



Sustainability of Oil Palm and Sugar Palm Diversification in Rokan Hulu Regency: A Study of Economic, Ecological, and Social Dimensions Using the MDS Method

Yeni Kusumawaty, Risda Lenita Sari, Susy Edwina*, Sispa Pebrian, Evy Maharani

(Received December 2024/Accepted August 2026)

ABSTRACT

Oil palm is a leading commodity that greatly contributes to community welfare. The potential of a sizable land area presents an opportunity to optimize land use through diversification with sugar palm plants. The purpose of this study was to analyze the sustainability of oil palm and sugar palm diversification in Rokan Hulu Regency, Riau Province, using the Multidimensional Scaling (MDS) method through Rap–Arenga software. This study used a survey method with a sample of 25 farmers chosen using the snowball sampling technique. The results of the analysis showed a sustainability index of 73.91 in the economic dimension (quite sustainable), 50.70 in the ecological dimension (quite sustainable), and 56.94 in the social dimension (quite sustainable). Sensitive lever attributes that have a significant influence include access to capital institutions in the economic dimension, the level of pest and disease attacks in the ecological dimension, and the views of farmers on diversification in the social dimension.

Keywords: diversification, oil palm, sensitive attributes, sugar palm, sustainability

INTRODUCTION

Oil palm plantations are a leading commodity in Riau Province. Riau Province is one of the largest oil palm plantation centers in Indonesia, with an area of 2,868.1 hectares (BPS Indonesia 2024). Oil palm is the main commodity in Rokan Hulu Regency, with the majority of the population working as plantation workers. Rokan Hulu Regency has a very large potential for oil palm plantations at 271,286 hectares in 2022 and 331,037 hectares in 2023 (BPS Riau 2024).

The potential of a sizable land area presents an opportunity to optimize land use by diversifying, given the ecosystem conditions that are very suitable for the potential of sugar palm plants. The community is trying to diversify oil palm and sugar palm. Diversification of sugar palm plants is done by planting between oil palms or on the edge of oil palm plantations (Putri *et al.* 2022).

Diversification is the same as intercropping, where two or more crops are planted on the same land (Kusumawaty *et al.* 2024). The results of the study by Mulu *et al.* 2020 showed that intercropping is a part of polyculture farming that has succeeded in increasing the welfare of farmers with increased agricultural production and profits. The purpose of diversification is to improve the sustainability of agriculture and increase farmer income (Pratiwi 2021).

Diversification of oil palm and sugar palm in Rokan Hulu Regency faces some problems, namely the dependence of farmers on using chemicals, which is good for plant productivity but has an impact on ecological sustainability with the the potential to damage the environment. The limited knowledge possessed by farmers regarding diversification is also a problem in the social dimension which results in minimal participation of farmers in diversifying and minimal tapping resources.

Diversification of oil palm and sugar palm is an effective alternative from an economic perspective to increase farmer income and land optimization, thus it needs to align with the concept of sustainable agriculture. Sustainable agriculture is an agricultural system that is able to maintain the environment to meet human food and fiber needs in the long term (Virianita *et al.* 2019).

This study looks at sustainability from three dimensions, namely economic, ecological, and social. Economic sustainability emphasizes the fulfillment of economic needs, ecological sustainability maintains the integrity of the ecosystem, while social sustainability is related to the need for social welfare (Joisangadji *et al.* 2024). This concept is based on optimal management of available resources, with the aim of efficiently utilizing, preserving and improving environmental quality and natural resource conservation efforts (Purba *et al.* 2020).

Thus, the purpose of this study is to analyze the sustainability of oil palm and sugar palm diversification, and to identify sensitive attributes that influence the

Department of Agribusiness, Faculty of Agriculture, University of Riau, Riau 28292, Indonesia

* Corresponding Author:

Email: susy.edwina@lecturer.unri.ac.id

sustainability of oil palm and sugar palm diversification in Rokan Hulu Regency.

METHODS

This study was conducted in Rokan Hulu Regency, Riau Province, which already has a diversification system. The research period lasted from May to December 2024, used a survey with a closed questionnaire and a Likert scale to collect data. The snowball sampling technique was used to choose key informants, specifically the Head of the Social Forestry Business Group (KUPS) in the regency, who were then asked to recommend more smallholders as research samples.

