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Enablers and Barriers to Green Supply Chain Management with TOPSIS and MOORA for Prioritzing Decision-Making

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Abstract

Indonesia is the world's largest coconut producer. As a result, coconuts play an important role in sustaining millions of Indonesians' livelihoods. In 2021, a fear of cooking oil emerged, leading to a decline in production levels, reduced income for individuals, and an increase in commodity pricing both domestically and internationally. The scarcity of cooking oil, notwithstanding Indonesia's position as the leading global producer, indicates an imbalance between supply and demand. This research aims to investigate production problems as the root cause of coconut industry shortages, identify productivity-related issues through a literature review, and assess the urgency of the criteria presented in five Linkert scales. Listing problems is critical for determining the root of the problem, as well as the potential for increasing revenue and ensuring long-term sustainability through value-added initiatives in the green supply chain management (GSCM) scope. This study uses TOPSIS and MOORA analysis, a way of making decisions based on levels of importance and enabler barriers in the coconut industry, focusing on production and productivity.

Keywords: Green Supply Chain Management; Decision-Making; TOPSIS; MOORA; Multi-Criteria

1. Introduction

More than 6.3 million farmers rely on coconut (Cocos nucifera L.) as a significant source of income, and over 98% of small-scale landholders own coconut plantations. Understanding the practicality of all aspects of the palm, such as its bioenergy, economic worth, necessary dietary ingredients, and suitability for wooden crafts, provides compelling evidence for the significance of coconut availability (Sondak et al., 2023). The government is concerned about the coconut commodity because it serves as the population's primary source of income. This study aims to investigate the challenges faced by the coconut industry in relation to coconut production and productivity, as well as the potential for increasing revenue and ensuring long-term sustainability through value-added initiatives that match demand. Indonesia, the largest coconut grower globally, faces challenges in meeting export demands from other nations. This situation calls for a significant emphasis on enhancing production and productivity. Furthermore, the current cooking oil deficit in the country in 2021 poses a paradoxical situation that requires careful examination and assistance from management (Gunawan et al., 2021; Novarianto, 2023). Our aim is to provide scientific expertise to tackle the aforementioned challenges. Previous scientists conducted an analysis of the obstacles that impede the coconut industry from multiple perspectives, aligning with the industry's enablers and barriers.

An effective method to enhance production is by implementing innovative techniques in coconut seed cultivation to achieve optimal yield. The goal of selecting superior coconut seeds is to boost production while minimizing environmental, social, and economic impacts. This is achieved by using high-quality planting materials and establishing certified coconut seed gardens to replace unproductive palm trees (Alouw & Wulandari, 2020). The quantity of coconuts harvested has an impact on the overall production; high-quality seeds will decrease maintenance expenses and yield superior coconut components. Understanding the competitiveness of the product and the demand for it can help adjust the desired coconut seeds. Despite the significant demand for exports, the absence of processing systems has resulted in missed export opportunities, leading to substandard product quality. The major difficulty in the coconut industry is the absence of managerial proficiency and expertise (Achillas et al., 2018) in efficiently reducing production costs while upholding high quality standards (Purba et al., 2021), given the usefulness of all parts of the coconut. In modern times, processed coconut is widely used in the food, pharmaceutical, non-food, and energy industries. People widely use coconut and its derivative products (Asthutiirundu et al., 2022), which are beneficial to

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both people and other species while also providing economic benefits. Unlike previous studies in the coconut industry, which primarily focused on a single problem, it is crucial to concisely outline the primary obstacles in the industry, as they can significantly impact other matters. Moreover, we consider the goals of the coconut industry to enhance its long-term sustainability while simultaneously addressing its challenges.

GSCM is a sustainability approach that integrates environmental concern indicators into interdisciplinary topics, providing a multi-criteria solution in business, economic, technological, and social terms (Rosyidah et al., 2022). Coconut research has gained attention in online media. By utilizing data from the Statistics Indonesia (BPS), Google Scholar, and the Scopus database, a search for articles titled "coconut industry" and "coconut industry in Indonesia" revealed that the barriers pertaining to the coconut industry have emerged as a subject of discourse not just within Indonesia but also on a global scale. Effective management skills are crucial for improving the long-term viability of the coconut industry. Second, the skills required include evaluating the excellence of high-quality coconut seed knowledge and handling ability; third, we are assessing demand standards to determine the desired quality of the coconut industry; fourth, we are identifying by-products that enhance economic value and income; and fifth, staying updated with the regulations for coconut production and its derivatives in various countries. Using a five-point Linkert scale, we determine scores for addressing the barriers to the coconut industry. This study's novel contribution is to summarize the issues surrounding the coconut industry as barriers that impede GSCM implementation. Using TOPSIS and MOORA analysis, the next step is to rank these barriers as criteria and resolve them through a management strategy that aligns with the hierarchical decision-making objectives of improving the coconut industry, including production and productivity in their respective sectors.

