Coffee Supply Chain Performance Measurement in Ulu Belu District, Tanggamus Regency, Lampung Province

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Abstract

Ulu Belu District, as the largest producer of robusta coffee in Lampung Province, faces challenges throughout its coffee supply chain, from cultivation to marketing. This study aims to examine the structure of the coffee supply chain, evaluate its performance using the Supply Chain Operations Reference (SCOR) model combined with the Analytic Network Process (ANP), and recommend strategies for improvement. The identification results reveal that the coffee supply chain in Ulu Belu District involves several key actors, including farmers, commodity aggregators, collectors, business partners, ground coffee processors, domestic roasters, retailers, exporters, and consumers. This supply chain operates through the flow of products, information, and financial resources among these actors. The coffee supply chain performance measurement results in Ulu Belu District indicate a very poor overall performance score of 58.855. Performance at the three supply chain tiers also reflects concerning conditions: farmers scored 59.721, indicating a very poor performance; collectors scored 62.888, reflecting a poor condition; and business partnerships scored the lowest at 53.957, also categorized as very poor. The strategies for improving supply chain performance include providing training and outreach on Good Agricultural Practices (GAP), implementation of GAP and Good Handling Practices (GHP), implementation of the Common Code for the Coffee Community (4C) certification, increasing storage warehouse capacity, implementing Collaborative Planning, Forecasting, and Replenishment (CPFR) in supply chain management in Ulu Belu, determining safety stock, and planning delivery schedules.

Keywords: *ANP, Coffee, Performance Measurement, SCOR, Supply Chain.*

1. INTRODUCTION

Indonesia is the fourth largest coffee producer and exporter after Brazil, Vietnam, and Colombia (USDA, 2025). The total coffee production in Indonesia in 2024 was 654,000 tons. Lampung is the second largest producer of robusta coffee in Indonesia, with a total production of 108,069 tons in 2024 (Ditjenbun, 2024). The central areas of coffee development in Lampung Province are located in West Lampung and Tanggamus Regencies. In 2022, Robusta coffee production in Lampung reached 113,739 tons, primarily sourced from smallholder farmers (Directorate General of Estates, 2023). Tanggamus Regency is among the leading coffee-producing areas in Lampung Province. The area of Tanggamus Regency is 285,546.00 Ha, which contains a plantation area of 85,924.65 Ha. The plantation area has a share of 35% of the area of Tanggamus Regency (BPS Tanggamus Regency, 2020). Ulu Belu is a district in Tanggamus Regency that has the highest coffee production in Lampung Province. With a coffee production volume of 10,388 tons, Ulu Belu District stands out as one of the leading coffee producing areas in Lampung Province. While this figure is higher than that of many other areas in Lampung Province, it also reflects the region's significant role in national coffee output. However, various issues across the supply chain from upstream (cultivation and harvesting) to downstream (processing and marketing) indicate that there

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is still considerable room for improvement. Addressing these bottlenecks presents an opportunity for Ulu Belu to further increase its coffee production and enhance its contribution to Indonesia's foreign exchange through coffee exports.The problem in the downstream part of the coffee supply chain, such as in small industries, is having limited processing machines, which hinders the efficient processing of coffee beans, and a lack of innovation in creating diversification of processed coffee products. The low innovation is caused by farmers being accustomed to selling in the form of green beans (Darwis et al., 2020).

Product diversification and value addition are vital in improving supply chain performance, particularly in small-scale coffee industries. These businesses can move beyond merely selling raw coffee beans by innovating and developing new coffee-based products—such as ready-to-drink beverages, or cosmetic items. This shift allows them to capture more value at the processing and marketing stages. As a result, they can increase their revenue streams, reduce dependence on selling green beans, and gain access to a broader range of markets. This strengthens their competitive position and makes the supply chain more robust and sustainable in the long term. This shift contributes to efficiency by optimizing the use of raw materials, enhances agility by enabling businesses to respond quickly to changing consumer preferences, and promotes sustainability by supporting long-term economic viability and reducing overreliance on a single product type.

According to Shekarian et al. (2022), supply chain management is an integrated strategy for overseeing the movement of products, data, and financial resources throughout the whole supply chain from initial suppliers of raw materials to final consumers to enhance efficiency, agility, and sustainability. The system in the supply chain can run smoothly if there is certainty in the number of suppliers of raw materials and certainty the amount of demand. Measuring supply chain performance is important because of the large number of coffee supply chain actors involved. The results of measuring supply chain performance can be used as evaluation material to see the current performance position. In addition, the results of these measurements can be used as a basis for developing strategies to improve supply chain performance (Asrol et al., 2017).

