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CHARTING SUSTAINABILITY: TRIPLE BOTTOM LINE (TBL) ANALYSIS IN THE PALM OIL SUPPLY CHAIN LANDSCAPE

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Abstract

Background: The industrial sector depends on a sustainable supply chain, which requires an organization to integrate (trade off) social, technological, economic, and environmental factors. One industry that applies the triple bottom line concept is palm oil. The palm oil industry is believed to have two drawbacks: harm to the environment, and social welfare. Sustainable supply chains have the potential to increase social welfare, reduce environmental impact, and increase profitability.
Purpose: This study aims to enhance the understanding and implementation of sustainability in the palm oil supply chain through three key objectives: (1) mapping current sustainability practices and performance across all supply chain actors; (2) analyzing limitations and inconsistencies in existing sustainability measurement methods, particularly in addressing the Triple Bottom Line (TBL) dimensions; and (3) developing standardized, practical, and theoretically grounded Key Performance Indicators (KPIs) to support consistent and transparent sustainability evaluation.
Design/methodology/approach: The Matrix of Crossed Impact Multiplications Applied to a Classification (MICMAC) method was employed. This approach makes the strength of the correlation between the variables and secret to a more methodical and targeted solution more evident. Data were collected through surveys and in-depth interviews with 16 respondents, including managers, sustainability officers, and operational staff, across the palm oil supply chain. The research was conducted between August and December 2023 in North Sumatra, Indonesia, specifically in PTPN III and the Sei Mangkei Special Economic Zone (KEK Sei Mangkei).
Conclusion: Based on the Matrix of Direct Influences (MDI) and the Matrix of Indirect Influences (MII), important variables significantly affect other variables. A MICMAC analysis was conducted to determine the critical elements in the sustainability of the palm oil industry supply chain. This analysis serves as the basis for the variables of industrial productivity, financial performance, access to price information, level of industry employee education, and availability of infrastructure.
Originality/Value: This study employs the Matrix of Crossed Impact Multiplications Applied to a Classification (MICMAC) method to identify key triple bottom-line indicators for implementing sustainable supply chains. Because Many sustainability studies focus on descriptive analysis or case comparisons, few apply a modeling approach that shows inter-variable influence and causal mapping, which enhances strategic decision making and improves the practical applicability of sustainability frameworks.

Keywords: MICMAC method, sustainability, supply chain, palm industry

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INTRODUCTION

An organization must integrate (trade off) economic, social, technological, and environmental factors to establish a network of sustainable supplies, which is vital for the manufacturing industry (Beamon, 2008). A sustainable supply chain is described as a representation of the economic, social, environmental, and governmental policy aspects that are connected to the consumer fulfilment activity cycle, including design, procurement, manufacturing, packaging, and distribution activities (Seuring and Müller, 2008). According to Hassini et al. (2012), a sustainable supply chain can maximize social welfare, minimize environmental effects, and maximize profitability. To achieve this goal, triple bottom line (TBL) supply chain management, which integrates economic, social, and environmental perspectives, is essential. The TBL concept profit, people, and planet was introduced by Elkington 1997) and has since gained traction in the business sustainability space as a means of incorporating social, environmental, and economic factors into corporate decision-making (Wang and Lin, 2007). Furthermore, Hammer and Pivo (2017) asserted that putting the triple bottom line into practice can raise welfare and quality of life by generating income and jobs through company formation, expansion, and retention. As a result, there is a significant chance of enhancing well-being in numerous ways by incorporating TBL into supply chain management.

Palm oil is industrially used in the triple bottom-line approach. Environmental harm and social welfare are two perceived drawbacks of the palm oil industry (Oosterveer, 2015; Rist et al. 2010; Saswattecha et al. 2015). The topic of sustainable development in the palm oil sector and its effects on the environment and society has been widely covered in the literature. Enhancing the Performance of the Palm Oil Industry Using the Roundtable on Sustainable Palm Oil (RSPO) for the Environment, Particularly for Nature Conservation, is the subject of Pacheco et al. (2020). According to previous research, the growth of palm oil plantations is changing the climate and killing forests. Consequently, the RSPO must exert genuine control over the issue and adopt a more assertive stance against the destruction of forests. To meet the objectives of sustainable development, the growth of palm oil plantations must be weighed against a zero-deforestation policy and prohibition on the conversion of peatlands. By comparing plantations that were certified and those that were not, Carlson et al. (2018) found that sustainable palm oil certification can lower deforestation and fire rates.

One plantation commodity that is significant to Indonesian economic activity is palm oil. With a 13.5 percent share in non-oil and gas exports in 2021, palm oil ranks as the nation's second-largest export commodity after gas and oil in terms of foreign exchange earnings, according to the Ministry of Industry (2021). Based on the findings of Pahan (2016) and Suroso et al. (2021), Indonesia has emerged as the world's leading producer of palm oil and has grown rapidly since 2004 (Pahan, 2016; Suroso et al. 2021). Recent reports indicate intense competition in the palm oil industry at national and corporate levels (Rifin, 2010; Suroso et al. 2021).
Palm oil and palm kernel oil are used in a wide range of industries, including the food (particularly in the production of special fat products that replace cocoa butter), pharmaceutical (in the manufacturing of bath soap, medications, and cosmetics), and fractionation (particularly in the cooking oil industry) industries. Additionally, the export potential of palm oil has increased. Based on the amount of palm oil produced, the sector has generated a significant amount of output over the past three years. The palm oil sector grew by 48.30 percent in 2019. However, by 2021–2022, the total production is expected to rise from 54.5 million tons to 48.29 million tons. Plantations on the islands of Sumatra, Kalimantan, and Papua are likely to dominate the total output, exports, and stocks, all of which are predicted to rise significantly by 2050.

