Jurnal Teknologi Industri Pertanian 35 (3): 229-243, December 2025
DOI: https://doi.org/10.24961/j.tek.ind.pert.2025.35.3.229
ISSN: 0216-3160 EISSN: 2252-3901

Accredited based on the Decree of the Director General of Research and Development, Ministry of Higher Education, Science, and Technology No. 295/C/C3/KPT/2026.
Available online http://journal.ipb.ac.id/index.php/jurnaltin

SUPPLY CHAIN PERFORMANCE AND RISK ANALYSIS OF SIDIKALANG ARABICA COFFEE

ANALISIS KINERJA DAN RISIKO RANTAI PASOK KOPI ARABIKA SIDIKALANG

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Paper: Received December 09, 2024; Revised July 08, 2025; Accepted August 25, 2025

ABSTRAK

Kopi merupakan salah satu komoditas dengan potensi bisnis signifikan yang mengalami peningkatan dalam beberapa tahun terakhir. Penelitian ini bertujuan untuk mengidentifikasi struktur rantai pasok, menganalisis kinerja, dan menilai risiko pada rantai pasok kopi Arabika Sidikalang berdasarkan indikasi geografis untuk mengoptimalkan kinerjanya. Struktur rantai pasok dianalisis dengan metode Vorst, evaluasi kinerja menggunakan metode Supply Chain Operations Referee (SCOR AHP), dan penilaian risiko menggunakan metode House of Risk (HOR). Studi ini mengidentifikasi enam konfigurasi dalam rantai pasokan kopi Arabika Sidikalang, dengan fokus pada industri hotel, restoran, dan kafe. Anggota rantai pasok utama mencakup petani, usaha mikro, kecil, dan menengah (UMKM), hotel, restoran, dan kafe. Analisis kinerja menunjukkan bahwa petani, UMKM, hotel, dan restoran masuk dalam kategori sedang dengan skor antara 50%-70%, sedangkan kafe memiliki kinerja baik dengan skor 75%. Analisis risiko menyoroti bahwa mempertahankan standar kualitas yang stabil berdampak pada kepuasan konsumen dan keberlanjutan bisnis. Strategi optimalisasinya antara lain peningkatan budidaya petani, perluasan pasar UMKM, diversifikasi produk di sektor HOREKA, dan peningkatan ketahanan risiko. Menjunjung tinggi tuntutan konsumen dengan integritas mencerminkan profesionalisme dan meningkatkan kepuasan konsumen, yang pada gilirannya mendukung keberlanjutan bisnis jangka panjang.

Kata kunci: kopi, SCOR AHP, struktur rantai pasok, kinerja rantai pasok, HOR

ABSTRACT

Coffee has become one of significant commodity with grown business potential in recent years. This research aims to identify the supply chain structure, analyze performance, and assess risks in the Sidikalang Arabica coffee supply chain, which is recognized for its geographical indication, to optimize its performance. The supply chain structure is analyzed using the Vorst method, while performance evaluation employs the Supply Chain Operations Reference (SCOR AHP) method, and risk assessment is carried out using the House of Risk (HOR) method. The study identifies six configurations in the Sidikalang Arabica coffee supply chain, primarily serving the hotel, restaurant, and café (HORECA) industry. Key supply chain members include farmers, micro, small, and medium enterprises (MSMEs), hotels, restaurants, and cafés. Performance analysis reveals that farmers, MSMEs, hotels, and restaurants fall into the medium category, scoring between 50%-70%, whereas cafés demonstrate strong performance with a 75% score. Risk analysis highlights that maintaining consistent quality standards significantly impacts consumer satisfaction and business sustainability. Optimization strategies include improving farmer cultivation, expanding MSME markets reach, diversifying products in the HORECA sector, and strengthening risk resilience. Integrated approach provides both theoretical contribution to supply chain studies and practical strategies by enhancing quality consistency, market competitiveness and supporting long-term business sustainability.

Keywords: coffee, SCOR AHP, supply chain structure, supply chain performance, HOR

INTRODUCTION

Based on BPS data (2022), North Sumatra Province is one of Indonesia's coffee production centers with a land area of ±141,277.78 ha or 11.16% of the total national land area and Dairi Regency is an important with 12,088 ha production area but the production is quite low, only 9,612 tons (North Sumatra Province Agriculture Office (2021) so need improvements, especially in supply chain management using the supply chain network structure mapping approach, performance evaluation, and risk analysis. Supply chain management according to Chopra and Meindhl (2016) is a combination of planning, coordination, and control of business processes and business activation in a supply chain system aimed at meeting consumer demand at the lowest cost. The system owned by the supply chain is a system that is probabilistic, complex, has regular,

*Coressponding Author

dynamic, and interrelated elements, and has certain goals (Suharjito *et al.,* 2011).

Supply chain management that runs well can build networking and collective action between supply chain actors such as raw material producers, processors, and consumers (Latifah, 2016) to coordinate and achieve the goals of all supply chain actors (Hamdala *et al.,* 2017). Networking and collective action in the supply chain management of Sidikalang Arabica coffee can be done if the chain structure has been recorded, so to support this research, the Vorst (2006) model is used to map the supply chain structure of Sidikalang Arabica coffee.

Supply chain performance evaluation needs to be carried out to measure, control, and formulate performance improvements based on established strategies (Hadiguna, 2016). According to Asrol *et al.* (2017), holistic improvements in supply chain management can improve supply chain integration and performance. Holistic improvements to supply chain management using evaluation techniques can be carried out by measuring supply chain performance. According to Nawi *et al.* (2017), measuring the performance of a supply chain can provide an overview of the overall performance of each supply chain actor. Supply chain performance measurement is carried out using performance metrics that are adjusted to the business activities of Sidikalang Arabica coffee (Elroad *et al.,* 2013). According to Asrol *et al.* (2017), the use of performance metrics for measuring supply chain performance must be adjusted to the business activities of the industry being studied because the characteristics and supply chain management of each particular business are different. For example, the Gayo Arabica coffee industry according to Jaya *et al*. (2014) has characteristics in supply chain management that require quality fulfillment. So for Sidikalang Arabica coffee, performance analysis and special risk analysis are needed as a reference for evaluating the performance of the Sidikalang Arabica coffee supply chain. Performance evaluation using the right performance measurement can bring significant improvements in business activities (Bai and Sarkis, 2012). Improvement measures are reviewed comprehensively by observing the integration and coordination of goods, money, and information from all supply chain actors (Imanulla *et al.,* 2016). After the performance evaluation, another thing that needs to be considered in the management of the Sidikalang Arabica coffee supply chain is the risk in supply chain activities. Risk is a condition of uncertainty that can cause threats from internal or external and has the potential to have a negative impact on organizational goals (Tuncen and Alpan, 2010). According to Lavastre *et al.* (2012), supply chain risk can occur from the beginning to the end of business activities in a supply chain management so a special risk analysis is needed in the Sidikalang Arabica coffee supply chain management.

