

ANALYSIS OF THE SUSTAINABILITY OF OIL PALM PLANTS ON PEATLANDS IN JAMBI PROVINCE

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ARTICLE HISTORY

Received [14 May 2025]

Revised [04 June 2025]

Accepted [15 June 2025]

Abstract

Oil palm plantations in the peatlands of Jambi Province pose sustainability challenges due to their impact on the environment, especially groundwater depreciation and greenhouse gas emissions. This study aims to analyze the development, sustainability status, and key leverage factors that affect the sustainability of independent oil palm in peatlands. The research was carried out in three districts in Jambi Province using *purposive* and *simple random sampling* methods, with 100 farmers as respondents. The data analysis method was carried out descriptively and quantitatively using *the RAP-Palm Oil* and *Multidimensional Scaling (MDS)* models. The results show that the average plant life is 20 years with a productivity of 930 Kg/Ha/Year. The sustainability of oil palm plantations is in the category of quite sustainable with a multidimensional index score of 60.18. The economic dimension recorded the highest score of 78.65, the technology dimension 47.07 and the institutional dimension 48.47. The main leverage factors include peat maturity, selling price of Fresh Fruit Bunches, land ownership status, use of superior seeds, and the existence of field companions. This research provides an important picture for policy-making in improving the sustainability of oil palm in peatlands. From the results of this study, it gives implications that this research contributes to the achievement of SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land). However, the low score in institutional and technological aspects shows the need for an integrated strategy to truly support sustainable development so that it is important to strengthen farmer organizations, cooperatives, and the role of field assistants so that the sustainability of oil palm plantations will be maintained.

Keywords: Oil Palm, Peatlands, SDG's, Self-reliance, Sustainability

How to Cite: Author, A.A., & Author, B.B. (2025). Instructions/Template for Preparing Manuscript for JISEB. *Scientific Journal of Socio-Economic Business*, 28 (01), 43-55.
<https://doi.org/10.22437/jiseb.43706>



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INTRODUCTION

Jambi Province, located on the island of Sumatra, Indonesia, has a tropical climate that is very supportive of oil palm growth. As one of the main producers of oil palm in Indonesia, Jambi Province has a very large area of oil palm plantations spread across various regions. These oil palm plantations make a significant contribution to the regional economy. However, most of these plantations are located on peatlands, which have physical characteristics that require careful management. Peat soil in Jambi has properties such as easy to dry and not reverse, easy to sink, and has low carrying capacity, as well as limited soil fertility. Therefore, proper peatland management is indispensable to prevent land degradation.

Peatlands are ecologically different from mineral lands; their ecological functions include large carbon storage, local hydrological settings, and biodiversity habitats. Drainage for agricultural purposes leads to the oxidation of peat organic matter and substantial CO₂ emissions – a phenomenon that has been identified as a major source of field emissions in Indonesia and Southeast Asia. Therefore, the conversion and management of peat for oil palm poses serious climate and environmental implications if not managed with proper conservation and mitigation principles. The results of regional studies show that emissions from peatlands that are drained and degraded can make a major contribution to total national emissions (Hay et al., 2010);

From a socio-economic point of view, oil palm on the scale of independent smallholders plays an important role in the welfare of agrarian households. However, the implementation of national sustainability standards (ISPOs) and sustainable farming practices at the farmer level often face obstacles such as limited access to technical training, weak institutions (e.g., lack of formation of groups or cooperatives), uncertainty of land ownership, and limited financing. Evaluation of ISPO implementation in independent smallholders shows that there is a gap between certification requirements and smallholder readiness, which requires an acceleration strategy and institutional support. (Ward et al., n.d.)

A number of studies focusing on the context of peat and oil palm have identified various intervention pathways: rewetting to reduce the risk of peat oxidation, peat conversion restriction policies, strengthening value chain governance, and scenarios of withdrawing crops from peatlands to reduce carbon emissions. Studies in Sumatra, including a scenario analysis of peat plantation withdrawals in Jambi, emphasized the need for an integrated approach that takes into account the trade-offs between climate mitigation goals and local economic needs. (Ward et al., n.d.)