Four distinct sections structure this work, as follows: The first section clarifies the research's importance and the gap to the current work, while the second section clarifies previous research literature and its contribution to the current study. The third part delves into the specific methods and tools employed. This section covers the research steps and compares TOPSIS and MOORA analyses to make informed decisions about potential barriers. The fourth section of the paper summarizes the results and highlights the findings and accomplishments made during the observation steps. It also explains the strategies used in this study to arrive at these conclusions. The final piece, known as the Conclusion, provides a concise overview of each discovery and outlines the priorities for decision-making based on these results.

2. Literature Review

GSCM has been used by a wide range of industries. Examining comparable procedures, funding sources, and enabler barriers in different industries provides valuable insights into the implementation of Green Supply Chain Management (GSCM) in the coconut industry. GSCM has the ability to provide a robust and cohesive description, backed by several empirical facts. Challenging industrial sustainability issues, especially those related to production and productivity, necessitate the application of a scientific approach known as GSCM(Adi Wijaya & Armyn Machfudiyanto, 2023).

2.1. Steps of Adopting of GSCM in The Coconut Industry

Table 1 presents the research journey of the coconut business, highlighting the gaps in the application of Green Supply Chain Management (GSCM) to address the encountered challenges(Chaudhuri et al., 2024).

Table 1. The Current Gap Studies in GSCM and The Associated Barriers

Focus Area	Gap Studies and Barriers	References
Implementing dependable pricing modeling and forecasting can alleviate the challenges of value chain actors and enable the industry to adapt to its evolving conditions more effectively.	To achieve optimal income and prices, the coconut industry requires a complete product chain, which means **the barriers of lack of knowledge, expertise, and an unskilled labor force exist.**	(Achillas et al., 2018; Gunawan et al., 2021; Waidyarathne & Abeysekara, 2020; Zainol et al., 2023)
The government is implementing a program about coconut plant disturbances with the aim of increasing coconut production and improving their living standards by providing superior seeds.	The government's role is to provide comprehensive and consistent education on the planting of superior seeds to reduce failures due to technological understanding, which means the barriers to **the short-term profit effect influence the adoption of cleaner technologies**, as well as **the gaps in government regulations and frameworks.**	(Achillas et al., 2018; Alouw & Wulandari, 2020; Pormon et al., 2021; Zainol et al., 2023)
Innovative and non-invasive techniques evaluate the quality of shredded coconut in the	It's crucial to focus on maintaining quality standards and diversifying product offerings to consistently add value, which means	(Achillas et al., 2018; Asthutiirundu et al., 2022; Elfahmi et al., 2024; Purba et al., 2021;

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Focus Area	Gap Studies and Barriers	References
UHT coconut milk as a unique chance for state-of-the-art quality control.	the barriers of **the bounded rationality** implication and **financial performance pressures.**	Suksangpanomrung et al., 2024)
Transforming assessments of sustainability at the farm level into actionable measures for sustainability.	Maintaining sustainability requires environmental management, production flows, and stakeholders, which means overcoming barriers to **environmental issues and managing miscommunication**.	(Achillas et al., 2018; Rodrigues et al., 2018)

2.2. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Multi-Objective Optimization by Ratio Analysis (MOORA)

Barriers to GSCM need to be grouped into real problems, even if they are written in different sentences but still have the same meaning. To resolve this sequence of problems, multi-criteria decision-making is required. TOPSIS is a decision-making system that evaluates alternatives based on their distance from both a positive ideal solution and a negative ideal solution. It is commonly used in decision-making processes (Kusi-Sarpong et al., 2015), (El Alaoui, 2021) . MOORA serves as a technique for decision-making, employing a ratio to determine the optimal and least optimal material alternative that meets the combined requirements of individual responses (Ram Kumar et al., 2021), (Singh et al., 2024). Both methods are used to prioritize hierarchical decision-making to enable the barriers as alternatives that are identified in the research gaps.

3. Methodology

The first step in the TOPSIS and MOORA analysis is to determine alternatives. The research establishes the alternatives by identifying the research gaps, as listed in Table 1. We determined the importance of each alternative by scrutinizing their urgency in several literature reviews conducted over the past five years. Our focus is production and productivity in the coconut industry, using a five-scale Likert scale to determine weight as an indicator of importance and ensuring long-term sustainability through value-added initiatives that match demand.

