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Enhancing Sustainability of the Palm Oil Agro-Industry: A Study from the Leveraging Factors of Supply Chain Management

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Abstract. The imperative of sustainable development necessitates meeting present needs without compromising the well-being of future generations and the long-term health of our planet. Consequently, the promotion of new patterns of sustainable supply chain management practices is gaining momentum. This research endeavors to contribute to the implementation of sustainable chain management practices within the context of complex palm oil agro-industry enterprises. Specifically, the study aims to design a comprehensive framework to enhance the sustainability of the palm oil agro-industry. To achieve this, we employ the Multi-Dimensional Scaling (MDS) technique and analyze data using the Rap-Palm Oil (Rapid Appraisal for Palm Oil) method, which is grounded in the triple bottom line concept encompassing economic, social, and environmental dimensions. The findings reveal that supply chain management practices in palm oil agro-industry enterprises exhibit a high level of sustainability. Notably, factors enabling sustainability within the economic dimension include promotion reliability, responsiveness levels, and product quality. Within the social dimension, factors encompass workplace safety assurances, freedom of worship guarantees, and promotion of career paths. In the environmental dimension, factors comprise waste gas emissions management, utilization of environmentally friendly packaging, and efficient use of electrical and gas energy.

Keywords: palm oil, sustainable supply chain management, multidimensional scalling (MDS), agro-industry enterprises

1. Introduction

Crude palm oil holds significant importance as a strategic commodity for the Indonesian economy, serving as a crucial raw material for various industries, including cooking oil, cosmetics, detergents, and biofuels. The palm oil sub-sector in Indonesia has experienced remarkable growth, expanding from approximately 106 thousand hectares in the late 1960s to 2.5 million hectares in 1997 (A., 2000). This sector not only contributes to the economy but also creates employment opportunities, as it is a labor-intensive industry. The escalating demand for energy, food, and agro-industrial materials has further intensified the need for palm oil as a raw material (Corley, 2009; Seuring & Müller, 2008). According to data from the Ministry of Agriculture in 2020, Indonesia's crude palm oil (CPO) production increased from 31 million tons in 2015 to 42.9 million tons in 2018. This surge in demand has compelled all stakeholders to intensify production efforts (Astuti, 2021; Cisneros et al., 2021a). It is worth noting that oil palm is the most productive among commercially grown oil crops, exhibiting up to ten times higher productivity compared to crops like sunflower, soybean, and rapeseed (Darby, 2014).

Research on the sustainability of the palm oil industry has been extensively conducted (Bok et al., 2022; Khatun et al., 2017; Oliphant & Simon, 2022; Tan & Lim, 2019). However, the expansion and intensification of the palm oil agro-industry have resulted in sustainability challenges within the supply chain. These challenges include environmental damage, land grabbing, and poor working conditions (Cisneros et al., 2021b; Widyaningrum et al., 2020). To address these issues, collaboration among all stakeholders within the supply chain is necessary to foster the sustainability of the palm oil agro-industry (Ayompe et al., 2021; Susilo, 2003). In other hand, according to Silvestre et al. 2018), collaborative efforts among stakeholders can lead to unforeseen negative outcomes. Therefore, it can be concluded that there is inconsistency among different research studies. This inconsistency becomes a research gap in the field.

Sustainable Supply Chain Management (SSCM) emerges as a potential solution to support the sustainability of the palm oil agro-industry. SSCM integrates the triple bottom line, encompassing economic, social, and environmental aspects, into core business processes, with the aim of achieving long-term growth (Dai et al., 2021; Indah et al., 2019; Susanti & Maryudi, 2016; Umar et al., 2021). By implementing SSCM practices in the palm oil agro-industry, it is possible to benefit all stakeholders while minimizing negative impacts on the economy, society, and the environment.

To ensure the effectiveness of sustainable practices in palm oil agro-industrial supply chain management, a multidimensional approach is required, considering the economic, social, and environmental dimensions—the three main pillars of Sustainable Supply Chain Management (SSCM) (Cyplik et al., 2013). This study focuses on assessing the sustainability level of supply chain management practices within the palm oil agro-industry in Indonesia using multidimensional scaling analysis through the Rap-Palm Oil technique. The respondents in this study were purposefully selected from the palm oil agro-industry, which encompasses various companies involved in processing palm oil into derivative products, such as cooking oil, butter, chocolate, soap, shampoo, detergent, and cosmetics. These companies encounter a range of supply chain management issues, including increased production levels and cultivated areas, higher value of derivative products, reduced selling prices, and environmentally unfriendly land clearing methods. Hence, the research aims to evaluate the sustainability level and develop managerial policy recommendations that promote supply chain sustainability across the economic, social, and environmental dimensions.

2. Theoretical Background

2.1. Sustainability concept

The concept of sustainability in recent years has continued to develop due to various demands to create a good production system that can meet consumer needs that continue economically, socially, and environmentally (Angulo-Mosquera et al., 2021; Nababan et al., 2008). The concept of sustainability is

a derivative of the triple bottom line concept, which emphasizes the balance of three dimensions or the triple bottom line, namely economic, social and environmental (Laurett et al., 2021). The main goal of the concept of sustainability is to ensure that the next generation can take advantage of the resources that exist today (Ab. Aziz et al., 2023; Liebetruth, 2017). Industry players who play a role in the product manufacturing process play an important role in implementing and supporting sustainable production practices.