The number of samples chosen was 25 smallholders because they were already at the saturation point acquired from 5 selected sub-districts from a total of 16 sub-districts in the regency, namely Rambah, Rambah Samo, and Rokan IV Koto, Ujungbatu, and Tandun. Since the five selected sub-districts had potential for oil palm and sugar palm diversification, the number of samples was deemed sufficient to represent the situations of diverse

smallholders in the regency.

This study used both primary and secondary data. Primary data were observations about the economic, ecological, and social sustainability of oil palm and sugar palm diversification. The features of each dimension were related to sustainability theory, past research, and field situations.

Table 1 shows the attributes used. Each feature was evaluated using ordinal scale data and then rated using a Likert scale with a score range of 1–4, indicating 1 (very poor) to 4 (extremely good).

The data analysis employed was both descriptive and quantitative. The findings of the attribute assessment using a Likert scale were then examined with Rap-Arenga software. The Multidimensional Scaling (MDS) method's analytical steps were carried out using Microsoft Excel, beginning with data centralization and input and ending with result interpretation.

The Rap-Arenga study results suggested that the index value correlates with the sustainability status category (Table 2). The sensitive features (key indicators) were then analyzed using Rap-Arenga's leverage analysis tool. An attribute is considered sensitive if it has the highest Root Mean Square (RMS)

Table 1 Sustainability attributes of oil palm and sugar palm diversification in Rokan Hulu

Dimensions	Attribute
Economic	1 Land area 2 Ease of market access/marketing 3 Planters' income 4 Stability of sugar palm sap selling price 5 Productivity level of diversified crops 6 Land ownership status 7 Capital/credit institutions 8 Marketing chain
Ecological	1 Weed, pest, and disease control 2 Level of pest and disease attacks 3 Land suitability 4 Number of sugar palm trees 5 Intensity of fertilizer use 6 Intensity of pesticide use 7 Intensity of land cleaning/weeding 8 Type of sugar palm seedlings
Social	1 Farmer education 2 Family participation 3 Farmer age 4 Farmer's views on diversification 5 Source of farming information 6 Intensity of extension activities 7 Participation in extension activities 8 Participation in farmer group activities

Table 2 Sustainability index values

Index	Category
0.00–25.00	Poor (not sustainable)
25.01–50.00	Less good (less sustainable)
50.01–75.00	Moderate (moderately sustainable)
75.01–100.00	Good (very sustainable)

Source: Kavanagh & Pitcher in Sari *et al.* (2022).

value of any attribute. The higher the shift in RMS value, the more sensitive the indicator's significance in improving the sustainability status.

RESULTS AND DISCUSSION

Respondent Characteristics

The characteristics of diversified farmers in Rokan Hulu Regency can be seen in Table 3.

Multidimensional Sustainability Analysis

Sustainability analysis of oil palm and sugar palm diversification is reviewed from three main dimensions of sustainability, namely economic, ecological and social. The sustainability index of each dimension can be seen the flyover diagram presented in Figure 1.

The flyover diagram shows the relative position of the sustainability score of each dimension's

diversification. The index value for the economic dimension is 73.91, ecological dimension is 50.70, and social dimension is 56.94. The three dimensions of economy, ecological, and social are quite sustainable. The concept of sustainable development does not require all index values of each dimension to have the same magnitude, but rather a region must have a more dominant dimension to be a priority for improvement. (Syarifatullah *et al.* 2022).

Based on Rap–Arenga analysis (Table 4), the stress value of each dimension is <0.25 and the R² value is 0.94. These results indicate that in accordance with field conditions and the attributes used, each dimension in the study is statistically good

Economic Dimension

The results of the Rap–Arenga analysis show the index value on the economic dimension is 73.91 (moderately sustainable), which indicates that the

