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Evaluation of Sustainability Supply Chain Performance in the Food Industry: A Case Study

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ABSTRACT

Evaluating sustainability in the food supply chain has multiple benefits, including reducing environmental impact, meeting regulations, satisfying consumer demands, improving efficiency, and enhancing business reputation. This paper outlines a Sustainability Supply Chain Management (SSCM) framework using the Analytic Hierarchy Process (AHP) to weigh Key Performance Indicators (KPIs). With 12 variables and 39 KPIs, the method involves data collection, performance measure selection, and analysis. KPIs with lower weight values highlight areas needing improvement, such as recycling costs, personnel expenses, sales responsiveness, eco-friendly labelling, distribution efficiency, green product development, recycled material usage, employee capabilities, product reputation, worker satisfaction, and stakeholder trust. Based on KPI weights, recommendations include prioritizing energy use in production and marketing, ensuring timely product delivery, maintaining product quality, streamlining production processes, focusing on energy efficiency, promoting eco-labelling, fostering eco-awareness, and advancing environmental technology.

1. Introduction

Sustainability in supply chain performance is an ever-evolving aspect that adapts to changing business and market demands for socially and environmentally responsible practices [1]. Numerous businesses now incorporate sustainability into their supply chain strategies, measuring performance in sustainable practices to improve transparency and accountability [2, 3]. Innovation is crucial to achieving sustainable supply chain performance, with companies prioritizing environmentally friendly product development, sustainable materials, and enhanced energy and resource efficiency [4, 5]. Sustainable supply chain performance also helps meet standards that build trust with customers and stakeholders [5]. Sustainability Supply Chain Management (SSCM) is a fundamental concept in environmentally conscious supply chain management. Appiah and Odartey [6] define SSCM as an environmentally conscious framework for conventional supply chain management. These considerations include product design [7, 8], supplier selection [9],

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material procurement [10], manufacturing activities, packaging activities, product delivery activities to consumers, and end-of-life product management [11, 12]. By adopting SSCM, businesses are able to align their objectives [[13], formulate policies [14], and strategize to achieve cost-effectiveness and high profit margins while considering environmental factors [15]. This concept has evolved into Sustainability Performance Measurement for Green Supply Chain Management, which involves the development of Key Performance Indicators within the context of sustainable development, taking into account economic, environmental, and social perspectives [14].

Research has extensively explored the impact of sustainable supply chain management practices on company performance [16-23]. This study conducts a comprehensive systematic review of prior sustainable supply chain management research. It identifies established frameworks, methodologies, and research challenges while offering insightful recommendations for future research directions. The research focuses on elucidating the potential contributions of sustainable green supply chain management to sustainable consumption and production. The author provides actionable frameworks and strategies tailored to support the food industry in practically implementing sustainable supply chain practices, specifically emphasizing economic and stakeholder considerations. Areas such as energy efficiency, environmental considerations, and consumer responses, which could bolster the Sustainability Supply Chain Management (SSCM) performance, are yet to be presented.

However, previous research has shown that assessing sustainability performance in supply chains involves complex and diverse considerations that include environmental, social and economic aspects. The process of collecting and evaluating data to measure the impact of each of these factors can be a complicated and time-consuming task. As market environments and food supply chains are dynamic, they often involve multiple suppliers, partners and production lines. Therefore, understanding and evaluating sustainability performance across the supply chain is inherently a complex task as it involves various entities with different policies and practices. This suggests that this topic is interesting to investigate.

This paper emphasizes the significance of assessing the sustainability of supply chains within the food industry. The implementation of this approach facilitates the achievement of a harmonious equilibrium among environmental, economic, and social aspects of sustainability, thereby making a valuable contribution to the broader objectives of sustainable development within the operational framework [24]. Supply chain practices have been observed to confer a competitive advantage, yield reputational benefits, and enable adaptability to the contemporary challenges encountered by the food industry [25]. Researchers aim to enhance and assess performance evaluation in the realm of Sustainable Supply Chain Management (SSCM) through the utilization of the Analytic Hierarchy Process (AHP) and Key Performance Indicator (KPI) methodologies. These approaches aid companies in effectively managing, measuring, and enhancing their sustainable performance within the supply chain. The Analytic Hierarchy Process (AHP) is a methodology that enables the identification, comparison, and decision-making regarding significant factors that play a role in sustainability. These factors encompass energy efficiency, waste management (as referenced in [26]), carbon emissions, sustainable utilization of raw materials (as mentioned in [9]), and social impacts (as indicated in [27]. Patidar, et al. [28] state that Key Performance Indicators (KPIs) are employed to assess the attainment of sustainability objectives and targets, encompassing areas such as greenhouse gas emissions, utilization of renewable energy, reduction of waste, efficiency in transportation, sustainability levels of suppliers, and levels of consumer satisfaction with sustainable products.