The phenomenon of oil palm sustainability in peatlands is an important issue, considering its impact on the environment. Oil palm plants on peatlands can lead to a decrease in groundwater levels and greenhouse gas emissions, potentially exacerbating climate change. Therefore, joint efforts between the government, industry, and the community are needed to maintain a balance between oil palm production and the preservation of the peat environment. This study aims to analyze the development of oil palm plantations in peatlands, the sustainability status of oil palm in Jambi Province, and the leverage factors that affect this sustainability. Although the international and national literature has extensively reviewed the ecological impacts and policies related to peat, there is still a gap in research that incorporates multidimensional analysis (ecological, economic, social, technological, institutional) especially in the context of independent smallholders in the peatlands of Jambi Province. This study aims to fill this gap by: (1) assessing the sustainability status of independent smallholder oil palm businesses in Jambi peatlands using the RAP-

MDS approach, (2) identifying the leverage factors that have the most influence on each sustainability dimension. The findings are expected to provide direction for policymakers and field actors to formulate contextual and evidence-based interventions and look at the challenges and opportunities in achieving the sustainability of oil palm farming on peatlands in Jambi Province

RESEARCH METHODS

This research was carried out in Jambi Province with a focus on oil palm farmers who manage peatlands. The selection of locations was carried out deliberately (*purposive sampling*) with consideration to select the most representative farmers for this study. The *purposive sampling* technique was used to determine a suitable sample and represent the population, namely oil palm farmers operating on peatlands in Jambi Province. The sample extraction method used in this study is *Simple Random Sampling*. This method allows for random sample selection without regard to strata in the population. Based on data from the Jambi Provincial Plantation Office, the total population of oil palm farmers in the three districts where the study was located is 114,592 people. Using the Slovin formula with 10% precision, a sample of 100 farmers was obtained. From the number of samples, a proportional allocation calculation is carried out to determine the number of samples taken from each district. Muaro Jambi Regency produced 63 samples, Tanjung Jabung Barat Regency 25 samples, and East Tanjung Jabung Regency 12 samples.

In terms of data analysis, this study combines descriptive and quantitative methods. Descriptive analysis is used to describe and describe the problems that occur based on data collected in the field, while quantitative analysis is used to measure the difference in economic prospects between oil palm planted on peatlands and mineral land. To evaluate the sustainability of oil palm in peatlands, the study used the RAP-Palm Oil (*Rapid Appraisal for Palm Oil*) model, developed by the University of British Columbia. The Multidimensional Scaling (MDS) technique is also used to analyze the sustainability position based on various attributes assessed, including ecological, economic, social, technological, and institutional dimensions.

RESULTS AND DISCUSSION

Characteristics of Respondent: Farmers

An overview of oil palm farmer farming in the peatlands of Jambi Province shows that most farmers depend on oil palm as their main source of income. The average age of the respondent farmers is 52 years old and the majority are in the productive age category, who are still active in developing their farming businesses. The education level of farmers is generally low, with the majority graduates from elementary to high school. The average number of family members is six people, which can be a potential workforce in the family. In terms of experience, farmers have an average of 16 years of farming experience, showing a sufficient level of skill and knowledge in managing farming.

The average area of land managed is 2.19 hectares, with most farmers owning between 1 and 2.6 hectares. Managed oil palm plants have generally entered the production phase, with an average plant lifespan of nine years. The production of fresh fruit bunches (FFB) produced by farmers averaged 930 kg/ha/year, with the highest yield reaching 3,000 kg and the lowest 250 kg/ha/year. Of the total respondents, 72 farmers already have producing crops, while the rest are still in the stage of not producing. This data shows that oil palm smallholders in the study area are quite experienced and still productive, although challenges such as low education and fluctuations in production yields remain concerns.