In this study, the robusta coffee supply chain in Ulu Belu District is assessed using a combination of the Supply Chain Operations Reference (SCOR) model and the Analytic Network Process (ANP) method. The SCOR model is employed because it provides a standardized framework for evaluating supply chain performance through five key attributes: reliability, responsiveness, agility, cost, and asset management. It enables organizations to understand, measure, and systematically improve their supply chain processes by aligning them with best practices and benchmarks. Meanwhile, the ANP method is chosen for its ability to handle complex, interdependent decision-making environments. Unlike traditional linear models, ANP accommodates feedback and interrelationships among elements making it suitable for evaluating the multi-criteria nature of supply chain performance. It allows for prioritizing key performance indicators (KPIs) by considering expert judgment and the interdependence of SCOR attributes. Combining SCOR and ANP offers a comprehensive and robust approach: SCOR provides the structural basis for identifying performance dimensions, while ANP enhances decision-making by determining the relative importance of each performance indicator. Through this integrated approach, the study aims to generate meaningful insights for robusta coffee supply chain actors in Ulu Belu, helping them identify current performance and determine strategic improvements. The specific objectives of the study are to examine the structure of the robusta coffee supply chain, analyze its performance using SCOR and ANP, and provide targeted recommendations to enhance its efficiency, sustainability, and competitiveness.

2. MATERIAL AND METHODS

Data were collected in Ulu Belu District, Tanggamus Regency, Lampung Province. The location of this study was chosen purposively because Ulu Belu District has the highest coffee production of all districts in Lampung Province. This research was carried out with the initial stages being a preliminary survey and literature study conducted to understand and find out the condition of the coffee supply chain so that the research runs well and correctly. Furthermore, the problem can be identified by conducting direct observations in Ulu Belu District. The issues that have been identified are then formulated, and the research objectives are determined. The second stage is the collection of primary and secondary data. Primary data was collected using purposive and snowball sampling for all coffee supply chain actors in the Ulu Belu district. Furthermore, the coffee supply chain can be identified by describing the problems of supply chain performance using the direct interview method with experts.

In this study, supply chain modeling will be carried out to determine the actors involved in the coffee supply chain in Ulu Belu District. In addition, supply chain modeling can help describe the existing coffee supply chain conditions. In the initial performance measurement stage, Key Perfomance Indicator (KPI) determination is carried out based on 5 core processes: plan, source, make, deliver, return in SCOR version 12.0. The selection of the SCOR version 12 Level 3 model in assessing coffee supply chain performance is based on several strategic and contextual considerations. SCOR 12 is still a relevant standard and is widely used in traditional agribusiness industries such as coffee because this model focuses on basic logistics processes such as planning (Plan), procurement (Source), production (Make), shipping (Deliver), and returns (Return). Level 3 of this model provides the operational details needed to measure activities more granularly, from harvesting and processing to distributing coffee to end consumers. In addition, SCOR 12 has been widely tested and supported by various literature and previous case studies, making it easier to compare (benchmark) and validate the analysis results. Meanwhile, the another version, such as the SCOR Digital Standard (version 13), is more oriented towards digital transformation and automation of industrial processes, which in practice have not been fully implemented in the coffee supply chain, which tends to be traditional and labor-intensive (Özkanlısoy et al., 2023). Therefore, SCOR 12 Level 3 is more appropriate and applicable for this context.

Then, it is continued by creating a KPI network model to determine the clusters and nodes identified and describe the network model. The instruments used in this study were KPI validity questionnaires, KPI weighting questionnaires, and performance assessment questionnaires. This questionnaire was validated through face validity and was assessed by 5 (five) selected experts, consisting of 2 (two) field agricultural extension officers, 1 (one) lecturer from a supply chain management expertise group, and 2 (two) experienced coffee farmers from the Ulu Belu District. These experts were selected based on their qualifications and relevant experience in coffee agroindustry and supply chain. The agricultural extension officers were chosen for their active role in providing technical assistance and field-level support to coffee farmers in Ulu Belu for more than 5 (five) years. The lecturer was selected based on their academic background and research experience in supply chain management, particularly within agroindustry. The coffee farmer experts were chosen due to their long-standing involvement in coffee cultivation, processing, and marketing, with at least 10 (ten) years of practical experience. They recognized leadership roles in local farmer groups. Their collective insights were considered valuable in evaluating the content validity and relevance of the questionnaire items to ensure alignment with real-world practices in the coffee supply chain. Futhermore to ensure the validity of the SCOR (Supply Chain Operations Reference) scores used as key performance indicators (KPIs), it is essential to consider the qualifications of the respondents, as their assessments significantly influence the overall analysis. Therefore, respondent selection was based on clearly defined criteria. In this study, coffee farmers, as the initial sampling point, were required to meet the following criteria: coffee farming must be their primary occupation,

and they must own a minimum of 1 hectare of land. Collectors and members of Coffee Farmer Groups (KUB) were selected based on their involvement in the coffee business for at least five years and their knowledge and skills in coffee cultivation, processing, and marketing within the Ulu Belu District.

