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Ecological and Socio-Economic Sustainability of Built Environment of Peatlands Using Rap-Disease Control with Multi-Dimensional Scaling

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ABSTRACT

It has been largely known that degradation of peatlands causes fires and floods. This condition is exacerbated by poorly built environment in sanitation and living behavior of the community, which has detrimental impact on public health. This impact was felt more severely by vulnerable population groups such as toddlers, children, pregnant, breastfeeding women, people with disabilities and the elderly. The purpose of this study was to analyze the status of disease control by using a research object in built environment of peatlands in Bangko, Rokan Hilir, Riau, Indonesia. This study uses a quantitative approach. The data analysis method used is inferential analysis with the Multidimensional Scaling (MDS) Rap-disease control in children under five years (DCCUFY) approach. This research was conducted through survey to assess the status of disease control with primary data collection conducted by filling in the scale scoring and strengthened by secondary data. The results of the analysis obtained that the sustainability status of disease control was categorized as less sustainable. Meanwhile, socio-cultural dimension was included in moderately sustainable. The leverage age analysis showed some critical elements in improving ecological and socio-economic sustainability including economic facilities, economic accessibility, the unemployment rate, poverty rate, clean living habits, environmental sanitation, water quality, environmental health counseling, community participation, the role of traditional leaders, utilization of health centers and building conditions.

1. INTRODUCTION

Excessive use of peatlands had environmental impact on ecological and socio-economic spheres [1-3]. which in practice has caused forest fires and carbon emissions [4-6]. On the other side, carbons emissions have tremendous effects on climate change that influence livestock and food production worldwide [7]. The National Disaster Management Agency (2019), states that 99 percent of forest and land fires that occur in water are caused by humans and only 1 percent are caused by natural factors. The problems faced are environmental changes in peatlands in many areas in Indonesia today were plantations and mining. Moreover, highly occupied peatlands result in poor environmental sanitation and poor clean-living behavior. The peatland degradation also causes fires and floods. The haze not only disrupts health, but it also disrupts trade and economic activities. This haze disaster raises various potential health problems for affected communities [8, 9]. This impact was felt more severely by vulnerable population groups such as toddlers, children, pregnant or breastfeeding women, people with disabilities, and the elderly.

Exposure to smoke can cause upper respiratory tract infection which is characterized by symptoms of nasal congestion, coughing, painful swallowing, and accompanied by hoarseness. Continuously exposure to smoke and complaints can cause Lower Respiratory Tract Infection (LRTI). In LRTI, inflammation of the alveoli can occur, causing the main symptom, namely shortness of breath, eye irritation, irritation of the sclera and cornea of the eye, causing a feeling of pain [10-12]. Moreover, floods cause sanitation to deteriorate and consequently cause diarrhea and skin diseases. Diarrheal disease is an endemic disease in Indonesia, especially in the toddlers. The incidence of diarrhea is caused by various factors including nutritional, food, socio-economic and environmental factors [13]. Bangko in Rokan Hilir had most of its area consisting of peatlands. This district is a peaty lowland and has shallow groundwater quality which is generally of poor quality which is unsuitable to be used as clean water. This area is on the coast and the Rokan River watershed is an area prone to inundation. Environmental-based diseases are one of the dominant factors caused by clean water facilities and feces disposal sites. Mafazah [14] revealed that the availability of clean water facilities is positively related to the incidence of diarrhea, and the toddlers among the worst affected group in unhealthy environment. This needs regional government to provide clean water to meet water needs as one of the strategic policies to address environment-

based diseases. The purpose of this study was to analyze the status of disease control by using a research object in built environment of peatlands in Bangko, Rokan Hilir, Riau, Indonesia. The novelty of this article lies in its focus on disease control in a specific built environment, namely peatlands. Additionally, the study's focus on disease control in children under five years old further highlights its unique contribution to the field of public health and environmental research.