However, to realize sustainable product results, a collaboration between stakeholders is needed that pays attention to social, economic, and environmental aspects in daily business operations (Khodakarami et al., 2015; Maulidah & Wahib Muhaimin, 2021). The concept of sustainability can support production activities in designing strategic arrangements to keep operating in the future. Despite the importance of industry players in implementing and supporting sustainable production practices, there is limited knowledge about how these players can effectively coordinate their efforts to integrate social, economic, and environmental considerations into their daily business operations. This research gap highlights the need for further investigation into the specific strategies and mechanisms that can facilitate and promote sustainable practices throughout the value chain, ultimately ensuring the long-term viability and success of businesses operating in a sustainable manner.

2.2. Sustainable Supply Chain Management

Sustainable Supply Chain Management (SSCM), or sustainable supply chain management, is part of supply chain management that has been developed and focuses more on the triple bottom line concept to address the challenges of limited natural resources, increasing global population from consumption and production activities, logistics and increased waste (Maulidah, 2020). SSCM is a triple bottom line implementation related to economic, social, and environmental dimensions to improve efficiency and effectiveness of product and service management, production, and distribution processes in achieving the objectives of related parties to increase profits, competitiveness, organizational resilience in the short and long term (Ahi & Searcy, 2013).

Implementing sustainable supply chain management is mostly carried out by organizations or companies considering the social and environmental dimensions of the economic dimension (Allen et al., 2021). Supported by research by Hong et al. (2018) which states that SSCM is an important aspect that shows that the basis for achieving sustainable development is the existence of a social dimension so that it can achieve sustainable economic growth. Applying SSCM in business processes can help increase economic growth while considering the social and environmental dimensions.

Implementing SSCM in the company can also help increase the company's competitiveness and reputation. Through SSCM, the company can manage resources efficiently while still paying attention to social responsibility and achieve the desired financial performance, which can increase the company's competitive advantage (Di Vaio & Varriale, 2020; Dubey et al., 2017; Rebs et al., 2019). Supported by Tsai et al., who stated that the existence of SSCM in business processes could help achieve a competitive advantage in facing the wider social environment (Tsai et al., 2021). The basis for implementing SSCM in a company is to integrate sustainable development through supply chain management (Krajewski L et al., 2013). Achieving sustainable development through applying SSCM in a company will provide many benefits, especially on the economic dimension, driven by the supply chain management on the social and environmental dimensions.

To achieve supply chain management sustainability in a company, it is necessary to pay attention to the entire supply chain network in which there is a flow of information, cooperation, connectivity, and coordination (Machado & Luchko, 2021; Maulidah et al., 2020). There are three basic elements of a sustainable supply chain, namely: financial responsibility, environmental responsibility, and social responsibility (Tomislav, 2018). All aspects of cooperation between actors in the supply chain can support sustainable supply chain management through managing the social, environmental, and economic dimensions of business processes. The concept of sustainable supply chain management can

be seen in Figure 1.

Fig.1: Supply Chain and Sustainability Concept.
Source: Krajewski et al (2013)

Furthermore, Rajeev et al. describe the development of the sustainable supply chain management concept into the sustainable supply chain triangle (Rebs et al., 2019). The environmental dimension in sustainable supply chain management is viewed from the ecological footprint, emission trading, environmentally sustainable practices, pollution management, green consumer attitude, environmental strategy, green supplier management GSM, and waste management. In the social dimension, sustainable supply chain management can be identified through social impacts and measuring, standards and codes of conduct, social development, health and safety practices, product safety, community initiatives, work safety, and labor health. Sustainable supply chain management in the economic dimension can be seen in distribution, marketing, design, production, purchasing, strategy, and reverse logistics. Integration between environmental, social, and economic dimensions will form sustainable supply chain management, including sustainable distribution, sustainable marketing, sustainable finance, sustainable design, sustainable production, sustainable purchasing, sustainable development, sustainable strategy (including governance), sustainable performance measurement, and management, sustainable closed-loop supply chain. The development of the concept of sustainable supply chain management can be seen in Figure 2.

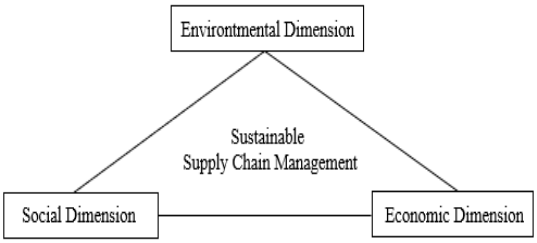

Fig.2: The development of the sustainable supply chain management concept
Source: Rajeev et al (2017)

Sustainable supply chain management focuses on integrating supply chain management with the concept of sustainability. The sustainable supply chain concept can conclude that the study dimension in sustainable supply chain management consists of three dimensions/aspects: economic, social, and environmental. The development of the concept of sustainability in the supply chain results in the emergence of sustainable performance, which can be viewed from three perspectives, namely: economic performance (integration in investments access to financial markets); environmental performance (reduction of pollution, security of installation/plants, security of products, exhaustion of resources); and social performance (equal treatment, good working behavior, respect for human rights) (Farooq et al., 2009). Sustainable performance in the development of the concept of sustainability can be seen in Figure 3.