The weighting of the coffee supply chain KPI was carried out using the ANP method. The results of the weighting of the inter-cluster relationships are arranged in a cluster metric. The weighting is continued on the inter-node relationships arranged in the appropriate metric cells. The supermatrix obtained is unweighted, so weighting is needed to obtain a weighted supermatrix. The way to get the weighted supermatrix is calculated by multiplying the value of the cluster matrix cell by the value of each unweighted supermatrix cell.

The next stage in processing performance data is normalization, which aims to standardize the scale of the KPI value. Each KPI has a different scale of measurement, so equalizing the parameters by normalizing using the Snorm de Boer equation is necessary. The values obtained from the performance measurement results are categorized based on different scales. Therefore, data normalization is required to calculate overall performance and facilitate the measurement of each metric. Normalization can be carried out using the Snorm de Boer formula as seen in Formula 1 and 2.The final value will be calculated by multiplying the normalization result by the ANP weight of each work indicator. The multiplication results are added up to obtain the total value.

a. Snorm de Boer Normalization (Larger is Better)

$$\text{Snorm} = \frac{(Si - Smin)}{(Smax - Smin)} \text{ x100} \quad (1)$$

b. Snorm de Boer Normalization (Lower is Better)

$$\text{Snorm} = \frac{(Smax - Si)}{(Smax - Smin)} \text{ x100} \quad (2)$$

Description:

Si : The actual value achieved for the indicator

Smax : The performance value of the best achievement

Smin : The performance value of the worst achievement

Each indicator score is then converted into a value from 0 to 100. It is important to note that a score of 0 represents the poorest performance, while a score of 100 represents an excellent performance. These values follow the categorization used in the Snorm De Boer method (Hasibuan et al., 2018).

The final stage is analysis and discussion. This analysis involves the results of modeling the coffee supply chain, performance measurement, and recommendations for improvement. From the final value obtained as seen in Table 1, a proposal for improvement is given to address the root cause of the problem in the robusta coffee supply chain in Ulu Belu District. Furthermore, conclusions can be drawn from the results obtained as a basis for making recommendations and suggestions for further research.

Table 1. Supply Chain Performance Standard Value Classification

Perfomance Score	Criteria
95 -100	Excellent
90 - 94	Very good
80 - 89	Good
70 - 79	Fair
60 - 69	Poor
<60	Very Poor

Source: (Syahputra et al., 2020)

3. RESULTS AND DISCUSSION

3.1 Coffee Agroindustry Profile in Ulu Belu District

Tanggamus is the second largest coffee-producing district after West Lampung in Lampung Province. Tanggamus Regency has 20 Districts with a coffee plantation area of 41,552 Ha and a total production of 33,821 tons in 2022 (Statistics Tanggamus Regency, 2024). The area with the most significant coffee production in Tanggamus Regency is Ulu Belu District. On average, coffee trees in Ulu Belu District are 25-30 years old and have a legacy since the 1990s. The age of the coffee tree influences coffee tree production. Coffee plants start to be productive at around 4–5 years of age, peak production between 10–15 years, and their productivity declines after that age. Rejuvenation of plants through techniques such as pruning is highly recommended to maintain optimal yields after the plants have passed their peak productive period. Several farmers in Lampung Province, especially in Tanggamus, have been included in the verification (4C). PT Nestle Indonesia carried out the verification program as a form of corporate social responsibility (CSR). 4C is a level-below certification assessment system to improve coffee quality and farmer welfare and sustain the coffee economy. Coffee farmers in Ulu Belu District have institutions that manage community forests. It functions to improve community welfare by managing resources optimally, fairly, and sustainably (Larasati et al., 2021).

3.2 Respondent Profiles

Respondent profiles offer valuable information about their background, experience, and decision-making patterns in agricultural business operations. The respondents' profiles included age, education level, land area, and experience in the coffee agroindustry. The respondent profile can be seen in Table 2. As seen in Table 2. the average age of farmers in the young age category is 20-40 years (50.000%). and the old age is 51-60 years (23.333%). The age of farmers is related to the application of technology; the young age category is faster in applying new technology and indicators of the level of human resources, productive or not, in running their farming business. Higher education makes it easier to adapt or apply technological developments.