2. MATERIALS AND METHODS

This study analyzes the level of sustainability of disease control in Bangko, Rokan Hilir Regency, Riau using Multidimensional Scaling (MDS) Rap-disease control in children under five years (Rap-DCCUFY) ordination technique. Multidimensional Scaling (MDS) was largely used to assess ecological conditions in a specific environment [15-18]. This research was conducted through survey to assess the status of disease control in Bangko which was specifically designed and adapted to research needs. The subject of the survey is the status of disease control in Bangko with the object of investigation being the respondents involved in disease control measures in Bangko. This study involved 105 respondents as sample by using simple random sampling. The survey method to assess the status of disease control would be conducting a cross-sectional survey by using questionnaires distributed to respondents. To assess disease control, the survey included questions about the prevalence and incidence of the disease, as well as the measures taken to control and manage it. Additionally, the survey may include questions on the availability and utilization of healthcare services, nutritional status, sanitation, water and air quality as well asother relevant factors that may impact the spread of the disease.

The types of data collected in this study are primary data and secondary data. Primary data are data obtained directly from the research field, either in the form of measurements, observations, or interviews. Secondary data are data collected by other people for their own purposes and have categorization or classification according to needs. Data collection methods consist of literature studies, surveys, and in-depth interviews. Data collection in the context of filling in the scale scoring is strengthened by secondary data. The analytical methods used consist of a comparative analysis method (based on literature studies and expert judgment), and a sustainability analysis method, namely the Multidimensional Scaling (MDS) technique using Rap-fish software. MDS is a statistical analysis technique that performs multidimensional transformations. Rap-fish stands for Rapid Appraisal of Fisheries, which is a Non-Parametric Multi-Dimensional Scaling approach [19-21]. It has been used to examine sustainability in many sectors [22-30].

The analysis was performed in the form of values for the level of sustainability and leverage attributes of disease control in toddlers. The score given to each attribute will determine the position of sustainability against two reference points, namely high and low attributes. The determination of leverage attributes in disease control is based on the Root Mean Square (RMS) value. The RMS value indicates the magnitude of the role of each attribute on the sensitivity of the sustainability status [31]. One of the principles used in determining the leverage attribute based on the RMS value is the mean value principle.

3. RESEARCH RESULT

3.1 Dimensional analysis in ecological sustainability

The sustainability of the ecological dimension is described in 8 attributes, namely air quality, water quality, building conditions, environmental sanitation, flood events, Smog, frequency of sick toddlers, and nutritional status. The results of the sustainability analysis by using Rap-DCCUFY on the ecological dimension as shown in Figure 1 obtained a sustainability index is classified as less sustainable. This gives an interpretation that the ecological conditions in disease control are under pressure. The results of the Monte Carlo analysis of disease control on the ecological dimension were moderately sustainable.