The second step is to define barriers as alternatives to normalization. Figure 1. (step 1 and step 2) presents an overview of these six alternatives in the coconut industry, focusing on production and productivity. The third step in TOPSIS analysis involves calculating the distance from weighted alternatives to identify positive and negative ideal solutions and then determining the preference value of each alternative for ranking purposes. The third step in MOORA analysis involves creating a normalized matrix, determining the maximum and minimum values of the matrix elements, multiplying these values by the significance coefficient, and determining the ranking as shown in fig 1.

The fourth stage is a comparison of the two decision-making analyses of the TOPSIS method and the MOORA method. The TOPSIS method ranks based on the farthest descending distance from the negative alternative. The MOORA method ranks the maximum value minus the minimum. The method bases its ranking on the descending order of the maximum value minus the minimum value. The fifth stage involves visualizing the ranking results to compare the decision-making hierarchy between the TOPSIS and MOORA methods, which will assist management in making decisions based on quantitative analysis of the objective criteria.

The five stages are described in a research process that describes applying the methodology of enablers and barriers to green supply chain management with TOPSIS and MOORA for prioritizing decision-making. Figure 1. illustrates the research process for identifying the production and productivity barriers in the coconut industry when implementing green supply chain management from various literature review perspectives.

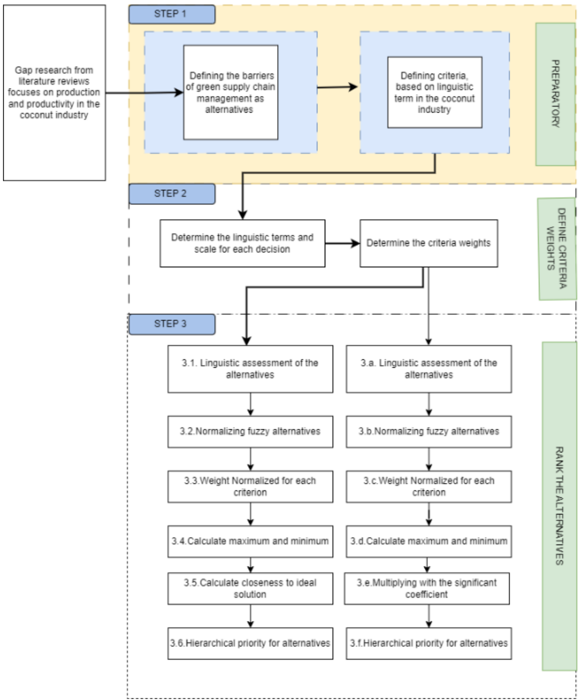

Figure 1. Research Process

Figure 1. step 3.1 and step 3.a – Define The alternatives A_i (Table 2), assignment of ratings to the alternatives and criteria weights (Table 3). The formula is as follows:

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$$\begin{matrix} & C_1 & \cdots & C_n \\ A_1 & X_{11} & \cdots & X_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ A_m & X_{m1} & \cdots & X_{mm} \\ & W_1 & \cdots & W_n \end{matrix} \quad (1)$$

$A_i =$ Alternatives, $X_i =$attribute of the alternative being measured. $X_{ij} =$performance alternative A_i with attribute X_j as shown in Table 4.

Figure 1. step 3.2 and 3. b – Construct the normalized decision matrix, where r_{ij} represents the normalized of alternative A_i according to criteria C_i (Table 4) The formula for a normalized matrix is as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (2)$$

r_{ij} = normalized matrix, X_{ij}= decision matrix

Figure 1. step 3.3 and 3.c – Construct the weighted normalized matrix as shown in Table 5.

$$v_{ij} = w_j \times r_{ij} \quad (3)$$

V_{ij} = Normalized decision matrix with weight V. w_i =weight of criteria C_i.

Figure 1. step 3.4 – Determine maximum and minimum as shown in Table 5.

$$A^+ = \{ V_1^+, \ldots, V_n^+ \} = \{ (max_i v_{ij} | j \in \Omega_b), (min_i v_{ij} | j \in \Omega_c) \} \quad (4)$$

$$A^- = \{v_1^-, \ldots, v_n^-\} = \{(min_i v_{ij} | j \in \Omega_b), (max_i v_{ij} | j \in \Omega_c) \} \quad (5)$$

A^+ = positive ideal solution, A^- = negative ideal solution

Figure 1. step 3.d – Determine the maximum (Vij) value of each beneficiary objective count on performance denoted as m and the minimum (Vij) value of each count of costs on performance denoted by (u-m). The formulas (6) and (7) respectively illustrate this as shown in Table 5.