Table 2. Respondent Profile

Characteristics		Number of People	Percentage (%)
Age	20^{th} - 40^{th}	15	50.000
	41^{th} - 50^{th}	8	26.667
	51^{th} - 60^{th}	7	23.333
Education	Elementary school	10	33.333
	Junior High School	9	30.000
	Senior high school	8	26.667
	Bachelor's Degree	3	10.000
Land Area	1 - 2 ha	9	30.000
	3 - 4 ha	14	46.667
	5 - 6 ha	7	23.333
Experience in Coffee's Agroindustry	$<5^{yo}$	5	16.667
	5^{yo} - 10^{yo}	25	66.667
	$>10^{yo}$	5	16.667

The level of education of respondents as coffee farmers in Ulu Belu District is dominated by elementary schools (33.333%). The characteristics of the land area range from 3-4 ha (46.667%). which is included in the large category. According to Amanah (2018), land is one of the important factors in carrying out development. As land area increases, farmers face higher production costs and must earn more to cover those expenses. Financially stable farmers tend to adopt innovations more readily, as their strong economic capacity gives them the confidence and resources to invest in new technologies, methods, and practices. As shown in Table 2, most respondents (66.667%) have 5 to 10 years of experience managing robusta coffee farming. This indicates that they possess

a moderate to high level of practical knowledge and are relatively experienced in operating their farming businesses. Despite having a relatively low level of education, experienced farmers can still manage their businesses well (Ariyanti et al., 2019).

3.3 Robusta Coffee Supply Chain Structure in Ulu Belu District

The robusta coffee supply chain structure in Ulu Belu District involves several actors from upstream to downstream: farmers, commodity aggregators, collectors, business partnership or joint business groups (KUB), ground coffee processors, domestic roasters, retailers, exporters, and consumers. Coffee supply chain model in Ulu Belu District can be seen in Figure 1.

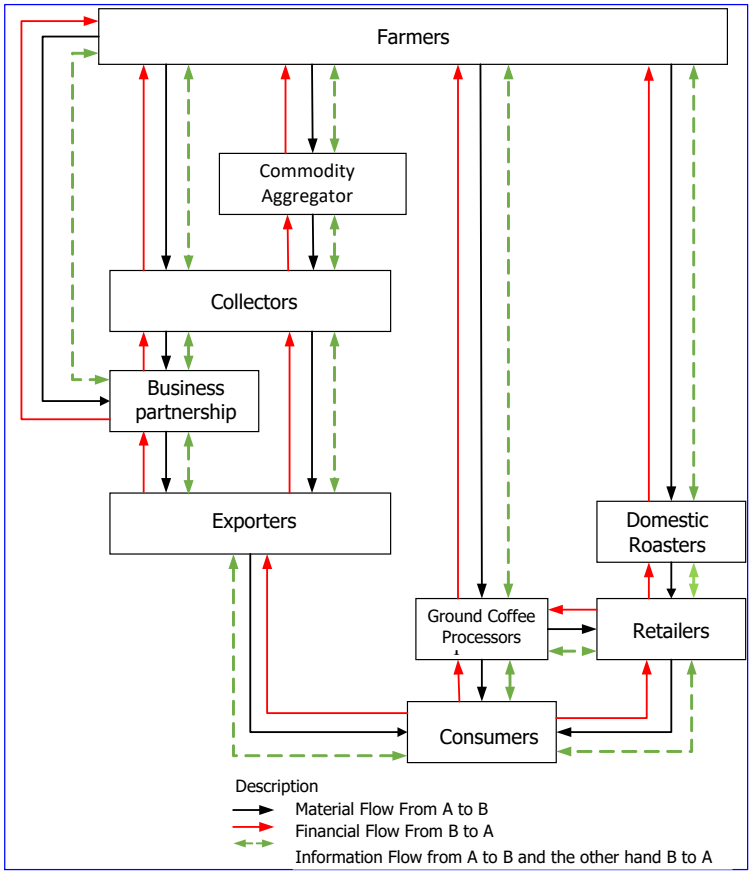

Figure 1. Robusta Coffee Supply Chain Model in Ulu Belu District

1. Information Flow

The flow of information in the coffee supply chain includes information on prices, delivery times, payment systems, quantities, and services between actors in the coffee supply chain. Information related to the coffee supply chain in Ulu Belu District flows from upstream to downstream or vice versa. Information flowing from upstream to downstream is the quantity and quality of coffee supply. Meanwhile, information flowing from downstream to upstream is the price of coffee per kilogram and the quality of coffee (water content, dirt content, size, and smelly beans). The flow of information between farmers and collectors in the robusta coffee supply chain in Ulu Belu has not run smoothly. In the upstream part, the price of coffee obtained by farmers is often delayed, and the amount of market demand is unknown. This is due to a lack of cooperation or partnership between farmers and marketing institutions. Information related to coffee prices is conveyed through online communication with whatsApp, and website.