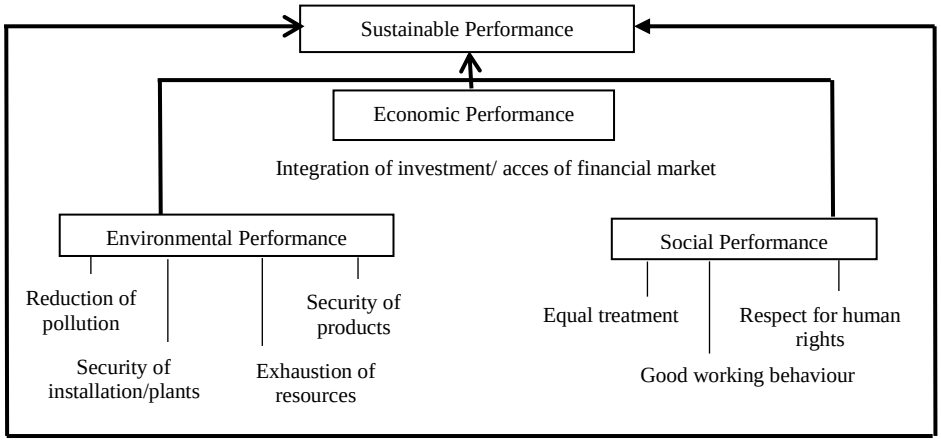

Fig.3: Sustainable Performance
Source: Farooq and Reynaud, 2009

3. Research Methodology

3.1. Materials

Respondents in this study were determined purposively, specifically palm oil agro-industry. Several potential agro-industrial companies (enterprises) that process palm oil into palm oil derivative products include cooking oil, butter, chocolate, soap, shampoo, detergent, and cosmetics. The company is affected by issues in its supply chain management, both positive and negative. Issues discussed include: increased production levels and planted areas, increased added value of derivative products, decreased selling values, and land clearing methods considered environmentally unfriendly. This is an important point of this research, to measure the level of sustainability and the formulation of increasing its sustainability from the economic, social, and environmental aspects.

3.2. Instrumentation

The Multidimensional Scaling (MDS) method is used to answer the objectives of this study, namely determining the sustainability status of the implementation of supply chain management for the palm oil agro-industry and designing a strategy formulation to improve the sustainability of supply chain management for the palm oil agro-industry. The achievement of sustainability performance is measured based on the index value and sustainability status of the palm oil agro-industry.

MDS is a statistical method to analyze the effects of several variables between variables that simultaneously go through several iteration stages (Machado & Luchko, 2021). Determining the sustainability status of palm oil agro-industry supply chain management adopts the Rapfish analysis technique (Rapid Assessment Techniques for Fisheries). Rapfish is an analytical method for evaluating sustainability in a multidisciplinary manner based on the technique of ordination with MDS (Nababan et al., 2008). The value of the supply chain sustainability index of palm oil agro-industry using Rapfish has a bad to good value with a range of 0-100. Then in this value range, there are four sustainability values criteria: 0-25 in bad status, 26-50 in poor status, 51-75 in sufficient status, and 76-100 in good status (Susilo, 2003). Furthermore, in this case, the term Rap-Palm Oil is used to describe the analysis of the sustainability of supply chain management for the palm oil agro-industry.

3.3 Procedure

Leverage, Monte Carlo, and Stress scores are important in MDS analysis. The results of the calculation of leverage will determine the variables that have a strong influence and serve as the main focus in improving sustainability. Monte Carlo is used to determining the level of accuracy generated by the Rap-Palm Oil analysis calculation model. The difference in sustainability values between Monte Carlo and Rap-Palm Oil results shows the resulting data's sensitivity. The following Figure 4 is the procedure

for applying the sustainability of supply chain management analysis using the Rap-Palm Oil Technique.

The term "Multidimensional" means that this technique is not limited to one or two measurement dimensions (Borg & Groenen, 2005). In this study, three dimensions of the triple bottom line were used to measure the level of sustainability: economic, social, and environmental. Each dimension is broken down into several variables. Sixteen (16) variables to measure the economic dimension, 14 variables to measure the social dimension, and ten (10) variables to measure the environment's dimensions. Table 1 is an arrangement of variables and variable measurements used in determining the supply chain sustainability of the palm oil agro-industry.

