as well as any man-made resources that are used to exploit fish resources (Nikiuluw, 2002). Fisheries Resources Management under the Indonesian regulation No. 45/ 2009 is the utilization of fish resources and its sustainability started from pre-production, production, processing to marketing carried out in a fishing business systems. Fishery resources and the coastal area have a very large role in the development of economic in Indonesia, but the excessive use has been the cause of environmental damage (ADB, 2012).

One of the factors causing water pollution in coastal and marine areas is the activity of inhabitant and industry. (Gumilar, 2012, Dahuri, 2003, and the World Bank, 2006). The impact of water pollution in coastal and marine areas is eutrophication and the decrease of the sea oxygen levels as the most prominent that ultimately lead to mass mortality in marine life, thus the sustainability of fishery resources is threatened.

Sustainability has a meaning that the resource’s management should have the same benefit of the present and future, according to the OECD (1993) the sustainability for coastal areas has physical, chemical/biological, and social parameters. Physical parameters is related to the area, and the physical condition of coastal areas, the chemistry/biology parameter is related to water quality, the amount of oxygen, the number of species, marine life and vegetation. While social indicator is related to the density of the area, public access to the beach, existing infrastructure, and public participation.

There are three main indicators to measure the level of sustainability of coastal fisheries resources management, which are ecology, economic and social, (Dahuri 2003). For a more complete analysis of sustainability, we also need to analyze the indicator of institutional and infrastructure (Directorate General of Capture Fisheries, 2011). The problems encountered in the management of coastal fisheries resources is the low awareness of the stakeholders of the importance of sustainability, and the existence of contestation in the utilization that tends to over fishing (Aduri 2005, Dahuri et al, 1996; Cicin Sai and Knetcht, 1998). The level exploitation exceeds the MSY (maximum sustainable yield) or the occurrence of excessive (overfishing) will reduce the sustainability of the fishery resource use.

Natural ecosystem of coastal areas has 4 main functions for human life: (1) life-support services, (2) convenience services, (3) natural resource providers, and (4) waste receiver. Based on the above four ecosystem functions, by ecological, there are three conditions that can ensure the achievement of
sustainability development, which are: (1) spatial harmony, (2) assimilation capacity and (3) the use of sustainability. The performance indicator of the fisheries management can be seen from several dimensions namely Ecology, economy and social (Dahuri et al, 2003).

1 Methodology
The research was conducted at the Thousand Islands Administrative Regency, which was in Untung Jawa island, Tidung island that are located at the position 106°20'00"BT - 106°57'00" BT and 5°10'00 "LS - 5°57'00" LS. The research started from March 2012 to December 2012. Data were collected from expert respondents using ordinal questionnaire designed according to the attributes of each indicator, 0 for bad and 3 for good.

To detect the level of sustainability we use Multidimensional Scaling (MDS). MDS is a multivariate statistical analysis that can be used as multiple variables to determine the position of an object based on similarity or dissimilarity (Groenen, PJF; Velden and M. Vane; 2004). Yaoung, FW (2009) stated that MDS is a data analysis technique which displays it in the form of geometric images based on the similarity or the lack of resemblance, based on the euclids distance. The use of this analysis is through several stages, among others:

1) The determination of the fisheries sustainability indicators of the Thousand Islands that include five dimensions which are: ecological, economic, social, legal and institutional, as well as infrastructure and technology. Each dimension is then measured using the attributes of each.

2) The valuation of each attribute in an ordinal scale is based on sustainability criteria of each dimension. Each attribute of each dimension was conducted for the valuation based on the scientific judgment by the expert respondents according to the requirement. Ordinal scoring given in the range of 0-2, or 0-3, or in accordance with the attributes character that describe the valuation level from the lowest (0) to the highest level (3).