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2. Methods

The focus of this research centres around a case study conducted at a Small Medium Enterprise (SME) known as Tape Chips. The methodology employed in this study utilizes the Supply Chain Sustainability Measurement (SSCM) framework, which encompasses several key stages, including data collection [29], variable weighting, Analytic Hierarchy Process (AHP), selection of performance measures for sustainability supply chain using Key Performance Indicators (KPIs), and subsequent data analysis. The conceptual framework employed in this study is illustrated in Fig. 1.

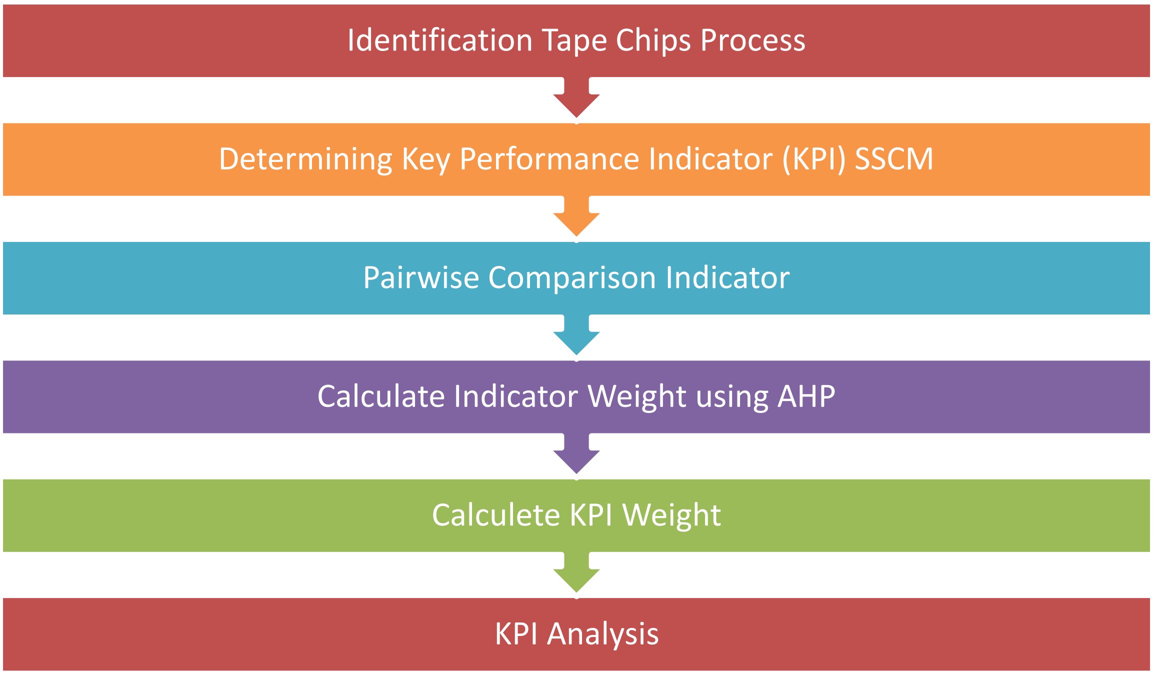

Fig. 1. The framework

2.1 Data collection

The process of data collection is conducted with the purpose of acquiring information that serves as input for subsequent data processing activities. The data was obtained by conducting a comprehensive review of relevant literature, making direct observations, conducting interviews with subject matter experts (SMEs), and analyzing available documentation. The researchers conducted observations in order to gather data pertaining to the supply chain, production, and selected performance measures of raw materials in the context of SSCM.