Results of Rap-MDS Analysis of each Dimension

Rap-MDS analysis is used to look at each dimension that indicates sustainability. The five dimensions include: Ecology, Economy, Social, Technology and Institutional. Each dimension has different challenges and leverage potentials. The MDS Rap results of each dimension can be seen in the following image:

1. Ecological Dimension and Economic Dimension

The ecological dimension is one of the dimensions that is seen as sustainable in relation to the environment of oil palm plantations on peatlands. Meanwhile, the economic dimension shows the economic side with the existence of oil palm plantations on peatlands. The results of his MDS Rap can be seen in the following image:

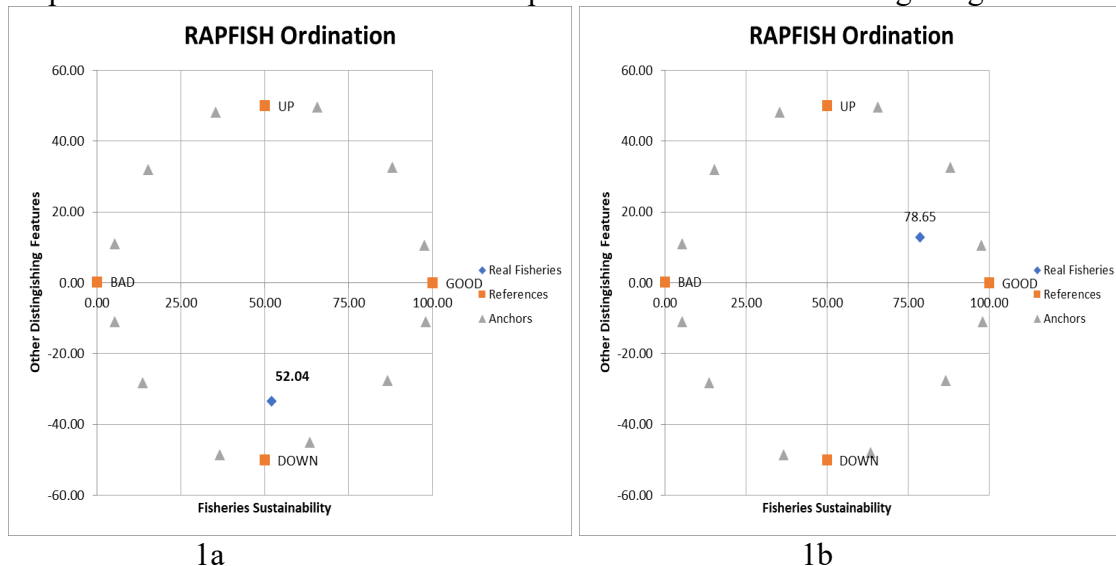


Figure 1. MDS Rap Results on Ecological and Economic Dimensions

Figure 1 explains that the sustainability index in the ecological dimension was recorded at 52.04%, which is included in the category of quite sustainable. This shows that the carrying capacity of the environment in the research area is still within the threshold that allows cultivation activities to run without drastically damaging ecological functions. However, the position of the index in the lower quadrant in its ordination graph indicates significant ecological pressures. Some sensitive attributes, such as peat maturity and soil pH suitability, need to be addressed immediately so that sustainability can be maintained. Without policy intervention and management based on land characteristics, the value of this index has the potential to decline over time.

Meanwhile, the economic dimension showed the best performance with a sustainability index of 78.65%, included in the sustainable category. The index point is in the upper quadrant (figure 1b), which reflects stable economic conditions and supports sustainability. This high value indicates that the current palm oil economic system has provided real benefits to farmers and business actors, especially through good market access and favorable selling prices. This achievement also shows that the assistance programs and policy interventions that have been implemented are relatively effective. However, the sustainability of the economy still needs to be maintained through institutional capacity building, price stability, and inclusive and equitable access to financing.

