



Key Actor Selection for Sustainable Supply Chain Based on Integration of SCOR DS-TOPSIS in Tapioca and Mocaf Agro-Industry

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Article Info

Article type:
Research Article

Article history:
Received November 23, 2025
Received in revised form January 3, 2026
Accepted March 25, 2026
Available online April 14, 2026

Keywords:
business process
KPI performance matrix
Mocaf
preference value
tapioca

ABSTRACT

Objective: High wheat flour imports pose a high risk to the sustainability of the food industry in the event of trade wars and product boycotts by exporting countries, creating an urgent need to develop local flour as an alternative to imported wheat flour consumption. This study aims to identify and analyze sustainability related performance challenges within the tapioca and Mocaf flour supply chains in West Java.

Methods: The research applies an integrated of the SCOR DS and TOPSIS to determine priority solutions for improving the KPI performance matrix based on key actors in the supply chain. A stratified sampling method was used in West Java, specifically in Bogor, Sukabumi, Bandung, Garut, and Sumedang.

Results: The findings show that tapioca SMEs represent the ideal solution node for improving supply chain performance, with a preference value of 0.50. Based on this ideal solution, performance improvement in the tapioca and Mocaf agro-industry supply chain in West Java should focus on coarse tapioca SMEs, prioritizing Source Availability in the KPI AM.1.1 Cash to Cash Cycle.

Conclusion: Enhancing the performance of tapioca and Mocaf flour supply chains particularly by strengthening Source Availability and shortening the AM.1.1 Cash to Cash Cycle at coarse tapioca SMEs will reinforce the economic resilience of local flour-based agro-industrial actors. These improvements foster inclusive and sustainable industrial development and support the achievement of Sustainable Development Goal 9 on Industry, Innovation and Infrastructure.

Cite this article: Santosa, S. H., Marimin., Sunarti, T. C., & Munandar. J. M. (2026). Key Actor Selection for Sustainable Supply Chain Based on Integration of SCOR DS-TOPSIS in Tapioca and Mocaf Agro-Industry. *International Journal of Supply and Operations Management*, XX(X), pages. <https://doi.org/10.22034/ij som.2026.110954.3518>



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Publisher: Kharazmi University
DOI: <https://doi.org/10.22034/ij som.2026.110954.3518>

1. Introduction

The processed food industry in Indonesia currently faces significant challenges in achieving sustainability, particularly concerning its reliance on imported raw materials. The current flour consumption pattern in Indonesia stands at 2.7 kg per capita per year with 53.98% of the wheat supply sourced from and price fluctuations from suppliers to end consumers can reach up to 32.4% from importers to consumers (Statistic Indonesia, 2023). This consumption dependency has led Indonesia to import 11.7 million tons of wheat grains to meet the production needs of flour in the (Statistic Indonesia, 2024). This situation poses stability issues for the food industry for countries that have a high dependency on imports of wheat flour and wheat grains, especially in the event of trade conflicts, war or product boycotts.

Conflicts such as the Russia and Ukraine war underscore the fragility of wheat-dependent food industries, where crisis-driven demand shifts can push facility location and resilience strategy costs above 90% of total system expenses, and inadequate robust planning may increase information related costs by about 27% (Rahbari et al., 2025). Global crises, particularly the Russia and Ukraine war, have intensified demand volatility and raised wheat supply chain costs, thereby heightening Indonesia's exposure to price and supply shocks and reinforcing the urgency of developing resilient local flours such as tapioca and Mocaf.

Addressing the dependency on imported wheat flour can be achieved by developing alternative local flour sources that can replace wheat flour. Tapioca flour and Mocaf represent local flour options with significant potential to substitute for wheat flour in products such as noodles, bread, and cookies, potentially reaching a 100% substitution rate (Trisna et al., 2016).

The supply chain for the tapioca and Mocaf agro-industry faces serious challenges due to a decline in cassava production, which has decreased by 1.5 million tons across Indonesia (Ministry of Agriculture of the Republic of Indonesia, 2023). In West Java, a key production center for cassava, productivity has dropped by 599,000 tons (Ministry of Agriculture of the Republic of Indonesia, 2023). The availability of sufficient raw materials is a crucial factor in the successful management of supply and local flour business operations (Suradi, 2023).

Small and medium enterprises (SMEs) producing tapioca and Mocaf in this region face challenges in meeting diverse market demand (Ronie et al., 2025). The cassava market management is currently dominated by middlemen, resulting in farmers lacking clear information regarding market needs (Santosa et al., 2022; Tama et al., 2019).

This situation creates issues in the supply-demand balance within the supply chain, leading to inefficiencies in the flow of raw materials, information, and financial aspects. Ensuring a sustainable supply and effective management of raw materials, information, and finances is crucial (Pinguanglek et al., 2017). Enhancing transparency in price and market information can improve the performance of each actor in the supply chain while simultaneously increasing the competitiveness of the local flour-based food industry (Bell et al., 2016; Ghadimi & Aouam, 2021).

The decline in raw cassava supply from farmers, along with the challenges faced by small and medium enterprises in processing tapioca and Mocaf, represents a critical challenge that must be addressed to enhance the performance of the local flour supply chain. Resolving these issues is essential for effectively substituting imported wheat flour products. One promising final product for this substitution is cookies, where wheat flour can be replaced with tapioca and Mocaf by up to 50% to 100% rate (Trisna et al., 2016). A thorough analysis of the supply chain performance at each actor level is necessary to identify improvements for key actors and formulate corrective measures for the tapioca and Mocaf agro-industry supply chain in West Java.

The novelty of this study lies in an innovative SCOR DS TOPSIS based decision framework that transforms supply chain process mapping into quantifiable, actor specific improvement priorities, thereby enhancing the resilience, continuity, and sustainable development of tapioca and Mocaf flour supply chain in accordance with Sustainable Development Goals (SDGs) 9. This research advances SDGs 9 by promoting resilient infrastructure, inclusive and

sustainable industrialization, and innovation to strengthen national food self-reliance through locally sourced flours specifically tapioca and Mocaf thus reducing dependence on imported wheat and wheat flour.

2. Literature Review of Integration Priority Rating Method

The SCOR method has been employed to evaluate the performance of Maintenance, Repair, and Overhaul (MRO) processes, while AHP is used to prioritize which processes should be redesigned based on their MRO performance scores (Palma-mendoza, 2014). Supplier selection for a major hypermarket in Selangor, Malaysia has also been conducted using an integrated AHP–SCOR approach, where AHP determines the weights or importance levels of 41 criteria and SCOR is applied to rate supplier performance according to business processes (Nazim et al., 2017). In both cases, integrating AHP and SCOR enables the identification of the most appropriate processes for redesign within the airline MRO context.

SCOR has been combined with ANFIS (Adaptive Neuro-Fuzzy Inference System) to appraise and rank suppliers against 14 sustainability-oriented factors, such as technological advancement, cost efficiency, reliability, and delivery punctuality. In this framework, TOPSIS first generates performance scores for the suppliers, which are subsequently used as inputs to ANFIS to capture nonlinear relationships and forecast the sustainability of supplier performance (Okwu & Tartibu, 2020). A separate study applies SCOR to quantify supplier performance and Fuzzy TOPSIS to derive normalize KPI values in a performance matrix for identifying the most suitable supplier, but the analysis concentrates primarily on cost and delivery process metrics and does not explicitly integrate environmental and social sustainability dimensions across the entire supply chain (Rahbari et al., 2025).

The integration of ANP and SWOT has been applied to analyse the Iranian saffron supply chain and export system during the COVID-19 pandemic at a strategic level by structuring factors into Strengths, Weaknesses, Opportunities, and Threats and then prioritising development strategies through combined AHP–SWOT and ANP–SWOT, yielding a ranked list of high-level policy options rather than operational process improvements (Dorcheh & Rahbari, 2024). This approach is not suitable for the present study because it cannot identification performance issues in the tapioca and Mocaf supply chain at the operational level covering plan, order, source, transform, fulfil, and return needed to support decisions on improving key actors in a sustainable supply chain. The integrated SCOR DS–TOPSIS method offers a innovation and, to the authors' knowledge, previously unexplored approach for identifying priority actors for performance improvement in the sustainable tapioca and Mocaf agro-industrial supply chain.

3. Materials and Methods

The probabilistic sampling method is employed when the population of observations is known, while the non-probabilistic sampling method is used when the population size is unknown (Meister et al., 2023). Analysis for identifying the ideal solutions to improve supply chain performance is conducted through the integration of SCOR DS model and TOPSIS. The SCOR DS model is applied to measure supply chain performance based on sustainable variables such as plan, order, source, transform, Fulfill and return (Adwiyah et al., 2024; Sassone et al., 2024). TOPSIS is a multi-criteria decision-making method used to determine the ideal solution among various alternatives, utilizing normalized values to establish preference scores for selecting alternatives (Anbarkhan, 2023).