2.2 Data analysis

The data analysis was performed by carefully selecting the most appropriate methodology that aligned with the specific problem under investigation. The initial phase entails the application of the Analytic Hierarchy Process (AHP) to assign appropriate weights to the Key Performance Indicators (KPIs) within the Supply Chain Sustainability Management (SSCM) performance evaluation model. Subsequently, the subsequent action

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Jurnal Teknik Industri
Vol. 24, No. 2, August 2023, pp. 95-108

entails the identification and prioritization of key performance indicators (KPIs) with the utmost and minimal weights, thereby facilitating the analysis of small and medium-sized enterprises (SMEs) sustainable supply chain management (SSCM) performance. Moreover, a comprehensive analysis of the performance of each indicator can be provided with regard to activities related to Sustainable Supply Chain Management (SSCM). The weight with the highest value signifies the indicators that hold primary significance for small and medium enterprises (SMEs). In contrast, the weight with the lowest value signifies indicators that necessitate greater attention.

The AHP procedure is a decision analysis method that involves pairwise comparisons between elements involved in a decision. The first stage in the AHP procedure is the calculation of weights, which is done by performing matrix multiplication based on reference [30] [25]. Next, the results of the pairwise comparison questionnaire, expressed in a rating scale, are entered into the matrix table. It is important to note that the scale used in filling out the questionnaire is a pairwise comparison scale, which can be found in Table 1. The importance of consistency in AHP analysis is indicated by the CR value of each perspective, which should be less than or equal to 0.1, indicating that the analysis results are consistent and acceptable [30]. In addition, the RI (Random Index) value is a random consistency index, which has an absolute value. For example, if the number of elements being compared (n) is 4, then the RI value is 0.9.

Furthermore, the consistency of the comparison results was evaluated by calculating the Consistency Ratio (CR) value for each variable. It is important to note that the CR value must be ≤ 0.1 for the weighting results to be acceptable and justifiable. If the CR value exceeds this threshold, then corrective and refinement measures need to be taken, for example, by reviewing the questionnaire completion. In Phase 2, in Table 2, it can be observed that the CR value for each variable meets the consistency criteria set because the value is ≤ 0.1. In addition, it should be noted that the Random Index (RI) value is used as a random consistency index and has an absolute value, as described in Table 2. For example, if the number of variables (n) is 10, then the RI value is 1.49.

Table 1. Pairwise comparison scale

Interest Intensity	Definition	Explanation
1	Equally important	The two elements have the same contribution to the goal
3	A little more important	One element is slightly stronger than the other
5	More important	One element is stronger than the other elements
7	Much more important	One element is very strong compared to other elements
9	Absolutely more important	Evidence prefers one element over another as the highest possible level of affirmation
2,4,6,8	The middle value between two adjacent comparisons	Sometimes, it is necessary to interpolate from a rating scale because there is no precise scale to describe it

Table 2. Random index value (RI).

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.34	1.41	1.45	1.49

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3. Results and Discussion

3.1 Identification of SME Supply Chain

In Identification of SME Supply Chain, the supply chain flow can be reviewed in Fig. 2. SME supply chains can be identified based on four key points. First, sustainable decision-making is an important aspect of selecting suppliers, materials, and environmental risk management. SMEs need to consider environmental, social, and economic factors in the decision-making process, including energy efficiency and sustainable product innovation. Second, collaboration with stakeholders, including suppliers, business partners, and other stakeholders, plays an important role in achieving sustainable performance. SMEs can utilize research results to strengthen cooperation, share knowledge, and build joint initiatives to improve sustainability throughout the supply chain. Third, measuring and reporting sustainable performance is a crucial step. SMEs are advised to adopt the framework and metrics that have been proposed in this study to measure and report on sustainable performance in the supply chain. Finally, technological innovation and digitalization also play a big role. The adoption of technological solutions such as sensor-based monitoring, data analytics, information-sharing platforms, and other technologies can improve operational efficiency while reducing environmental impacts in SME supply chains. By paying attention to these four aspects, SMEs can build sustainable and resilient supply chains for the future.