Grand View Research estimates that global palm oil demand will continue to grow from 74.01 million tons in 2014 to reach 128.20 million tons in 2022. The compound annual growth rate is expected to reach 7.3 percent from 2014 to 2022. According to Grand View Research View Research, although the largest share of palm oil consumption is still held by the Asia Pacific with a percentage of 65 percent of global demand, Central and South America is estimated to show the highest growth of up to 8 percent from 2015 to 2022. The palm oil industry views the performance of sustainable supply chain management of palm oil products as ideal, although it naturally takes time to reach perfect conditions. To date, green supply chain (GSC) implementation and other forms of sustainable supply chain management based on palm oil are still in the early stages of development. The new GSC does not yet prioritize every facet of sustainability; instead, it concentrates on the implementation of ecologically responsible development plans. As a result, many aspects of the implementation of sustainable supply chain management for palm oil remain unknown, such as the metrics or indicators used to evaluate the triple bottom line effectiveness of the implementation of palm oil supply chain management. Furthermore, little is known about the variables that affect how well the palm oil industry works in terms of sustainable supply chain management.

It is evident from many research findings that an organized ranking of variables (elements) has not been created. Thus, MICMAC is one technique that can be utilized to develop a structured context of interactions between variables as a step in developing a more fundamental strategy. Godet and Dupperin first presented the Matrix of Crossed Impact Multiplications Applied to a Classification (MICMAC) method as a structural analysis technique in 1973. Through the types of relationships that exist between variables and the systematic and structured ranking of system pieces, this method provides an answer to the complexity. The MICMAC approach is frequently used (Soesanto, 2021).

The palm oil industry plays a vital role in the global food, fuel, and cosmetic supply chains. However, it continues to face significant challenges regarding its sustainability credentials, particularly amid growing international pressure for environmentally and socially responsible practices. While voluntary certifications and regulatory frameworks such as RSPO, ISPO, and MSPO have been introduced to improve sustainability performance, there remains a notable deficiency in the industry's ability to systematically assess and benchmark sustainable outcomes across its supply chain. The absence of a standardized, evidence-based performance measurement mechanism hampers not only internal improvements but also the sector's credibility and acceptance in global markets.

Moreover, as supply chain actors ranging from smallholders to multinational corporations increasingly compete within a value-driven economy, the downstream development of the industry is intrinsically linked to the sustainability of its upstream practices. Despite scattered initiatives and progress in isolated areas, the current level of sustainable performance within the palm oil sector remains insufficient to elevate productivity, drive inclusive growth, and enhance the global reputation of palm oil products (Elkington, 1997; Schouten and Glasbergen, 2011). This disconnect points to a critical research gap: the need for a comprehensive framework capable of identifying, measuring, and managing the key performance indicators of sustainability in the palm oil supply chain based on the Triple Bottom Line (TBL) framework.

This study adopts a structured problem-solving approach grounded in the Triple Bottom Line (TBL) framework to address the complex sustainability challenges in the palm oil supply chain. It begins by identifying critical gaps in economic, environmental, and social performance among supply chain actors. Through stakeholder engagement and data analysis, this study maps current practices and identifies inconsistencies in sustainability assessment methods. A gap analysis is then used to evaluate the existing tools, highlighting areas where measurement and implementation fall short. Based on these findings, this study proposes standardized TBL-based Key Performance Indicators (KPIs) to guide transparent, inclusive, and measurable sustainability performance. This approach ensures that the solutions are both practical and adaptable to real-world contexts, thereby contributing to a more resilient and accountable palm oil industry.

This study is innovative because it evaluates sustainability throughout the palm oil supply chain by holistically applying the Triple Bottom Line (TBL) concept. This study incorporates economic, environmental, and social factors into a comprehensive diagnostic model, in contrast to earlier studies that concentrated on discrete actors or single dimensions (Elkington, 1997). Additionally, it presents actionable and standardized TBL-based KPIs, providing a useful instrument for standardizing sustainability measurements and enhancing accountability, transparency, and strategic decision-making in the sector (Porter and Kramer, 2011; Seuring and Müller, 2008).

This study aims to enhance the understanding and implementation of sustainability in the palm oil supply chain through three key objectives: (1) mapping current sustainability practices and performance across all supply chain actors, (2) analyzing limitations and inconsistencies in existing sustainability measurement methods, particularly in addressing the Triple Bottom Line (TBL) dimensions, and (3) developing standardized, practical, and theoretically grounded Key Performance Indicators (KPIs) to support consistent and transparent sustainability evaluation.

METHODS

Both primary and secondary data were used in this study. Quantitative and qualitative data are required. Data that are already available and that can be acquired immediately are referred to as secondary data. Primary data must be obtained directly from the original source through one- to two-hour planned in-person and online zoom meetings with people who will participate as research respondents and have relevant expertise and connections to the issue under investigation. Data were collected through surveys and in-depth interviews with 16 respondents, including managers, sustainability officers, and operational staff, across the palm oil supply chain. Time series data from the BPS, Ministry of Industry, and Ministry of Agriculture were used as secondary data in this study. The time series for 2017–2022 is the data structure utilized.

Surveys were conducted in the field, and interviews were conducted to gather primary data. The research was conducted between August and December 2023 in North Sumatra, Indonesia, specifically in PTPN III and the Sei Mangkei Special Economic Zone (KEK Sei Mangkei). The information gathered takes the shape of a triple-bottom-line concept-related sustainable supply chain. Using Micmac (Cross Impact Matrix Multiplication Applied) software, this study identifies the essential variables that will be used in the implementation of palm oil SSCM in Sei Mangkei PTPN III. There are two primary phases in this analysis method: the Micmac module procedure, variable collection studies, and focus group discussions. Figure 1 illustrates the steps of key variable identification and analysis using Micmac software.