Table 3 Characteristics of farmers in Rokan Hulu Regency

. Res- pon- dent	Internal characteristics					Eksternal characteristics		
	Age (year)	Level of education	Farming experience (Year)	Number of family dependent	Land area (ha)	Availability of extension activities	Involvement in farmer groups	Access to means of production
1	49	Lower Secondary	30	5	0.5	No	No	Yes
2	53	Higher Secondary	20	4	2.5	No	No	Yes
3	64	Undergraduate	10	2	2	Yes	Yes	Yes
4	44	Lower Secondary	20	2	2	No	No	Yes
5	37	Primary School	5	3	0.25	No	No	Yes
6	44	Islamic Lower Sec.	15	2	0.5	No	No	Yes
7	39	Primary School	21	6	0.5	Yes	Yes	Yes
8	36	Lower Secondary	15	3	1	Yes	Yes	Yes
9	54	Undergraduate	10	6	3	Yes	Yes	Yes
10	30	Higher Secondary	5	0	2	Yes	Yes	Yes
11	62	Primary School	20	1	2	Yes	Yes	Yes
12	30	Higher Secondary	5	1	0.5	No	No	Yes
13	48	Higher Secondary	13	1	1.25	No	No	Yes
14	54	Primary School	10	2	1	No	No	Yes
15	47	Higher Secondary	20	1	0.5	No	No	Yes
16	60	Higher Secondary	30	1	1	No	No	Yes
17	35	Undergraduate	8	1	2	Yes	Yes	Yes
18	59	Primary School	20	1	2	Yes	Yes	Yes
19	44	Primary School	20	3	1	Yes	Yes	Yes
20	30	Higher Secondary	10	3	1	Yes	Yes	Yes
21	42	Undergraduate	20	3	2	Yes	Yes	Yes
22	55	Lower Secondary	30	4	1	No	No	Yes
23	53	Primary School	30	3	1	Yes	Yes	Yes
24	63	Lower Secondary	30	1	0.25	Yes	Yes	Yes
25	54	Primary School	25	2	0.5	Yes	Yes	Yes

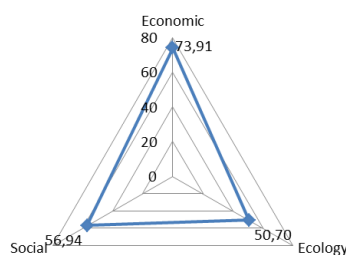


Figure 1 Sustainability flyover diagram.

management of oil palm and sugar palm diversification is quite good, and it can still be cultivated in the future (Figure 2). The resulting index value can be increased by focusing on strengthening sensitive attributes.

The economic dimension has a low value on the attribute of the productivity level of the aren palm, because the production of aren palm plants only produces 1–10 L/frond/day and is not in accordance with the Regulation of the Minister of Agriculture (2013) which states that natural aren palm plants can produce >20 L/frond/day. Efforts to increase the sustainability index of the aren palm productivity levels are through effective fertilization. The use of organic and inorganic fertilizers in a balanced manner can increase the growth of aren palm plants (Ariyanti *et al.* 2017).

The results of the leverage analysis on the economic dimension show that there are 3 sensitive attributes that influence the sustainability for diversification, namely capital/credit institutions, ease of market access/ marketing, and stability of sugar palm sap selling price.

Capital/credit institutions with a value of 4.75 are the highest value and the main sensitive attribute, because farmers generally do not utilize capital/credit institutions. Farmers prefer to use their own capital because they are free from the pressure or risk associated with loans. This result is in line with Muharani *et al.* (2024) that despite availability of adequate capital credit, they are not fully utilized, due to concerns of farmers paying off loans and interest, which causes them to be tied up in debt. Capital/credit institutions are a means for farmers to gain access to the capital needed to develop their farming businesses. The availability of adequate capital is an opportunity to optimize and expand their farming businesses.

The second sensitive attribute is ease of market access/marketing. Ease of market access is an

important aspect to facilitate selling of products and earning income. Good market access is an important factor in the marketing process, because it allows farmers to sell their crops more efficiently and earn optimal income. Market access simultaneously affects income (Cahyo *et al.* 2024). Market access in Rokan Hulu is relatively easy based on the high demand for aren sap, so that farmers do not experience difficulties in marketing their products.

The third sensitive attribute is the stability of sugar palm sap selling price. The stability of sugar palm sap selling price is a key factor in the sustainability of oil palm and aren diversification, because it supports the economic resilience of farmers. The price of aren sap in Rokan Hulu is quite stable, which is IDR 10,000/L, according to Warsito (2018) the price of aren sap is around IDR 10,000/L.

Ecological Dimension

The results of the Rap–Arenga analysis for the index value in the ecological dimension is 50.70 (moderately sustainable). The ecological dimension has a low value in the attributes of seedling type, intensity of fertilizer use, and intensity of pesticide use (Figure 3). The seedling type attribute is low because farmers rely on local aren seedlings whose quality is inconsistent, so that plant growth is less than optimal and reduces the potential for sap production. The low intensity of fertilization and pesticide use indicates that farmers do not yet understand the right recommendations to increase production. Research by Yustina *et al.* (2019) emphasized the need for education and training for farmers to understand the use of fertilizers and pesticides according to recommendations.