2. Social Dimension and Technology Dimension

The social and technological dimension is a dimension that shows a level of sustainability. The results of MDS raps on these two dimensions can be seen in the following image:

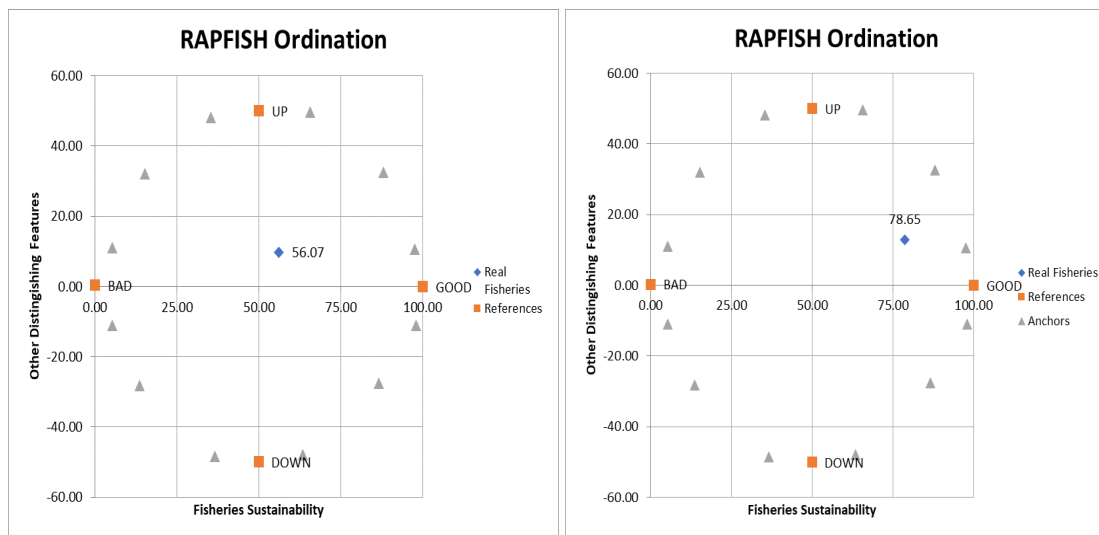


Figure 2. MDS Rap Results on Social and Technological Dimensions
 Source: MDS Analysis Data

3. Institutional Dimension

The last dimension is the institution that is the most important part of sustainability, because it is thought that institutions have an important role in the sustainability of farmers who manage oil palm plantations on peatlands. The results of the MDS Rap can be seen in the following image:

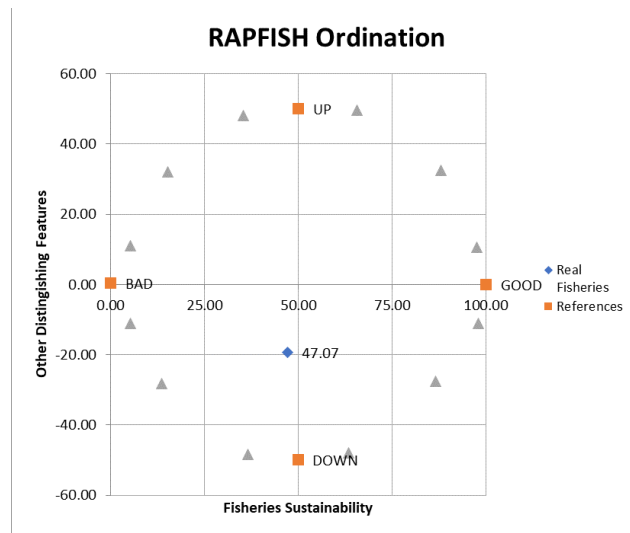


Figure 3. The Results of the MDS Rap on the Institutional Dimension
Source: MDS Analysis Data

Figure 3 shows that the institutional dimension recorded an index value of 48.47%, which is also classified as less sustainable. The position of the index point close to the lower quadrant reflects weak institutional support for the sustainability of palm oil management. The six main attributes in this dimension – participation in farmer groups, the role of extension workers, involvement in sustainability activities, understanding of sustainability concepts, access to financial institutions, and training – still show suboptimal performance. This condition indicates the need to increase institutional capacity, both from the internal side of farmers (knowledge and awareness), as well as external support such as training, counseling, and financing. Systematic and coordinated interventions will be key to building resilient institutions that are able to support sustainability as a whole.