$$\sum_{i-1}^{i=m} r_{ij} \quad (6)$$

$$\sum_{i=m+1}^{u} r_{ij} \quad (7)$$

Figure 1. step 3.5 – Calculate the distance between each alternative and the ideal solution to determine the positive and negative ideal solutions as shown in Table 6. The distance for positive ideal solution (D_i^+):

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_i^+)^2}, \ i = 1, \ldots, m \quad (8)$$

The distance for negative ideal solution (D_i^-):

$$D_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_i^-)^2}, \ i = 1, \ldots, m \quad (9)$$

Calculate the relative closeness to the ideal solutions

$$CC_i = \frac{D_i^-}{D_i^- + D_i^+}, \ i = 1, \ldots, m \quad (10)$$

Figure 1. step 3.e – Subtracted the beneficiary with cost as shown in Table 6.

$$Y_i = \sum_{i-1}^{i=m} w_j * r_{ij} - \sum_{i=m+1}^{u} w_j * r_{ij} \quad (11)$$

Figure 1. step 3.6 – Rank according to CC_i. The closer the CC_i to 1 as shown in Table 6, the closer it is to the ideal solution, as the hierarchy of alternatives for priority decision-making will be made. Figure 1. step 3.f – Rank according to Y_i. Sort the rank descending. The higher the value, the higher the desire as shown in Table 6.

4. Result and Discussion

People often use the term "green supply chain" to refer to a shift from traditional supply chain management techniques. Consistently adhering to green supply chain management guidelines will yield advantages, particularly in relation to operating expenses, thereby ensuring the long-term viability of the organization. During the first implementation of green supply chain management, conflicts often arise between short-term gains and long-term costs, posing challenges to sustainability.

Table 2. Barriers to Green Supply Chain Management (A_i)

(A_i)	Barriers of Green Supply Chain	References
A1	The lack of knowledge, expertise, and an unskilled labor force	(Achillas et al., 2018;Lamba & Thareja, 2020; Sondak et al., 2023)
A2	The influence of short-term profit on the adoption of cleaner technologies	(Achillas et al., 2018;Lamba & Thareja, 2020;Sarkis & Dou, 2018)
A3	The gap in government regulation and framework	(Achillas et al., 2018; Lamba & Thareja, 2020)
A4	The implications of bound rationality and financial pressures	(Achillas et al., 2018; Lamba & Thareja, 2020)
A5	Environmental issues	(Achillas et al., 2018; Lamba & Thareja, 2020)
A6	The management miscommunication	(Achillas et al., 2018; Lamba & Thareja, 2020; Sondak et al., 2023)

This study's alternatives (**A_i**) and criteria are based on the five Linkert scales, and its definition of value is based on a literature review that pinpoints production and productivity gaps in the coconut industry. The study balanced the weights in the criteria so that they could be used as input for both the TOPSIS method and the MOORA method at the same time, as shown in Table 3 and Table 4.

Table 3. Assesments of Criteria Weights

(C_j)	Linguistic Term	Scale/ Weight	Performance
C_1	Lifetime product schedule with added value	0.3	Benefit
C_2	Product development and innovation	0.4	Benefit
C_3	Marketing and branding costs to meet the demand for sustainability	0.2	Cost
C_4	Production cost efficiency with optimization	0.1	Cost

The linguistically formulated criteria are transformed into a quantitative standard, or weight, to illustrate the importance of standardization. We assess

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the weight according to the urgency of the criteria. As the weight increases, the significance of the criteria intensifies. Performance benefits provide a qualitative assessment of the influence on company quality, while cost criteria provide quantitative results in the form of costs.

Table 4. Linguistic Assessment of the Alternatives and Normalizing fuzzy alternatives for TOPSIS and MOORA

A_i	Criteria				Calculation Criteria for TOPSIS and MOORA	Calculation Criteria for TOPSIS and MOORA	Calculation Criteria for TOPSIS and MOORA	Calculation Criteria for TOPSIS and MOORA
	C1	C2	C3	C4	C1	C2	C3	C4
A1	0.3	0.5	0.1	0.1	0.391	0.625	0.140	0.130
A2	0.4	0.2	0.1	0.4	0.521	0.250	0.140	0.521
A3	0.1	0.3	0.4	0.4	0.130	0.375	0.560	0.521
A4	0.4	0.4	0.1	0.4	0.521	0.500	0.140	0.521
A5	0.4	0.1	0.4	0.1	0.521	0.125	0.560	0.130
A6	0.1	0.3	0.4	0.3	0.130	0.375	0.560	0.391
Optimum	Max	Max	Min	Min				
Rij	0.768	0.800	0.714	0.768				

We assign an importance number to each alternative based on the criteria. The alternative's higher number indicates a strong correlation with the intended criteria, a process known as normalization that serves as the foundation for TOPSIS and MOORA computations as shown in Figure 1. steps 3.2 and 3.b. and steps 3.3 and 3.c.