2. Financial Flow

The financial flow from farmers in each chain ends at the exporter. All actors carry out the payment process with a cash payment system. The cash payment system is used because the distance between farmers and collectors is not far, and farmers need cash for their daily needs. In the buying and selling transaction process, there is a difference in coffee prices between collectors

and business partnership when buying coffee from farmers. Collectors buy coffee from farmers for IDR 22,400 per kg, and business partnership buys coffee from farmers for IDR price. 22,500 per kg. Although business partnership has a higher purchase price, farmers prefer to sell to collectors. This is because collectors accept all types of coffee quality, the distribution distance is not too far, and collectors lend capital to farmers. The income received by coffee farmers in Ulu Belu District can be seen in the production of 860 kg/Ha; farmers get a profit of around IDR 15,804 per kg, collectors 470 per kg, and business partnerships 325 per kg. Based on the B/C calculation, it can be seen that farmers get a value of 3.09, meaning that for every IDR 1.00 spent by farmers, they will receive IDR 3.09. The B/C ratio of coffee farming in Ulu Belu District can be said to be profitable. B/C determines the distribution of profits and costs incurred by each supply chain actor (Sylvia & Ismoyowati, 2020). The robusta coffee trading activity in Ulu Belu District has a market form, namely the oligopoly market. This type of market has few collectors and can suppress the price they pay farmers. Coffee pricing is based on several coffee indicators, such as water content and defect value (rotten, black, broken, and brown beans.

3.4 Measuring Coffee Supply Chain Performance in Ulu Belu District

The validation results obtained 12 key performance indicators; the KPI is valid if three respondents answered "yes" to the KPI, and if only two answered "yes," then the KPI is not declared valid. The resulting KPI can be seen in Table 3.

Table 3. Key Performance Indicator (KPI)

No	KPI	Unit
1	Delivery accuracy	%
2	Perfect item condition	%
3	Orders delivered in full	%
4	Cultivation cycle time	Day
5	Shipping cycle time	Day
6	Capacity increase adaptability	%
7	Capacity decrease adaptability	%
8	Capacity increase flexibility	Day
9	Total of supply chain management cost	Rp
10	Cost of goods sold	Rp
11	Profit	Rp
12	Cash-to-cash cycle time	Day

After obtaining the KPI for supply chain performance assessment, the weight calculation is carried out for each KPI using ANP. The coffee supply chain performance measurement network model can be seen in Figure 2. This figure illustrates the network structure connecting SCOR business processes to performance attributes and their associated performance metrics. Each box represents a component of the SCOR model, and the values in parentheses indicate the respective weights. Arrows show the direction of influence from processes to attributes and then to specific metrics, highlighting the integrated nature of performance measurement. Based on the data processing results using ANP, it can be seen that at the business process level, planning has the highest weight with a value of 0.102, and shipping (delivery) has the lowest weight with a value of 0.038. This value is influenced by coffee agro-industry actors who need planning in preparing land for replanting unproductive coffee plants, post-harvest processing, and marketing coffee. Shipping has the lowest value in the business process because this KPI is considered less important than other KPIs. The shipping process will run if farmers or collectors have supplies or stock of coffee to be shipped. Therefore, a better coffee cultivation process is prioritized, starting from plant care, fertilization, pest control, and proper post-harvest processing. This can help increase coffee production while the shipping task will run smoothly if sufficient coffee is available. At the performance attribute level, assets have the highest weight with a value of 0.171, and responsiveness has the lowest weight with a value of 0.024. Assets are an important KPI in robusta coffee performance because they affect the use of technology and machinery in running a farming

business. Using machinery and technology in the cultivation process will reduce the cost of coffee plant maintenance, increasing profits. Responsiveness has the lowest value in performance attributes because this KPI is considered no more important. The responsiveness of supply chain actors will run well if human resources understands the cultivation process for the marketing activities of coffee to consumers with existing technology. This can be seen from the many trainings, field schools, and other government and private sector coaching.