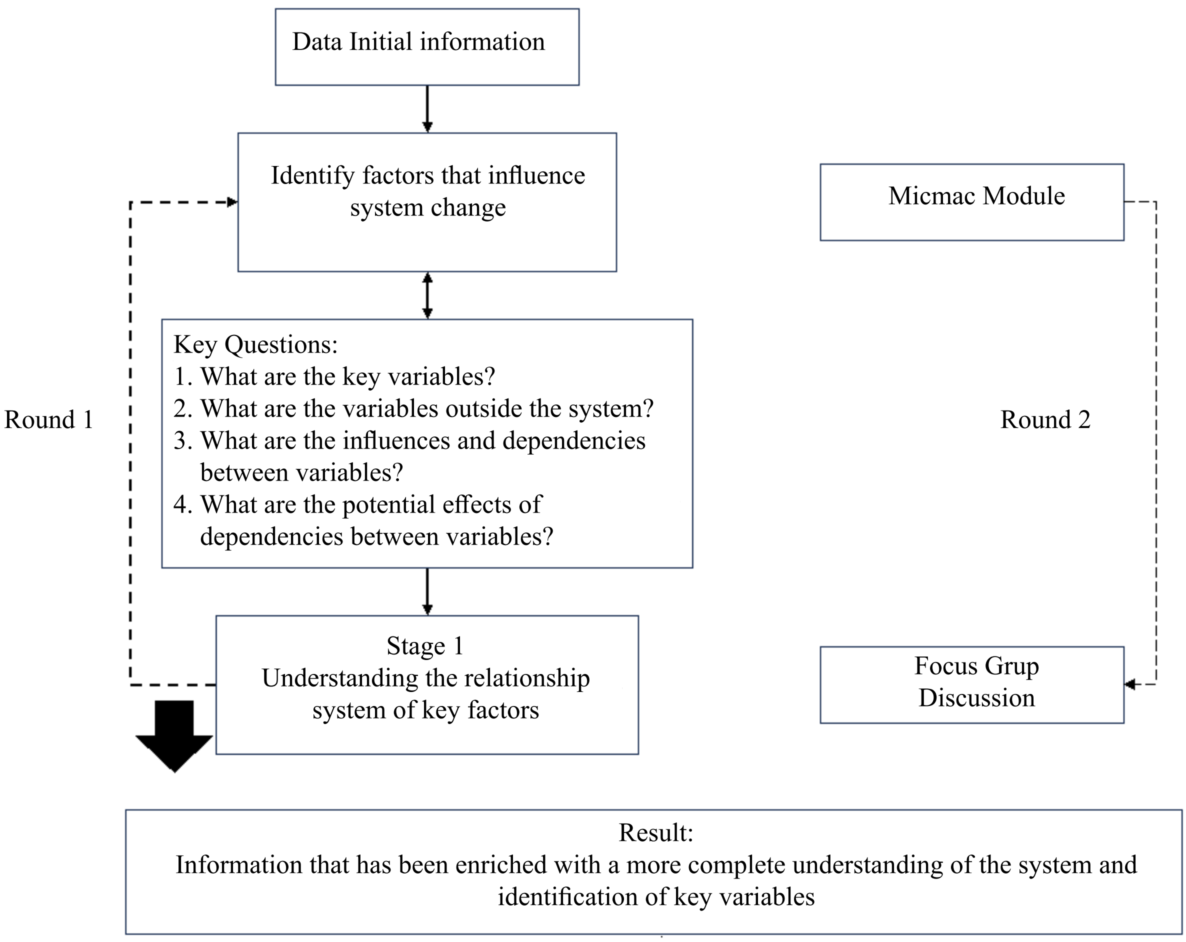

Figure 1. Stages of identification and analysis of key variables with Micmac Software (Delgado-Serrano et al. 2015b; Delgado et al. 2020)

The Micmac Method (cross-impact matrix multiplication) was used in the data analysis for classification. The Institut d'Innovation Informatique pour I'Entreprise (Godet, 2000) created Micmac, a piece of software that updates qualitative structural analysis methodologies with quantitative ones (del Mar Delgado-Serrano et al. 2015). Micmac uses matrix features in its operation (Arcade et al. 2003; Bootz et al. 2019; Majumdar et al. 2016). The objective of Micmac is to locate and examine the primary variables of a system. Micmac has an advantage over other structural methodologies in that it enables the arrangement and hierarchy of a system's strategic variables, as well as the understanding of their interconnected impacts. The benefit of the MICMAC approach is its structural analysis, which uses matrix properties to convert previous qualitative data into quantitative information (Sharma et al. 2023). Benjumea-Arias et al. (2016) claim that MICMAC's capacity to classify and ascertain the arrangement of strategic variables and their interdependency is another benefit to offer a solid and convincing foundation for addressing these issues. The primary variables of a system can also be determined and examined using the Micmac approach (Ariyani and Fauzi, 2019).

This feature will guide policy focus, which is highly helpful in the policy-making process because the focus of policies is often on variables that are deemed "irrelevant and fail." The variables examined in this study were the input versions of variables that were discovered and identified. The primary and secondary data are the types of information gathered. The economic, social, and environmental dimensions are the three that are used as references for creating attributes or variables (Table 1).