3.1. Sampling Method

The determination of sample size is conducted using the lemeshow method, employing stratified, purposive, and snowball sampling techniques. The Lemeshow method is utilized to ascertain the sample size when the population cannot be precisely identified (Naing et al., 2022). The formulation of the Lemeshow method is as follows (Kramer & Zimmerman, 2007):

$$n = \left(\frac{Z^2 - p(1-p)}{d^2} \right)$$

Where:

n = Sample size

Z^2 = Value of the confidence level at significance level ($\alpha/2$)

P = Estimated proportion of the observed population

d = Margin error

Stratified sampling is a sampling method that ensures each subgroup or stratum within the population is represented according to the appropriate proportions (Masyithah et al., 2025). Purposive sampling is a technique in which the researcher selects specific individuals or groups based on criteria relevant to the research objectives (Paul et al., 2013). This method is utilized to identify SMEs producing coarse and fine tapioca. Snowball sampling is a technique in which already participating individuals assist in finding and recommending new participants, thereby forming a network (Chang & Chen, 2022).

3.2. SCOR DS

The Supply Chain Operation Reference Digital Standard (SCOR DS) method assesses supply chain issues with a focus on Orchestrate, where the business processes involved are plan, order, source, transform, Fulfill, and return (ASCM, 2022; Khairunnisa Naziro, 2025; Kunovjanek et al., 2022). The determination of weights for each level using pairwise comparison as follows:

3.2.1 Vektor Eigen (VE)

The Eigen Vector (EV) serves to determine the relative weights of the criteria or alternatives being analyzed. The calculation of the EV is as follows: (Al Khoiry et al., 2022)

$$VE (Ki) = C^n \sqrt{\left(\prod_{j=1}^n a_{ij} \right)} \quad (1)$$

3.2.2 Priority Vector (VP)

The Priority Vector (PV) is the result of the normalization process, indicating the order of importance of the criteria or alternatives being evaluated. The formulation of the Priority Vector (PV) is as follows: (Singh & Sarkar, 2019)

$$Vp (Ki) = \frac{VE (Ki)}{\sum VE} \quad (2)$$

3.2.3 Consistency Index (CI)

The Consistency Index (CI) is a measure used to assess the extent to which the judgments in the comparison matrix remain consistent. The formulation of the Consistency Index (CI) is as follows: (Zhu et al., 2020)

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

3.2.4 Consistency Ratio (CR)

The Consistency Ratio (CR) is the comparison between the Consistency Index and a random value, used to measure the level of consistency in decision-making. The formulation of the Consistency Ratio (CR) is as follows: (Cinar & Cebi, 2020)

$$CR = \frac{CI}{RI}; CR < 0.1 \text{ (Konsisten)} \quad (4)$$

3.2.5 Determination of Snorm Value

Snorm de Boer (Supply Chain Operations Reference Norm) is a measure used to assess and compare supply chain performance against established standards. The calculation of Snorm de Boer is as follows: (Ernawati et al., 2022)

$$\text{Larger is Better: } Snorm = \left(\frac{Si - Smin}{Smax - Smin} \right) \times 100 \quad (5)$$

$$\text{Lower is Better: } S_{norm} = \left(\frac{S_{max} - S_i}{S_{max} - S_{min}} \right) \times 100 \quad (6)$$

3.2.6 Performance Value Matrix

Performance Value Matrix is developed based on the performance value assessment of the business processes namely plan, order, source, transform, Fulfill and return across five actors in the supply chain within the SCOR DS framework. The decision matrix based on performance values is as follow: (Wątróbski et al., 2022).

$$\text{SCOR DS Performance Value} = (w_1 \times S_{norm}(K_1)) + (w_2 \times S_{norm}(K_2)) + (w_n \times S_{norm}(K_n)) \quad (7)$$

Where:

W = Weight AHP

Snorm (k) = Normalization Score Value

3.3. TOPSIS

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is a multicriteria decision-making approach that evaluates alternatives based on how close they are to the positive ideal solution and how far they are from the negative ideal solution (Lima-Junior & Carpinetti, 2016). The formulation of TOPSIS is as follows: (Lima-Junior & Carpinetti, 2016).

3.3.1 TOPSIS-SCOR DS Integration Matrix

The integration of SCOR performance values is carried out by mapping the business process scores of each actor in the supply chain, obtained from SCOR DS, into the TOPSIS framework. A mathematical relation matrix is used to link SCOR DS outputs to the TOPSIS performance matrix, where the p is performance row corresponds and a is actor (farmers, coarse tapioca, fine tapioca, Mocaf, and cookies), and the row sets consist of Plan (P1, P2, ..., Pm), Order (O1, O2, ..., Om), Source (S1, S2, ..., Sm), Transform (T1, T2, ..., Tm), Fulfill (F1, F2, ..., Fm), and Return (R1, R2, ..., Rm). Based on this performance matrix and the SCOR DS row sets, the formulation for constructing the TOPSIS decision matrix is then derived as follows:

$$\text{Total Plan} = \sum_{p \in \text{plan}} PV_{p,a} \quad (8)$$

$$\text{Total Source} = \sum_{s \in \text{source}} PV_{s,a} \quad (9)$$

$$\text{Total Order} = \sum_{o \in \text{order}} PV_{o,a} \quad (10)$$

$$\text{Total Transform} = \sum_{t \in \text{transform}} PV_{t,a} \quad (11)$$

$$\text{Total Fulfill} = \sum_{f \in \text{fulfill}} PV_{f,a} \quad (12)$$

$$\text{Total Return} = \sum_{r \in \text{return}} PV_{r,a} \quad (13)$$

3.3.2 Normalization of the Decision Matrix

Normalization vector in the TOPSIS method serves to convert the values of various alternatives into a uniform scale, facilitating comparison in determining the ideal solution. This can be observed in the following formula: (Pathan et al., 2022)

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{i2ij}}} \quad (14)$$

3.3.3 Ideal Solution Level

The Positive Ideal Solution (A^+) represents the best alternative, where the maximum values are taken for advantageous criteria and the minimum values for disadvantageous criteria. The formulation of the desired solution is as follows: (Pathan et al., 2022)

$$A^+ = \{(v_1^+, v_2^+, \dots, v_n^+) = (\max_j v_{ij} | i \in i^*), (\min_j v_{ij} | i \in i^{**})\} \quad (15)$$

The Negative Ideal Solution (A^-) represents the worst alternative, where the maximum values are taken for advantageous criteria and the minimum values for disadvantageous criteria. The formulation of the desired solution is as follows: (Pathan et al., 2022)

$$A^- = \{(v_1^-, v_2^-, \dots, v_n^-) = (\max_j v_{ij} | i \in i^*), (\min_j v_{ij} | i \in i^{**})\} \quad (16)$$

3.3.4 Classical Euclidean Distance

The technique for measuring the distance between two points in the context of decision analysis is crucial. In the TOPSIS method, this is used to determine how close the evaluated alternatives are to the ideal solution. The Euclidean distance is defined as follows: (Gul & Yucesan, 2022)

$$D_i^+ = \sum_{j=1}^n \sqrt{(V_{ij} - V_i^+)^2} \quad (17)$$

$$D_i^- = \sum_{j=1}^n \sqrt{(V_{ij} - V_i^-)^2} \quad (18)$$

3.3.5 Preference Value

The Preference Value refers to a measure that indicates how well an alternative meets the specified criteria in the decision-making process. The formulation of the preference value is as follows: (Gul & Yucesan, 2022)

$$C_i^* = D_i^+ / (D_i^+ + D_i^-) \quad (19)$$

3.3.6 Business Model Canvas

The Business Model Canvas (BMC) is a visual framework that summarizes how a business creates, delivers, and captures value through key components such as Value Proposition, Channels, Customer Segments, Key Activities, Key Resources, and Key Partners. This framework facilitates the analysis and innovation of business models (Salwin et al., 2022; Taipale-Eräväla et al., 2020)

4. Results

The challenges within the agro-industrial supply chain of cassava and Mocaf in West Java currently impact the availability of cassava raw materials and flour products. This situation necessitates an analysis of the supply chain conditions among five key actors: farmers, coarse tapioca SMEs, fine tapioca SMEs, Mocaf SMEs, and cookie SMEs. The analysis will proceed through the following stages:

4.1 Development of the SCOR DS Structure

The initial stage of the research involves developing the SCOR DS structure for assessing supply chain performance. This development is based on a literature review and in-depth interviews with researchers, government agencies, associations, and industry practitioners. The SCOR DS hierarchical model was established through a structured review of the relevant literature and then corroborated by domain experts, stakeholders, and industry associations. The

literature review is utilized to analyze the key variables related to the initial problems in supply chain performance, as detailed in Table 1.

Table 1. Literature review for development SCOR DS Structure

Authors	Study result
(Adwiyah et al., 2024)	The SCOR DS for palm oil industry performance utilizes an 11 KPI performance matrix, with the optimal KPI matrix achieving a perfect order.
(Wijaya Apip et al., 2025)	The SCOR DS employs a 20 KPI performance matrix. The highest weight is assigned to the KPI for earnings before interest and taxes
(Sassone et al., 2024)	The SCOR DS structure includes Orchestrate, Plan, Source, Transform, Fulfill, and Return, wherein the Sales Process receives the highest research attention.

The results of the literature review identification are employed to develop the SCOR DS structure, which can be utilized to measure the supply chain performance of tapioca and Mocaf in West Java. The findings from the literature review were combined with input from experts, stakeholders, associations, and supply chain actors to define the appropriate relationships within the SCOR DS hierarchy as a performance assessment tool for the tapioca and Mocaf supply chain in West Java, as presented in Table 2.