3) Calculating the sustainability index and analyze the status of sustainability. Score estimation of each dimension is expressed by the worst scale (bad) 0% to the best (good) 100%. Sustainability index is the value of each dimension that describes the level of sustainability. This sustainability index value can be seen in Table 1.

<table>
<thead>
<tr>
<th>Index Value</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00-25,00</td>
<td>Poor (not continuous)</td>
</tr>
<tr>
<td>25,01-50,00</td>
<td>Less (less sustainable)</td>
</tr>
<tr>
<td>50,01-75,00</td>
<td>Enough (quite sustainable)</td>
</tr>
<tr>
<td>75,01-100,00</td>
<td>Good (very sustainable)</td>
</tr>
</tbody>
</table>

Note: Sources: Fauzi and Anna (2005)

Through the MDS method, the position of the point of sustainability can be visualized through the horizontal and vertical axis. With the rotation, the position of the point can be visualized on a horizontal axis with a rate value of sustainability index score of 0% (bad) to 100% (good). The illustration of the ordination result of the sustainability index value shown in Figure below.

The index value of sustainability of each dimension can be visualized at the same time in the form of a kite diagram. The symmetrical of kite diagram is determined by the sustainability index of each dimension (ecological, economic, social, institutional and technology). Besides that, the value of sustainability index of each dimension can be displayed on the diagram.

To view the most sensitive attribute that contributes to the sustainability index, it has conducted the sensitivity analysis by looking at the change in Root Mean Square (RMS) on the x-axis ordination (Kavanagh, 2001 in Budiharsono, 2007). In evaluating the effect of errors in estimating the value of ordination we used Monte Carlo analysis.
Goodness of fit in MDS is reflected from the amount of S-Stress value that is calculated based on the value of S and R². Lower stress value indicates a good fit, a high S value indicates the opposite. In the approach with Rap-Fish, a good model is shown by a smaller stress value less than 0.25 or S < 0.25 (Fauzi and Anna 2005). Good R² value is the total value approaching 1. Overall the stages in sustainability analysis using the MDS can be seen in Figure 1.

2 Result and Discussion
2.1 Ecological dimension
The analysis result using Rapfish shows that the sustainability index for ecological dimension is amounting 48.63, as on Figure 2.

This result shows that the ecological dimension in the management of fisheries resources in the Thousand Islands is in the category of less sustainable. The results of leverage analysis (Figure 3) showed that the intensity of community’s waste is the attribute with the highest value. This shows us that people’s awareness to manage the waste/trash is still low, and more often people throw that waste/trash in the river.

2.2 Economic dimension
The results of the analysis in Figure 4 shows that the economic dimension has a value of 55.44 above the midpoint between bad and good, it means that the economic dimension is in the category of fairly continuous based on the range of sustainability index value.
Of the 11 attributes on the economic dimension, the results of the leverage’s analysis based on expert assessment shows the most sensitive attribute that contributes to the economic dimension is the number of fishery workers (3.62), and the percentage of poor people (2.59) as shown in Figure 5.

This is because most of the people in Tidung and Untung Jawa islands work in the fisheries sector as traditional fishermen, and as a labors, they earn the wage ranging from 300,000-500,000 rupiahs or USD 30-50 / month. To increase the sustainability index on economic dimension, it is necessary to pay special attention to the workers in this sector, through funding assistance and post-capture processing training, thus providing value-added economy. With the increasing value-added economy, it will give directly impact to the increasing of the fishermen’s income, and it will also give the impact to the decline of the number of poor society.

The number of workers in the fisheries sector is 80% of the total population skilled fishermen using floating fishing nets cultivation and having the ability to process their fish by their own to increase their economic value-added.

2.3 Social dimension
The results of analysis of sustainability index on social culture dimension (Figure 6) shows the value of sustainability index of 56.54, this indicate that this dimension is quite sustainable. The main factor that makes this dimension quite sustainable is the potential of human resources absorption in the fisheries sector in the Thousand Islands is still very large, so it can still be used for a long time, in addition to the number of workers absorbed, then it will have a positive impact on the increasing of people's income.