Table 1. Indicators for assessing sustainable supply chain performance

Long label	Short label	Description	Theme	Source
Palm oil industry productivity	Econ01		Economy	(Abdul-Hamid et al., 2022)
Financial performance and financial competitiveness of the palm oil industry	Econ02		Economy	(Lin et al., 2011; Raut et al., 2017; Tundys and Wiśniewski, 2018)
Incentives, low instalments, fast payback period	Econ03		Economy	(Tundys and Wiśniewski, 2018)
Business transparency	Econ04		Economy	(Jafarnejad et al., 2017)
Ease of access to price information	Econ05		Economy	(Raut et al., 2017)
Efficient utilization of resources	Econ06		Economy	(Seuring and Müller, 2008)
Logistics Optimization	Econ07		Economy	(Chan et al., 2018)
Strategic collaboration and information	Econ08		Economy	(Genovese et al., 2017)
Education level of industrial employees	Soc01		Social	(Seuring and Müller, 2008)
Average age of industry employees	Soc02		Social	(Seuring and Müller, 2008)
Availability of infrastructure in industrial activities	Soc03		Social	(Kobza and Schuster, 2016)
Entrepreneurs' ethics towards the palm oil industry	Soc04		Social	(Lin et al., 2011; Tundys and Wiśniewski, 2018)
Working conditions, employee rights and welfare of palm oil industry employees	Soc05		Social	(Lin et al., 2011)
Commitment to transparency and traceability	Soc06		Social	(Zhou and Piramuthu, 2015)
Forest destruction or forest burning	NV01		Environment	(Yang et al., 2022)
Suitability of land and agroclimate for oil palm plantations	NV02		Environment	(Chapman et al., 2018)
The area of oil palm plantations managed by the industry	NV03		Environment	(Tey et al., 2021)
Technical application of cultivation and transportation of oil palm to industry	NV04		Environment	(Brandenburg et al., 2014; Genovese et al., 2017)
Implementation of ISO 14000 standards	NV05		Environment	(Carter et al., 2008)
Environmental pollution	NV06		Environment	(Carter et al., 2008)
The existence of cover crops (RTH)	NV07		Environment	(Sutawidjaya et al., 2021)
Environmentally friendly technology	NV08		Environment	(Ameer and Othman, 2012)
Environmental Management System	NV09		Environment	(Mulyati and Geldermann, 2017)

The attributes or variables used or built as questionnaires were based on results obtained directly from in-depth interviews, Focus Group Discussions (FGD), and direct observation. Information gathering through questionnaires was carried out on stakeholders, such as policymakers for a system in the salt sector in the Madura region, related agencies (government), the salt industry, salt farmers, and expert respondents. The implementation of a questionnaire that describes the direct relationship between variables was carried out by quantifying the use of a scale from 0 to 3 and P, as illustrated by Godet (2000):

0 = no relationship (non-existent)
1 = Weak relationship (low direct influence)
2 = Equal relationship (medium–direct influence)
3 = Strong relationship (high direct influence)
P = potential (potential influence)

The level of influence of each variable was then calculated by compiling these variables on the Matrix of Direct Influence (MDI) using the Micmac software. The MDI serves as the foundation matrix for creating the potential direct influence matrix (MPDI), which projects the strength of the variable's effect if the system changes, and indirect influence matrix (MII), which displays the intensity of the variable's indirect influence.

RESULTS

Mapping Current Sustainability Practices and Performance Across All Supply Chain Actors

The goal of this study is to identify and record the present practices and metrics of sustainability for several players in the palm oil supply chain, such as producers, processors, distributors, and regulators. This study investigates how stakeholders understand and apply sustainability in terms of the economy, environment, and society through surveys, interviews, and focus groups. The results show a great deal of heterogeneity in the performance criteria, awareness, and dedication. By mapping these practices, this study offers a thorough baseline of ongoing sustainability initiatives, identifies areas of strength and weakness, and guides the creation of focused enhancements that are in line with the Triple Bottom Line (TBL) framework.

Based on the results of distributing questionnaires and FGDs, there are variables that have been determined, and the relationship between the variables that have been constructed has been quantified so that a direct influence matrix is obtained, as shown in Table 2. Through the MICMAC application, Figure 2 in the form of a Matrix of Data Influence (MDI) has been changed to a variable map that reflects or depicts the graphic position of the relationship between influence-dependencies (influence-dependence chart) in four sectors (quadrants) (Figure 3).

The sustainability indicators were determined by conducting an in-depth literature review and field observations. The interviews were conducted with stakeholders. The results obtained were then used as material for brainstorming and discussions from expert sources through FGD. This process was carried out repeatedly, including the comparison of indicators with the help of Micmac software, so that the results of the sustainability indicators for the PTPN III PT INL KEK Sei Mangkei chain industry emerged. These indicators reflect the performance of each sustainability dimension in the palm oil industry, in accordance with Figure 3.

Table 2. Tabulation of the relationship between influence and dependence

	V1	V2	V3…	Vn	Influence (Y-Axis)
V1	0	(V1,V2)	(V1,V3)	(V1,Vn)	Σ(Var1-j)
V2	(V2,V1)	0	(V2,V3)	(V2,Vn)	
V3	(V3,V1)	(V3,V2)	0	(V3,Vn)	
…					
Vn	(Vn,V1)	(Vn,V2)	(Vn,V3)	0	
Dependence (X-Axis)	Σ(Var1-j)				