Table 2. Expertise, Stakeholder, Association, and Actor for development SCOR DS Structure

No	Expertise, Stakeholder, Association, and Actor
1	National Research and Innovation Agency (BRIN) as an Expert in Tapioca and Mocaf Production
2	Head of Administration Subdivision, Food Crops, Horticulture, and Plantation Department of Bogor Regency. as a Stakeholder in Agricultural Extension Management
3	National Executive Board of the Indonesian Cassava Society (MSI) as an Association Managing Cassava-Based Processed Products
4	Farmers Group Association (Gapoktan) as an Actor in Cassava Raw Material Supply
5	Owner CV Tani Sadulur as an Actor in Coarse Tapioca Production
6	Head of Marketing CV Wangun for Fine Tapioca Business as an actor in Fine Tapioca Production
7	Barokah Women Farmers Group (KWT) as an Actor in Mocaf Flour Production
8	Owner of Cassakies Cookies as an Actor in Cookies Production Using Tapioca and Mocaf

The configuration of experts, stakeholders, associations, and actors presented in Table 2 provides an institutional foundation for the hierarchical SCOR DS model. This arrangement brings together perspectives from research institutions, government agencies, farmer groups, and cassava-based agro-industries, ensuring that the model reflects actual roles and responsibilities along the tapioca and Mocaf supply chain. These institutional inputs are then translated into process categories and performance indicators that populate the SCOR DS framework.

Based on the results of the literature review and in-depth interviews with individuals possessing relevant expertise, professions, and stakeholders, 11 process categories and 18 KPI performance metrics were identified within the SCOR

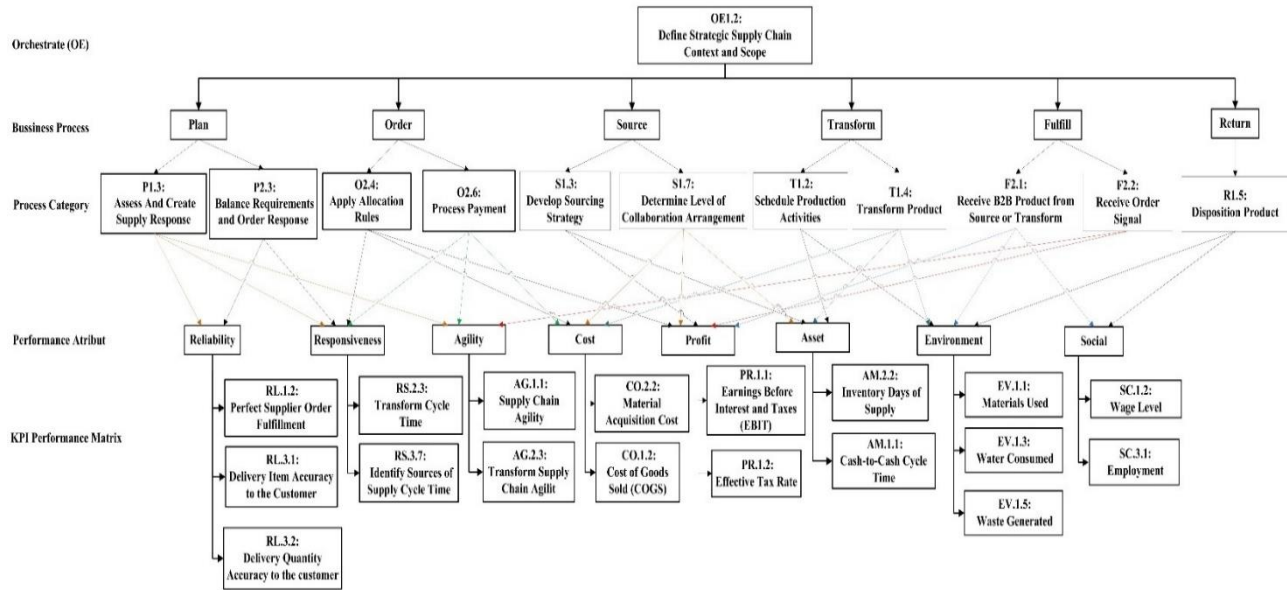


Figure 1. The Structure of SCOR DS

DS structure. The structure of SCOR DS is illustrated in Figure 1.

4.2 Determination of Sample Size

The research locations were determined based on the five largest cassava production regions in West Java, namely Garut, Sukabumi, Bandung, Sumedang, and Bogor, which contribute a total production of 1,210,207 tons, accounting for 81% of the total production in West Java (Horticulture, 2022). The determination of the number of farmers and tapioca SMEs is presented in Table 3.

Table 3. Basis for Determining the Value of the Lemeshow Component

Authors	Result
(Paul et al., 2013)	If $P < \alpha$ (5%) is significant level, it indicates a 5% risk of rejecting the true H_0
(Agussabti et al., 2022)	The variables of capital and farmer participation demonstrate a significant effect at the α level ($P < \alpha$ (5%)), leading to the rejection of the H_0 .
(Robertson et al., 1984)	This study adopts $\alpha = 5\%$ (significance level = 95%), recognizing that sample size directly influences interval width and thus the precision of the estimates
(Kramer & Zimmerman, 2007)	Population limitations can be addressed using $\alpha = 10\%$, whereby $P < \alpha$ (10%) leads to the rejection of the H_0 ,
(Naing et al., 2022)	With a prevalence value of 25% and a margin of error of 10%, the population boundary is determined to be 15% to 35%

Based on the criteria for determining parameter values, the sample size of farmers and small-medium enterprises (SMEs) producing raw tapioca in the five sampling regions was established. The Lemeshow method was employed due to the inability to identify the population of actors, as detailed in Table 4.

Table 4. Determination of Sample Size Using the Lemeshow Method

Actor	Component Value				Sample Size	Sampling Method
	α	Z (1- α /2)	P	d		
Casava Farmer	0,05	1,96	0,25	0,1	72	Purposive Sampling
Coarse Tapioca SMEs	0,10	1,65	0,15	0,1	35	Purposive Sampling

The selection of SMEs producing raw tapioca was carried out using purposive sampling with a minimum production criterion of once per week and a minimum use of 1000 kg of cassava per production, ensuring connectivity with SMEs producing raw tapioca. The number of SMEs in Bogor is 18, Sukabumi is 8, Bandung is 5, and in Sumedang is 4. Purposive sampling techniques were also employed to identify SMEs producing fine tapioca that are connected to those producing raw tapioca, with a minimum production capacity of 1000 kg per production. Based on purposive sampling, a total of 5 active SMEs producing fine tapioca were identified in the regions of Bogor, Bandung, and Sukabumi.

The selection of Mocaf and Cookies SMEs, the Snowball method was utilized due to the very limited population and lack of clear information regarding the locations of these SMEs. Total of 8 samples of Mocaf SMEs were obtained, with 3 samples from Bogor, 2 sample from Sukabumi, 2 sample from Bandung, and 1 sample from Sumedang. The Snowball sampling yielded 13 Cookie SMEs were obtained, with 4 sample from Bogor, 2 sample from Sukabumi, 4 samples from Bandung, and 3 samples from Garut.

4.3 Integration of SCOR DS-TOPSIS

The issues surrounding the performance of sustainable supply chains can be analyzed using the SCOR DS method in a holistic manner for multiple actors, integrating a sustainable performance assessment model and multi-actor multi-criteria decision-making. The integration of the SCOR DS model and TOPSIS for determining ideal solutions to improve supply chain performance, based on the prioritization of actor improvements, is as follows:

Based on the network structure, the SCOR DS analysis was conducted across five actors in the supply chain, including 72 samples of cassava farmers. The weighting of all actors was performed using the SCOR DS hierarchy and integrated using the geometric mean method. The weights at the Orchestrated Level (OE) in relation to the Business Process (BP), with a consistency ratio (CR) of less than 0.10, are presented in Table 5.

Table 5. Results of the OE-BP Level Weighting in the SCOR DS Model for Farmers

OE - BP	Plan	Order	Source	Transform	Fulfill	Return	VE	VP	VA	VB	λ_{max}	CI	CR
Plan	1.00	3.33	1.89	0.90	3.55	0.22	1.28	0.16	1.03	6.31			
Order	0.30	1.00	0.23	0.23	0.46	0.16	0.32	0.04	0.26	6.26			
Source	0.53	4.38	1.00	0.58	2.70	0.28	1.00	0.13	0.79	6.19	6.30	0.06	0.05
Transform	1.11	4.31	1.71	1.00	4.37	0.36	1.53	0.20	1.19	6.12			
Fulfill	0.28	2.19	0.37	0.23	1.00	0.27	0.49	0.06	0.40	6.39			
Return	4.62	6.17	3.58	2.81	3.77	1.00	3.20	0.41	2.66	6.51			

Based on the geometric mean results from farmers in the regions of Bogor, Sukabumi, Bandung, Garut, and Sumedang, the weighting values at the Business Process (BP) and Process Category (PC) levels were obtained, with a consistency ratio (CR) of less than 0.1. The determined weights at the BP-PC level for farmers are presented in Table 6.