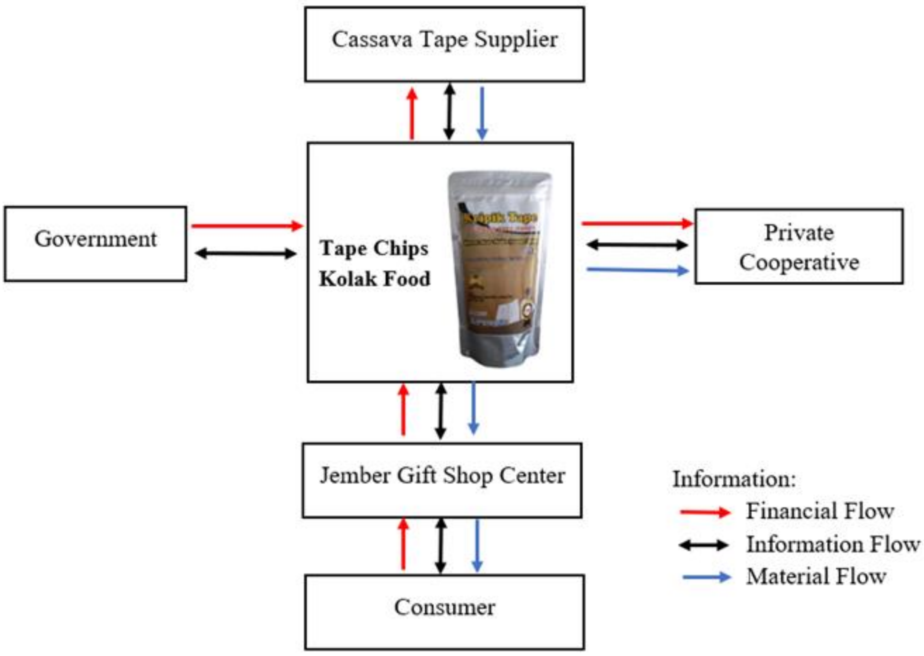

Fig. 2. Flow of Supply Chain of Tape Chips

3.2 Variable and KPI Identification

This study aims to evaluate the sustainability of the sustainability supply chain performance in SMEs using KPIs. KPIs are key indicators providing information about achieving an organization's strategic goals [31]. In this context, KPIs cover various aspects, such as strategic objectives, related key indicators, benchmarks used, and the effectiveness of each KPI. A total of 39 KPIs were used in the chain performance assessment. The results of the identification of variables and KPIs can be seen in Table 3.

Jurnal Teknik Industri
Vol. 24, No. 2, August 2023, pp. 95-108

Table 3. Variable and KPI Identification

Perspective	Variable	Indicators/ KPIs	KPI code
Economy	Finance	Cost of purchasing raw materials and additional materials	FN101
		Cost of packaging materials	FN102
		Production cost	FN103
		Energy use costs (water, gas, and other fuels)	FN104
		Inventory costs	FN201
		Finished product shipping costs	FN202
		Recycling costs	FN301
		Waste handling or disposal costs	FN302
		Profit margin	FN401
		Personnel costs (workers)	FN501
	Service	Timely delivery	SR101
		Service sale	SR102
		Service product returns	SR103
	Quality	The percentage of defect-free products	QT101
		Production process quality (scarp and rework)	QT102
		Product quality (level of consumer complaints)	QT201
		Availability of guarantees on environmentally friendly products	QT202
	flexibility	Request flexibility	FX101
		Delivery flexibility	FX102
		Flexibility of the production process	FX103
Environment	Level of process management	Process optimization level of waste reduction (reuse/recycle)	LP101
		Total energy use	LP102
		Process efficiency	LP103
		There is reused energy	LP104
		Totally eco-friendly product	LP105
		Waste levels, emissions, and pollution control	LP201
	Product features	The rate of use of recycled materials in products	FP101
		Availability of eco-labeling (environmentally friendly labels)	FP102
	Environmental technology	Cleaner production technology level	ET101
		Number of new products and processes	ET102
Social	Management commitment	The level of effort in motivating employees	MC101
		Environmental management initiatives and environmental responsibility	MC102
	working conditions	Number of trained workers	WC101
		Worker quality	WC102
	Consumer satisfaction	Level of consumer satisfaction	CS101
		Product reputation in the eyes of consumers	CS102
	Employee development	The level of satisfaction/comfort of employees towards work	ED101
		Initiative of a training program	ED102
	Relations with stakeholder	The level of stakeholder trust	RL101

3.3 Weighting Variable and KPI using AHP

The results show that the weighting is done in detail on each variable in the Sustainability Supply Chain. Detailed information regarding the results of weighting each variable can be found in Table 4. The analysis from Table 4 shows that the variables from various perspectives have varying weights. From an economic perspective, the quality variable shows the highest weight with a value of 0.54. In contrast, the flexibility variable has the lowest weight, with a value of 0.06. From an environmental perspective, the product features variable has the highest weight, with a value of 0.48.