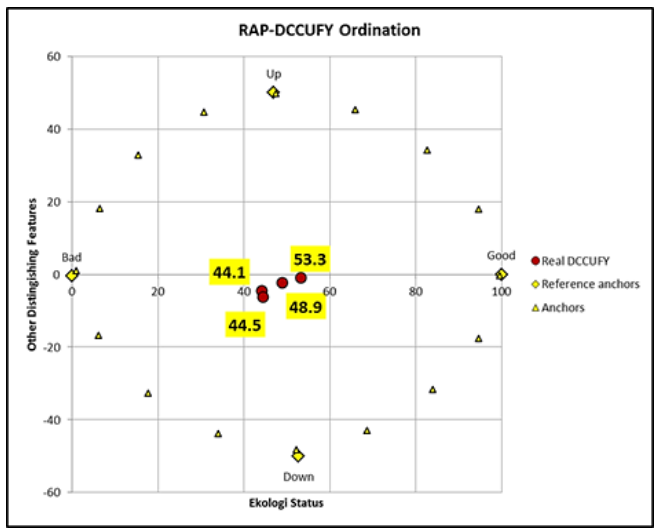

Figure 1. Ecological dimension sustainability index

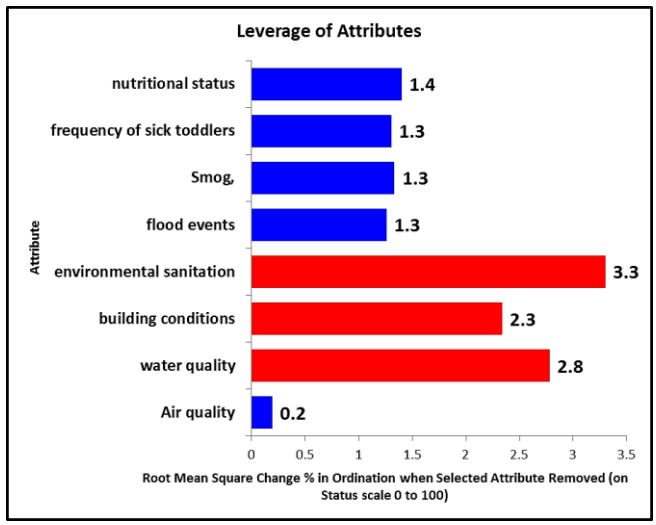

Figure 2. Leverage attributes of ecological dimensions in root mean square

The results of the Rap-DCCUFY in terms of validity analysis are acceptable, considering that the validation test results obtained show the difference between the sustainability index and the Monte Carlo value at study locations was a very small difference of 0.1% - 0.3%. This value indicates that the effect of error or the impact of scoring errors is relatively small. In addition to obtaining the sustainability index, the Rap-DCCUFY analysis also produces output in the form of

leverage of attributes.

The leverage attribute is the attribute that gives the highest percentage value in the sustainability of a management dimension. Leverage of attributes analysis aims to determine the attributes that are sensitive to the sustainability of the ecological dimensions in disease control (Figure 2). The results of the Rap-DCCUFY analysis for the ecological dimension show that the attributes that have the most influence on the sustainability of the ecological dimension are environmental sanitation (RMS = 3.3), water quality (RMS = 2.8), and building conditions (RMS = 2.3). Kavanagh and Pitcher [31] stated that the RMS value indicates the magnitude of the role and influence of each attribute on the sensitivity of the sustainability status.

3.2 Dimensional analysis in economic sustainability

The sustainability of the economic dimension is described in 7 attributes, namely; community income, poverty level, regional GRDP per capita, unemployment rate, existence of economic facilities, economic accessibility, job opportunities/business opportunities. The results were to show the analysis of Rap-DCCUFY on the economic dimension. Figure 3 obtained a sustainability index which was classified as unsustainable. Moreover, the results of the Monte Carlo analysis of disease control with the economic dimension were found was less sustainable.

The results of the Rap-DCCUFY analysis are acceptable considering that the results of the validation test obtained the difference between the sustainability index and the Monte Carlo value at the research locations showing a very small difference of 0.0% - 3.0%. This value indicates that the effect of error (error) or the impact of scoring errors is relatively small. According to Kavanagh and Pitcher [31], the difference in value of Monte Carlo Analysis - Rap Analysis > 5 showed inadequate results as an estimator of the sustainability index value. The difference in value of the two analyzes <5 showed adequate results to estimate the index value. Thus, the Rap-DCCUFY model for the economic dimension is declared adequate as an estimator of the value of the sustainability index.

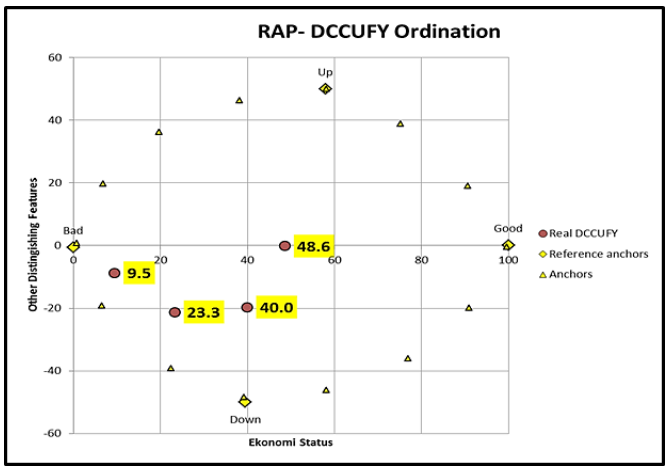

Figure 3. Dimension index in economic sustainability

In addition to obtaining the sustainability index, the Rap-DCCUFY analysis also produces output in the form of leverage age of attributes. The leverage attribute is the attribute that gives the highest percentage value in the sustainability of a management dimension. Leverage age analysis aims to determine the attributes that are sensitive to the sustainability of the economic dimensions in disease control (Figure 4).