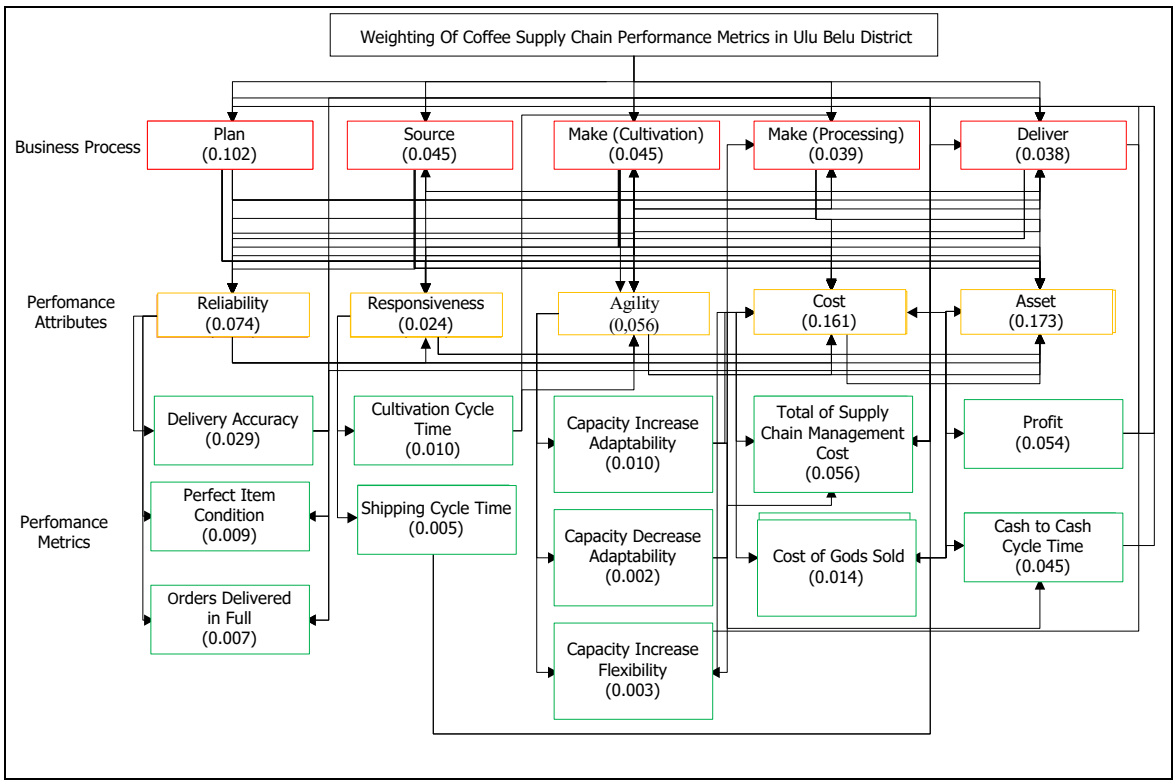

Figure 2. Robusta Coffee Supply Chain Model in Ulu Belu District

3.5 Coffee Supply Chain Performance Measurement Results at Farmer Tier

Most farmers in Ulu Belu District sell coffee as green beans to collectors. Farmers act as producers of robusta coffee for consumption in the downstream sector. Based on the results of performance measurements that can be seen in Table 4, the coffee supply chain in Ulu Belu District is known that farmers get a bad score (59.721). Each key performance indicator influences this score. Based on observations in the field, several farmer performances are less than optimal. The age of coffee trees is pretty old, so coffee production decreases, less fertile coffee land and technology in cultivation, and coffee processing is not maximized in its use. This causes a very low score for coffee farmers in Ulu Belu District.

Table 3 presents the weighted values of key performance indicators (KPIs) related to farmer performance in the robusta coffee supply chain in Ulu Belu District. The performance measurement of the coffee supply chain was carried out by analyzing actual data within the performance matrix and comparing it to the best and worst benchmark values. This comparison produces a performance score for each indicator. The performance matrix was processed using the Snorm de Boer normalization method, which standardises values (parameters) within the KPIs to obtain a comparable score for each indicator. The next stage involved determining the performance score of robusta coffee in the Ulu Belu District by multiplying each normalized score by its respective KPI weight. The results reveal the performance level of each indicator, which is then classified as excellent, very good, good, fair, poor, and very poor. Based on these classifications, further analysis is conducted to identify weak indicators, followed by recommendations for improvement.

Table 4 shows that the performance matrix has the highest weight value on farmer performance, which is influenced by profit factors (26.980) and total management costs (9.086).

The profit matrix (on asset attributes) is an important factor and is highly considered because farmers as coffee producers are oriented towards the profits generated (Prasmatiwi et al., 2017). Profit is an important KPI in robusta coffee performance because the profits obtained by farmers are used to develop their farming businesses. For example, coffee farmers in Ulu Belu have started using modern technology. Using sprayer machines to spray coffee plants and grass-cutting machines makes it easier to clean coffee fields. Using machines in coffee maintenance can reduce maintenance costs, thereby increasing the profits farmers obtain. There is a need to develop coffee cultivation to increase coffee productivity so that the profits are more significant. Long-term coffee development carried out by farmers is the rejuvenation of coffee plants that are 25-30 years old. The use of quality seeds will affect the coffee produced. In addition, according to Pratama (2015), coffee farmers in Ulu Belu stores postpone coffee sales due to fluctuating prices and the uncertainty of the coffee price received by farmers. The advantage of delaying coffee sales is that farmers can obtain a higher coffee selling price, thereby increasing greater profits. This illustrates that coffee farmers have the potential to increase coffee income and have a tremendous opportunity to develop their farming businesses. Total management costs (in cost attributes) are ranked second highest among farmers.