The leverage’s analysis to the 9 attributes on this dimension shows there are three attributes that are the most sensitive and should get the attention to increase the sustainability value of social and culture dimension, such as: the role of indigenous people in the fisheries sector (6.37), the number of villages with population working in the fisheries sector (5.50) and the distance to the settlement farms and fishing (4.75).

It is necessary to do the intervention of the government’s policy to involve the Government in the efforts of indigenous peoples in the management of a thousand islands region, as shown in Figure 7.

2.4 Legal and Institutional Dimension
The value of sustainability index of the Legal and Institutional (Figure 8 based on the Rapfish analysis result stating as 43.73, (categorized as less sustainable). Main factor that influences this dimension becomes less sustainable is due to the lack role of indigenous people in the management of the
fisheries sector, and local culture that does not blend with the fisheries system. The society already has groups in accordance with their community, either community workers, traders or community leaders, but they tend not to care about the ways of fishing done by people/fishermen using blast fishing, or other ways. There is still no local institutional that is involved in the fisheries management in the Thousand Islands, it was entirely done by the government, and it also reinforced from analysis results of the leverage factor to determine the sensitive attribute (Figure 9).

2.5 Technology and infrastructure dimension

The value of sustainability index of the technology and infrastructure dimension based on the RAPFISH Analysis result is at 34, 17 (Figure 10), categorized as less sustainable. The road that connects inter-islands has its limitation, and it is clarified from the leverage factor analysis result on this dimension (11 images).

Leverage analysis that was conducted on 9 attributes in this dimension (Figure 11) shows there were two very sensitive attributes: the support of road infrastructure (4.98) and standardization of product quality (4.76). Inter-islands transport is very limited and often disrupted by the weather. Besides that, society’s knowledge is also still very limited, especially to the post-harvest technology where they should ensure the quality of fish and can last longer, and because of this limited knowledge of technology, caused the low quality of the fish.

2.6 Test of validity

Test of validity using Monte Carlo analysis and the results of MDS, at the level of 95% was obtained the
sustainability index value of fisheries resources management in the Thousand Islands and shows the difference of the average value of the two analyzes are very small (1.27%). This means that the MDS analyzes model was adequate to estimate the sustainability index value of the fisheries in the Thousand Islands. The differences small value indicates the error that has been made in the analysis process due to fault of score given and it can be minimized or avoid (Fauzi et al., 2005).

Monte Carlo Analysis can also be used as simulation methods to evaluate the impact of random error in the statistic analysis conducted to the entirely dimension (Kavanagh and Pitcher, 2004). The result of MDS and Monte Carlo Analysis is shown on Table 2.

Table 2 Difference of sustainability index value of Rap-Insus in the Thousand Islands and the Monte Carlo analysis

<table>
<thead>
<tr>
<th>Dimension</th>
<th>MDS</th>
<th>Monte Carlo (MC)</th>
<th>Difference (MDS-MC)</th>
<th>Difference (MDS-MC)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecology</td>
<td>48.63</td>
<td>49.96</td>
<td>1.33</td>
<td>2.69</td>
</tr>
<tr>
<td>Economy</td>
<td>55.44</td>
<td>55.03</td>
<td>0.41</td>
<td>0.74</td>
</tr>
<tr>
<td>Social</td>
<td>56.64</td>
<td>55.73</td>
<td>0.91</td>
<td>1.60</td>
</tr>
<tr>
<td>Legal and Institutional</td>
<td>43.73</td>
<td>44.28</td>
<td>0.55</td>
<td>1.25</td>
</tr>
<tr>
<td>Infrastructure and Technology</td>
<td>34.17</td>
<td>34.21</td>
<td>0.04</td>
<td>0.11</td>
</tr>
<tr>
<td>Average</td>
<td>47.72</td>
<td>47.84</td>
<td>0.65</td>
<td>1.27</td>
</tr>
</tbody>
</table>