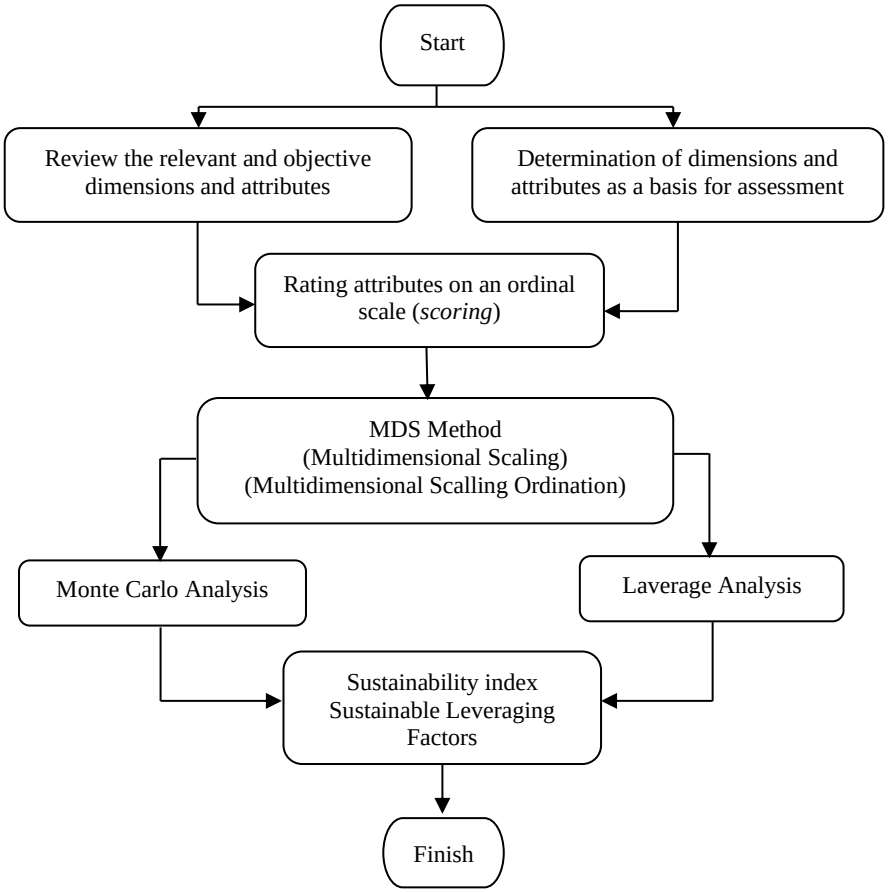

Fig.4: Rap-Palm Oil Technique

Table 1. Sustainability Dimension Attribute Measurement

No	Dimension	Variables	Variable Measurement	Sustainability Performance Measures
1	Economic	E1	Supplier Relationship	• Assessment methods are used for each dimension of the Triple Bottom Line (economic, social, and environmental). • Rapfish analysis assessment: 1 = Bad 10 = Fine • Sustainability Scale: 0.00-25.00 = Bad (doesn't continue) 25.01- 50.00 = Less
		E2	Input availability rate	
		E3	Quality of inputs supplied by Suppliers	
		E4	Timeliness of the production process	
		E5	Standard operating procedures for the production process	
		E6	Product quality	
		E7	Product responsiveness	
		E8	Packaging quality	
		E9	Packaging design	
		E10	Packaging size differentiation	
		E11	The level of product availability in the market	
		E12	Customer trust in the Brand (Brand)	

No	Dimension	Variables	Variable Measurement	Sustainability Performance Measures
		E13	Level of price competition with similar products	(less continuous) 50.01- 75.00 = Enough
		E14	Promotion reliability Tingkat	(quite continuing)
		E15	The level of reliability of delivery to consumers	
		E16	After-sales Service Level	
2	Social	S1	Employee workload	
		S2	Wage/salary rate	
		S3	Work safety guarantee for employees	
		S4	Health insurance for employees	
		S5	Guaranteed freedom of worship for employees	
		S6	Company support for labor unions	
		S7	Employee capacity-building process	
		S8	Employee career advancement process	
		S9	Active role in religious activities	
		S10	Active role in educational activities	
		S11	Active role in health activities	
		S12	Active role in public infrastructure improvement	
		S13	Active role in environmental activities	
		S14	Empowerment/absorption of local workers	
3	Environt-mental	N1	Use of safe inputs/raw materials	
		N2	Implementation of hygienic standards in the production process	
		N3	Use of environmentally friendly packaging	
		N4	Solid waste handling	
		N5	Handling of liquid waste	
		N6	Handling of gas emission waste	
		N7	Efficient use of water sources	
		N8	Efficient use of fuel energy sources	
		N9	Support zero waste campaign practices	
		N10	Application of the concept of 3R (Reduce, Reuse, Recycling)	

Based on the MDS method to determine the value or index of supply chain sustainability of the palm oil agro-industry, it can be done through the calculation of Rap-Palm oil through the following stages (Hikmah et al., 2011):

1. Determine attributes where there are 30 attributes in this study, each of which is 16 attributes of the economic dimension, 14 of the social dimention, and 10 of the environmental dimension.
2. Assessing each attribute using an ordinal scale based on the sustainability criteria in Figure 5.
3. Assessing the index and sustainability status of the palm oil agro-industrial supply chain in each dimension and multi-dimensional.
4. Leverage analysis which aims to determine sensitive attributes.

Analysis to determine the level of accuracy of the resulting Rapfish model.

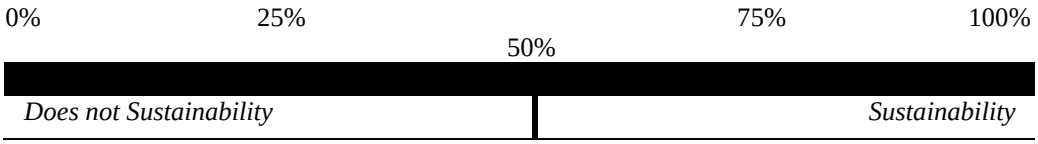

Fig.5: Illustration of Sustainability Index and Status

Table 2. Sustainability Index and Status Criteria

Index Value (%)	Sustainability Status
0,00 - 25,00	Not Continuing
25,01 - 50,00	Less Continuous
50,01 - 75,00	Enough Continues
75,01 - 100,00	Very Continuous

4. Result

The sustainability of supply chain management of the palm oil agro-industry is determined through the Multidimensional Scaling (MDS) method based on Microsoft Excel with Add-ins Rapfish 1.6. This study uses the triple bottom line concept to analyze sustainability, namely economic, social and environmental dimensions. The economic dimension has 16 attributes, the social dimension has 14 attributes, and the environmental dimension has ten (10) attributes. The following is the result of the sustainability analysis of the national palm oil agro-industry supply chain.

4.1. Sustainable Supply Chain Analysis using Goodness of Fits Palm Oil Agro-Industry

Based on the results presented in Table 3, the resulting Stress value is less than <0.25 through two iteration stages. The iteration process stops when the Stress value < 0.25. If the stress value is < 0.25, it can be said that it is accepted or the calculation results are accurate. Furthermore, the results of the R-Square (RSQ) value obtained have a value of <1 or close to a value of 1, so the resulting data is mapped perfectly. The results of the statistical tests show that the Rap-Palm Oil data model can be used as a tool to assess the supply chain sustainability of the palm oil agro-industry.