Table 6. Results of the BP-PC Level Weighting in the SCOR DS Model for Farmers

BP-PC	Plan	Order	Source	Transform	Fulfill	Return	Weights
P1.3: Assess and Create Supply Response	0.77						0.13
P2.3: Balance Requirements and Order Response	0.23						0.04
O2.4: Apply Allocation Rules		0.20					0.01
O2.6: Process Payment		0.80					0.03
S1.3: Develop Sourcing Strategy			0.19				0.02
S1.7: Determine Level of Collaboration Arrangement			0.81				0.10
T1.2: Schedule Production Activities				0.32			0.06
T1.4: Transform Product				0.68			0.13
F2.1: Receive B2B Product from Source or Transform					0.77		0.05
F2.2: Receive Order Signal					0.23		0.01
R1.5: Disposition Product						1.00	0.41
OE-BP Weights Level	0.16	0.04	0.13	0.20	0.06	0.41	1

Based on the geometric mean results, the weighting values at the Process Category (PC) level in relation to the Performance Attributes (PA) at the farmer level were obtained. The results of the questionnaire responses, with a consistency ratio (CR) threshold of less than 0.1 yielded the determined weights, as presented in Table 7.

Table 7. Results of the PC-PA Level Weighting in the SCOR DS Model for Farmers

PC-PA	P1.3	P2.3	O2.4	O2.6	S1.3	S1.7	T1.2	T1.4	F2.1	F2.2:	R1.5	Weights
Reliability (RL)	0.16	0.81										0.05
Responsiveness (RS)	0.84	0.19	0.64	0.51								0.13
Agility (AG)	0.34			0.30						0.75		0.06
Cost (CS)			0.16	0.19	0.64			0.23				0.05
Profit (PF)			0.20		0.23	0.39			0.11	0.25		0.06
Asset (AS)					0.13	0.61	0.17	0.39				0.13
Environment (EN)							0.83	0.38	0.64		0.77	0.45
Social (SC)									0.25		0.23	0.11
BP-PC Weights Level	0.13	0.04	0.01	0.03	0.02	0.10	0.06	0.13	0.05	0.01	0.41	1

Based on the geometric mean results, the weighting values at the third level, specifically the Performance Attributes (PA) in relation to the Key Performance Indicator (KPI) Performance Matrix (PM) for farmers, were obtained. The weights were determined with a consistency ratio (CR) of less than 0.10, as shown in Table 8.

The SCOR DS values for cassava farmers are subsequently normalized by incorporating the weights derived from the Analytical Hierarchy Process (AHP). The AHP weighting process, and values for cassava farmers are normalized through the Snorm de Boor technique. This normalization aligns with the performance trends reflected by each variable in the KPI performance matrix. The resulting normalized performance for farmers is presented in Table 9.

Table 8. Results of the PA-PM Level Weighting in the SCOR DS Model for Farmers

PA-PM	RL	RS	AG	CS	PF	AS	EN	SC	Weight
RL.1.2: Perfect Supplier Order Fulfilment	0.56								0.029
RL.3.1: Delivery Item Accuracy to the Customer	0.28								0.014
RL.3.2: Delivery Quantity Accuracy to the customer	0.16								0.008
RS.2.3: Transform Cycle Time		0.61							0.082
RS.3.7: Identify Sources of Supply Cycle Time		0.39							0.053
AG.1.1: Supply Chain Agility			0.74						0.047
AG.2.3: Transform Supply Chain Agility			0.26						0.017
CO.2.2: Material Acquisition Cost				0.65					0.035
CO.1.2: Cost of Goods Sold (COGS)				0.35					0.019
PR.1.1: Earnings Before Interest and Taxes (EBIT)					0.43				0.024
PR.1.2: Effective Tax Rate					0.57				0.032
AM.2.2: Inventory Days of Supply						0.17			0.022
AM.1.1: Cash-to-Cash Cycle Time						0.83			0.107
EV.1.1: Materials Used							0.12		0.054
EV.1.3: Water Consumed							0.64		0.288
EV.1.5: Waste Generated							0.24		0.107
SC.1.2: Wage Level								0.15	0.016
SC.3.1: Employment								0.85	0.091
PC-PA Weights Level	0.05	0.13	0.06	0.05	0.06	0.13	0.45	0.11	1

Table 9. Normalization Value KPI Performance Matrix

Business Process	Performance Attribute	Performance KPI Matrix	UoM	Actual	Minimum	Maximum	Normalization Value	
Plan	Reliability	RL.1.2	%	99.25	96.08	100.00	80.85	
		RL.3.1	%	99.08	91.04	99.89	90.89	
		RL.3.2	%	100.00	96.13	100.00	100.00	
	Responsiveness	RS.2.3	Days	258.75	228.75	319.17	66.82	
		RS.3.7	Days	3.68	1.00	8.69	65.16	
	Agility	AG.1.1	%	99.08	95.69	99.72	84.14	
		AG.2.3	Days	2.00	1.00	3.21	54.72	
	Order	Reliability	RL.1.2	%	99.25	96.08	100.00	80.85
			RL.3.1	%	99.08	91.04	99.89	90.89
			RL.3.2	%	100.00	96.13	100.00	100.00
		Responsiveness	RS.2.3	Days	258.75	228.75	319.17	66.82
			RS.3.7	Days	3.68	1.00	8.69	65.16
Order		Responsiveness	RS.2.3	Days	258.75	228.75	319.17	66.82
	RS.3.7		Days	3.68	1.00	8.69	65.16	
	Cost	CO.2.2	Rp	2700.00	2305.56	3075.00	48.74	
		CO.1.2	Rp	705.56	533.33	805.56	36.73	
	Profit	PR.1.1	Rp	40.42	0.00	64.44	62.72	
		PR.1.2	%	0.51	0.00	1.37	62.94	
	Order	Responsiveness	RS.2.3	Days	258.75	228.75	319.17	66.82
RS.3.7			Days	3.68	1.00	8.69	65.16	
Agility		AG.1.1	%	99.08	95.69	99.72	84.14	
	AG.2.3	Days	2.00	1.00	3.21	54.72		
Order	Cost	CO.2.2	Rp	2700.00	2305.56	3075.00	48.74	

Business Process	Performance Attribute	Performance KPI Matrix	UoM	Actual	Minimum	Maximum	Normalization Value
		CO.1.2	Rp	705.56	533.33	805.56	36.73
	Profit	PR.1.1	Rp	40.42	0.00	64.44	62.72
		PR.1.2	%	0.51	0.00	1.37	62.94
	Asset	AM.2.2	Days	2.00	1.26	3.43	66.03
		AM.1.1	Days	261.54	256.88	320.79	92.70
Source	Cost	CO.2.2	Rp	2700.00	2305.56	3075.00	48.74
		CO.1.2	Rp	705.56	533.33	805.56	36.73
	Profit	PR.1.1	Rp	40.42	0.00	64.44	62.72
		PR.1.2	%	0.51	0.00	1.37	62.94
	Asset	AM.2.2	Days	2.00	1.26	3.43	66.03
		AM.1.1	Days	261.54	256.88	320.79	92.70
	Cost	CO.2.2	Rp	2700.00	2305.56	3075.00	48.74
		CO.1.2	Rp	705.56	533.33	805.56	36.73
	Asset	AM.2.2	Days	2.00	1.26	3.43	66.03
		AM.1.1	Days	261.54	256.88	320.79	92.70
Transform	Environment	EV.1.1	Kg	94.72	58.19	128.19	52.18
		EV.1.3	M ³	24.24	18.13	38.33	69.76
		EV.1.5	Kg	15.00	10.00	26.60	69.87
	Asset	AM.2.2	Days	2.00	1.26	3.43	66.03
		AM.1.1	Days	261.54	256.88	320.79	92.70
		EV.1.1	Kg	94.72	58.19	128.19	52.18
Environment	EV.1.3	M ³	24.24	18.13	38.33	69.76	
	EV.1.5	Kg	15.00	10.00	26.60	69.87	
	PR.1.1	Rp	40.42	0.00	64.44	62.72	
	Profit	PR.1.2	%	0.51	0.00	1.37	62.94
		EV.1.1	Kg	94.72	58.19	128.19	52.18
	Environment	EV.1.3	M ³	24.24	18.13	38.33	69.76
		EV.1.5	Kg	15.00	10.00	26.60	69.87
Fulfill		Social	SC.1.2	Rp/Day	60000	50000	70833
	SC.3.1		People	3.19	2.74	4.69	76.60
	Agility	AG.1.1	%	99.08	95.69	99.72	84.14
		AG.2.3	Days	2.00	1.00	3.21	54.72
	Profit	PR.1.1	Rp	40.42	0.00	64.44	62.72
		PR.1.2	%	0.51	0.00	1.37	62.94
	Environment	EV.1.1	Kg	94.72	58.19	128.19	52.18
Return		EV.1.3	M ³	24.24	18.13	38.33	69.76
		EV.1.5	Kg	15.00	10.00	26.60	69.87
	Social	SC.1.2	Rp/Day	60000	50000	61667	85.71
		SC.3.1	People	3.19	2.74	4.69	76.60

The rank of the required performance improvements among tapioca and Mocaf supply chain actors. This study first organizes the SCOR DS framework into a hierarchical structure and associates each process level with a set of quantifiable KPI performance matrix. The Analytical Hierarchy Process (AHP) is then applied to assign weights to SCOR DS attributes and metrics based on expert assessments, so that the resulting performance appraisal captures both strategic priorities and real operational conditions in the agro-industrial tapioca and Mocaf.