	1: Econ01	2: Econ02	3: Econ03	4: Econ04	5: Econ05	6: Econ06	7: Econ07	8: Econ08	9: Soc01	10: Soc02	11: Soc03	12: Soc04	13: Soc05	14: Soc06	15: NV01	16: NV02	17: NV03	18: NV04	19: NV05	20: NV06	21: NV07	22: NV08	23: NV09
1: Econ01	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	1	0
2: Econ02	0	0	1	0	2	2	2	2	2	2	1	0	0	0	0	1	1	2	0	0	0	0	1
3: Econ03	3	3	0	3	3	3	3	3	3	3	1	0	0	0	0	0	0	3	0	0	3	3	0
4: Econ04	3	0	0	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	2	0
5: Econ05	3	3	0	0	0	3	3	2	2	2	0	0	0	0	0	0	0	2	0	0	0	2	0
6: Econ06	3	3	0	0	3	0	3	2	2	2	0	0	0	0	0	0	0	2	0	0	0	2	0
7: Econ07	3	3	1	0	3	3	0	2	2	2	0	0	0	0	0	0	0	2	0	0	0	2	0
8: Econ08	3	3	0	0	3	3	2	0	2	2	0	0	0	0	0	0	0	2	0	0	0	2	0
9: Soc01	3	3	0	0	3	3	2	2	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0
10: Soc02	3	3	0	0	3	3	2	2	2	0	0	0	0	0	0	0	0	2	0	0	0	2	0
11: Soc03	3	3	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	3	0
12: Soc04	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13: Soc05	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14: Soc06	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15: NV01	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16: NV02	3	3	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	0	0
17: NV03	3	3	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	2	0
18: NV04	2	3	1	0	3	3	3	3	3	3	1	0	0	0	0	0	0	0	0	0	0	2	0
19: NV05	3	2	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	2	0
20: NV06	3	2	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	2	0
21: NV07	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0
22: NV08	2	3	1	0	2	2	2	2	2	2	1	0	0	0	0	0	0	3	0	0	0	0	0
23: NV09	0	0	1	0	3	3	3	3	3	3	0	0	0	0	0	0	0	3	0	0	0	2	0

Figure 2. Tabulation Matrix of Data Influence (MDI)

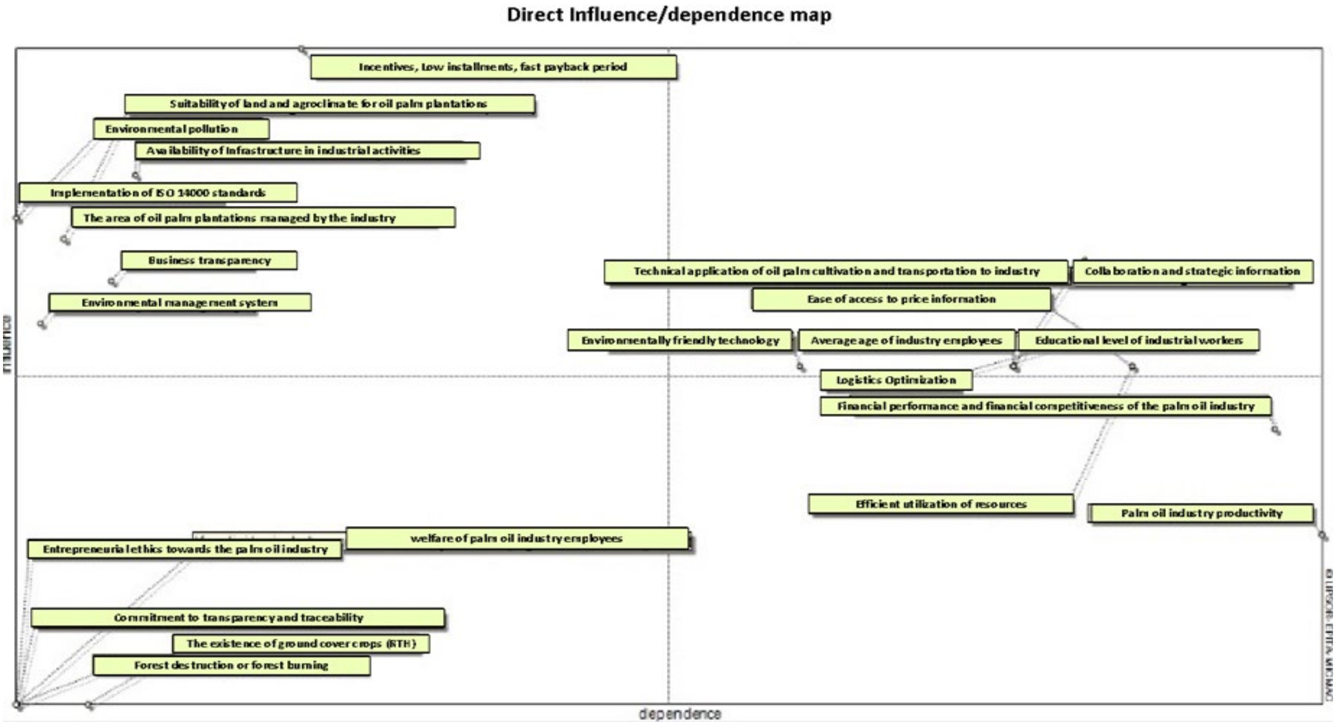

Figure 3. Direct Influence Matrix

Analyzing Limitations and Inconsistencies in Existing Sustainability Measurement Methods, Particularly in Addressing The Triple Bottom Line (TBL) dimensions

Particularly in the context of the palm oil supply chain, current sustainability measurement techniques frequently fail to fully capture the complexity of the Triple Bottom Line (TBL), which consists of economic, environmental, and social elements. Numerous instruments are not standardized, do not account for the interdependencies between indicators, and are frequently restricted to one-dimensional evaluations. Through stakeholder input and MICMAC analysis, this study critically assesses these gaps to identify fragmented data-gathering techniques, overlapping definitions, and inconsistent measurements. This study establishes a foundation for more comprehensive, integrated, and significant assessment frameworks that more accurately capture the systemic character of sustainability across various supply chain participants by highlighting these constraints.