The results of the leverage analysis on the ecological dimension show 3 sensitive attributes that influence the sustainability of oil palm and sugar palm

Table 4 Goodness of fit of each dimension

Dimension	R^2 Value	Stress Value	Interpretation
Economic	0.94	0.13	Good
Ecological	0.94	0.13	Good
Social	0.94	0.14	Good

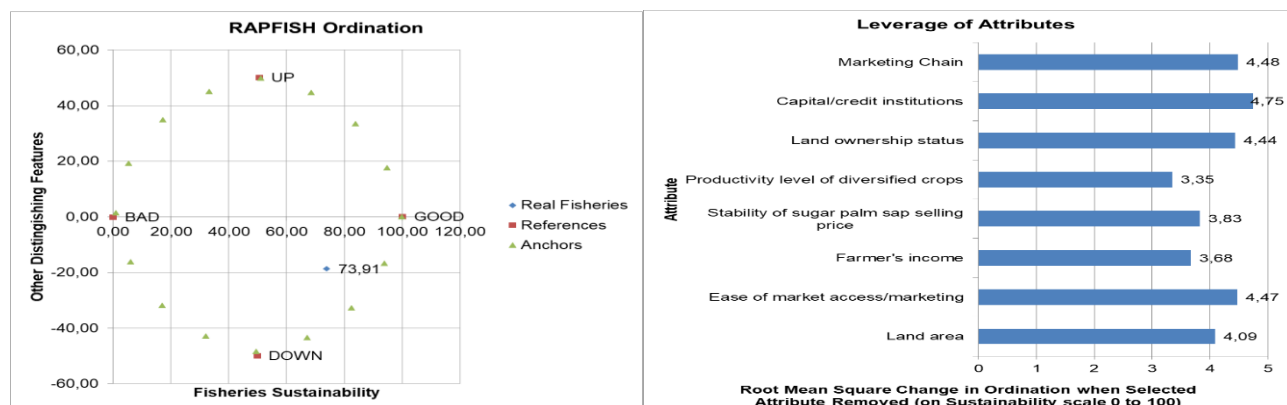


Figure 2 Index values and sensitive attributes in the economic dimension.

diversification, namely the level of pest and disease attacks, the number of sugar palm trees, and land suitability.

The level of pest and disease attacks show a value of 6.70 which is the highest value and the main lever sensitive attribute, which affects the quality and production results. The level of pest and disease attacks on diversification in Rokan Hulu is classified as never, hence sugar palm plants can grow more optimally with increased production of sap (Suera *et al.* 2023).

The second sensitive attribute is the number of aren trees. The number of aren trees affects the income of farmers. Research by Nur *et al.* (2024) shows that the development of aren plants can increase export potential because its economic value is high and increases the income of farmers. The number of aren trees in Rokan Hulu is relatively low with an average of 28 trees and the number of trees producing aren sap is only 4 trees.

The third sensitive attribute is land suitability. Land suitability plays an important role in supporting the sustainability of oil palm and sugar palm diversification in Rokan Hulu. According to Irani *et al.* (2024), suitable land plays an important role in supporting plant growth

and optimal sustainability. The type of soil in Rokan Hulu is mineral soil with a pH of 5.5–7.5 that is suitable for optimal growth of sugar palm, which is pH 6–7.

Social Dimension

The results of the Rap–Arenga analysis shows the index value on the social dimension is 56.94 (moderately sustainable). The social dimension has a low value for the intensity attribute of extension activities, because only two out of five sub–districts have the potential for diversification of oil palm and sugar aren (Figure 4).

The results of the leverage analysis on the social dimension show that there are 4 sensitive attributes that influence the sustainability of oil palm and sugar palm diversification, namely the views of farmers on diversification, participation in extension activities, sources of farming information, and participation in farmer group activities.

The farmer's view on diversification with a sensitivity value of 6.50 is the highest value and the main lever attribute. The results of this study are in line with the farmer's expectations to achieve more stable income and support the diversification program as an alternative when oil palm prices fluctuate or fall.