Risk analysis in the supply chain management of Sidikalang Arabica coffee aims to map risk events, risk sources, and mitigation actions that occur in every activity of supply chain actors (Kersten et al., 2007). Risk analysis is said to be successful if the damage caused by risk decreases or resilience to a risk event increases (Shahbaz *et al.,* 2018). Evaluation and improvement are absolute things that must be done by every business so that they remain relevant to the situation. Currently, coffee is one of the agro-industrial commodities that has high potential, so this research aims to map the network structure, carry out performance analysis, and carry out risk analysis of the Sidikalang Arabica coffee supply chain, which can be a reference for improving the performance of the Sidikalang Arabica coffee supply chain.

RESEARCH METHODS

Research Stages

This research was conducted due to the increasing demand for Sidikalang Arabica coffee products, so it requires improvement strategies to increase Sidikalang Arabica coffee supply chain performance. The research held from October 2022 to July 2023 in Sitinjo District, Sumbul District, Sidikalang District, and Parbuluan District, Dairi Regency, North Sumatra. The research began situational analysis of the Sidikalang Arabica coffee supply chain. The results of situational analysis will be a reference for identifying the supply chain structure and the supply chain performance of the Sidikalang Arabica coffee. After the supply chain structure and performance metrics that affect supply chain performance are identified, the research continues to the stage of supply chain structure analysis and performance measurement to obtain an overview of the structure and mechanism of supply chain performance and the performance value of the Sidikalang Arabica coffee supply chain actors. The complete research framework can be seen in Figure 1.

The method used in identifying the supply chain structure of Sidikalang Arabica coffee is the Vorst method (2006). This method is used to map chain management, network structure, business processes, and resources owned by each supply chain actor. These factors can be used to manage the network in activities to meet consumer demand and win the competition with competitors (Shukla *et al.,* 2011). Identification of the supply chain structure using the Vorst method (2006) can be seen in Figure 2. Performance measurement is carried out by all supply chain actors using the SCOR AHP method from the Supply Chain Council Rev 12.0 in 2014 with the help of expert assessments. Experts can come from practitioners and academics.

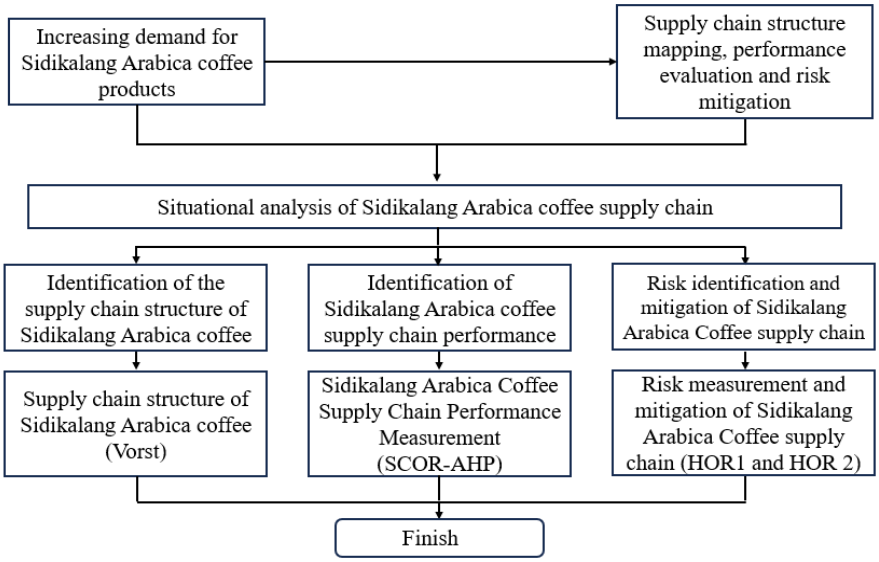

Figure 1. Research Framework

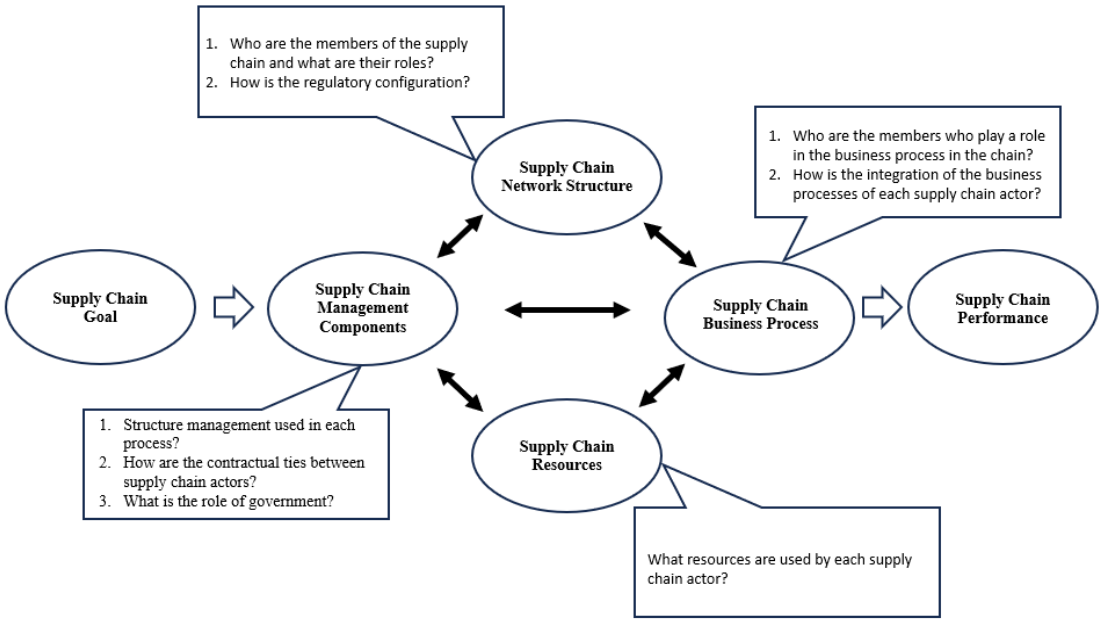

Figure 2. Identification of the Arabica coffee supply chain structure Sidikalang Vorst (2006)

Experts from practitioners are people who are self-taught or academic in a particular field and experts from academics are experts who study a science through higher education. According to Marimin (2017), someone can be said an expert if they had experience 5 years or more in the field they are engaged in. The selection of experts was carried out using the purposive sampling method. The experts involved were 2 founders of MSMEs with Sidikalang Arabica coffee products, 1 operational manager of Sidikalang Arabica coffee MSMEs, 1 farmer producing Bali Kintamani Arabica coffee products, 1 General Manager of PT. X which is engaged in the cafe industry, 1 operational manager of PT. Y which is engaged in the production of Arabica coffee and 1 academic who is a researcher and all experts are use coffee based on geographical indications. Expert assessments Consistency ratio value <0.1 are taken as the average value using the Geomean method in Microsoft Excel. The results of calculating the average value of each comparison in the business process, performance parameters, performance attributes, and performance metrics are then entered into the matrix assessment in the SuperDecisions V3.2 application to obtain the weight of each variable used. The results of the calculation of the performance metric weight multiplied by the performance score will produce the performance value of each performance metric and then grouped into the performance value category. The complete hierarchy of the Sidikalang Arabica coffee supply chain performance weighting can be seen in Figure 3.