According to the analysis, 23 variables have been shown to affect the palm oil industry's supply chain performance. These important variables are categorized into four clusters of characteristics that influence how well a firm performs, particularly when implementing sustainable supply chain management that considers the triple bottom line (economic, social, and environmental) when developing and implementing business operations. To ascertain each variable's degree of influence, these variables were then placed in the Matrix of Direct Influence (MDI) using the Micmac software. A potential direct influence matrix (MPDI), which projects the intensity of the variable's direct effect, and an indirect influence matrix (MII), which displays the intensity of the variable's indirect influence, are compiled using the MDI basic matrix variable's influence if the system changes in the future. From the results of filling in the MDI, the position of the variables can be determined on the direct influence and dependency map, which is then divided into four typologies: determinant variables or those with the highest relationship. The result of the Micmac analysis, which is the determinant variable, is the industrial productivity. According to Nasrun et al. (2020), productivity is a comparison between production results and the land area. According to Yohansyah et al. (2014), the factors that influence palm oil productivity are land suitability and agroclimate variables for palm oil plants. The success of oil palm cultivation is closely related to the level of production that can be achieved. The level of production that can be achieved is determined by the genetic potential of the plant material, potential of the land, and the level of crop management. Oil palm plants (Elaeis guineensis) can grow optimally in areas with a tropical climate with a long sunlight of 5-12 hours/day. The ideal rainfall ranges from 2,000-3,500 mm/year with a minimum of 100 mm/month. In areas with rainfall of less than 1,450 mm/year and more than 5,000 mm/year, oil palm plants cannot grow. Temperatures range between 24-290C with the best production between 25-270C, while the suitable height is between 1-500 meters above sea level (Syakir, 2010). Palm oil grows in mineral, peat, and tidal soils. The cultivation of oil palm plants on peatlands is relatively good because peatlands have physical properties that are always waterlogged, slow decomposition of organic matter, low mass density, sponges (absorbing and retaining large amounts of water), and large areas of oil palm plantations managed by industry on a very large company scale. Therefore, the wider the plantation area, the more fruit will be produced; thus, superior human resources and experts in this field need to be able to manage very large areas of land. Therefore, the education level of industrial employees is important.

Use of technology to promote more effective and efficient gardening practices. Therefore, large areas of land can produce high productivity. For the availability of infrastructure for industrial activities, the government supports the development of the downstream palm oil industry, and issued Industrial Minister Decree No.13 of 2010 concerning a guide map for the development of downstream palm oil industry clusters in three places: North Sumatra, Riau, and East Kalimantan. In this policy, there is an action plan and achievement target in the development stage. The action plan provides a clear planning framework and stages that can be measured and evaluated by stakeholders (Ministry of Industry, 2010). The medium-term targets for the 2010–2014 period that the government wants to achieve are (1) the development of downstream palm oil industry clusters in North Sumatra, Riau, and East Kalimantan; (2) a conducive business and investment climate; and (3) competitive infrastructure.

The environmental pollution variable refers to palm oil plantations, an important economic sector in many countries, including Indonesia. However, in addition to significant economic benefits, palm oil plantations have also raised serious environmental concerns. Studies related to oil palm plantations in Indonesia include environmental problems such as deforestation (McCarthy and Cramb, 2016), land and forest fires (Simorangkir, 2007), loss of biodiversity (Foster et al. 2011; Nantha and Tisdell, 2009), peatlands, land degradation (Fairhurst and McLaughlin, 2009), carbon gas emissions (Austin et al. 2015), social problems such as land conflicts (Rahmanulloh et al. 2013), food security (Haugen, 2009), and health problems. economics (Dewi et al. 2005; Zen et al. 2006), and biofuels (Fortin, 2011; Lee et al. 2011). Various studies on smallholder farmers have been concerned with issues of production, the environment, and land-use conflicts (Hidayat et al. 2018; Noor et al. 2017).

Considering the impact of environmental pollution, the government implemented the ISO 14000 standard and an environmental management system. To achieve a sustainable palm oil industry, it is necessary to implement the ISO 14000 standard consistently. Several objectives to be achieved in implementing ISO 14000 are (1) optimizing productivity and saving costs (efficiency). (2) reducing environmental risks, (3) improving the organization's image, (4) increasing sensitivity to public attention, and (5) improving the decision-making process. Environmental management is not static but dynamic, so adaptation or adjustment when changes occur in the company, which include company resources, processes, and activities. Adjustments are also needed if changes occur outside the company, such as changes in laws, regulations, and knowledge caused by ecological development.

Incentives are strategies to improve service quality and social welfare, commitment to transparency and traceability, low installments, fast payback periods, business transparency, financial performance, easy access to prices, and the welfare of employees in the palm oil industry. On the cost side, it cannot influence the input prices. Therefore, we must look for a combination of inputs that are cheapest but produce the most. These eight variables are important factors.

The variables in quadrant II are relay variables, indicating that the system will be affected if these variables are changed. These variables include the application of oil palm cultivation and transportation techniques, strategic collaboration and information, environmentally friendly technology, the average age of employees in the industry, and logistics optimization. Quadrant III includes variables of financial performance and competitiveness of the palm oil industry and the efficient use of resources. Quadrant IV shows variables that have a small influence on the sustainability of the palm oil industry, namely entrepreneurship ethics towards palm oil, the existence of cover crops (RTH), forest damage or forest burning, working conditions, and employee rights.