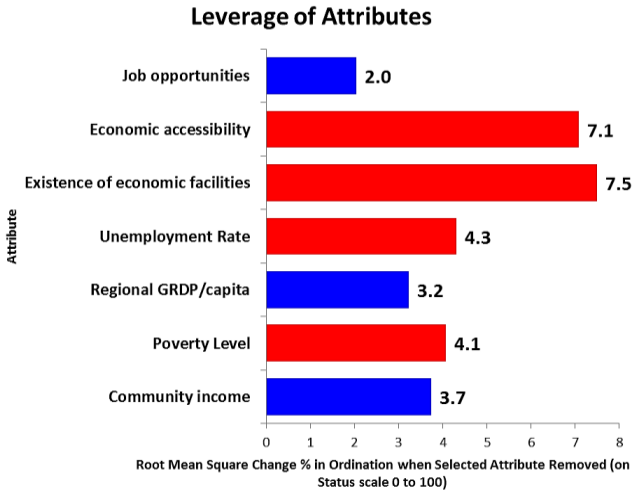

Figure 4. Leverage attributes of economic dimensions in root mean square

The results of the Rap-DCCUFY analysis for the Economic dimension show that the attributes that have the most influence on the sustainability of the economic dimension are state of economic means (RMS = 7.5), economic accessibility (RMS = 7.1), unemployment rate (RMS = 4.3) and poverty level (RMS = 4.1). Kavanagh and Pitcher [31] state that the RMS value indicates the magnitude of the role or influence of each attribute on the sensitivity of the sustainability status.

3.3 Dimensional analysis in socio-cultural analysis

The sustainability of the socio-cultural dimension is described in 10 attributes, namely level of community education, traditional leaders, local wisdom on health, community participation, clean living habits, availability of regulations, environmental health education, utilization of health centers, availability of medical personnel, availability of health facilities. The results of the sustainability analysis of disease control by using Rap-DCCUFY on the socio-cultural dimensions obtained a sustainability index which was classified as less sustainable (Figure 5). This gives an interpretation that socio-cultural conditions are an obstacle in controlling disease in toddlers. The results of the Monte Carlo analysis of disease control with the economic dimension obtained was moderately sustainable.

The results of the Rap-DCCUFY analysis are acceptable, considering that the validation test results showed only a very small difference of 0.1% - 0.7% between the sustainability index and the Monte Carlo value at the research locations. This difference suggests that the effect of error or the impact of scoring errors is relatively small.

Using Kavanagh and Pitcher's [31] classification, the Rap-DCCUFY model for the ecological dimension is considered adequate for estimating the sustainability index value. Kavanagh and Pitcher [31] also demonstrated that Monte Carlo analysis could serve as a simulation method to assess the impact of random error in statistical analysis across all dimensions. In a similar vein, Fauzi and Anna [28] described

how Monte Carlo analysis could indicate errors resulting from the scoring of each attribute. Given the multidimensional variations in scoring due to differing opinions, the data analysis process is carried out repeatedly to address errors in input data or to compensate for missing data.