Table 3. Goodness of Fit Analysis of Supply Chain Sustainability

Sustainability Dimension	Sustainability Index	Stress Value	R^2 Value
Economics	81.01	0,13263	0,95722
Social	77.16	0.13493	0.95473
Environtmental	81.61	0.13745	0.95525
Average	79,92	0,13500	0,95573

Source: Primary Data Processed (2022)

4.2. Sustainability Index Analysis Through the Monte Carlo Method

The application of the Monte Carlo analysis is to determine the error factor of the model used in the sustainability analysis. The calculation results show that the sustainability index value differs from the Rap-Palm Oil analysis results. The iteration stages in the Monte Carlo analysis were carried out as many as 25 iterations or repetitions. The results of the Monte Carlo analysis on the palm oil agro-industrial supply chain can be seen in Table 4.

Tabel 4. Monte Carlo Sustainability Analysis Results with Rap-Palm Oil

Sustainability Dimension	Sustainability Index		Diffr.
	Rap-Palm Oil	Monte Carlo	
Economy	81.01	80.67	0.33
Social	77.16	77.18	0.02
Environtment	81.61	81.14	0.46

Source: Primary Data Processed (2022)

Based on the results of the Monte Carlo analysis presented in Table 4, it is known that the difference between the value of the Monte Carlo analysis and Rap-Palm Oil is <1. If the resulting Rapfish and Monte Carlo values have a difference of <1.5, then the data used has a high level of precision (Jimenez et al., 2021). Therefore, the data used in determining the sustainability of the palm oil agro-industry

supply chain can be accounted for and accurate to be used as material for analysis to determine policies in improving the sustainability of the palm oil agro-industry supply chain.

4.3. Analysis of Index and Sustainability Status of Agro-Industry Palm Oil

After analyzing the Goodness of Fits from the Rap-Palm Oil model, the next step is to make a flyover diagram to find out the combination of the results of the three dimensions of sustainability status, namely economic, social and environmental. Based on the results of the kite diagram, the average value of the palm oil agro-industry supply chain sustainability index is 79.92, so the value is included in the highly sustainable category because it is included in the value interval of 75.01-100.00. Of the three dimensions of sustainability, the one with the best index value is the environmental dimension, with an index value of 81.61. Then the lowest sustainability index value is in the social dimension with a value of 77.16. The results of the kite diagram analysis can be seen in Figure 6.

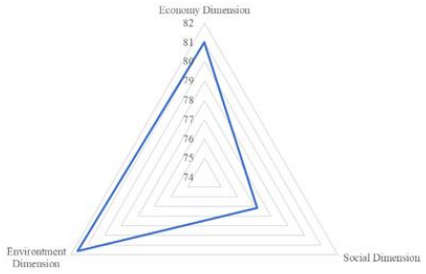

Fig.6: Agro-Industry Palm Oil Sustainability Kite Diagram

Based on the results of the kite diagram in Figure 6, the social dimension has the lowest value compared to the values in other dimensions. This is because there is a need to optimize the rights of employees who work in the palm oil agro-industry. To improve the social dimension, the palm oil agro-industry needs to pay attention to three sensitive attributes, namely health insurance, guaranteeing the right to freedom of worship, and the existence of career path support for employees. Therefore, it is necessary to formulate a policy strategy so that the value of the social sustainability index can increase through three sensitive attributes. The following is the value of each dimension in agro-industry palm oil.

5. Discussion

5.1. Index Value and Status of Economic Dimension Sustainability

Based on the calculation results of the Multidimensional Scaling method using the Rap-Palm Oil tool based on the Excel application, the analysis of the sustainability index value on the economic dimension has an average value of 81.01. The results of these values indicate that the economic dimension in the supply chain of the palm oil agro-industry is included in the highly sustainable category because the value held is in the interval 75.01-100.00 (Fauzi Dzikrillah et al., 2017; Jimenez et al., 2021; Yasir Haya & Fujii, 2020). The status of sustainability in the economic dimension can be seen in Figure 7. The results from the economic dimension are sufficient to support the sustainability of the palm oil agro-industrial supply chain.

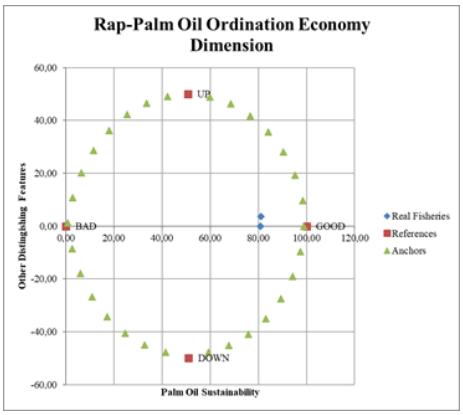

Fig.7: Results of the Economic Dimension Sustainability Ordination

5.2. Social Dimension Index Value and Sustainability Status

The results of the MDS analysis through the Rap-Palm Oil analysis tool in the Excel application program obtained the sustainability index value with an average of 77.16. These results indicate that the sustainability index value is included in the highly sustainable category. The social dimension index value in the oil palm agro-industrial supply chain is highly sustainable because it is included in the interval value of 75.01-100.00 (Fauzi Dzikrillah et al., 2017; Jimenez et al., 2021; Yasir Haya & Fujii, 2020). Therefore, the results of the sustainability index of the social dimension can support the sustainability of the palm oil agro-industrial supply chain. The status of sustainability on the social dimension can be seen in Figure 8.