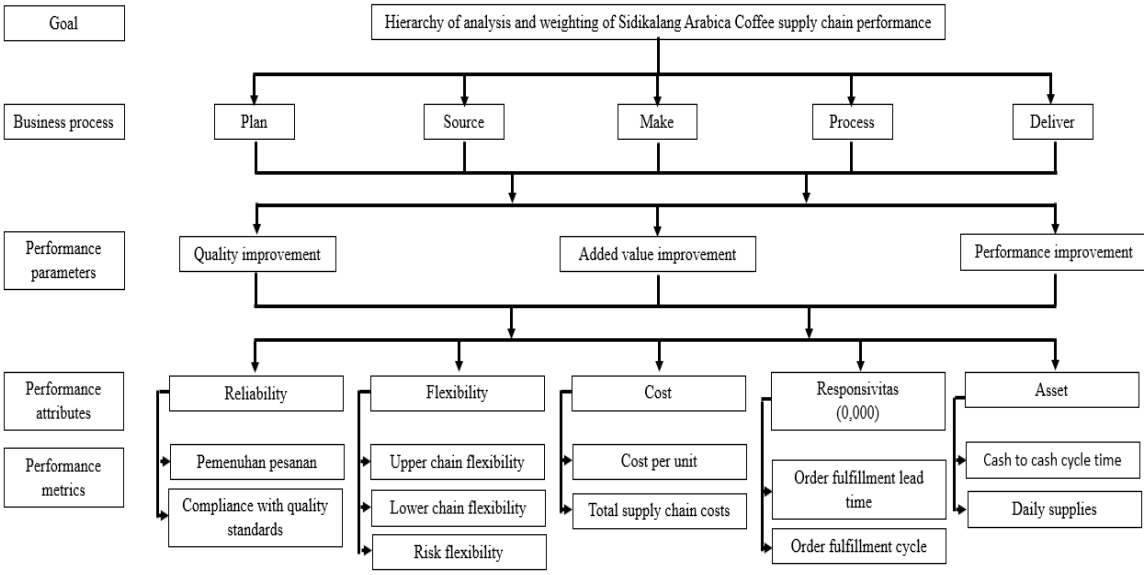

Figure 3. Hierarchy of performance measurement for the Sidikalang Arabica coffee supply chain

Risk analysis is carried out using the House of Risk (HOR) method which is a modification of the FMEA (Failure Modes and Effect of Analysis) method and the HOQ (House of Quality) model. The HOR method is carried out in 2 stages, namely HOR 1 to identify risk events, risk sources and calculate risk source priorities and HOR 2 to identify potential risk mitigation actions to avoid risk events, minimize the level of damage, or increase the resilience of supply chain management from potential risk events (Ulfah *et al.,* 2016). Steps taken in the HOR method.

1. HOR phase 1
   a. Identify risk events (Ei) and risk sources (Aj).
   b. Create a simulation of the possibility of risk events (Ei) and risk sources (Aj).
   c. Develop a relationship matrix of Ei and Aj with the provisions, 0: no correlation, 1: weak correlation, 3: moderate correlation, and 9: strong correlation.
   d. Formula for calculating the ARP value of Aj:

$$ARPj = Oj \cdot \sum Si \cdot Rij$$

   e. Sort the ARP values from highest to lowest. Use the Pareto diagram Aj (priority selection Aj) in preparing risk mitigation actions
2. HOR phase 2
   a. Reference data in compiling mitigation or preventive action (PAk) is the priority value of Aj.
   b. Compiling logical actions in preventing risk sources
   c. Correlation analysis of Aj and PAk with the provisions of 0, 1, 3, and 9.
   d. Calculation of the effectiveness value of each PAk with the formula:

$$TEk = \sum(ARPj \cdot Ejk)$$

   e. The degree of difficulty (Dk) is measured by the application of PAk using a scale of application difficulty 3: low, 4: medium and 5: high.
   f. Calculation of Effectiveness to difficulty ratio with the formula:

$$ETDk = TEk\ Dk$$

   g. Sort the priority of PAk with reference to the value of $ETDkk$

RESULTS AND DISCUSSION

Situational Analysis of Sidikalang Arabica Coffee Supply Chain

Situational analysis was conducted to map the network structure, chain management, resources and business processes that occur in the Sidikalang Arabica coffee supply chain.

Network Structure and Supply Chain Configuration

a. Farmer – Collective trader – PT. X Special Economic Zones Medan – Consumer
b. Farmer – Collective trader – Inter-regional wholesaler – Inter-regional retailer – Consumer
c. Farmer – Farmers group – Collective trader – PT. X Special Economic Zones Medan –Consumer
d. Farmers – Farmers group – Collective trader – Inter-regional wholesaler – Inter-regional retailer – Consumer
e. Farmer – Farmers group – Inter-regional wholesaler – Inter-regional retailer – Consumer
f. Farmer – Farmers group – MSMEs – Consumer

Sidikalang Arabica coffee supply chain actors and their roles (Figure 4) are explained below:

a. Farmer
   Sidikalang Arabica coffee farmers are members of the supply chain that produce coffee from planting to harvesting. Arabica coffee is generally harvested at the age of 4 years and reaches maximum production at the age of over 7 years. The main harvest is carried out twice a year.

b. Collective trader
   Collective trader buy coffee from farmers in the form of fruit logs or green beans. The fruit received in the form of logs will be milled until dried. If the fruit received in the form of green beans, the treatment given is sorting and drying. The turnover cycle at the collector is quite high. Shipments to the Medan Special Economic Zone are carried out 1 to 2 times a week with a quantity of 2.5 tons to 3 tons and shipments to inter-regional traders 1 time in 1 week.
c. PT. X Special Economic Zone Medan (SEZs Medan)
   PT. X is located in the Medan Special Economic Zone (SEZs Medan) which is a special industrial area formed by the government as a driver of the North Sumatra economy. SEZs Medan Medan is a place for processing various agricultural commodities originating from North Sumatra.
d. Inter-Regional Traders
   Each region in North Sumatra Province, especially Dairi Regency, sets one day every week as a market day or what is often called "pajak". Inter-regional traders are traders who come from other regions who buy coffee every day this market is held. Coffee purchased by inter-regional traders is in the form of green beans.
e. Inter-Regional Wholesaler
   Inter-regional wholesaler of Sidikalang Arabica coffee products generally come from Jakarta to meet the needs of Sidikalang Arabica coffee products in the Java region. Large inter-regional retailers cooperate with inter-regional traders who buy products directly from farmers.
f. Farmers Group
   Farmer groups are groups of farmers who form groups that generally have 15 to 20 members. Farmer groups are intermediaries between farmers and various stakeholders. With government stakeholders, farmer groups are generally used for distribution of subsidized fertilizers, training for farmers and distribution of other assistance from the government. From non-government stakeholders, farmer groups are a channel used to carry out cooperation and agreements with farmers. Agreements can be in the form of agreements on price, quality and quantity of products.
g. Micro, Small and Medium Enterprises
   Micro, Small and Medium Enterprises (MSMEs) are one of the non-governmental business entities that cooperate with farmers. This business entity can be a Village-Owned Enterprise (BumDes), *Commanditaire Vennootschap* (CV) and Trading Business (UD). MSMEs buy coffee products from farmers with predetermined standards to meet consumer product quality demands. Purchasing Sidikalang Arabica coffee products through MSME channels is generally used by certain consumer segments. Consumers at this level require product quality based on geographical indications that need product characteristics.
h. Consumers
   Consumers are the last member in the Sidikalang Arabica coffee supply chain. Consumers can come from individuals or industries.