Developing standardized, practical, and theoretically grounded Key Performance Indicators (KPIs) to support consistent and transparent sustainability evaluations

To overcome disparities in sustainability measurements throughout the palm oil supply chain, this study suggests a set of Key Performance Indicators (KPIs) based on the Triple Bottom Line (TBL) paradigm. To guarantee validity and comparability, these KPIs are theoretically sound and useful for operational applications. They provide a standardized instrument for assessing social, environmental, and economic aspects, and are based on stakeholder input and factual data. In addition to enabling inclusive and sustainable value creation across all supply chain actors, KPIs assist firms in meeting regulatory or certification requirements, guiding strategic decisions, and publicly evaluating progress.

The conclusions of this research offer a solid foundation for all stakeholders engaged in policy formation to concentrate on the factors found in the determinant and relay quadrants that have a significant impact on other variables.

Figure 4 shows that the other variables have a relatively strong relationship with the variables connected by blue arrows. Variables that have a very strong indirect influence are indicated by red arrows. The shift in the overall position of the variables from direct to indirect influences is shown in the displacement map in Figure 4.

In several previous findings, it was found that important factors that influence company performance, especially in implementing sustainable supply chain management that pays attention to triple bottom line aspects (economic, social, environmental) and the development and implementation of company operations on environmental factors, are: Land area Plants, Implementation of ISO 14000 standards, Environmental Pollution and Environmental Management Systems, the social factors are Commitment to transparency and traceability, Education level of Industrial employees, Availability of Infrastructure, Entrepreneurs' ethics towards the palm oil industry, and employee welfare In general, the variables- The main variable in shaping company performance, especially in implementing sustainable supply chain management which pays attention to triple bottom line aspects (economic, social, environmental), development and implementation of company operations. is support for environmental and social variables. Environmental factors are natural conditions, whereas social factors include support for employees.

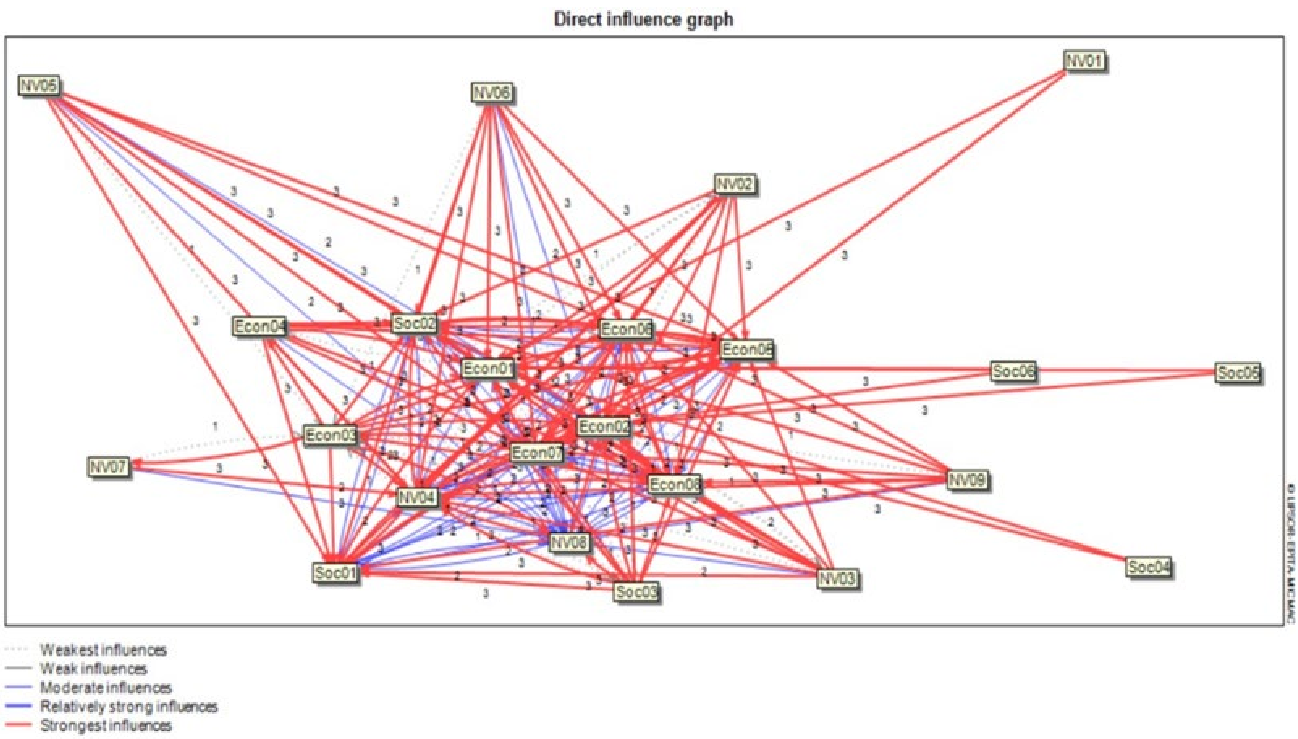

Figure 4. Relationship Between Each Factor

This study found that there are other more important factors in implementing sustainable supply chain management that focus on the triple bottom line aspects (economic, social, and environmental) and the development and implementation of company operations, namely, industrial productivity, financial performance, access to price information, level of industry employee education, infrastructure availability, entrepreneurial ethics towards the palm oil industry, employee welfare, commitment to transparency and traceability, plantation area, implementation of Iso 14000 standards, environmental pollution, and environmental management systems. These 13 variables are transmitted through five linkage/relay variables (connecting variables): technical implementation of oil palm cultivation and transportation, strategic collaboration and information, environmentally friendly technology, average age of industrial employees, and logistics optimization.