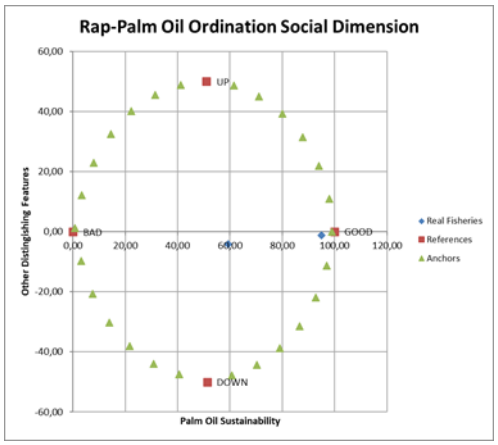

Figure 8. Results of the Social Dimension Sustainability Ordination

5.3. Index Value and Status of Environtmental Dimension Sustainability

Based on the Multidimensional Scaling method analysis using the Rap-Palm Oil tool through the Excel program, the average value of the sustainability index value of the environmental dimension of the palm oil agro-industry supply chain is 81.61. Based on the value of the sustainability index of the environmental dimension, it can be seen that the sustainability status of the environmental dimension in the supply chain of the palm oil agro-industry is included in the highly sustainable category. The sustainability index value generated on the environmental dimension is included in the interval 75.01-100, which is included in the highly sustainable category (Fauzi Dzikrillah et al., 2017; Jimenez et al., 2021; Yasir Haya & Fujii, 2020). Therefore, the results of the environmental dimension sustainability index value can support the sustainability of the palm oil agro-industrial supply chain. The results of the environmental dimension sustainability status ordination can be seen in Figure 9.

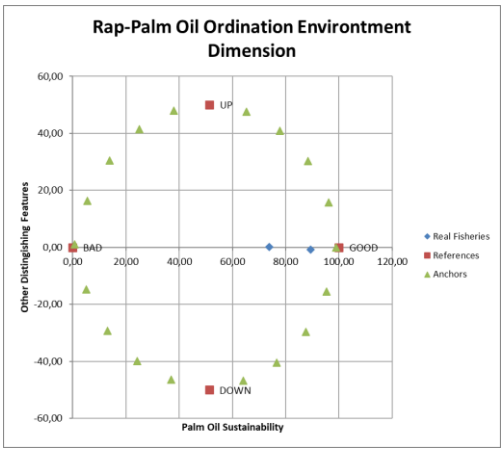

Fig.9: Results of the Environmental Dimension Sustainability Ordination

The use of MDS can be seen from the point of sustainability position through the horizontal and vertical axes. MDS analysis can be described through two ordinate axes, namely vertical and horizontal, to project a point on the horizontal line with an extremely bad point with a value of 0% and a good extreme point with a value of 100%. The attributes used in the economic dimension include: (E1) Supplier relationship; (E2) The level of availability of inputs supplied by suppliers; (E3) Quality of inputs supplied by suppliers; (E4) Timeliness of the production process; (E5) Standard operating procedures for the production process; (E6) Product quality (Indonesian National Standard); (E7) Product responsiveness level (MUI Halal label, Nutritional Composition, Expiration Date); (E8) Packaging quality; (E9) Packaging design; (E10) Differentiation of packaging sizes; (E11) The level of product availability in the market; (E12) Customer trust in the Brand (Brand); (E13) Level of price competition with similar products; (E14) Promotion reliability level (advertising, discount, bundling, promotional package); (E15) The level of reliability of delivery to consumers and (E16) The level of after-sales service (service product returns) (Mahida & Handayani, 2019).

As for the attributes contained in the social dimension, there are as many as 14 attributes, including (S1) Employee workload (regional/national work standards); (S2) Wage/salary level (regional wage/national standard); (S3) Work safety guarantee for employees; (S4) Health insurance for employees; (S5) Guarantee of freedom of worship for employees; (S6) The company's support for the Trade Union; (S7) Employee capacity improvement & development process (education, training, & skills); (S8) The process of increasing employee career paths; (S9) Active role in religious, social activities, (S10) Active role in educational, social activities; (S11) Active role in health social activities; (S12) Active role in social activities to improve public infrastructure; (S13) Active role in environmental, social activities; and (S14) Empowerment/absorption of local workers.

As for determining the value of the supply chain sustainability index of the palm oil agro-industry, it is carried out using 10 attributes, namely (N1) Use of inputs/raw materials that are safe for health; (N2) Application of hygienic standards in the production process; (N3 Use of environmentally friendly packaging; (N4) Solid waste management; (N5) Liquid waste management; (N6) Gas emission waste management, (N7) Efficient use of natural resources (water) systems, (N8) Use of natural resource systems Efficient (electricity, gas) campaigns (N9) Support in zero waste campaign practices (e.g., effective and efficient use of products) in their promotions and (N10) Application of the 3R concept (Reduce, Reuse, Recycling) on returned products.

5.4. Managerial Policy Recommendations for Agro-Industry Palm Oil Supply Chain Sustainability

The design of policy recommendations to improve the performance of the sustainability index value is

obtained through a leverage analysis of each dimension. The implementation of leverage analysis is used to determine sensitive attributes that can affect the index value and sustainability status of each dimension of the palm oil agro-industry. The table of leverage analysis results on each economic, social and environmental dimension.

Table 5. Rap-Palm Oil Leverage Analysis Results

Dimension					
Economy		**Social**		**Environtment**	
Leverage Attributes	**Sensitivity Analysis**	**Leverage Attributes**	**Sensitivity Analysis**	**Leverage Attributes**	**Sensitivity Analysis**
Promotion reliability level (E14)	1,35	Health insurance for employee (S4)	1,72	Handling of gas emission waste (N6)	2,29
Product responsitivity level (E7)	1,07	Guaranteed freedom of worship for employees (S5)	1,60	Use of environmentally friendly packaging (N3)	2,26
Product quality (E6)	1,06	Employee career advancement process (S8)	1,13	Efficient use of natural resource systems (N8)	2,10

Source: Primary Data Processed (2022)

The results from Table 5 show that the analysis of leverage based on the economic dimension can be seen from the 16 attributes that have been analyzed; three sensitive attributes can affect the value of the sustainability status. The three (3) attributes that have the greatest leverage value include; (E14) Promotion reliability level (advertising, discount, bundling, promotional package), (E7) Product responsiveness level (MUI Halal label, Nutritional Composition, Expiration Date), and (E6) Product quality (Indonesian National Standard). Therefore, to increase the value of the sustainability index, it is necessary to pay attention to the three attributes with the highest leverage value.