Chain Management

Supply chain management of Sidikalang Arabica coffee starts from the type of product produced at the farmer level. Product management, market competition to contractual agreements given to coffee that is harvested specifically and harvested haphazardly will be different. The management given to coffee that is harvested specifically will follow the contractual agreement that has been made between micro, small and medium enterprises (MSMEs) and consumers. This agreement can be in the form of the drying process and techniques used to produce green coffee beans to the level of bitterness if consumers request the product in the form of roasted coffee beans or coffee powder. The management used in coffee that is harvested haphazardly is generally only for green coffee beans with a water content of 11% to 12%.

Supply Chain Business Process

The supply chain business process of Sidikalang Arabica coffee with the flow of trade from MSMEs starts from the request for coffee from consumers with certain specifications. MSMEs then provide information on the amount of coffee cherry needs to be processed to farmers through farmer groups. The calculation of the amount of coffee needed is 1:3 which means that to produce 1 kg of green coffee beans requires 3 kg of coffee cherries. The coffee cherries then processed by natural process, honey process and full washed process according to consumer demand. The final products divided into 3, namely green coffee beans, roasted coffee beans and coffee powder. In this business process the flow of information and money comes from consumers to MSMEs and farmers, while the flow of goods comes from farmers then the processing process is carried out at MSMEs and the final product is sent to consumers. In hotel, restaurant and cafe (HORECA) industry the calculation of coffee powder used for each dish is 10 grams - 15 grams or 80 dishes for every 1 kg of coffee powder.

Supply Chain Resources

Supply chain resources owned by members of the Sidikalang Arabica coffee supply chain are physical resources, technological resources, capital resources and human resources. Physical resources consist of infrastructure, transportation equipment and production facilities. Technological resources in the Sidikalang Arabica coffee supply chain are still not very significant.

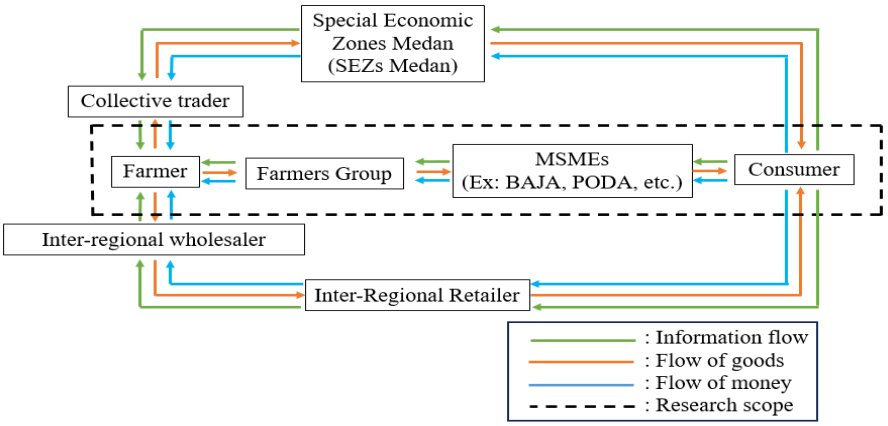

Figure 4. Supply chain flow pattern for Sidikalang Arabica Coffee

Some of the uses of technology that have been used are the use of biological agents Trichoderma sp. and organic fertilizers. Human resources, farmers' capital resources come from personal capital and recently farmers have begun to be able to cooperate with banks using KUR (People's Business Loan). Human resources are workers who carry out cultivation, processing, shipping until they reach consumers.

Sidikalang Arabica Coffee Supply Chain Performance Analysis

Supply chain performance measurement is carried out by supply chain actors from upstream to downstream (Putri *et al.,* 2020) to monitor, control, communicate and optimize the supply chain structure (Al-Douri, 2018), increase effectiveness and efficiency (Rakhman *et al.,* 2018), increase supply chain transparency (Awwad *et al.,* 2018), increase competitive advantage (Stefanovic and Stefanovic, 2011) to become comparative data at the operational and strategic levels (Seleheen *et al.,* 2018) this needs to be done because competition in business is getting higher (Kot, 2018; Pathak *et al.,* 2019). The results of supply chain performance measurement can be used by supply chain actors to conduct evaluations, increase competitiveness and become material for supply chain improvement (Elrod *et al.,* 2013). Implementation of continuous improvement of the supply chain can be observed from the improvement of service to consumers, reduced cycle time, increased responsiveness to consumer demand (Tatoglu *et al.,* 2016), and increased product quality (Janaki *et al.,* 2018).

The calculation of the performance weighting of the Sidikalang Arabica coffee supply chain was carried out using the SuperDecisions V3.2. The weighting results at the business process level were 0.221 for plan/planning, 0.156 for source/procurement, 0.265 for make/cultivation, 0.242 for process/processing and 0.114 for deliver/shipping. The plan, make and process weights are the 3 highest weights at the business process level because according to experts, these 3 things are the most basic in maximizing the potential of Sidikalang Arabica coffee. At the performance parameter level, the weighting for quality improvement is 0.349, added value improvement is 0.489 and performance improvement is 0.161. Increasing added value has the highest value because according to expert assessments, maximizing the added value of products that are correlated with the characteristics of coffee is the main key in developing the Sidikalang Arabica coffee business. At the performance attribute level, the 2 attributes that have the highest values are the asset and reliability attributes with weights of 0.248 and 0.222 respectively. This represents that the importance of daily inventory that meets consumer quality standards and the increasingly short cash-to-cash cycle time are factors that greatly influence the Sidikalang Arabica coffee supply chain. The image of the hierarchy and weighting value of the Sidikalang Arabica coffee supply chain performance can be seen in Figure 5.

The performance measurement results are then categorized into 5 categories in Table 1.