Based on the results of weight assignment and normalization, SCOR DS determined for each KPI Performance Matrix, using the business process structure for each actor. The weights for Coarse tapioca, Fine Tapioca, Mocaf, and Cookies SMEs are subsequently established. The results of AHP weighting in the SCOR DS hierarchy for all Tapioca and Mocaf agro-industry supply chain actors are presented in Figure 2.

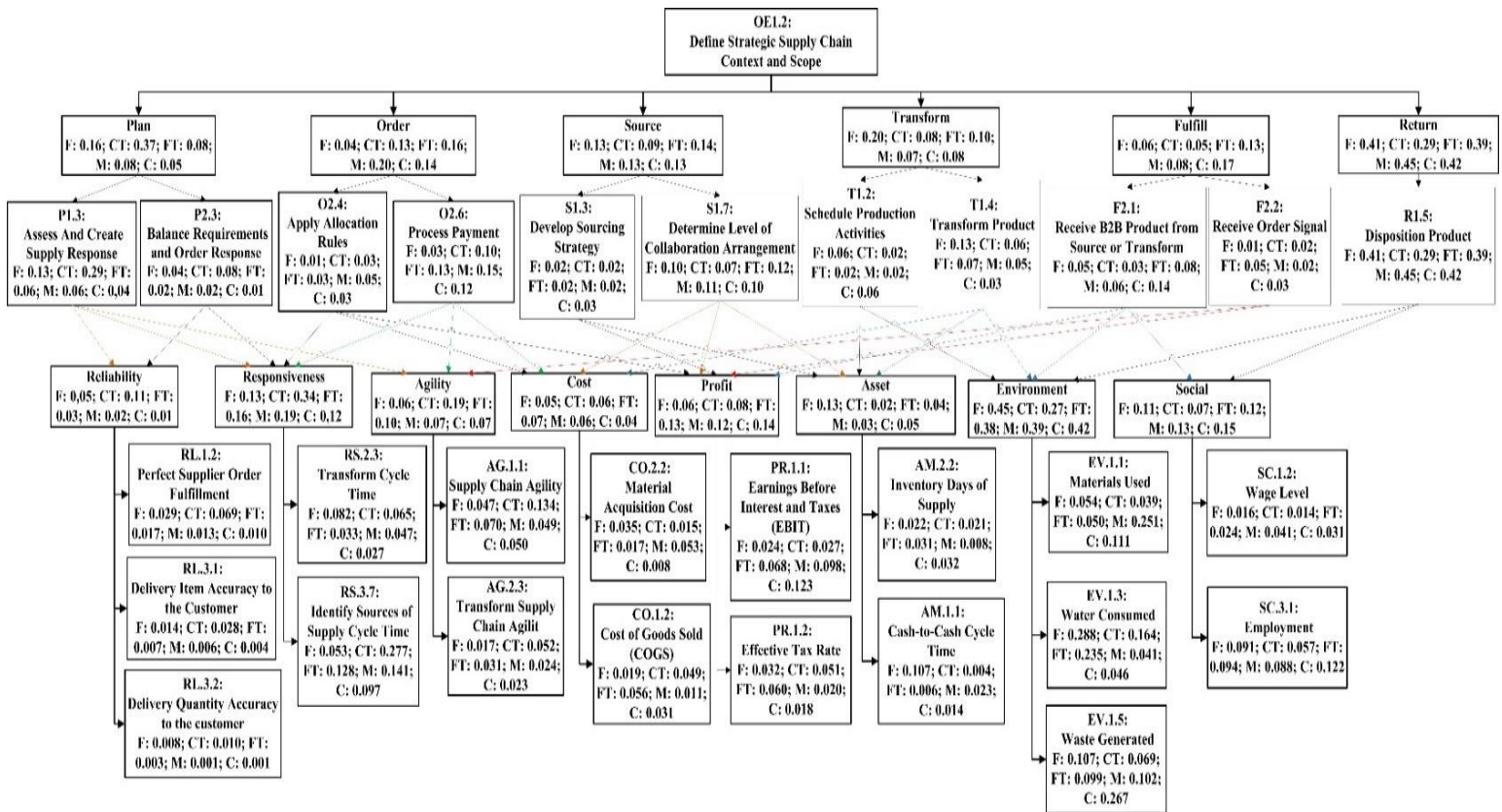


Figure 2. AHP Weights for all Actor within the SCOR DS Framework

Based on the determined weights, data normalization was subsequently performed using the Snorm de boer method. The results of the data normalization for 72 cassava armers (F), 35 coarse tapioca SMEs (CT), 5 fine tapioca SMEs (FT), 11 Mocaf SMEs (M), and 14 cookiesSMEs (C). The Normalized Values for Each Actor within the SCOR DS framework are presented in the Figure 3.

The Validation and reliability testing of the questionnaire results are based on the Consistency Ratio (CR) value (Iskandar et al., n.d.). A Consistency Ratio (CR) > 10% indicates that expert pairwise judgements are internally consistent and reliable, so the resulting AHP weights for SCOR DS indicators provide a sound basis for evaluating supply chain performance (Dorcheh & Rahbari, 2024). The CR values for each actor are presented in Table 10.

Variable	Farmers		Coarse Tapioca SMEs		Fine Tapioca SMEs		Mocaf SMEs		Cookies SMEs		CR Status (> 0,10)
	λ_{max}	CR	λ_{max}	CR	λ_{max}	CR	λ_{max}	CR	λ_{max}	CR	
P1.3 (Reliability - Responsiveness - Agility)	3.05	0.05	3.06	0.05	3.05	0.04	3.09	0.07	3.02	0.01	Valid
P2.3 (Reliability - Responsiveness)	2	0	2	0	2	0	2	0	2	0	Valid
O2.4 (Responsiveness - Cost - Profit)	3	0	3.06	0.05	3.05	0.04	3.09	0.07	3.06	0.05	Valid
O2.6 (Responsiveness - Agility - Cost)	3	0	3.05	0.04	3.06	0.05	3.04	0.03	3.04	0.04	Valid
S1.3 (Profit - Asset)	2	0	2	0	2	0	2	0	2	0	Valid
S1.7 (Cost - Profit - Asset)	3.03	0	3.04	0.04	3.05	0.04	3.04	0.03	3.06	0.05	Valid
T1.2 (Asset - Environment)	2.04	0	2	0	2	0	2	0	2	0	Valid
T1.4 (Cost - Asset - Environment)	3	0	3.06	0.05	3.06	0.04	3.06	0.06	3.05	0.05	Valid
F2.1 (Profit - Environment - Social)	3.04	0.03	3.05	0.05	3.05	0.05	3.05	0.05	3.02	0.02	Valid
F2.2 (Agility - Profit)	2	0	2	0	2	0	2	0	2	0	Valid
R1.5 (Environment-Social)	2	0	2	0	2	0	2	0	2	0	Valid
Performance Attribute (PRA)-											
Performance KPI Matrix (PRKM)											
Reliability (RL 1.2 - RL 3.1 - RL 3.2)	3.05	0.046	3.06	0.05	3.06	0.05	3.06	0.06	3.03	0.03	Valid
Responsiveness (RS 2.3 - RS 3.7)	2	0	2	0	2	0	2	0	2	0	Valid
Agility (AG 1.1 - AG 2.3)	2	0	2	0	2	0	2	0	2	0	Valid
Cost (CO 2.2 - CO 1.2)	2	0	2	0	2	0	2	0	2	0	Valid
Profit (PR 1.1 - PR 1.2)	2	0	2	0	2	0	2	0	2	0	Valid
Asset (AM 2.2 - AM 1.1)	2	0	2	0	2	0	2	0	2	0	Valid
Environment (EV 1.1 - EV 1.3 - EV 1.5)	3.07	0.06	3.05	0.05	3.06	0.05	3.04	0.03	3.02	0.02	Valid
Social (SC 1.2 - SC 3.1)	2	0	2	0	2	0	2	0	2	0	Valid

Based on the Consistency Ratio (CR) analysis used to assess the coherence of the AHP based SCOR DS questionnaire responses hierarchy, all items at every hierarchy level yielded a Consistency Ratio (CR) > 0.1. This result indicates that all SCOR DS questionnaire items are internally consistent and valid answered by respondent, and therefore appropriate for use in the subsequent normalization step and computation of performance values every actor in supply chain structure. Based on the AHP weights and the normalization with CR > 0.1 of each actor, the integrated performance score values across all actors within the supply chain, at the Business Process level and the KPI Performance Matrix in the SCOR DS framework are presented in Table 11.