The highest leverage value is owned by attribute (E1) with a value of 1.35. This value means the palm oil agro-industry must pay attention to business promotion activities. Based on Mix et al. (2018), promotion plays an important role in marketing palm oil products because with the promotion; the company can provide information about the features, functions, and how to get it to the public. To increase promotional activities, the company should determine the target market and the marketing mechanism to optimize the promotion.

The next attribute that influences changes in the value of the sustainability index of the economic dimension is (E7), with a value of 1.07. Responsive palm oil products, by paying attention to consumer demand, the product will be able to increase sales of palm oil products. Therefore, to improve supply chain sustainability, the economic dimension of the palm oil agro-industry must pay attention to consumer demand for products. Then the last attribute that can affect the value of the supply chain sustainability index of the palm oil agro-industry economy dimension is (E6) product quality with a value of 1.06. Products produced by the palm oil agro-industry must already have standards because, with standardization, consumers feel safe in product consumption. The existence of standardization in processed palm oil products can provide quality standards so that they are safe and nutritious for consumption. Leverage analysis based on economic dimensions can be seen in Figure 10.

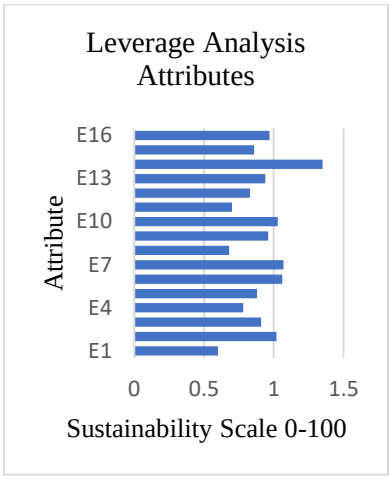

Fig.10: Leverage Analysis Economic

Based on the analysis of social dimension leverage in Table 5, the results of the 14 attributes have three attributes that have the greatest leverage value, namely (S4) Health insurance for employees; (S5) Guarantee of freedom of worship for employees; and (S8) The process of increasing employee career paths. Therefore, from the results of the leverage analysis, sensitive attributes need to be considered further in increasing the value of the sustainability index of the social dimension.

Health insurance for employees is the attribute of the highest social dimension, so it is the most sensitive compared to other attributes, with a value of 1.72. The health of employees is something the palm oil agro-industry must pay attention to. The health of workers in the palm oil agro-industry needs to be considered because it can directly affect employee performance (Indah et al., 2019). With employee health insurance, the palm oil agro-industry can achieve increased performance.

The attribute that can affect the value of the sustainability index on the social dimension is the guarantee of freedom of worship with a value of 1.60. Ensuring employees' freedom to worship according to their respective beliefs can avoid the possibility of social conflict. Ensuring and protecting workers' worship rights can reduce social conflict risk. Based on these conditions, palm oil agro-industry companies should maintain employee freedom in religious activities to reduce the potential risk of social conflict. The next sensitive attribute that can affect the sustainability index value of the social dimension of the palm oil agro-industrial supply chain is the career path for employees, with a value of 1.13. Employees are the most important asset in a palm oil company; improving the quality of employees, it can be done by providing training to support career paths. It can be done to improve employee performance by providing job training and motivation for a clear career path (Faradistia R. Paputungan, 2013). The existence of support for career paths will motivate employees to increase work performance. Leverage analysis based on social dimensions can be seen in Figure 11.

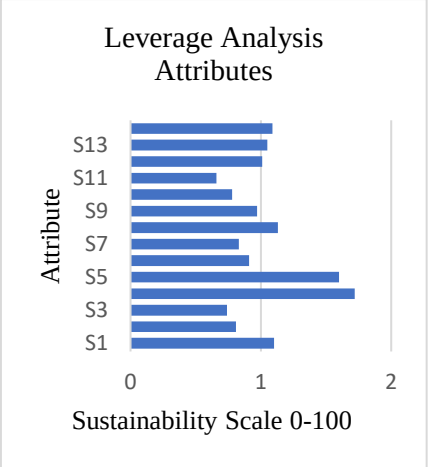

Fig.11: Leverage Analysis Social Dimension

The results of the analysis of leverage on the environmental dimension state that of the ten (10) attributes used, three sensitive attributes need attention. The three sensitive attributes are (N6) Handling of gas emission waste; (N3) Use of environmentally friendly packaging; and (N8) Efficient use of natural resource systems (electricity, gas). The three attributes of the sensitive environmental dimension need to be considered by the palm oil agro-industry to increase the value of the environmental dimension sustainability index in the supply chain of the palm oil agro-industry. Leverage analysis based on environmental dimensions can be seen in Figure 12.