Table 5. Finding Solution for TOPSIS and MOORA

A_i	Weights 0.3 C1	0.4 C2	0.2 C3	0.1 C4	A+ Max	A- Min	MOORA Max	Min
A1	0.117	0.250	0.028	0.013	0.250	0.013	0.367	0.041
A2	0.156	0.100	0.028	0.052	0.156	0.028	0.256	0.080
A3	0.039	0.150	0.112	0.052	0.150	0.039	0.189	0.164
A4	0.156	0.200	0.028	0.052	0.200	0.028	0.356	0.080
A5	0.156	0.050	0.112	0.013	0.156	0.013	0.206	0.125
A6	0.039	0.150	0.112	0.039	0.150	0.039	0.189	0.151

TOPSIS computes positive and negative solutions depending on each criterion; however, MOORA's solution calculation relies on performance benefits and costs, making the performance assessment maximum for benefits and minimum for costs in MOORA significantly impactful for decision-making, as shown in Table 5.

Table 6. Closeness (CCi) to Ideal Solution and Rank for TOPSIS and MOORA

A_i	Positive	Negative	Closeness TOPSIS	Closeness MOORA	A_i	Rank TOPSIS	A_i	Rank MOORA
A1	0.351	0.259	0.425	0.326	A5	0.492	A1	0.326
A2	0.174	0.149	0.461	0.176	A4	0.483	A4	0.276
A3	0.153	0.133	0.466	0.025	A3	0.466	A2	0.176
A4	0.231	0.216	0.483	0.276	A2	0.461	A5	0.081
A5	0.184	0.178	0.492	0.081	A6	0.451	A6	0.038
A6	0.161	0.133	0.451	0.038	A1	0.425	A3	0.025

Table 6 delineates the maximum and lowest distances, or closeness, for each criterion. Establishing proximity as a foundation for the priority hierarchy is essential for evaluating alternatives. The TOPSIS selected closeness is to determine the farthest distance from the negative ideal solution. MOORA evaluates the closeness by subtracting each choice from its maximum and minimum values, then revealing the highest rank.

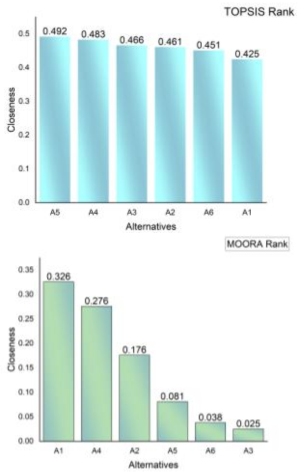

Figure 2. Prioritize Decision-Making on The Alternatives based on TOPSIS rank and MOORA rank

The hierarchy of alternative decision-making for TOPSIS in closeness order is: A5, A4, A3, A2, A6, A1. The hierarchy of the alternatives decision-making for MOORA in closeness order is A1, A4, A2, A5, A6, and A3. The closeness results indicate that alternative solutions A4 and A6 in TOPSIS and MOORA share an identical urgency ranking in decision-making.

5. Conclusion

Indonesia, the country's largest coconut producer, must consider measurable factors when processing its products. Production and productivity issues are significant because they are impacting society's economic conditions, ultimately influencing state income. Policymakers should take into consideration the problems and criteria identified in various literatures, as this is a significant concern. These issues keep cropping up in literature reviews about coconut production.

The beneficiary and the cost are simple, but they are difficult to define. We identified additional areas for further investigation after examining the literature reviews that formed the scientific foundation for this research: During this study, the beneficiary criteria establish the guidelines for achieving public pleasure on an emotional level, while the cost primarily focuses on the actual involved in overcoming obstacles. However, it is essential to define specific boundaries between the terms "beneficial" and "cost" by a scientifically measurable study in order to have a significant impact on the MOORA analysis. To avoid severely affecting the analysis, it is crucial to pay close attention when transforming linguistic concepts into values for normalization in TOPSIS analysis. However, this study has found that the implications of bound rationality, financial pressures (A4), and management miscommunication (A6) are at the same level of rank in both TOPSIS and MOORA.

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