Table 11. Supply Chain Performance Values Based on Weights and Normalization Values

Business Process	Performance Matrix	AHP Weight (AW)					Normalization Value (NV)					Performance Value (AW x NV)				
		Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs	Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs	Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs
Plan	RL.1.2	0.029	0.069	0.017	0.013	0.010	80.851	60.000	100.000	100.000	84.906	2.314	4.126	1.721	1.334	0.831
	RL.3.1	0.014	0.028	0.007	0.006	0.004	90.895	67.230	100.000	80.000	59.322	1.273	1.911	0.731	0.459	0.212
	RL.3.2	0.008	0.010	0.003	0.001	0.001	100.000	89.714	100.000	100.000	67.692	0.830	0.891	0.295	0.148	0.096
	RS.2.3	0.082	0.065	0.033	0.047	0.027	66.820	63.158	85.714	78.261	96.000	5.459	4.133	2.843	3.690	2.562
	RS.3.7	0.053	0.277	0.128	0.141	0.097	65.162	68.235	66.667	100.000	92.857	3.451	18.899	8.564	14.145	9.049
	AG.1.1	0.047	0.134	0.070	0.049	0.050	84.138	76.364	100.000	94.118	78.723	3.961	10.204	6.969	4.592	3.916
	AG.2.3	0.017	0.052	0.031	0.024	0.023	54.717	50.000	50.000	88.889	75.000	0.905	2.580	1.574	2.168	1.699
	RL.1.2	0.029	0.069	0.017	0.013	0.010	80.851	60.000	100.000	100.000	84.906	2.314	4.126	1.721	1.334	0.831
	RL.3.1	0.014	0.028	0.007	0.006	0.004	90.895	67.230	100.000	80.000	59.322	1.273	1.911	0.731	0.459	0.212
	RL.3.2	0.008	0.010	0.003	0.001	0.001	100.000	89.714	100.000	100.000	67.692	0.830	0.891	0.295	0.148	0.096
	RS.2.3	0.082	0.065	0.033	0.047	0.027	66.820	63.158	85.714	78.261	96.000	5.459	4.133	2.843	3.690	2.562
	RS.3.7	0.053	0.277	0.128	0.141	0.097	65.162	68.235	66.667	100.000	92.857	3.451	18.899	8.564	14.145	9.049
Order	RS.2.3	0.082	0.065	0.033	0.047	0.027	66.820	63.158	85.714	78.261	96.000	5.459	4.133	2.843	3.690	2.562
	RS.3.7	0.053	0.277	0.128	0.141	0.097	65.162	68.235	66.667	100.000	92.857	3.451	18.899	8.564	14.145	9.049
	CO.2.2	0.035	0.015	0.017	0.053	0.008	48.736	50.000	53.608	61.832	54.667	1.684	0.728	0.936	3.293	0.413
	CO.1.2	0.019	0.049	0.056	0.011	0.031	36.735	51.546	57.143	39.535	52.941	0.697	2.503	3.217	0.421	1.622
	PR.1.1	0.024	0.027	0.068	0.098	0.123	62.716	29.688	45.455	61.905	45.238	1.514	0.798	3.092	6.089	5.584
	PR.1.2	0.032	0.051	0.060	0.020	0.018	62.944	100.000	25.000	100.000	100.000	2.008	5.148	1.497	1.967	1.810
	RS.2.3	0.082	0.065	0.033	0.047	0.027	66.820	63.158	85.714	78.261	96.000	5.459	4.133	2.843	3.690	2.562
	RS.3.7	0.053	0.277	0.128	0.141	0.097	65.162	68.235	66.667	100.000	92.857	3.451	18.899	8.564	14.145	9.049
	AG.1.1	0.047	0.134	0.070	0.049	0.050	84.138	76.364	100.000	94.118	78.723	3.961	10.204	6.969	4.592	3.916
	AG.2.3	0.017	0.052	0.031	0.024	0.023	54.717	50.000	50.000	88.889	75.000	0.905	2.580	1.574	2.168	1.699
	CO.2.2	0.035	0.015	0.017	0.053	0.008	48.736	50.000	53.608	61.832	54.667	1.684	0.728	0.936	3.293	0.413
	CO.1.2	0.019	0.049	0.056	0.011	0.031	36.735	51.546	57.143	39.535	52.941	0.697	2.503	3.217	0.421	1.622
Source	PR.1.1	0.024	0.027	0.068	0.098	0.123	62.716	29.688	45.455	61.905	45.238	1.514	0.798	3.092	6.089	5.584
	PR.1.2	0.032	0.051	0.060	0.020	0.018	62.944	100.000	25.000	100.000	100.000	2.008	5.148	1.497	1.967	1.810
	AM.2.2	0.022	0.021	0.031	0.008	0.032	66.026	62.766	84.848	89.655	62.162	1.443	1.293	2.669	0.696	2.013
	AM.1.1	0.107	0.004	0.006	0.023	0.014	92.699	88.980	81.481	92.308	69.231	9.939	0.378	0.492	2.149	0.982
	CO.2.2	0.035	0.015	0.017	0.053	0.008	48.736	50.000	53.608	61.832	54.667	1.684	0.728	0.936	3.293	0.413
	CO.1.2	0.019	0.049	0.056	0.011	0.031	36.735	51.546	57.143	39.535	52.941	0.697	2.503	3.217	0.421	1.622

Business Process	Performance Matrix	AHP Weight (AW)					Normalization Value (NV)					Performance Value (AW x NV)				
		Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs	Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs	Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs
	PR.1.1	0.024	0.027	0.068	0.098	0.123	62.716	29.688	45.455	61.905	45.238	1.514	0.798	3.092	6.089	5.584
	PR.1.2	0.032	0.051	0.060	0.020	0.018	62.944	100.000	25.000	100.000	100.000	2.008	5.148	1.497	1.967	1.810
	AM.2.2	0.022	0.021	0.031	0.008	0.032	66.026	62.766	84.848	89.655	62.162	1.443	1.293	2.669	0.696	2.013
	AM.1.1	0.107	0.004	0.006	0.023	0.014	92.699	88.980	81.481	92.308	69.231	9.939	0.378	0.492	2.149	0.982
Transform	CO.2.2	0.035	0.015	0.017	0.053	0.008	48.736	50.000	53.608	61.832	54.667	1.684	0.728	0.936	3.293	0.413
	CO.1.2	0.019	0.049	0.056	0.011	0.031	36.735	51.546	57.143	39.535	52.941	0.697	2.503	3.217	0.421	1.622
	AM.2.2	0.022	0.021	0.031	0.008	0.032	66.026	62.766	84.848	89.655	62.162	1.443	1.293	2.669	0.696	2.013
	AM.1.1	0.107	0.004	0.006	0.023	0.014	92.699	88.980	81.481	92.308	69.231	9.939	0.378	0.492	2.149	0.982
	EV.1.1	0.054	0.039	0.050	0.251	0.111	52.183	39.669	57.895	50.000	12.931	2.825	1.563	2.898	12.557	1.431
	EV.1.3	0.288	0.164	0.235	0.041	0.046	69.759	60.185	100.000	100.000	100.000	20.059	9.900	23.522	4.129	4.584
	EV.1.5	0.107	0.069	0.099	0.102	0.267	69.874	53.542	42.105	64.000	100.000	7.459	3.708	4.183	6.518	26.721
	AM.2.2	0.022	0.021	0.031	0.008	0.032	66.026	62.766	84.848	89.655	62.162	1.443	1.293	2.669	0.696	2.013
	AM.1.1	0.107	0.004	0.006	0.023	0.014	92.699	88.980	81.481	92.308	69.231	9.939	0.378	0.492	2.149	0.982
	EV.1.1	0.054	0.039	0.050	0.251	0.111	52.183	39.669	57.895	50.000	12.931	2.825	1.563	2.898	12.557	1.431
	EV.1.3	0.288	0.164	0.235	0.041	0.046	69.759	60.185	100.000	100.000	100.000	20.059	9.900	23.522	4.129	4.584
	EV.1.5	0.107	0.069	0.099	0.102	0.267	69.874	53.542	42.105	64.000	100.000	7.459	3.708	4.183	6.518	26.721
Fulfill	PR.1.1	0.024	0.027	0.068	0.098	0.123	62.716	29.688	45.455	61.905	45.238	1.514	0.798	3.092	6.089	5.584
	PR.1.2	0.032	0.051	0.060	0.020	0.018	62.944	100.000	25.000	100.000	100.000	2.008	5.148	1.497	1.967	1.810
	EV.1.1	0.054	0.039	0.050	0.251	0.111	52.183	39.669	57.895	50.000	12.931	2.825	1.563	2.898	12.557	1.431
	EV.1.3	0.288	0.164	0.235	0.041	0.046	69.759	60.185	100.000	100.000	100.000	20.059	9.900	23.522	4.129	4.584
	EV.1.5	0.107	0.069	0.099	0.102	0.267	69.874	53.542	42.105	64.000	100.000	7.459	3.708	4.183	6.518	26.721
	SC.1.2	0.016	0.014	0.024	0.041	0.031	48.000	56.270	54.348	39.063	64.286	0.761	0.790	1.282	1.609	1.963
	SC.3.1	0.091	0.057	0.094	0.088	0.122	76.596	56.962	81.818	72.727	72.000	6.953	3.252	7.717	6.405	8.794
	AG.1.1	0.047	0.134	0.070	0.049	0.050	84.138	76.364	100.000	94.118	78.723	3.961	10.204	6.969	4.592	3.916
	AG.2.3	0.017	0.052	0.031	0.024	0.023	54.717	50.000	50.000	88.889	75.000	0.905	2.580	1.574	2.168	1.699
	PR.1.1	0.024	0.027	0.068	0.098	0.123	62.716	29.688	45.455	61.905	45.238	1.514	0.798	3.092	6.089	5.584
	PR.1.2	0.032	0.051	0.060	0.020	0.018	62.944	100.000	25.000	100.000	100.000	2.008	5.148	1.497	1.967	1.810
	Return	EV.1.1	0.054	0.039	0.050	0.251	0.111	52.183	39.669	57.895	50.000	12.931	2.825	1.563	2.898	12.557
EV.1.3		0.288	0.164	0.235	0.041	0.046	69.759	60.185	100.000	100.000	100.000	20.059	9.900	23.522	4.129	4.584
EV.1.5		0.107	0.069	0.099	0.102	0.267	69.874	53.542	42.105	64.000	100.000	7.459	3.708	4.183	6.518	26.721
SC.1.2		0.016	0.014	0.024	0.041	0.031	85.710	56.270	54.348	39.063	64.286	1.359	0.790	1.282	1.609	1.963
SC.3.1		0.091	0.057	0.094	0.088	0.122	76.596	56.962	81.818	72.727	72.000	6.953	3.252	7.717	6.405	8.794

Based on the integration of SCOR DS performance values from all actors, the performance scores for each actor were obtained according to the business processes: plan, order, source, transform, Fulfill, and return. The performance values for the Business Process of each actor in the tapioca and Mocaf agro-industrial supply chain in West Java are presented in Table 12.