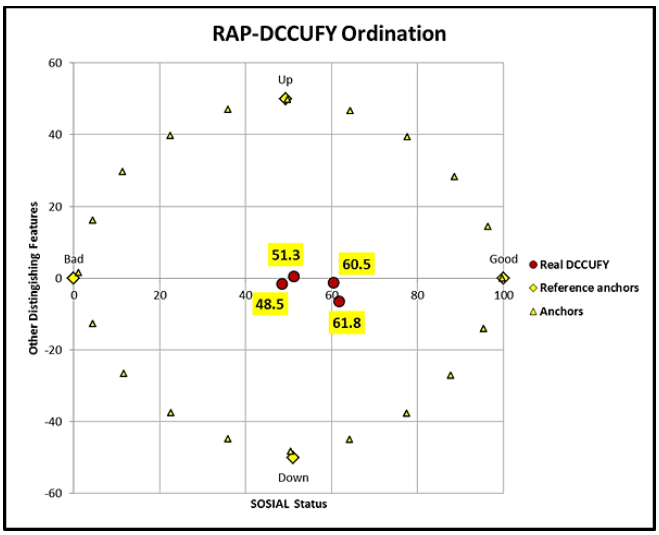

Figure 5. Sustainability Index of socio-cultural dimensions

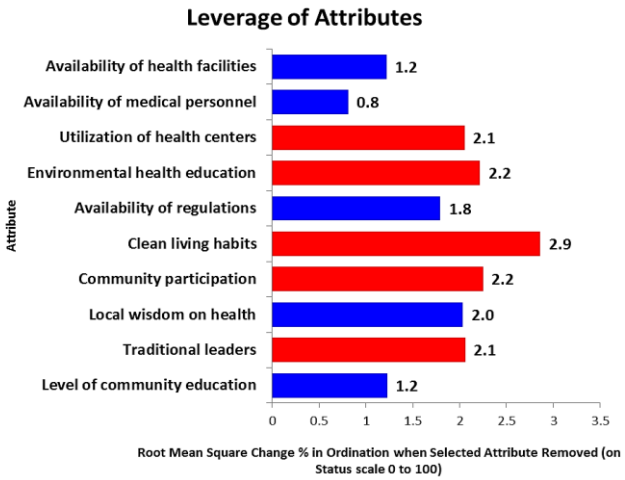

Figure 6. Leverage attributes of socio-cultural dimensions in root mean square

The results of the Goodness of Fit Test also show that the sustainability index estimation model is usable, with a Squared Correlation (R2) value of 0.9381, which is close to 1. The closer the R-square value is to 1, the better the data fits the model. This value indicates that more than 93.81% of the variance in the data can be explained by the model, while the remaining 6.19% is explained by other factors. Kavanagh and Pitcher [31] state that an (R2) value of more than 80 percent indicates a good and sufficient sustainability index estimation model.

The inaccuracy test results were used to examine the measure of lack of fit, or the stress value. The stress value obtained was 0.1712, which is close to 0. The closer the stress value is to zero, the more the model output resembles the actual situation; conversely, a higher stress value indicates a less suitable model. A stress value below 20% is considered tolerable, and thus with a stress value of 17.12%, the model is deemed acceptable according to Kavanagh and Pitcher [31].

In addition to obtaining the sustainability index, the Rap-DCCUFY analysis also produces output in the form of the leverage of attributes. The leverage attribute is the one that contributes the highest percentage value to the sustainability of a management dimension. The leverage analysis aims to identify attributes that are sensitive to the sustainability of the socio-cultural dimension in disease control (Figure 6). According to the Rap-DCCUFY analysis for the socio-cultural dimensions, the attributes exerting the most influence on sustainability are clean living habits (RMS = 2.9), community participation (RMS = 2.2), environmental health education (RMS = 2.2), traditional leaders (RMS = 2.1), and the utilization of health centers (RMS = 2.1). Kavanagh and Pitcher [30] note that the RMS value signifies the extent of each attribute's role or influence on the sustainability status's sensitivity.

4. DISCUSSION

The results of the sustainability analysis by using Rap-DCCUFY analysis on overall ecological dimension were classified as less sustainable. Furthermore, Monte Carlo analysis of disease control on the ecological dimension were moderately sustainable. The leverage analysis for the ecological dimension show that the attributes that have the most influence on the sustainability of the ecological dimension are environmental sanitation (RMS = 3.3), water quality (RMS = 2.8) and building conditions (RMS = 2.3). The results are in line with Cahya [32] in examining ecological sustainability in urban agriculture. The results are also consistent with previous research [33-35].

Furthermore, the results of Rap-DCCUFY on the economic dimensions found that sustainability index which was classified as unsustainable. The results of the Monte Carlo analysis of disease control with the economic dimension were found was less sustainable. The results of the Rap-DCCUFY analysis for the economic dimension show that the attributes that have the most influence on the sustainability of the economic dimension are state of economic means (RMS = 7.5), economic accessibility (RMS = 7.1), unemployment rate (RMS = 4.3) and poverty level (RMS = 4.1). The results are in line with Melo et al. [23], Poveda [27], Patawari et al. [25]. In this regard, policies to improve the community's economy are related to infrastructure development programs and economic accessibility, and poverty reduction. Infrastructure development is carried out in improving economic facilities and infrastructure. The development and improvement of economic infrastructure is considered to have direct effect on the increase in economic accessibility. Moreover, the poverty reduction program is carried out through increasing family income by opening new jobs or alternative livelihoods, as well as training and business capital assistance in the culinary, agricultural and fisheries sectors. This linkage was supported by previous findings [25, 36] stating that environmental sustainability was related with poverty reduction. Moreover, family income also determines the purchasing power of food and other facilities such as education, housing and public health that can affect nutritional status.