Table 4. Results of Robusta Coffee Supply Chain Performance Measurement

Performance	Weight	Farmers		Collectors		Business Partnership	
		Score	Perfor-mance	Score	Perfor-mance	Score	Perfor-mance
Delivery accuracy	0.122	73.435	8.928	94.400	11.477	92.500	11.246
Perfect item condition	0.036	82.957	2.994	89.600	3.234	76.500	2.761
Orders delivered in full	0.030	69.348	2.072	84.000	2.510	12.500	0.374
Cultivation cycle time	0.039	53.620	2.065	26.667	1.027	41.667	1.605
Shipping cycle time	0.020	100.00	1.987	13.333	0.265	25.000	0.497
Capacity increase adaptability	0.046	61.130	2.834	58.000	2.689	33.000	1.530
Capacity decrease adaptability	0.013	90.000	1.135	32.000	0.404	58.000	0.731
Capacity increase flexibility	0.026	8.885	0.229	21.739	0.559	65.217	1.678
Total of supply chain management cost	0.222	40.956	9.086	20.000	4.437	25.000	5.546
Cost of goods sold	0.037	5.474	0.203	13.532	0.501	17.335	0.641
Profit	0.374	72.087	26.980	94.000	35.181	65.000	24.328
Cash-to-cash cycle time	0.036	33.333	1.208	16.667	0.604	83.333	3.021
Total of Performance		59.721		62.888		53.957	
Average of Performance		58.855 (Very Poor)					

According to Mulyanti (2017), financial management is the management of financial functions such as obtaining and using funds. Financial management plays a role in providing critical information that helps develop and implement strategies in a business. Total management costs in Ulu Belu can be described as forming farmer organizations and managing farming businesses. Farmer groups provide training such as minimizing coffee maintenance costs and marketing management; also, there are certified coffee farmers. According to Marindra (2018), the total cost of plant maintenance incurred by certified farmers is lower than that of non-certified farmers, with certified farmers' farming costs of IDR 4,722,059 while non-certified farmers are IDR 8,383,768 per hectare per year. The high costs are due to the use of chemical pesticides and the use of labor. The costs incurred by farmers in maintaining coffee plants until harvest are pruning costs, fertilizer purchase costs, harvesting costs, drying costs, and shipping costs.

Table 4 shows that the flexibility of increasing capacity (0.229) and the cost of goods sold (0.203) have low values on farmer performance. The value of the KPI flexibility of increasing

capacity shows that farmers are less able to meet unplanned consumer demand increases for 30 days. This condition needs to be evaluated from upstream to downstream with the chain member with the lowest value, namely farmers. For example, good coffee cultivation has not balanced the increase in coffee shop businesses that require coffee as a raw material. Limited machines in coffee processing (coffee skin peeling machines/hullers, roasting machines, sorting machines, grinding machines), low levels of farmer human resources in applying cultivation and processing technology, and coffee trees are more than 25 years old (Darwis et al., 2020). This is what causes farmers in Ulu Belu to be less able to meet unplanned consumer demand increases. The second KPI with the lowest value is the cost of goods sold (in the cost group). This KPI is considered less important than other KPIs.

The price received by coffee farmers in Ulu Belu fluctuates quite a bit. Farmers often experience delays in information on changes in coffee selling prices (time lag). This can cause the price farmers receive to be lower than the prevailing price, especially for farmers who provide a deferred payment system. In addition, coffee farmers still process coffee traditionally, such as during harvesting and processing activities. Farmers generally sell coffee with quality coffee beans picked carelessly, high water content, and defective coffee beans (coffee beans that are not whole or broken, hollow beans, odd-shaped beans, hollow beans, beans that have no aroma, and blackened beans). Defective coffee beans and those with high water content cause the selling price to collectors to be lower. Good coffee beans have a water content of around 12%.

3.6 Coffee Supply Chain Performance Measurement Results at the Collector Tier

Coffee collectors in Ulu Belu District play a role in collecting coffee from farmers to be sold to business partnerships. Based on the results of measuring the performance of the coffee supply chain in Ulu Belu District in Table 4, it is known that collectors get a poor score (62.888). Field observations show that the cause of the collector's poor performance is that collectors running their coffee buying and selling business have problems related to coffee quality. The quality received by collectors is randomly picked and has a relatively high water content. Coffee collectors have limited coffee storage warehouses and limited coffee processing machines (coffee skin peeling machines/hullers, roasting machines, sorting machines, grinding machines). The performance matrix has the highest weight value, seen in Table 4, in collector performance, which is influenced by profit factors (35.181) and delivery accuracy (11.477). KPI (on asset attributes) is an important and highly considered factor. According to Dewi (2015), profit can positively affect a business's quality. If a business experiences profit growth, it indicates that the financial performance of the business is in good condition.