In contrast, the environmental technology variable has the lowest weight of 0.13. As for the social perspective, the customer satisfaction variable shows the highest weight with a value of 0.44, while the relationship with stakeholder variable gets the lowest weight of 0.05. Finally, the Consistency Ratio (CR) is calculated for each perspective to evaluate the consistency of the weighting results. It was found that the Consistency Ratio value for variable weighting must be ≤ 0.1 for the weighting results to be considered accurately acceptable.

Table 4. Result Weighting variable using AHP

Perspective	Variable	Weight	CR
Economy	Finance	0.23	0.04
	Quality	0.54	
	Service	0.17	
	flexibility	0.06	
Environment	Level of process management	0.40	0.01
	Product Features	0.48	
	Environmental technology	0.12	
Social	Management commitment	0.26	0.06
	Working conditions	0.15	
	Consumer satisfaction	0.44	
	Employee development	0.10	
	Relations with stakeholders	0.05	

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Furthermore, the research also included a weighting on each indicator or Key Performance Indicator (KPI) in the Sustainable Supply Chain, with detailed results listed in Table 5. The results of this research provide deep insight into the importance of weighting in ensuring the sustainability of a sustainable supply chain.

3.4 Discussion and Recommendations

This research reveals that weighting Key Performance Indicators (KPIs) is essential in prioritizing, meeting stakeholder or consumer preferences, and developing strategies to evaluate sustainability performance. With a more detailed framework, measurement and decision-making related to supply chain sustainability can be done more accurately. The results of the variable weight calculation show that quality aspects have the highest weight in the economic perspective, followed by product features in the environmental perspective and customer satisfaction in the social perspective. It indicates that SMEs in this industry focus on maintaining the quality of tape chips, developing environmentally friendly products, including packaging, and paying serious attention to consumer feedback. On the other hand, flexibility, environmental technology, and stakeholder relations have the lowest weights. These findings indicate the importance of

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Jurnal Teknik Industri
Vol. 24, No. 2, August 2023, pp. 95-108

prioritizing critical performance areas to improve sustainability performance. Therefore, SMEs must pay attention to service factors and ease of product delivery, sales, and demand response to improve their supply chain systems. In addition, implementing environmental technologies, while demanding a large budget and not always easy, can significantly impact an SME's performance and reputation if done incrementally. Furthermore, Park and Li [32] state that SMEs should also consider their relationship with the government by complying with established policies.

Table 5. Indicator weighting of KPI.