2.7 Test of accuracy
The accuracy test of the MDS analysis (good and fit) obtained the coefficient of determination ($R^2$) between 93.86% - 95.18% or bigger than 80% and it can be categorized as good and fit (Kavanagh, 2001). The stress value of 0.14 to 0.16, or the difference of stress value is at 0.02 and with this result the obtained MDS analysis has a high accuracy (good and fit) to assess fisheries sustainability index in the Thousand Islands (Fisheries, 1999). The stress value of determination Koefisien on Rap-Insus analysis Rap-Insus in the Thousand Islands is presented in Table 3.

Table 3 Stress value and the value of determination ($R^2$) Rap-Insus result in the Thousand Islands

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Dimension of Ecology</th>
<th>Dimension of economy</th>
<th>Dimension Social</th>
<th>Dimension Legal and Institutional</th>
<th>Dimension Infrastructure and Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Value of Index</td>
<td>48.63</td>
<td>55.44</td>
<td>56.64</td>
<td>43.73</td>
<td>34.17</td>
</tr>
<tr>
<td>2</td>
<td>Value of Stress</td>
<td>0.142</td>
<td>0.136</td>
<td>0.134</td>
<td>0.148</td>
<td>0.135</td>
</tr>
<tr>
<td>3</td>
<td>Value of $R^2$</td>
<td>95.12</td>
<td>95.45</td>
<td>95.12</td>
<td>94.85</td>
<td>94.95</td>
</tr>
<tr>
<td>4</td>
<td>Number of Iteration</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

3 Discussion
Based on the analysis of the sustainability index value to the 5 dimensions that have been conducted, it can be illustrated by the kites diagram from fishery resources management in the Thousand Islands as Figure 12.

Figure 12 shows legal and institutional, technology and infrastructure, and the ecology are less or not sustainable. The limitation of the fishermen on fishing rules and the low enforcement of society’s institutional role making the system of the use of fisheries resources management becomes over fishing. While the lack of transportation making the Thousand Island region isolated from other areas in Jakarta, and

![Figure 12 Kites Diagram layang-layang of the fishery resources management in the Thousand Islands based on RAPFISH analysis result](http://ijms.biopublisher.ca)
at the same time the limitation of technology, especially the technology of preservation and processing of fishing making the income of fishermen becomes stagnant. In addition to the high increasing of sea pollution will give the negative impact to the fish productivity and causing the decrease of fishing result.

To ensure the sustainability of the fisheries resources management in the Thousand Islands, it is necessary to conduct the development strategy on ecosystem basis by involving all stakeholders (communities and local institutions, businessmen, and governments) and besides that develop the management regional zone into 2 (two); namely (1) management regional zone, (2) conservation regional zone. The management regional zone will be the centre of fishing or other economical activity, particularly in the south area around Tidung Island, Pari Island, Untung Jawa Islands and Pramuka Island. While the conservation regional zone, particularly in the north area around the 44 islands uninhabited like in Rambut and Onrust islands, it can be made as marine national park as well as marine tourism area.

Through this zoning system, the development of inter-islands transportation in the management area, and the development of technology of fish process can be more easier done, in addition to increase the involvement of public groups in fisheries management and it is also necessary to build the area for waste management process by integrated system in this region by involving the society and industries.

4 Conclusion and Suggestions

Based on 5 sustainability dimension that has been analyzed which are ecology, economy, social culture, legal and institutional, technology and infrastructure, the fisheries resources management in the Thousand Islands is in the category of less sustainable with the average sustainability index of 47.78 <50, so it need an intervention of government’s policy in the management, through the zoning system development in the management zone and conservation zone. To ensure the sustainability, it is necessary to do the ecosystem’s approach by involving all stakeholders of society, businessmen and government) in the management of fishery resources in the Thousand Islands.

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