Table 1. Performance value categories

Performance value (%)	Category
>40	Poor
45-50	Marginal
50-70	Average
70-90	Good
>90	Excellent

Source: Sumiati (2012)

Based on the calculation of the performance value of the Sidikalang Arabica coffee supply chain by comparing the factual and actual percentages, the final performance value at the farmer level was 54.268 (average), UMKM level 69.448 (average), hotel 62.883 (average), restaurant (average) 65.55 and cafe 75.074 (good). The results of measuring the performance of the Sidikalang Arabica coffee supply chain based on all members of the Sidikalang Arabica coffee supply chain can be observed in Table 2.

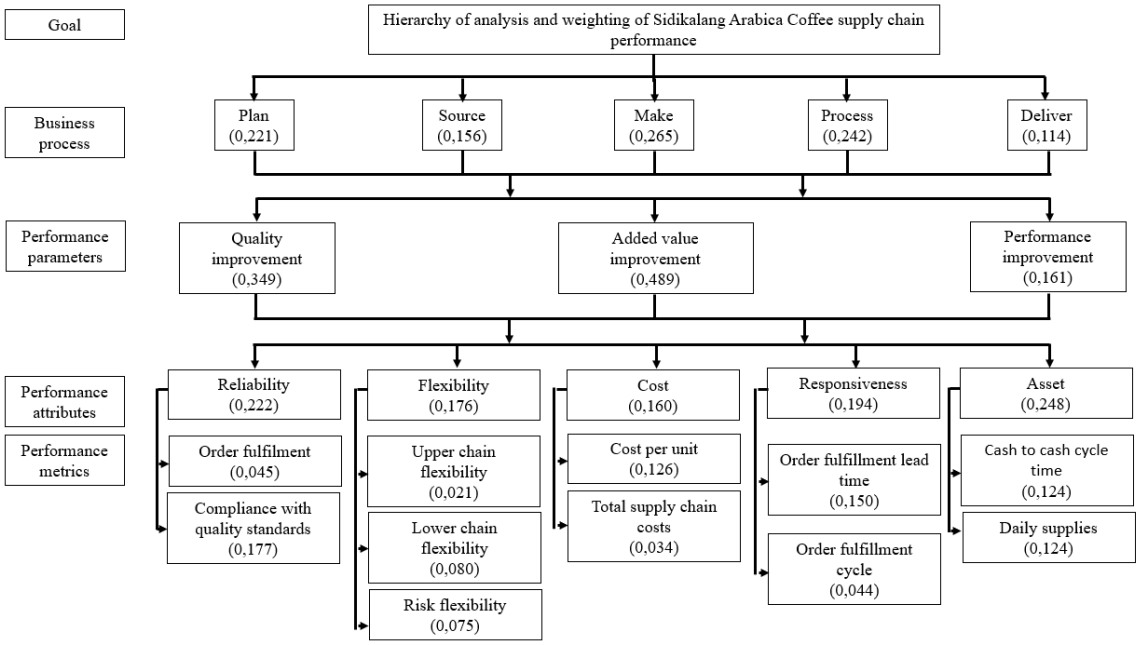

Figure 5. Hierarchy of analysis and weighting of Sidikalang Arabica coffee supply chain performance

Table 2. Results of measuring the performance of the Sidikalang Arabica coffee supply chain

Code	Performance metrics	Performance metrics (%)				
	(Level 4)	Farmer	MSMEs	Hotel	Restaurant	Cafe
R1	Order fulfilment	3.798	4.5	4.5	4.5	4,5
R2	Compliance with quality standards	17.7	17.068	5.531	7.375	17,7
F1	Upper chain flexibility	0.641	2.007	2.1	0.9	0,7
F2	Lower chain flexibility	4.8	6.338	2.133	3.273	4,667
F3	Risk flexibility	0.355	7.5	7.5	7.5	7,5
B1	Cost per unit	3.15	1.344	12.6	12.6	11,261
B2	Total supply chain costs	0.85	3.4	1.913	2.94	0,907
Q1	Order fulfillment lead time	7.5	6.6	7.031	9.531	8,006
Q2	Order fulfillment cycle	1.833	1.76	3.3	2.658	3,3
A1	Cash to cash cycle time	9.3	11.077	12.4	10.629	12,4
A2	Daily supplies	4.34	7.853	3.875	4.65	4,133
Total		**54,268**	**69.448**	**62.883**	**66.555**	**75.074**
Category		***Average***	***Average***	***Average***	***Average***	***Good***

The results of the performance measurement of the Sidikalang Arabica coffee supply chain which are carried out routinely can be used as a reference for evaluating to increase Sidikalang Arabica coffee supply chain performance. Based on the results of the performance measurement, several actions that can be used for optimization at the farmer level are by using better cultivation techniques so that the quality and quantity of production can meet consumer demand, especially for sudden requests. Optimization at the MSMEs level can be done by developing the market to the marketplace with a smaller product quantity and more variations in the form of green coffee beans, roasted coffee beans and coffee powder so that it is not too dependent on conventional consumers. Optimization at HORECA industry optimization actions that can be taken are by developing a marketing strategy by selling product variations in the form of roasted coffee beans or coffee powder.

Supply Chain Risk Analysis of Sidikalang Arabica Coffee

Risk Event Data Collection Results

Risks in supply chain management are divided into risks originating from within the system (operational) and from outside the system (disruptions). Risks from within the system include performance quality, costs, sales, credit, while risks from outside the system can include competition,

economic conditions, political conditions, and natural disasters (Mavi *et al.,* 2016). Risks in the supply chain can have a negative impact on supply chain activities, so risk management is needed to reduce the impact of risk events. Good risk management can overcome potential risks that occur in the supply chain and increase resilience to unexpected situations in the supply chain (Wu *et al.,* 2013). Staged risk management starts from risk data collection, risk assessment, risk analysis, risk mitigation actions to risk evaluation (Arifin *et al.,* 2018). The implementation of risk management requires proactive action from supply chain actors in allocating resources and collaborating so that risk management results are better (Lavastre *et al.,* 2012). Supply chain actors who understand risk management will understand potential events, sources and risk mitigation actions (Singh and Wahid, 2014).

The risk analysis of this study began with field observations, interviews with supply chain actors and experts to collect data on all risk events and sources of risk that occurred in field. The results of the identification of risk events were mapped with reference to the SCOR model which uses the stages of plan, source, make, deliver and return which are useful for describing risk events based on the processes that occur in each supply chain actor. The assessment for recorded risk events is given in the form of severity values (Si) and risk sources in the form of occurrence values (Oj). The collection of risk event data and risk sources that have been collected is sought for the level of relationship by conducting interviews with supply chain actors or experts to determine the aggregate value of potential risks. The supply chain actors used in this study consist of farmers, MSMEs, the hotel industry, the restaurant industry and the cafe industry located in Sitinjo District, Sumbul District and Sidikalang District, Dairi Regency, North Sumatra, but because of all the supply chain actors, the cafe industry is a chain actor with a core business of coffee, the risk analysis data of the supply chain actors displayed as a whole is the cafe industry.