Multidimensional Index

This value was obtained based on the assessment of 30 attributes from five dimensions of sustainability, namely environmental, economic, social, technological and institutional dimensions. The results of the multidimensional analysis with Rap-MDS on the sustainability of oil palm in peatlands can be seen in the following figure:

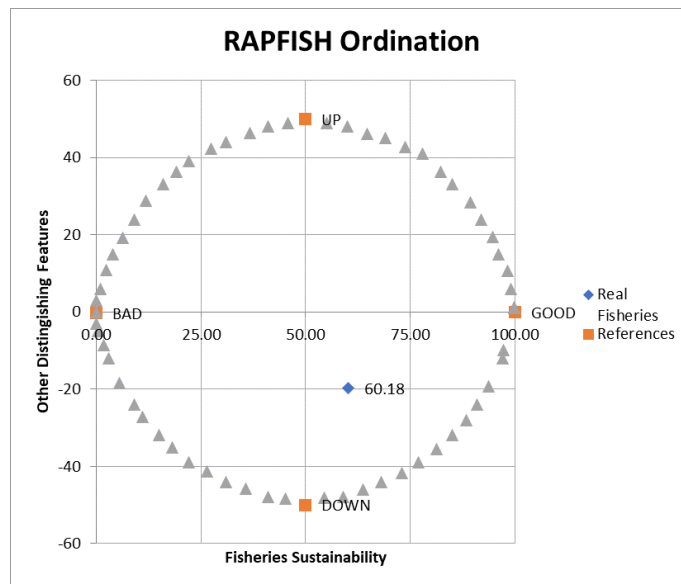


Figure 4. Multidimensional MDS RAP Analysis
Source: Data Analysis, 2024

Multidimensional dimension analysis is a combination of the five main dimensions of sustainability, namely ecological, economic, social, technological, and institutional. Figure 5 shows that the value of the sustainability index is 64.30. This value is in the fairly sustainable category, as indicated by the position of the point on the closer quadrant towards GOOD, although it has not yet fully reached ideal status. This index point indicates that in general the oil palm management system in peatlands has a relatively good foundation for sustainability, mainly supported by stronger economic and ecological dimensions, but there is still significant room for improvement in social, technological and institutional aspects. The ordination chart shows that the sustainability position has moved away from the BAD and DOWN points, which means that the trend towards development is towards a more positive condition. Nevertheless, cross-dimensional integration and increased synergy between stakeholders are absolutely necessary to optimize sustainability achievements. Improvement efforts cannot be made partially, but must be comprehensive, given that one weak dimension can affect the performance of another dimension systematically.

Leverage Analysis

Leverage analysis is an important stage in the RAP-MDS (Rapid Appraisal for Multidimensional Scaling) model that aims to identify the attributes or factors that are most sensitive to changes in the sustainability index. Each attribute has a *Root Mean Square (RMS) change* value that shows the extent to which a change in one attribute can affect the overall value of the sustainability index on a given dimension. The attributes with the highest RMS values are categorized as leverage factors, which means that improvements to those attributes will have the most significant impact on improving sustainability (Fauzi & Anna, 2005; Kavanagh & Pitcher, 2004).

Based on the results of the leverage analysis , there are a number of priority attributes that have high sensitivity values and significantly affect the sustainability of oil palm farming on peatlands. Addressing these factors is key to improving sustainability in various dimensions, which are as follows:

1. Ecological Dimension and Economic Dimension

The ecological dimension assesses the extent to which oil palm cultivation activities on peatlands maintain the ecological function of the land. Environmental balance in oil palm cultivation is very important. The results of the analysis show that the ecological dimension has the highest leverage value (RMS=15.96). This suggests that land with young peat is more susceptible to damage such as subsidence, fire, and carbon loss. In addition, soil pH (RMS = 10.42) is an important indicator, as pH mismatches can trigger the use of excessive fertilizers that damage the environment. Therefore, an ecosystem-based approach is crucial in the management of oil palm plantations on peatlands (Figure 5)