Table 12. Summary of SCOR DS Performance Values for All Actors in the Supply Chain

Business Process	Farmers	Coarse Tapioca SMEs	Fine Tapioca SMEs	Mocaf SMEs	Cookies SMEs
Plan	31.52	72.70	36.85	46.31	31.12
Order	30.97	71.25	44.25	57.91	40.30
Source	32.19	18.46	19.65	25.52	22.81
Transform	85.83	36.92	71.68	55.81	73.50
Fulfill	49.97	43.89	57.32	54.09	63.90
Return	38.65	19.21	39.60	31.22	43.49

Based on the Business Process performance values of the SCOR DS framework, a decision-making process was subsequently conducted to identify ideal improvements for key actors using the TOPSIS method. The TOPSIS method is employed to determine the ideal solution based on a Multi-Actor Multi-Criteria Decision-Making approach, leveraging the performance values of each actor within the SCOR DS framework. The Shannon entropy method is not applied because the weights of all selected criteria have already been obtained using AHP within the SCOR DS model. Shannon entropy based weighting is specifically intended to generate objective attribute weights in situations where these weights are entirely unknown to the decision maker (Garg et al., 2015). The results of the actor performance normalization using TOPSIS in the SCOR DS framework are presented in Table 13.

Table 13. Normalization Vector of Performance for Each Actor in the Supply Chain

Actor	Business Process					
	Plan	Order	Source	Transform	Fulfill	Return
Farmers	31.52	30.97	32.19	85.83	49.97	38.65
Coarse Tapioca SMEs	72.70	71.25	18.46	36.92	43.89	19.21
Fine Tapioca SMEs	36.85	44.25	19.65	71.68	57.32	39.60
Mocaf SMEs	46.31	57.91	25.52	55.81	54.09	31.22
Cookies SMEs	31.12	40.30	22.81	73.50	63.90	43.49
$\sum Xi^2$	10749.99	12972.91	2934.86	22384.96	14717.38	6297.99
$\sqrt{\sum Xi^2}$	103.68	113.90	54.17	149.62	121.32	79.36

The normalization vector will determine the distance between the ideal solution for positive priority actors (A^+) and the ideal solution for negative priority actors (A^-). The determination of ideal performance improvement solutions for actors is derived from the normalized values and performance priorities for each actor, which can be seen in Table 14.

Table 14. Determination of Normalized Values for Each Actor in the Supply Chain

Actor	Business Process					
	Plan	Order	Source	Transform	Fulfill	Return
Farmers	0.304	0.272	0.594	0.574	0.412	0.487
Coarse Tapioca SMEs	0.701	0.626	0.341	0.247	0.362	0.242
Fine Tapioca SMEs	0.355	0.389	0.363	0.479	0.473	0.499
Mocaf SMEs	0.447	0.508	0.471	0.373	0.446	0.393
Cookies SMEs	0.300	0.354	0.421	0.491	0.527	0.548
Positive A ⁺	0.701	0.626	0.594	0.574	0.527	0.548
Negative A ⁻	0.300	0.272	0.341	0.247	0.362	0.242

Based on the results from the positive and negative performance solutions for each actor in the supply chain, the distances to the ideal positive solution (D^+) and the ideal negative solution (D^-) are determined. These distances to the ideal alternative solutions are used to identify the priority actors for performance improvement in the tapioca and Mocaf agro-industrial supply chain in West Java, as presented in Table 15.

Table 15. Results of KPI Performance Matrix Improvement Priorities Based on Key Actors

Actor	Distance Between Actor		Preference Value (C_i)	Business Process Problem
	D^+	D^-		
Farmers	0.548	0.48	0.47	Order
Coarse Tapioca SMEs	0.540	0.53	0.50	Source
Fine Tapioca SMEs	0.494	0.39	0.44	Source
Mocaf SMEs	0.405	0.37	0.48	Source
Cookies SMEs	0.521	0.44	0.46	Source

The priority actor improvement to maintain the supply of cassava in the agro-industrial tapioca and Mocaf in West Java is identified as Coarse Tapioca SMEs, with the highest preference value (C_i) of 0.50. According to the ideal solution for improving the performance of the Coarse Tapioca SMEs actor, the business process source had the lowest score performance value of 18.46. The lowest KPI Performance Matrix from business process source was AM.1.1 Cash to Cash Cycle, with a KPI Performance Matrix value of 0.378 and this prioritized for improvement performance.

Research reliability was reinforced through field validation with cassava farmers (raw material suppliers) and coarse tapioca SMEs (key supply chain actors) within the integrated SCOR DS–TOPSIS framework. The validation confirmed that a typical coarse tapioca SME requires about 2.5 tons of cassava per production cycle and can operate up to six cycles per month under high demand, resulting in a monthly cassava requirement of roughly 15 tons, equivalent to almost one hectare of cassava output. If the performance issue on the AM 1.1 Cash-to-Cash Cycle in tapioca SMEs is resolved, the 35 sampled coarse tapioca SMEs in West Java would jointly demand approximately 525 tons of cassava per month, thereby increasing farmer's production cycles and stabilizing cassava supply across the tapioca and Mocaf agro-industrial supply chain.

4.4 Business Model Canvas

The problems within the cash-to-cash cycle in raw cassava SMEs have led to a decline in the availability of cassava raw materials among farmers. This issue causes an overstock of cassava among farmers, preventing them from harvesting their products since the selling prices do not cover the production costs. Consequently, farmers are shifting to other commodities. The cash-to-cash cycle issues in raw cassava SMEs can be illustrated in Figure 4.

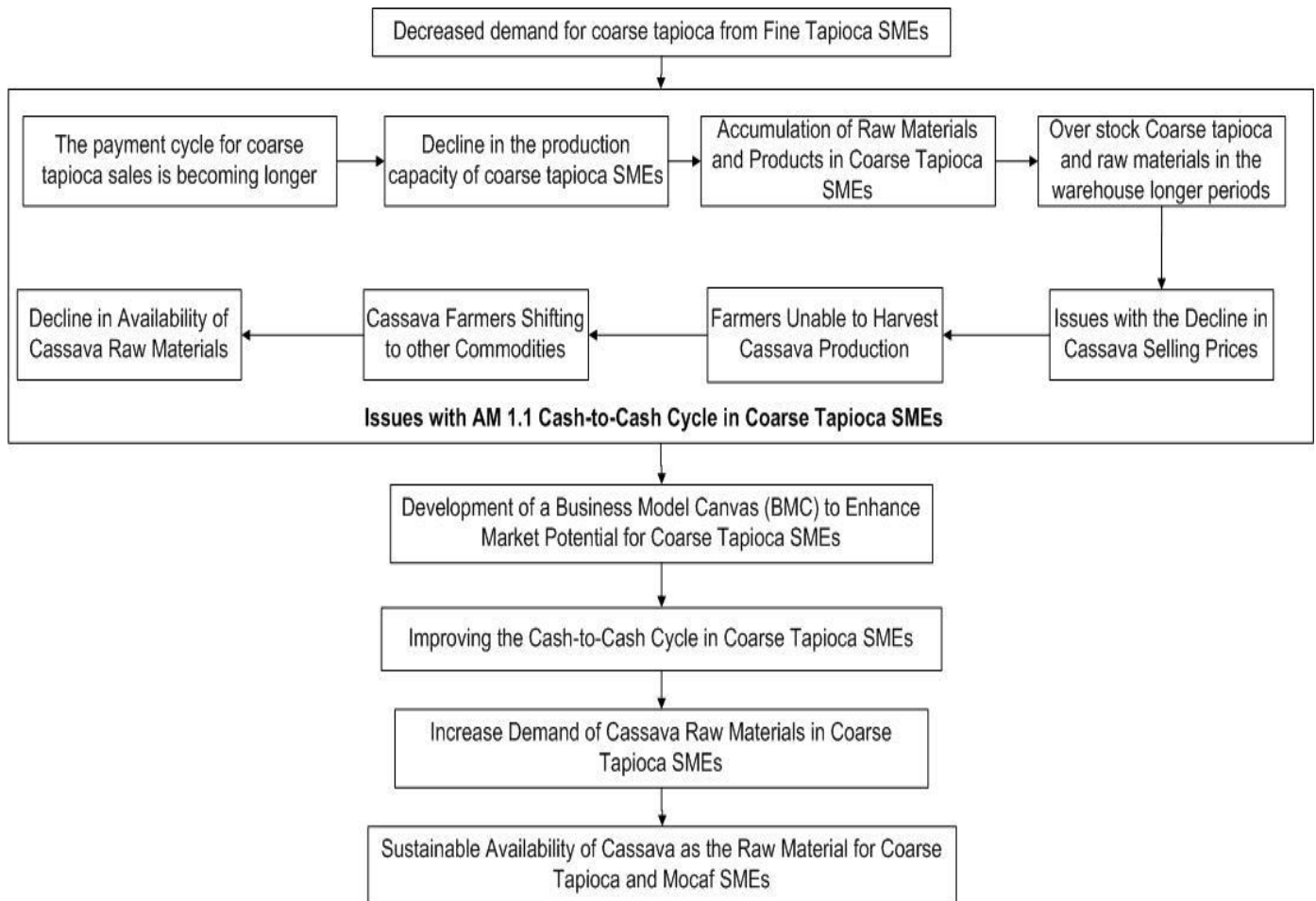


Figure 4. Solution for KPI Performance Matrix AM 1.1 Cash to Cash Cycle in Coarse Tapioca SMEs