There are 21 recorded risk events at the cafe industry player level. The highest *Si* value is 9 with risk events occurring in consumer segmentation (E14) and shifts in consumer tastes towards refreshing ingredients (E15). The lowest *Si* value risk events with a value of 5 are fluctuations in coffee prices on the market (E5), damaged raw materials (E6), UMKN stock is not always available on the same day (E9), the quality of the products produced is not always the same (E11), fluctuations in production costs occur when raw material prices increase (E16), errors made by employees (E18), fulfillment of requests takes more time for sudden high demand (E21). The complete data collection of risk events that occur at the cafe industry player level can be seen in Table 3.

Table 3. Risk events in the cafe industry supply chain

Code	Process	Risk event	*Si*
E1	*Plan*	There is no planning for the amount of stock availability	7
E2		There is no planning the amount of purchasing raw materials	7
E3		Promotional system planning not optimal	8
E4		There is no planning time to purchase raw materials	7
E5	*Source*	Coffee price fluctuations in the market	5
E6		Damaged raw materials	5
E7		Raw material quality is not always the same	7
E8		Raw material quality decrease during storage	7
E9		MSME stock is not always available on the same day	5
E10	*Process*	The quality of the processed raw materials is not always in maximum condition	7
E11		The quality of the products produced is not always the same	5
E12		Machine damage occurs	6
E13		Many other freshener products are chosen	7
E14		Consumer segmentation occurs	9
E15		Shift in consumer tastes towards fresheners	9
E16		There is a fluctuation in production costs when the price of raw materials increases	5
E17		Product quality stability that is correlated with consumer satisfaction	7
E18		Errors made by employees	5
E19		More and more competitors with the same product	7
E20		Determination of the final price of the product so that it has a level of competition with competitor	7
E21	*Deliver*	Fulfillment of requests takes more time in case of sudden high demand	5

Risk Agent Data Collection Results

Risk agent data collection is used to map risk sources that cause risk events in Sidikalang Arabica coffee supply chain actors. The results of the field data collection, the risk sources in the cafe-level chain actors were recorded as many as 23. The risk sources with the highest Oj value are product characteristics that are not maximized (A11), the price of coffee products is relatively higher than other refreshing ingredients (A16) and the variety and number of consumer demand are increasingly diverse and fluctuating A16). The risk sources with the lowest Oj value in the cafe-level supply chain actors are the processing process is not always carried out optimally (A4), there is no agreement on product quality standards (A5), there is no agreement with MSMEs to ensure the availability of goods (A7), periodic machine maintenance is not carried out (A10), employees do not carry out the SOP that has been determined optimally (A13), inventory management is not optimal (A17), coffee products with variants other than Arabica (A20), the growth of the cafe industry has increased sharply (A21). The results of the complete data collection of risk sources in the cafe industry supply chain actors can be seen in Table 4.

Correlation of Risk Events with Risk Agent

The correlation of risk events and risk agent is used to assess the relevance of a risk source to a risk event. The correlation weighting value between risk events and risk sources is indicated by the numbers 0, 1, 3 and 9. A value of 0 indicates that the risk event and risk source have no correlation, a value of 1 indicates that the risk event and risk source have a low correlation, a value of 3 indicates that the correlation between the risk event and risk source has a correlation while a value of 9 indicates that the correlation between the risk event and risk source has a strong correlation.

Aggregate Risk Potential

Aggregate analysis of potential risks is carried out to determine the most impactful risk sources that must be prioritized for mitigation. ARP analysis is based on the calculation of the aggregate value of the correlation between risk events and risk sources from each supply chain actor. The compilation of the ARP analysis sorting from the highest to the lowest. Based on the analysis of ARP values at the cafe industry level (Table 5), the source of risk with the highest ARP value is the product price which is relatively higher than other fresheners (A16) (ARP=4302) and the source of risk with the lowest ARP value is not carrying out regular machine maintenance (A10) (ARP=295). Consumers feel that the final price of the product given to consumers is still relatively high compared to other fresheners because the cafe industry is a food and beverage industry that prioritizes freshener products compared to food products so that competition in product sales between fresheners will be even higher. Competition between these products will be directly related to other sources of risk, namely the characteristics of the product that have not been maximized (A11) (ARP=2673). Characteristics will affect the level of consumer acceptance of product prices if they can be maximized properly.

Table 4. Sources of risk for cafe industry supply chain actors

Code	Risk agent	*Oj*
A1	Marketing strategy is not optimal	8
A2	There are no regular events that can increase consumer arrivals	7
A3	Demand increases at certain times (there are sudden events)	7
A4	The processing process is not always carried out optimally (related to the quality of raw materials, supporting materials, machines, etc.)	5
A5	There is no agreement on product quality standards	5
A6	Raw materials received from MSMEs are not always in optimal condition	6
A7	There is no agreement with MSMEs to guarantee the availability of goods	5
A8	The quality of raw materials from different suppliers varies	7
A9	Human error in employees	7
A10	No regular machine maintenance	5
A11	Product characteristics have not been maximized	9
A12	The quality of processed products varies	7
A13	Employees do not carry out the SOPs that have been determined optimally	5
A14	Not maximizing the added value of the place and product to attract customers	7
A15	Many other refreshing products are alternatives for consumers	7
A16	The price of coffee products is relatively higher than other refreshing ingredients	9
A17	Inventory management is not optimal	5
A18	The variety and number of consumer requests are increasingly diverse and fluctuating	9
A19	The level of consumer arrivals is very fluctuating	7
A20	Coffee products with variants other than Arabica	5
A21	Growth cafe industry is increasing rapidly	5
A22	Machine capacity is not too large	6
A23	Consumer information and knowledge affect product demand	7

Table 5. ARP values for cafe industry supply chain actors

Rating	Code	Source of Risk	ARP
1	A16	The price of coffee products is relatively higher than other refreshing ingredients	4302
2	A15	Many other refreshing products are alternatives for consumers	3297
3	A11	Product characteristics have not been maximized	2673
4	A8	The quality of raw materials from different suppliers varies	2394
5	A3	Demand increases at certain times (there are sudden events)	2373
6	A19	The level of consumer arrivals is very fluctuating	2142
7	A17	Inventory management is not optimal	2115
8	A18	The variety and number of consumer requests are increasingly diverse and fluctuating	1989
9	A12	The quality of processed products varies	1743
10	A9	Human error in employees	1638
11	A1	Marketing strategy is not optimal	1576
12	A4	The processing process is not always carried out optimally (related to the quality of raw materials, supporting materials, machines, etc.)	1550
13	A6	Raw materials received from MSMEs are not always in optimal condition	1464
14	A14	Not maximizing the added value of the place and product to attract customers	1407
15	A5	There is no agreement on product quality standards	1395
16	A23	Consumer information and knowledge affect product demand	1050
17	A13	Employees do not carry out the SOPs that have been determined optimally	1015
18	A20	Coffee products with variants other than Arabica	980
19	A21	Growth cafe industry is increasing rapidly	875
20	A7	There is no agreement with MSMEs to guarantee the availability of goods	855
21	A2	There are no regular events that can increase consumer arrivals	756
22	A22	Machine capacity is not too large	414
23	A10	No regular machine maintenance	295