The findings on Rap-DCCUFY's dimensional analysis in socio-cultural analysis showed that a sustainability index which was classified as less sustainable. The leverage analysis for the socio-cultural dimensions showed that the attributes that have the most influence on the sustainability of the socio-

cultural dimension are clean living habits (RMS = 2.9), community participation (RMS = 2.2), environmental health education (2.2), traditional leaders (2.1) and utilization of health center (RMS = 2.1). The results are in line with Frimawaty et al. [37], Rahmayanti and Ananda [22]. In terms of socio-cultural analysis, the results would imply that environmental health education policy, which concerns environmental sanitation and clean-living habits related to environmental sanitation programs, water quality and building conditions. The policy concerning the responsibility of traditional leaders and the community in preserving the wellbeing of young children is connected to the involvement of traditional leaders and community members. The study findings align with the research of Trisnowati [38], which highlights the crucial role of health cadres in promoting the wellbeing of young children. This involves providing health education to the community, empowering them to prevent illness, and engaging in group physical activities.

5. CONCLUSION

The results of the sustainability analysis by using Rap-DCCUFY analysis on the ecological dimension were classified as less sustainable. Furthermore, Monte Carlo analysis of disease control on the ecological dimension were moderately sustainable. The leverage analysis for the ecological dimension show that the attributes that have the most influence on the sustainability of the ecological dimension are environmental sanitation (RMS = 3.3), water quality (RMS = 2.8) and building conditions (RMS = 2.3). Furthermore, the results of Rap-DCCUFY on the economic dimension found that sustainability index which was classified as unsustainable. The results of the Monte Carlo analysis of disease control with the economic dimension were found was less sustainable. The results of the Rap-DCCUFY analysis for the economic dimension show that the attributes that have the most influence on the sustainability of the economic dimension are state of economic means (RMS = 7.5), economic accessibility (RMS = 7.1), unemployment rate (RMS = 4.3) and poverty level (RMS = 4.1). The findings on Rap-DCCUFY's dimensional analysis in socio-cultural analysis showed that a sustainability index which was classified as less sustainable. The leverage analysis for the socio-cultural dimensions showed that the attributes that have the most influence on the sustainability of the socio-cultural dimension are clean living habits (RMS = 2.9), community participation (RMS = 2.2), environmental health education (2.2), traditional leaders (2.1) and utilization of health center (RMS = 2.1). The results of the Rap-DCCUFY also showed that the model was valid considering that the results of the validation test obtained the difference between the sustainability index. The Monte Carlo value showed a very small difference, indicating that the effect of error or the impact of scoring errors is relatively small. In addition to obtaining the sustainability index, the Rap-DCCUFY analysis also produces output in the form of leverage age of attributes.

As implications, relevant stakeholders need to formulate some technical measures in disease control in toddlers in built environment of peatlands such as to improve community economic status, environmental health counseling, which concerns environmental sanitation and clean-living habits. The implications also included increasing the role of traditional leaders and the community regarding the importance of maintaining the health of toddlers, and construction of clean water facilities.

As to state the limitations, the study only focuses on the sustainability of the built environment of peatlands, and does not take into account the broader environmental impacts of the peatland ecosystem. The study is also limited to a specific region and may not be applicable to other peatland areas. The study only uses statistical methods to analyze sustainability and does not consider qualitative or subjective factors. Finally, the study does not consider the potential trade-offs or synergies between ecological, economic, and socio-cultural sustainability. As for suggestions to future research, they are expected to expand the scope of the study to consider broader environmental impacts of peatlands, such as biodiversity and carbon sequestration. Moreover, future studies are suggested to investigate the applicability of the method used in this study to other peatland areas and incorporate qualitative or subjective factors into the analysis of sustainability. Lastly, potential trade-offs and synergies between ecological, economic, and socio-cultural sustainability dimensions and the potential impact of policy interventions on sustainability outcomes in peatland areas need to be further explored.

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