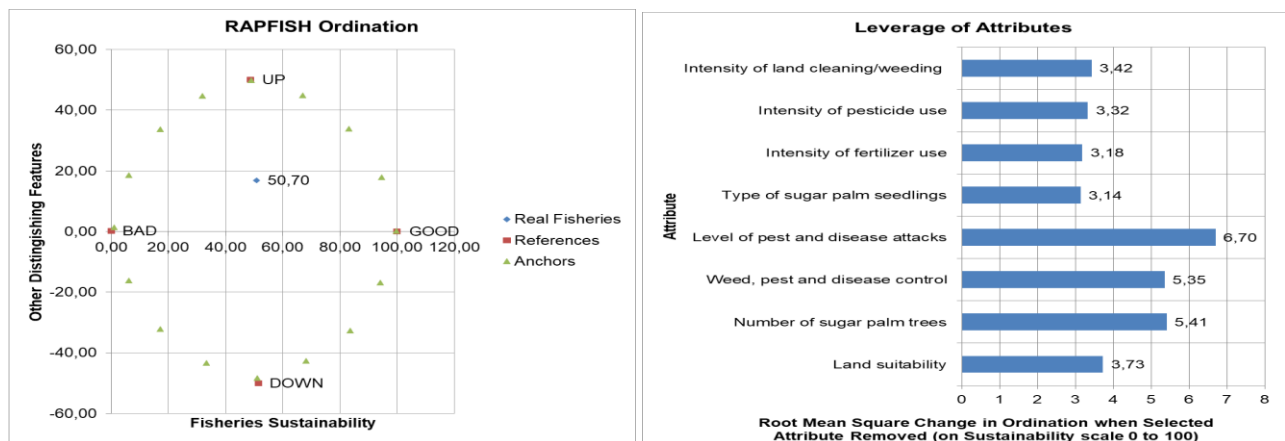


Figure 3 Index values and sensitive attributes in the ecological dimension.



Figure 4 Index values and sensitive attributes in the social dimension.

The second sensitive attribute is participation in extension activities. Farmers are quite active in participating in extension activities, because they have joined farmer groups. Through extension, farmers can access the latest information in the agricultural sector (Faisal 2020).

The third sensitive attribute is the source of farming information. Farmers rely on information from fellow farmers. Easy access to farming information sources increases farmers' understanding of more efficient farming management strategies. According to Rushendi and Zachronis (2016), knowledge of implementing agricultural innovation and technology is obtained through interactions between farmers or farmer groups.

The fourth sensitive attribute is participation in farmer group activities. The majority of active farmers join farmer groups and often participate in their activities. Referring to the research of Nalius *et al.* (2023) that agricultural information, extension, coaching and provision of agricultural equipment facilities cannot be separated from farmer groups.

Oil Palm and Sugar Palm Diversification Policy Model

Sensitive attributes that affect the sustainability of oil palm and sugar palm diversification need to be prioritized in planning and problem solving. The solution needed is a policy that is able to overcome the impacts of these sensitive attributes, in order to improve sustainability as a whole.

Policies must consider various aspects and resources, so they require a systematic and integrated approach. This will prevent impacts on other dimensions and worsen the sustainability status of oil palm and sugar palm diversification. Therefore, a policy strategy is needed to manage these sensitive attributes, in order to optimally support the sustainability of oil palm and sugar palm diversification. Sensitive attributes and policy models for each dimension can be seen in Table 5.

CONCLUSION

The sustainability of oil palm and sugar palm diversification in Rokan Hulu Regency was analyzed using three dimensions, namely economic, ecological, and social. All three dimensions fall under the 'moderately sustainable' category. The sensitive attributes of the main levers in the economic dimension are capital/credit institutions, the ecological dimension is the level of pest and disease attacks, and the social dimension is the views of smallholders on diversification. The suggestion obtained from the research results is that there needs to be an effort in each dimension by considering its sustainability and dominant attributes. Then the government is expected to fully support the diversification program and design

effective policies by taking into account the constraints of smallholders.

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Table 5 Sensitive attributes and policy models

Dimension	Sensitive attributes		Policy model	
Economic	1	Capital/credit institutions	1	People's Business Credit Program (KUR)
	2	Ease of market access (marketing)	2	Digital marketing platform
	3	Stability of sugar palm sap selling price	3	Partnership
Ecological	1	Level of pest and disease attacks	1	Development of Integrated Pest Management System (IPM)
	2	Number of sugar palm trees	2	Superior seed assistance program
	3	Land suitability	3	Technology-based land mapping
Social	1	Farmer's views on diversification	1–4 Empowerment of farmers	
	2	Participation in extension activities		
	3	Source of farming information		
	4	Participation in farmer group activities		

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