<table>
<tr><th>Perspective</th><th>Variable</th><th>KPI code</th><th>Weight</th><th>CR</th></tr>
<tr><td rowspan="20">Economy</td><td rowspan="10">Finance</td><td>FN101</td><td>0.13</td><td rowspan="10">0.02</td></tr>
<tr><td>FN102</td><td>0.11</td></tr>
<tr><td>FN103</td><td>0.14</td></tr>
<tr><td>FN104</td><td>0.16</td></tr>
<tr><td>FN201</td><td>0.08</td></tr>
<tr><td>FN202</td><td>0.1</td></tr>
<tr><td>FN301</td><td>0.06</td></tr>
<tr><td>FN302</td><td>0.06</td></tr>
<tr><td>FN401</td><td>0.1</td></tr>
<tr><td>FN501</td><td>0.06</td></tr>
<tr><td rowspan="3">Service</td><td>SR101</td><td>0.46</td><td rowspan="3">0.04</td></tr>
<tr><td>SR102</td><td>0.18</td></tr>
<tr><td>SR103</td><td>0.36</td></tr>
<tr><td rowspan="4">Quality</td><td>QT101</td><td>0.31</td><td rowspan="4">0,01</td></tr>
<tr><td>QT102</td><td>0.21</td></tr>
<tr><td>QT201</td><td>0.36</td></tr>
<tr><td>QT202</td><td>0.12</td></tr>
<tr><td rowspan="3">flexibility</td><td>FX101</td><td>0.24</td><td rowspan="3">0.02</td></tr>
<tr><td>FX102</td><td>0.21</td></tr>
<tr><td>FX103</td><td>0.55</td></tr>
<tr><td rowspan="10">Environment</td><td rowspan="6">Level of process management</td><td>LP101</td><td>0.16</td><td rowspan="6">0.04</td></tr>
<tr><td>LP102</td><td>0.27</td></tr>
<tr><td>LP103</td><td>0.27</td></tr>
<tr><td>LP104</td><td>0.08</td></tr>
<tr><td>LP105</td><td>0.09</td></tr>
<tr><td>LP201</td><td>0.13</td></tr>
<tr><td rowspan="2">Product features</td><td>FP101</td><td>0.16</td><td rowspan="2">-</td></tr>
<tr><td>FP102</td><td>0.84</td></tr>
<tr><td rowspan="2">Environmental technology</td><td>ET101</td><td>0.75</td><td rowspan="2">-</td></tr>
<tr><td>ET102</td><td>0.25</td></tr>
<tr><td rowspan="9">Social</td><td rowspan="2">Management commitment</td><td>MC101</td><td>0.25</td><td rowspan="2">-</td></tr>
<tr><td>MC102</td><td>0.75</td></tr>
<tr><td rowspan="2">working conditions</td><td>WC101</td><td>0.16</td><td rowspan="2">-</td></tr>
<tr><td>WC102</td><td>0.84</td></tr>
<tr><td rowspan="2">Consumer satisfaction</td><td>CS101</td><td>0.16</td><td rowspan="2">-</td></tr>
<tr><td>CS102</td><td>0.84</td></tr>
<tr><td rowspan="2">Employee development</td><td>ED101</td><td>0.16</td><td rowspan="2">-</td></tr>
<tr><td>ED102</td><td>0.84</td></tr>
<tr><td>Relations with stakeholder</td><td>RL101</td><td>1</td><td>-</td></tr>
</table>

The results show that the energy use KPI dominates in the financial variables with the highest weight of 0.16. At the same time, the recycling cost, waste handling and disposal cost, and personnel cost KPIs have the lowest weight of 0.05 each. It indicates that SMEs manage the energy budget during processing and marketing. However, it is essential to remember that other aspects, such as recycling costs, waste handling and disposal costs, and personnel costs, also significantly impact sustainable supply chain performance. Therefore, more attention must be paid to these aspects to achieve optimal green supply chain performance.

Meanwhile, in the service variable, the on-time delivery KPI plays a significant role, with the highest weight of 0.46, while the sales KPI has the lowest weight of 0.16. It shows that the main focus of SMEs is to maintain consistency in delivering products on time to maintain consumer loyalty. However, it is also necessary to pay attention to responsiveness in the sales process to maximize positive feedback and strengthen consumer loyalty. Thus, balancing on-time delivery and responsive sales is critical to improving SME performance in green supply chains.

The results show that in the quality variable, the KPI with the highest weight is the percentage of defect-free products with a value of 0.31. It indicates that SMEs tend to prioritize the production of high-quality products with low defect rates. On the other hand, the lowest weight is found in the KPI for the availability of environmentally friendly product guarantees, indicating that SMEs still pay less attention to environmentally friendly labels on packaging. Therefore, SMES need to consider implementing an eco-friendly warranty on packaging because, in addition to providing benefits to the environment, this can also increase consumer confidence in environmentally friendly products. In the flexibility variable, it is found that the production process flexibility KPI has the highest weight, with a value of 0.55. In contrast, the delivery flexibility KPI has the lowest weight, with a value of 0.21. It indicates that SMEs focus more on flexibility in the production process than product delivery. Related to this, previous research by Luthra and Mangla [33] emphasized the importance of prioritizing Industry 4.0 concepts to improve supply chain sustainability in developing countries, especially in the manufacturing sector.

At the process management level variable, it was found that the total energy use KPI had the highest weight with a value of 0.31. In contrast, the total green product KPI had the lowest weight, with a value of 0.08. It shows that SMEs focus more on energy use efficiency than green product development. Therefore, it is recommended that SMEs be more active in developing environmentally friendly products to support environmental sustainability. In the product feature variable, the eco-labelling availability KPI dominates with the highest weight of 0.83. At the same time, the recycled material usage rate KPI has the lowest weight with a value of 0.16. SMEs are starting to show greater interest in applying eco-labelling than in using recycled materials. Therefore, efforts to increase the use of recycled materials in production should also be considered a progressive step in adopting sustainable practices.