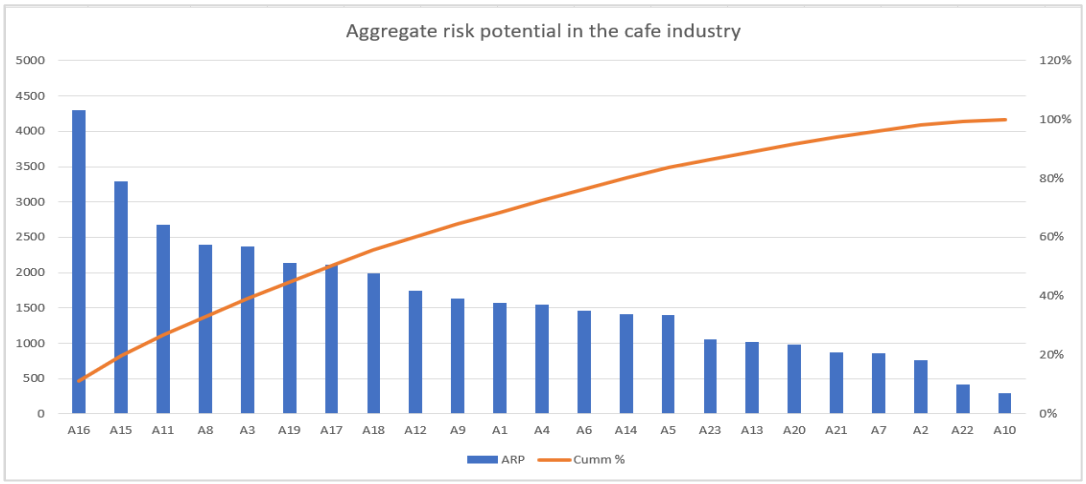

Figure 6. Pareto priority sources of risk for cafe industry supply chain actors

Based on the analysis using the Pareto diagram (Figure 6) on the ARP value and the cumulative percentage of ARP risk sources in the supply chain actors in the cafe industry (Figure 6), there are 14 risk sources that represent 80% of the highest cumulative ARP value with risk sources classified as A, there are 7 risk sources and risk sources classified as B, there are 7 risk sources. Risk sources with classification A include the price of coffee products which are relatively higher than other refreshment materials (A16) (ARP=4302), many other refreshment products which are alternatives for consumers (A15) (ARP=3297), product characteristics which have not been maximized (A11) (ARP=2673), quality of raw materials from various suppliers which are different (A8) (2394), demand increases at certain times (A3) (ARP=2373), the level of consumer arrivals which fluctuates greatly (A19) and the stability of product quality which has a correlation with consumer satisfaction (A17) while risk sources with classification B include variations in the number and demand of consumers which are increasingly diverse and fluctuating (A18) (ARP=1989), the quality of processed products varies (A12) (ARP=1743), human error in employees (A9) (ARP=1638), marketing strategies which are not optimal (A1) (ARP=1576), the processing process is not always carried out optimally (A4) (ARP=1550), raw materials received from MSMEs are not always in optimal condition (A6) (ARP=1464) and do not maximize the added

value of the place and product to attract customers (A14) (ARP=1407) (Table 8) while the results of the Pareto analysis of risk priorities for supply chain actors, farmers, MSMEs, the hotel industry and the restaurant industry can be observed in Table 7.

Table 6. Classification of risk sources for cafe supply chain actors

Rank	Code	ARP	Cumm	Cumm %	Classification
1	A16	4302	4302	11,23%	
2	A15	3297	7599	19,84%	
3	A11	2673	10272	26,82%	
4	A8	2394	12666	33,07%	A
5	A3	2373	15039	39,27%	
6	A19	2142	17181	44,86%	
7	A17	2115	19296	50,38%	
8	A18	1989	21285	55,58%	
9	A12	1743	23028	60,13%	
10	A9	1638	24666	64,41%	
11	A1	1576	26242	68,52%	B
12	A4	1550	27792	72,57%	
13	A6	1464	29256	76,39%	
14	A14	1407	30663	80,06%	
15	A5	1395	32058	83,71%	
16	A23	1050	33108	86,45%	
17	A13	1015	34123	89,10%	
18	A20	980	35103	91,66%	
19	A21	875	35978	93,94%	C
20	A7	855	36833	96,17%	
21	A2	756	37589	98,15%	
22	A22	414	38003	99,23%	
23	A10	295	38298	100,00%	

Table 7. Pareto risk priorities for supply chain actors for farmers, MSMEs, hotel industry, restaurant industry

No	Farmer	MSMEs	Hotel	Restaurant
1	Innovation in cultivation activities is not yet optimal	The distinctive characteristics of Sidikalang Arabica coffee products are less prominent	Last minute orders from consumers	There are certain events that cause a sudden increase in demand
2	Lack of business capital	Quality stability is not maintained properly	Unstable number of coffee product orders	There are fluctuations in demand for coffee products every day
3	The available seeds are not good	Many sudden requests from consumers	Coffee is only considered a side business in the hospitality industry	The price of coffee products is relatively higher than the price of other refreshing ingredients.
4	Farmers still farm in conventional ways	Warehouse management is not well organized		There are other types of coffee besides Arabica coffee products.
5	Profit potential is still not maximized	The product does not yet have a certificate from an authorized agency.		High demand only comes at certain times
6	The use of organic fertilizer is not yet optimal	There is no SOP for product quality standard management		
7	Fertilizer is expensive and rare	Water content measurement does not use standard measurements		
8		Coffee prices are very volatile		

Risk Mitigation Action Data Collection Result

The data collection of risk mitigation actions is compiled based on the risk sources that have been prioritized to be controlled with reference to the highest ARP value, namely risk sources with classification A and classification B that have been obtained from previous analysis. The implementation of mitigation actions is then measured for its realization using the degree of difficulty (Dk). There are 3 scales used in the implementation of mitigation actions, 3 representing a low level of difficulty, 4 representing a medium level of difficulty and 5 representing a high level of difficulty.

Risk mitigation actions compiled at the cafe industry level based on risk source priorities, there are 12 mitigation actions. Mitigation actions with a low level of implementation difficulty consist of 2 actions, including collaborating with raw material suppliers from different places (PA8) and recording consumer demand periodically (PA12), while mitigation actions with a high level of difficulty consist of 3 actions, including holding certain events to attract consumers (PA2), conducting research to improve product characteristics (PA7), and collaborating with banks (PA11). The results of the data collection of mitigation actions carried out at the cafe industry level can be observed in Table 8.

Correlation of Risk Agent and Risk Mitigation Action

The correlation between risk sources and risk mitigation measures is carried out with a weighting of 0.1,3,9. A weight of 0 measures has no relationship, a weight of 1 measure has a low relationship, a weight of 3 measures has a moderate relationship and a weight of 9 indicates measure has a strong relationship. Determination of the correlation between risk sources and risk mitigation in the House of Risk (HOR 2) analysis is carried out to calculate the Total Effectiveness (TEk) value of the mitigation measures to be carried out on risk sources.