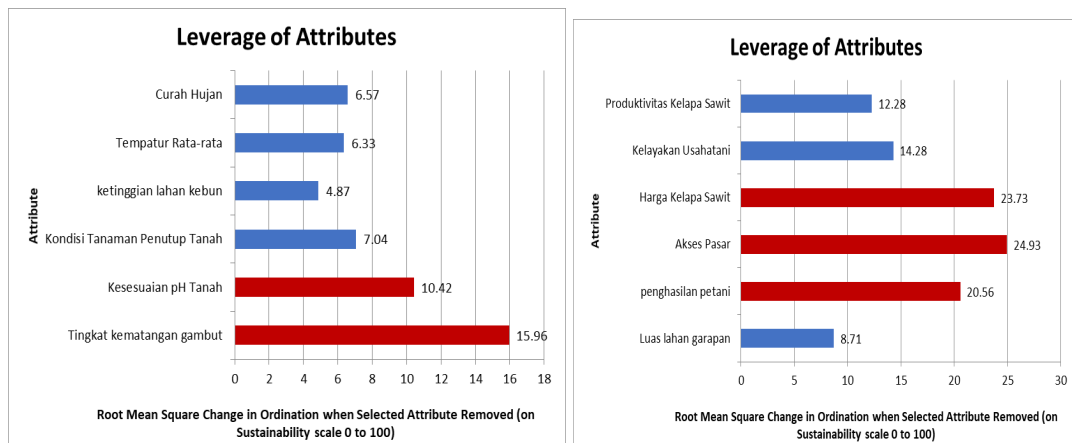


Figure 5. Leverage Analysis on the Ecological and Economic Dimensions
 Source: Data Analysis, 2024

Meanwhile, in the economic dimension, economic sustainability is related to the feasibility of business and the welfare of farmers. The three key attributes are market access (RMS = 24.93), selling price of FFB (RMS = 23.73), and farmer income (RMS = 20.56). Limited market access weakens farmers' bargaining positions, while price fluctuations demand policy intervention for stabilization. Adequate income is the basis for economic sustainability because it affects farmers' ability to invest and survive in farming.

2. Social and Technological Dimension

The dominant social factors included the intensity of counseling (RMS = 15.62), land ownership status (RMS = 13.93), and government policy support (RMS = 11.93). Effective counseling supports knowledge transfer and regulatory compliance, while legal certainty over land provides farm security. Government policies are a driver of social justice through technical assistance facilities, subsidies, and institutional strengthening (figure 6)

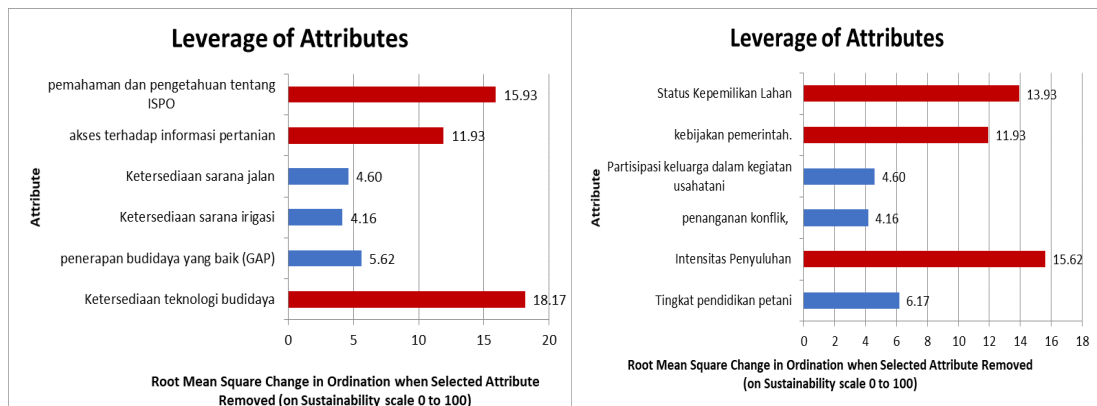


Figure 6. Leverage Analysis on Social and Technological Dimensions
 Source: Data Analysis, 2024