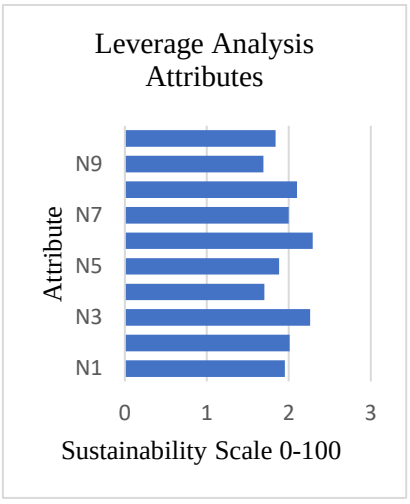

Fig.12: Leverage Analysis Environtmental

Handling of palm oil waste has the largest leverage value in the environmental dimension with a value of 2.29. The existence of production activities in the palm oil agro-industry results in gas waste that can pollute the surrounding environment. Process activities to produce palm oil processed products from plantations to ready-to-use products produce various harmful gases such as CH4, CO2, CO, and other gases (Awalludin et al., 2015; Umar et al., 2021). Therefore, for the palm oil agro-industry to continue, all related parties need to pay attention to the gas emissions produced so that production activities continue in an environmentally sound manner.

The next environmental dimension-sensitive attribute is environmentally friendly packaging with a value of 2.26. The packaging used by the palm oil agro-industry should be environmentally friendly by using packaging that has a fast decomposition time and labeling recycling on the packaging. The use of packaging made of bioplastic can be used as a solution in the use of environmentally friendly packaging

(Widyaningrum et al., 2020). The environment can easily degrade the use of bioplastics for packaging palm oil products. Finally, the third attribute in the environmental dimension of the palm oil agro-industrial supply chain is the application of efficient electricity and gas energy with a sensitivity value of 2.10. Efficient and effective use of electrical energy can affect the company's performance. Efficient and effective use of energy can reduce production costs (Hidayat et al., 2017).

The energy used to support the operational power of the palm oil agro-industry must be used efficiently to be environmentally sustainable. The following is a table in the formulation of policies to support the sustainability of the supply chain of agro-industry palm oil based on the results of leverage analysis on the Rap-Palm Oil method.

Table 6. Formulation of Strategic Policy for Agro-Industry Palm Oil

Dimension	Policy
Economics	Increase promotional activities appropriately
	Prioritizing consumer demand
	Optimizing product standardization
Social	Provide health insurance for employees
	Guarantee the freedom to worship according to belief
	Provide training and provide work motivation
Environtmental	Pay attention to the gas emissions produced
	Using bioplastic packaging
	Save energy in production operations

6. Conclusion and Implication

Based on the results of the research that has been done, several points can be drawn that can be concluded. Determine the sustainability of the national palm oil agro-industrial supply chain; it can be done using the triple bottom line concept covering economic, social, and environmental dimensions. To determine supply chain sustainability, 30 attributes are used as parameters for measuring the supply chain sustainability index of the national palm oil agro-industry. The economic dimension has 16 attributes, the social dimension has 14 attributes, and the environmental dimension has 10 attributes.

The Rapfish analysis results show that the national palm oil agro-industrial supply chain sustainability index on the economic dimension has a value of 81.01%, so it is included in the highly sustainable category. Furthermore, the social dimension has a sustainability index value of 77.16%, so the results are included in the highly sustainable category. Finally, the environmental dimension has a sustainability index value of 81.61%, which is included in the highly sustainable category. Of the three dimensions, the one with the lowest sustainability index value is the social dimension. This suggests that the palm oil agro-industry has made significant progress in managing its supply chain sustainably. The analysis also revealed that the environmental dimension had the highest sustainability index value, indicating that the industry has been successful in implementing sustainable practices related to the use of inputs, waste management, and efficient use of natural resources.

However, the social dimension had the lowest sustainability index value, indicating the need for improvement in areas such as employee welfare, career advancement opportunities, and support for social and religious activities. The leverage analysis identified specific attributes within each dimension that have the greatest influence on the sustainability index. For example, in the economic dimension, attributes related to promotion reliability, product responsiveness, and product quality were found to be crucial. In the social dimension, attributes such as health insurance, freedom of worship guarantees, and employee career paths were identified as sensitive areas. These findings can inform policy recommendations and strategies for improving sustainability in the palm oil agro-industry supply chain. This dimension needs to be considered further to increase the sustainability value. Increasing the value of sustainability by paying attention to three sensitive attributes, namely guaranteeing employee health, guaranteeing freedom of worship, and supporting career paths.

The findings of this study have several implications for the palm oil agro-industry and relevant stakeholders:

1. The results provide valuable insights for policymakers and industry leaders to develop policies and strategies that promote sustainable practices in the palm oil agro-industry. The identified sensitive attributes can be targeted for improvement to enhance sustainability in the economic, social, and environmental dimensions.
2. The study highlights the importance of engaging various stakeholders, including employees, suppliers, and consumers, in promoting sustainability in the palm oil agro-industry. Efforts should be made to address the social dimension's challenges, such as providing health insurance and supporting employees' career development.
3. The high sustainability index values can enhance the industry's reputation and improve market access for palm oil products. Consumers and international markets are increasingly demanding sustainably produced goods, and the palm oil agro-industry's commitment to sustainability can lead to increased market opportunities.

7. Limitation and Future Research Direction

Despite its contributions, this study has some limitations that should be considered:

1. The study's findings are based on specific data and context, so generalizing to other regions requires further research.
2. Collecting data over a longer period would provide a more comprehensive understanding of sustainability performanceand alternative approaches and tools could offer different perspectives on supply chain sustainability.
3. Building on the current study, future research can focus on the comparative analysis across different palm oil agro-industry contexts can identify regional variations and best practices, longitudinal studies for improvement in sustainability efforts, promoting transparency and traceability in the supply chain using technologies like blockchain, and exploring innovative practices and technologies can reduce the industry's environmental footprint and improve resource efficiency.

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