Determination of Risk Mitigation Actions

Mitigation action ranking is done by sorting the Effectiveness to Difficulty Ratio (ETD) value from highest to lowest. The ETD value is obtained by dividing the Total Effectiveness (TEk) value and the Degree of Difficulty (Dk) value. Furthermore, the priority of risk mitigation actions is described using the 80:20 Pareto diagram analysis.

Table 8. Mitigation actions for supply chain actors in the cafe industry

Code	Risk mitigation action	*Dk*
PA1	Innovating cafe spots to attract customers	4
PA2	Conducting certain events to attract consumers	5
PA3	Determining the schedule and quantity of raw material orders regularly	4
PA4	Setting standard coffee processing standards	4
PA5	Conducting employee training	4
PA6	Conducting periodic machine maintenance	4
PA7	Conducting research to improve product characteristics	5
PA8	Collaborating with raw material suppliers from different places	3
PA9	Conducting periodic SOP evaluations	4
P10	Implementing a reward and punishment system for employees	4
P11	Collaborating with banks	5
P12	Recording consumer demand periodically	3

Table 9. Pareto priority mitigation actions for cafe industry supply chain actors

Rank	Code	Risk Mitigation	TEk	Dk	ETD
1	PA8	Collaborating with raw material suppliers from different places	125478	3	41826,00
2	PA7	Conducting research to improve product characteristics	192526	5	38505,20
3	PA4	Setting standard coffee processing standards	137932	4	34483,00
4	PA9	Conducting periodic SOP evaluations	121047	4	30261,75
5	PA5	Conducting employee training	68174	5	17043,50
6	PA12	Recording consumer demand periodically	43596	3	14532,00
7	PA1	Innovating cafe spots to attract customers	52374	4	13093,50
8	PA2	Conducting certain events to attract consumers	47208	5	9441,60
9	PA3	Determining the schedule and quantity of raw material orders regularly	31857	4	7964,25
10	PA10	Implementing a reward and punishment system for employees	30060	4	7515,00
11	PA6	Conducting periodic machine maintenance	18164	4	4541,00
12	PA11	Collaborating with banks	14184	5	2836,80

Based on the results of the ETD value calculation, the mitigation action that has the highest ETD value for the supply chain actors at the cafe industry level is collaborating with raw material suppliers from different places (PA8) (ETD=41826.00) and the mitigation action that has the lowest ETD value is collaborating with banking parties (PA11).

Based on the analysis using a Pareto diagram using a comparison of 80:20, the priority of risk mitigation actions for actors in the supply chain of the cafe industry are 6, namely collaborating with suppliers of raw materials from different places (PA8), conducting research to improve product characteristics (PA7), setting standards for raw materials for coffee processing (PA4), conducting periodic SOP evaluations (PA9), conducting employee training (PA5) and recording consumer demand periodically (PA12). The complete priority of risk mitigation actions can be seen in Figure 7 while the results of the Pareto analysis of risk mitigation actions for actors in the supply chain of farmers, MSMEs, the hotel industry and the restaurant industry can be seen in Table 10.

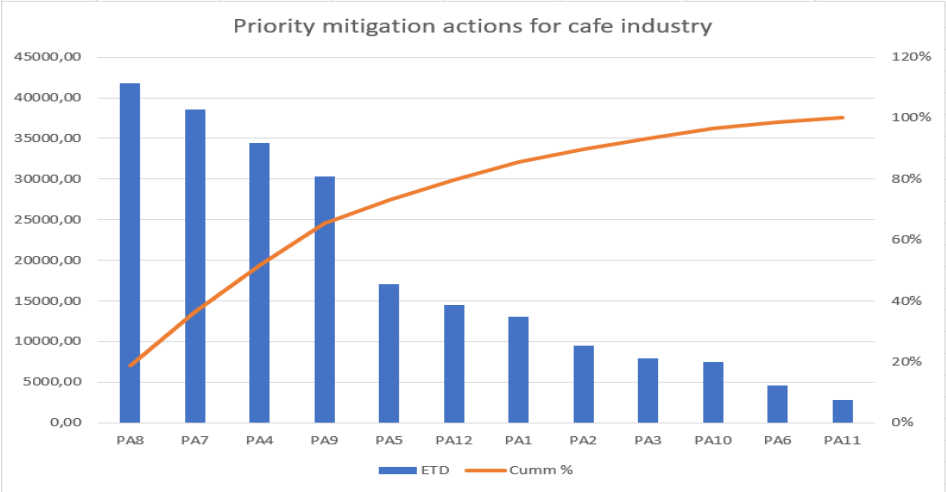

Figure 7. Pareto priority of risk mitigation actions for cafe industry supply chain actors

Table 10. Pareto priority risk mitigation actions for farmers, MSMEs, hotel industry and restaurant industry supply chain actors

No	Farmer	MSMEs	Hotel	Restaurant
1	Providing guidance and procedures for coffee cultivation	Conduct training and provide SOP for coffee processing process	Conducting evaluation on raw material inventory management	Recording sudden demand patterns to support inventory management
2	Providing training in making organic fertilizer	Cooperation contracts with assisted farmers	Recording the number and type of consumer demand for coffee products periodically	Increase product characteristics
3	Innovation in pest and disease control using biological agents	Supervise farmers so that the quantity and quality of products meet the specified targets		Looking for additional raw material suppliers
4	Cooperate with banks to provide capital for farmers	Obtain product certification from authorized institutions		Making agreements with MSMEs to ensure product availability
5	Providing quality seeds to fostered farmers			

CONCLUSIONS AND RECOMMENDATIOS

Conclusions

Based on the analysis results, there are 6 configuration structures of the Sidikalang Arabica coffee supply chain, namely through the MSME channel for consumers who are oriented towards product quality and characteristics and the collector and wholesaler channel for consumers of standard product quality. The performance categories that have been carried out on the supply chain actors of farmers, MSMEs, hotels and restaurants are still at an average level, while the performance of the cafe supply chain actors is already at a good level.

The sources of risk with the highest risk value for farmers, MSMEs, the hotel industry, the restaurant industry and the cafe industry are respectively the lack of innovation in Arabica coffee cultivation activities, the characteristics of Sidikalang Arabica coffee that are not highlighted, sudden orders from consumers, there are events that cause a sudden increase in demand and the price of coffee products is relatively higher than other refreshing ingredients, while the priority for risk mitigation is to provide guidance and procedures for coffee cultivation, conduct training and provide SOPs for coffee processing, conduct evaluations on inventory management, record sudden demand patterns to support inventory management and work with raw material suppliers from different places.

Recommendatios

Further research suggestions that can be carried out are to calculate the added value of each supply chain actor and formulate performance improvement strategies with reference to supply chain structure data, supply chain performance analysis, risk events, risk sources and potential actions for risk mitigation.

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