3. Institutional Dimension

The role of field extension workers is part of institutional performance. Field Extension can be an important aspect of sustainability. The results of the leverage analysis showed that field extension workers are the main lever in assisting farmers towards sustainable practices (RMS = 17.62. In addition, access to financial institutions (RMS = 11.93) is important for business capital, and training or mentoring (RMS = 8.93) plays a role in building the institutional capacity of farmers. Strong institutions allow farmers to access information, technology, and sustainable sources of financing. The results of the analysis can be seen in the following figure 7:

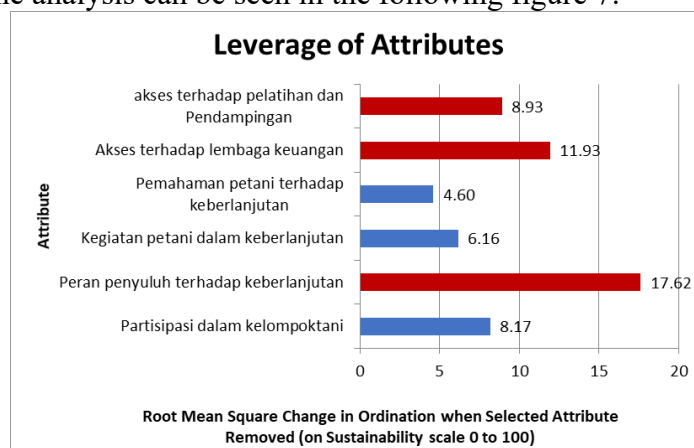


Figure 7. Leverage Analysis on the Institutional Dimension
 Source: Data Analysis, 2024

Validity Test and Model Accuracy Test

Paying attention to the results of the Monte Carlo analysis and the MDS analysis at the 95% confidence level, it was obtained that the value of the Sustainability Index of paddy rice farming in Pasar Terusan village, Muara Bulian District, Batanghari Regency showed that there was a difference in the value of the two analyses was (3.72%) or less than 5%. This means that the MDS analysis model produced is adequate to estimate the value of the Sustainability index of paddy rice farming in Pasar Terusan village, Muara Bulian District, Batanghari Regency. This very small difference in values

suggests that errors in the analysis process can be minimized or avoided. Errors caused by scoring each attribute, multidimensional scoring variations due to different opinions are relatively small, the data analysis process is carried out repeatedly is relatively stable, and errors in data input and missing data can be avoided (Fauzi et al. 2005). Monte Carlo analysis can also be used as a simulation method to evaluate the impact of random error in statistical analysis performed on all dimensions (Kavanagh and Pitcher 2004). The results of MDS and Monte Carlo analysis are presented in the following table.

Table 1. Monte Carlo analysis results for the Rap-Ricefield

Dimension	MDS (%)	Monte Carlo* (%)	Difference (MDS-MC) (%)
Ecology	52.04	51.86	0.18
Economics	78.65	76.34	2.32
Social	56.07	53.19	2.88
Technology	47.07	45.19	1.88
Institutional	48.47	47.21	1.26
Multi-size	60.18	57.8	2.4

Source: Processed Data, 2024

The smaller the "stress" value obtained, the better the quality of the analysis results carried out, but in contrast to the value of the determination coefficient (R²), the quality of the analysis results is better if the value of the determination coefficient (R²) is greater (closer to 1). Based on the results of the analysis, it can be seen that each dimension and multidimension has a much smaller "stress" value. The stipulation states that the "stress" value in the analysis using MDS is sufficient if a value of 25% is obtained (Edwarsyah 2008:163). The analysis produces statistical parameters that can be seen in the following table:

Table 2. Results of Rap-Ricefield Analysis for Some Statistical Parameters

Statistical Value	Multi-size	Ekologi	Economics	Social	Technology	Institutional
Stress	0.14	0.15	0.16	0.14	0.12	0.13
R ²	0.93	0.94	0.90	0.94	0.92	0.93
Sustainability Index	60.18	52.04	78.65	56.07	47.07	48.47

Source: Processed Data, 2024

From the results of the Rap-MDS analysis, it was obtained that the determination coefficient (R²) was between 90% - 94% or greater than 80% or close to 100%, meaning that the sustainability index estimation model was good and adequate (Kavanagh 2001). Meanwhile, the stress value is in the range between 12% - 16%. The determination value is close to 95-100% and the stress value is less than 25% so that the MDS analysis model obtained has high accuracy (goodness of fit) to assess the sustainability index of paddy rice farming in Pasar Terusan village, Muara Bulian District, Batanghari Regency (Fisheries, 1999). The score was obtained based on the assessment of 30 attributes divided into five dimensions, namely the ecological dimension (6 attributes), the economic dimension (6 attributes), the social dimension (6 attributes), the technological dimension (6 attributes) and the institutional dimension (6 attributes).

The results of the Monte Carlo analysis show that using Rap-MDS analysis as an analysis tool is very appropriate to analyze the sustainability status of oil palm in peatlands. The small difference between MDS and Monte Carlo values indicates that the scoring of attributes has a small error rate, MDS has high stability, and the system used has a good level of confidence. The sustainability status of oil palm in peatlands can be improved by improving all dimensions of its sustainability.

The results of the above test are in line with the facts in the field which show that the respondents stated that oil palm is the main source of household income (more than 70%) with an average productivity range of 830 kg/ha/year. The ecological dimension shows that the peatland at the research location shows signs of light subsidence due to shallow drainage systems. Most farmers have undertaken simple conservation such as planting cover crops or keeping drainage ditches from being too deep, which indicates early ecological awareness. The Social Side explained that most farmers are members of local farmer groups or cooperatives even though their functions are not optimal. Social solidarity is high, but education levels are low (the majority of elementary-high school graduates) limit understanding of formal sustainability principles such as ISPO or RSPO. The use of superior seeds has been implemented by around 60% of farmers, but some still use local seeds without certification. Access to training in environmentally friendly cultivation technology is still limited due to the lack of extension activities in peat villages. while in the institutional aspect, Field Agricultural Extension Workers (PPL) are active in several regions, but they are not evenly distributed. Access to formal financial institutions is low, only about 30% of farmers have access to people's business credit (KUR) for working capital.

This research has implications for the achievement of SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land). However, the low score in institutional and technological aspects shows the need for an integrated strategy to truly support sustainable development so that it is important to strengthen farmer organizations, cooperatives, and the role of field assistants so that the sustainability of oil palm plantations will be maintained.

CONCLUSION

The development of oil palm plantations on peatlands in Jambi Province shows that the average age of oil palm plants in the research area is around 20 years old, with an average land area of 2.19 hectares. The average production produced by the respondent farmers is 930 Kg/Ha/Year.

The level of sustainability of independent oil palm cultivation in peatlands in Jambi Province is generally in the category of quite sustainable with a multidimensional index value of 60.18. In the ecological dimension, sensitive attributes are peat maturity conditions, soil quality, and chemical fertilization intensity. For the economic dimension, the most decisive attributes are the selling price of FFB, access to the market, and the scale of the farming business. Meanwhile, in the social dimension, the most influential attributes include land ownership status, extension intensity, and participation in farmer groups. In the technology dimension, sensitive attributes include

the use of superior seeds, farmers' understanding of cultivation technology, and access to agricultural information. Meanwhile, in the institutional dimension, the most influential attributes are the existence of field assistants, the function of farmer cooperatives, and access to financing or business capital.

ACKNOWLEDGMENTS

Thank you to all parties who have helped so that this research can be carried out and completed

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