The results show that in the environmental technology variable, there are significant weight differences. The clean technology level KPI dominates with the highest weight of 0.75, while the number of new products and processes has the lowest weight of 0.25. It shows that SMEs are highly interested in developing environmental technology, especially in adopting cleaner and environmentally friendly technologies. On the other hand, in the management commitment variable, the KPIs of environmental management initiatives and responsibility for the environment occupy the highest position with a weight of 0.75. Meanwhile, the level of effort in motivating employees has the lowest weight of 0.25. From these results, SMEs show vital initiatives in environmental

Jurnal Teknik Industri
Vol. 24, No. 2, August 2023, pp. 95-108

management and responsibility but may need to increase efforts in motivating employees to participate in environmentally friendly practices. In the working conditions variable, the quality of workers KPI dominates with the highest weight of 0.84, while the number of trained workers KPI has the lowest weight of 0.16. It shows the importance of focusing on workforce quality in achieving environmental sustainability. The research also shows that environmental sustainability is closely related to supply chain management practices, financial performance, and technology, except in the strategic supplier partnership dimension. Therefore, according to Jum'a, et al. [34], careful monitoring and attention to these aspects are vital in ensuring practical environmental sustainability.

The results show that in the customer satisfaction variable, the KPI with the highest weight is the level of customer satisfaction, with a value of 0.84, while the lowest weight is on the product reputation KPI with a value of 0.16. It indicates that for SMEs, customer satisfaction has a more dominant role than product reputation in the eyes of consumers. Meanwhile, in the employee development variable, the training program initiative KPI occupies the highest position with a weight of 0.84. In contrast, the employee satisfaction or comfort level KPI has the lowest weight of 0.16. This result shows that training programs for SMEs take precedence over focusing on employee satisfaction or comfort. In the relationship with stakeholder variable, the highest weight is owned by the stakeholder trust KPI with a value of 1, which indicates that the level of trust from related parties is crucial. In the context of multi-tier supply chains, the study conducted by Govindan, et al. [35] also underlines the social sustainability mechanisms that need to be implemented. Resource dependency theory is used as a theoretical foundation to link the implementation of social sustainability aspects in this context.

3.5 Research Implications

This research carries significant positive implications in encouraging companies to adopt sustainable practices in their supply chains. With increased awareness of the importance of social and environmental responsibility, companies will be encouraged to make positive changes in the way they operate. The food industry will benefit greatly from this sustainability supply chain performance evaluation. They will become more serious about prioritizing sustainable practices in their operations, thereby reducing environmental impacts, improving social conditions, and increasing economic efficiency simultaneously. In addition, by providing relevant frameworks and performance indicators, this research also provides important support for SMEs in the tape chip industry. They will be able to strengthen their sustainability performance reporting, provide more transparent information to stakeholders, and demonstrate a stronger commitment to social and environmental responsibility.

In addition to encouraging companies and industries to operate responsibly, this research also has a significant impact on consumer behaviour. Evaluation of sustainability supply chain performance can influence consumer preferences for sustainable products. This results in the wider adoption of sustainable products and services, which, in turn, will encourage companies to focus on sustainability in their supply chains. SMEs that have adopted sustainable practices and are ready to follow regulatory changes in their supply chains will be able to attract more consumers who prioritize sustainability. Thus, this research not only shapes more sustainable consumption behaviour but also makes a significant contribution to achieving the overall goal of sustainable development.

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4. Conclusion

This study aims to evaluate the sustainability of the green supply chain in the tape chips food industry and assess the performance of the KPI calculation. In the production of tape chips, there are 12 variables and 39 performance indicators. Calculations using the AHP method resulted in the largest matrix value in environmental technology. This shows that it is necessary to do some alternative production processes to become more environmentally friendly. In the investigation, responsibility, and lack of attention to the environment are the main concerns, so the level of effort in motivating employees is needed. However, the limitation of this study is that it has not accurately determined the parameters for measuring environmental impact and has not been consistent in its long-term sustainability. This paper does not compare the production done by SMEs with a certain period. Therefore, future research is expected to measure SSCM performance consistently in handling environmental impacts.

Declarations

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Conflict of interest: The authors declare no conflict of interest.
Additional information: No additional information is available for this paper.

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