Based on the Triple Bottom Line (TBL) concept, the study's conclusions have several strategic ramifications for managers involved in the supply chain for palm oil. First, rather than being viewed as an afterthought corporate social responsibility (CSR) project, sustainability needs to be completely included in the main business plan. The ability of palm oil companies to strike a balance between economic growth, social justice, and environmental stewardship is becoming increasingly important for their long-term survival (Elkington, 1997; Lozano, 2015). This necessitates a change in managerial philosophy, so that revenue is sought with beneficial social and environmental effects. To operationalize this integration, managers must create reliable data-driven monitoring and evaluation (M&E) systems that evaluate performance across all three TBL dimensions. Labor conditions, contributions to local economic development, and greenhouse gas emissions are only a few examples of key performance indicators (Searcy, 2012). These indicators increase transparency for external stakeholders as well as internal responsibility. Additionally, it is crucial to engage stakeholders in an inclusive manner. Managers should cultivate fair partnerships with smallholder farmers and local communities through cooperative business models, capacity-building programmes, and contract-farming schemes. It has been demonstrated that these inclusive models increase output, lessen social tension, and foster the production of shared value (Vermeulen and Cotula, 2010).

Furthermore, enhancing the traceability and transparency of palm oil supply chains requires digital technology. To confirm deforestation-free sourcing, guarantee ethical labour practices, and satisfy rising consumer demands for sustainability, tools like blockchain, satellite monitoring, and Geographic Information Systems (GIS) can be used (Lambin et al. 2018; De Marchi et al. 2013). By implementing these solutions, one may ensure ongoing market access by adhering to new international laws such as the EU Deforestation Regulation (Regulation EU 2023/1115).

Corporate culture and organizational structures must also be changed to accommodate transformations that focus on sustainability. According to Eccles, Ioannou, and Serafeim (2014), this might mean encouraging cross-functional cooperation, incorporating sustainability objectives into performance review processes, and developing an innovative and environmentally conscious culture at all organizational levels. Finally, managers need to show a strong commitment to following voluntary international certifications, such as RSPO, as well as national sustainability standards, such as ISPO and MSPO. From the perspective of investors, consumers, and regulators, regulatory compliance not only reduces reputational risk but also strengthens the validity and credibility of sustainability promises (Schouten and Glasbergen, 2011).

Managerial Implications

According to the findings of this study, managers in the palm oil sector need to prioritize the important factors that were found to have the greatest effects on sustainability. These factors include infrastructure availability, employee education, financial performance, industrial productivity and environmental management systems. To accomplish this, we (1) Establish TBL-Based KPIs. Develop and apply standardized Key Performance Indicators aligned with economic, social, and environmental dimensions for internal performance monitoring and external reporting. (2) Investment in capacity building. The programme can improve employees' knowledge and skills, especially those related to sustainable practices and environmental compliance. (3) Implementation of ISO 14000 and EMS. Ensure the adoption and enforcement of environmental standards to reduce pollution and improve compliance. (4) Promote Transparency and Traceability. Digital tools (e.g., blockchain and GIS) are used to track sustainability performance across the supply chain. (5) Strengthening collaboration. Foster partnerships with stakeholders (including smallholders) through inclusive and fair value chain models.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Previous research has consistently highlighted a suite of critical determinants that shape corporate performance in sustainable supply chain management, particularly under the Triple Bottom Line (TBL) paradigm. On the environmental front, expansive plantation acreage, rigorous adherence to ISO 14000 standards, proactive pollution control, and comprehensive Environmental Management Systems have emerged as the foundational drivers. Equally pivotal are the social dimensions of organizational transparency and traceability commitments, workforce education and skill levels, robust infrastructure provision, ethical leadership within the entrepreneurial ecosystem, and comprehensive employee welfare programs. Collectively, these variables underscore that genuine sustainability performance hinges not only on natural resource stewardship but also on a company's capacity to invest in its human capital and institutional integrity. The synergy between environmental safeguards and social investment constitutes the principal engine propelling sustainable operational excellence across the palm oil value chain.

This study found that there are other more important factors in implementing sustainable supply chain management that focus on the triple bottom line aspects (economic, social, and environmental) and the development and implementation of company operations, namely, industrial productivity, financial performance, access to price information, level of industry employee education, infrastructure availability, entrepreneurial ethics towards the palm oil industry, employee welfare, commitment to transparency and traceability, plantation area, implementation of ISO 14000 standards, environmental pollution, and environmental management systems. These 13 variables are transmitted through five linkage/relay variables (connecting variables): technical implementation of oil palm cultivation and transportation, strategic collaboration and information, environmentally friendly technology, average age of industrial employees, and logistics optimization.

Recommendations

Based on the findings of this study using the Triple Bottom Line (TBL) framework, several key recommendations are proposed to enhance sustainability in the palm oil supply chain: (1) Strengthen Inclusive Economic Models: The involvement and development of all stakeholders, especially smallholders and marginalized groups, who make up a sizable share of the production base, are critical to the sustainability of the palm oil supply chain. Governments, business leaders, and development partners must promote more inclusive value chain architecture to achieve economic justice and resilience. (2) Enforcing and expanding sustainability certification schemes. Important instruments for encouraging responsible production are sustainability certificates, such as those offered by the Malaysian Sustainable Palm Oil (MSPO), Indonesian Sustainable Palm Oil (ISPO), and Roundtable on Sustainable Palm Oil (RSPO). However, uneven applications, smallholder coverage gaps, and inadequate monitoring mechanisms continue to limit their impacts. (3) Promote Transparent and Traceable Supply Chains. Transparency and traceability are essential components for sustainability in the palm oil supply chain. Establishing complete supply chain visibility from plantation to final product is crucial in a sector that is frequently criticized for opaque operations, covert environmental deterioration, and breaches of labor rights. Improved traceability systems not only aid in fulfilling legal obligations and certification requirements but also increase customer trust and provide access to ethical international markets.

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