Coarse tapioca SMEs represent the largest demand for cassava, requiring an average of 2,500 kg of cassava per production cycle, yielding 700 kg of coarse tapioca flour with a 28% extraction rate with production cycle for coarse tapioca SMEs is six times a month, requiring 15 tons of cassava as raw material. AM 1.1 Cash-to-Cash Cycle problem leads to the accumulation of cassava among farmers, causing Day Inventory Outstanding (DIO) and Day Sales Outstanding (DSO) and Day Payable Outstanding (DPO) to long of covering production costs in Coarse Tapioca SMEs. The Business Model Canvas to improve cash-to-cash cycle is illustrated in Figure 5.

Key Partners 1. Cassava Farmers Group (GAPOKTAN) 2. Cassava Cooperative 3. Universities/Research Institutions for develop flour drying and processing technologies 4. Department of Industry acts as the regulatory authority to support industry competitiveness. 5. Financial Institutions for improving production infrastructure 6. Logistics Partners ensure efficient transportation, distribution, and market access.	Key Activities 1. Daily Production Requirements Recap 2. Scheduling Cassava Purchases from Farmers 3. Farmer Partnership Management 4. Fulfilling Product Demand Based on Pre-Orders via Customer Purchase Orders 5. Closed-System Cassava Drying Process (Solar Tunnel Dryer) 6. Coordination with Transport or Shipping Services According to Delivery Schedule 7. Managing Social Media, Digital Orders, and Invoicing	Value Proposition 1. Quality of Coarse Tapioca Flour with 10% Moisture Content and 70% of Particles Passing Through 100 Mesh 2. Quality and Quantity of Coarse Tapioca Flour and Onggok in Accordance with Customer Orders 3. Guaranteed Fast, Scheduled, and On-Time Product Delivery	Customer Relationship 1. WhatsApp Contact for Customer Communication 2. Price Incentive System Based on Timely Customer Payments 3. Automated Payment Reminders and Digital Invoicing via WhatsApp 4. Continuous Product Promotion Updates on Social Media 5. Conducting Customer Visits	Customer Segment 1. Fine Tapioca Processing SMEs 2. Animal Feed Industry Utilizing Onggok as the Primary Raw Material
Cost Structure 1. Raw Cassava Purchase Costs from farmers 2. Production Operational Costs 3. Labor Wages for Milling, Starch Extraction, Soaking, and Drying Processes 4. Transportation Costs for Raw Material Delivery to Production Site 5. Product Distribution and Logistics Costs from Production Site to Consumers 6. Packaging Costs including sacks, labels, and binding materials. 7. Diesel Fuel Costs for Extraction Machinery 8. Internet Data Packages	Key Resources 1. Staff for Recording Raw Material Needs and Daily Order Volumes 2. Contractual Agreements with Farmers – securing a consistent supply of fresh cassava with an 8–9 month harvest cycle. 3. Working Capital for Production Infrastructure and Drying Facility Improvements. 4. Closed-System Flour Drying Using Solar Tunnel Dryer 5. Warehouse System Capable of Storing, Sorting, and Scheduling the Delivery of Raw Cassava from Farmers to Coarse Tapioca SMEs 6. Digital Application Management Staff for Order Administration, Marketing, and Invoice Payment Processing	Channels 1. Direct Business-to-Business (B2B) Partnerships with Fine Tapioca SMEs and Animal Feed Producers 2. Department of Industry for Recommendations and Identification of B2B Customers 3. WhatsApp Business for Order Placement, Stock Updates, and Delivery Confirmation 4. Promotion via Facebook Ads and youtube	Revenue Streams 1. Sales of Coarse Tapioca Flour Based on Purchase Orders (B2B) 2. Sales of By-Products (Onggok) to the Animal Feed Industry 3. Revenue from Long Term Supply Contracts	

Figure 5. Business Model Canvas for Cash-to-Cash Cycle Improvement in Coarse Tapioca SMEs

5. Discussion

This study reinforces the strategic importance of developing local flour-based supply chains as a response to the vulnerability created by high wheat flour imports in the context of potential trade wars and product boycotts. By focusing on the tapioca and Mocaf supply chains in West Java, the analysis shows that existing cassava-based agro-industrial networks already contain a critical leverage point for improving sustainability performance. Within the integrated SCOR DS–TOPSIS evaluation, coarse tapioca SMEs attain the highest composite priority score ($C_i = 0.50$), confirming their role as the key solution node for driving systemic improvements in source

The SCOR DS–TOPSIS results further indicate that the AM.1.1 Cash to Cash Cycle is the most critical KPI weakness at coarse tapioca SMEs, registering the lowest performance score among the assessed indicators. This underperformance reflects slow capital turnover, delayed payments, and uneven demand from downstream actors. The reduction in available cassava stocks is driven primarily by lower production in coarse tapioca SMEs rather than by poor management practices of intermediaries. This decline is closely associated with problems in the AM 1.1 Cash-to-Cash Cycle, particularly the accumulation of finished tapioca stock at the SME level. By redesigning the business model canvas to emphasise a value proposition of high-quality coarse tapioca with reliable delivery times, supported by appropriate key partners and clearly defined customer segments, the cash-to-cash cycle can be shortened.

The integration of SCOR DS–TOPSIS with a BMC-based redesign demonstrates that resolving sustainability-related performance challenges in the tapioca and Mocaf supply chains requires both quantitative prioritisation and business model innovation. By focusing improvement availability and accelerating the cash-to-cash cycle, the proposed framework supports more resilient cassava procurement, more reliable local flour supplies, and more inclusive benefits for smallholder farmers and Coarse Tapioca SMEs.

6. Conclusion and Recommendations

Coarse Tapioca SMEs is a key actor with the highest demand for cassava, reaching 2,500 kg per production cycle, making it a priority for enhance raw material supply performance, with a Ci value of 0.50. The KPI performance matrix issue that needs to be addressed for Coarse Tapioca SMEs is AM.1.1 Cash to Cash Cycle. The decline in demand for Fine Tapioca SMEs from Coarse Tapioca SMEs has resulted in a very slow cash to cash cycle, which adversely affects the absorption of farmers' harvests.

The accumulation of cassava on farmers' land has caused prices to drop below the farmers' production costs, resulting in farmers refraining from harvesting due to losses and shifting to other commodities. Based on this issue, future research will focus on developing an effective institutional model to maintain demand stability in Coarse Tapioca SMEs, thereby achieving supply-demand matching in the agro-industrial tapioca and Mocaf supply chain in West Java. A limitation of this study is that it only addresses the prioritization of KPI improvements and key actors using the SCOR DS–TOPSIS approach, without yet exploring dynamic scenarios related to harvest time uncertainty, seasonal variation, price fluctuations, cassava stock levels, and supply chain disruptions. Future research will focus on developing an institutional model based on system dynamics scenarios that is conceptually, computationally, and operationally validated for the tapioca and Mocaf agro-industrial supply chain in West Java.

Author Contributions

Conceptualization, Sesar Husen Santosa, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; methodology, Sesar Husen Santosa, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; validation, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; formal analysis, Sesar Husen Santosa; investigation, Sesar Husen Santosa; resources, Sesar Husen Santosa, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; data curation, Sesar Husen Santosa; writing—original draft preparation, Sesar Husen Santosa; writing—review and editing, Sesar Husen Santosa, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; visualization, Sesar Husen Santosa; supervision, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar; funding acquisition, Sesar Husen Santosa, Marimin, Titi Candra Sunarti, and Jono Mintarto Munandar. All authors have read and agreed to the published version of the manuscript Conceptualization.

Data Availability Statement

The data that support this study are available from the author upon reasonable request

Acknowledgements

This research was funded by the Center for Higher Education Financing and Assessment (PPAPT) of the Ministry of Higher Education, Science, and Technology (Kemdiktisaintek) in 2025, with BPI Number 202528112299.

Ethical considerations

The authors avoided data fabrication, falsification, and plagiarism, and any form of misconduct.

Funding

Center for Higher Education Financing and Assessment (PPAPT) of the Ministry of Higher Education, Science, and Technology (Kemdiktisaintek) in 2025, with BPI Number 202528112299.

Conflict of interest

The authors declare no conflict of interest

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