Collectors manage transportation in marketing coffee so that they can get big profits. When marketing coffee, collectors spend money on transportation, loading and unloading coffee, and drivers. Collectors reduce transportation costs by planning and scheduling in selling coffee. For example, collectors sort based on grade to get a high price. Coffee sales in Ulu Belu are carried out every three days from collectors to business partnerships. This can reduce transportation costs, and collectors can generate big profits. Delivery accuracy (on the reliability attribute) is ranked second in collector performance; this KPI measures orders sent completely and on time as agreed. According to Marfuah (2021), delivery accuracy is the main goal and challenge that needs to be faced. Another thing that needs to be considered in delivery accuracy is the collaborative relationship between suppliers to create an effective chain.

Farmers send coffee to collectors with coffee quality that is not too low. Collectors receive various types of coffee, such as random and red-picked coffee. On average, coffee sent by farmers to collectors has a water content that is not too high and by the established standards. This is because farmers in Ulu Belu have little understanding of good coffee processing. Agricultural extension workers (PPL) and the coffee industry provide an understanding of coffee processing, which provides field schools. Farmers and collectors in Ulu Belu have good working relationships and communication, such as collectors overseeing several farmer groups in Ulu Belu, and coffee farmers get raw materials from collectors, such as insecticides, fertilizers, and agricultural equipment. Good working relationships and communication between farmers and collectors will

impact the quality of coffee sent to partnership business. This is in line with Soka's opinion (2017), which is that farmers need to communicate with consumers to ensure that the coffee is by the quality and quantity of the order and that there are no errors in the information on the quantity of coffee sent. Table 4 shows that the performance matrix of the delivery cycle time (0.267) and the adaptability of capacity reduction (0.404) have a value low on collector performance. Delivery cycle time is the time needed to deliver products to consumers. This KPI is considered less important than other KPIs because farmers experience delays in sending coffee to collectors. Farmers need three days in one week to send coffee to collectors. This is the cause of collectors experiencing delays in sending coffee to partnership business.

The delay in the delivery process is due to the length of the drying process carried out by farmers. The drying process depends on unpredictable weather. Coffee drying is carried out on tarpaulin-covered land, and the land for coffee drying is limited. This causes farmers to take longer in the manual drying and sorting, which takes a long time in the delivery cycle. The adaptability of capacity reduction has a low value because several SCOR performance measurement results have a value of 0, meaning that no supply chain actors have requested a reduction or agreed to a reduction in capacity. The problem so far is not because the product is not finished but because of the scarcity of the product (Diah & Syarief, 2016). Coffee farmers in Ulu Belu do not want a decrease in coffee capacity. However, farmers have problems with marketing, namely that the coffee produced is sold individually so that it gets a low price. Small sales capacity and traditional marketing methods by word of mouth.

3.7 Coffee Supply Chain Performance Measurement Results at Business Partnerships (KUB) Tier

Business partnerships in Ulu Belu District plays a role in storing and sending coffee to exporters. Based on the coffee supply chain performance measurement results, which can be seen in Table 4, it is known that business partnerships received a very poor score (53.957). Based on the performance measurement results, business partnerships has several problems: farmers prefer to sell coffee to collectors rather than to business partnerships, limited coffee bean storage warehouses, and fluctuating coffee prices occur quickly. In addition, inappropriate transportation facilities, long distances, and poth/oled road conditions can result in high transportation costs. The performance matrix has the highest weight value, which can be seen in Table 4 on business partnerships performance, which is influenced by profit factors (24.328) and accuracy of delivery (11.246). Profit KPI (in asset attributes) is an important and highly considered factor. According to Madani et al. (2022), profit is the primary goal of forming every business entity or company. One method to gain profit is to pay attention to sales volume and reduce operational costs incurred. Business partnerships plays a role in increasing the added value of robusta coffee distributed to exporters. Increasing the added value is done by applying processing techniques using drying and sorting machines. Modern drying techniques can produce coffee quality that meets export requirements with a minimum water content of 12%. The processing techniques used by business partnerships can increase the profits obtained. Delivery accuracy (on the reliability attribute) is ranked second in business partnerships performance. The KPI for delivery accuracy is an important factor and is highly considered. Collectors in Ulu Belu work with business partnerships to meet coffee needs, so collectors send coffee to business partnerships according to the agreed quality. Business partnerships guides farmers regarding post-harvest coffee processing to obtain quality that meets export standards. In addition, the role of the government in improving the quality of coffee exports and post-harvest coffee technology is stated in Regulation Number 52/Permentan/OT.140/9/2012 and the coffee export policy, namely ISCOffee.

Based on the description, business partnerships always tries to improve the quality of coffee by conducting coaching, such as field schools related to coffee plant care, reducing the use of chemicals, and better post-harvest coffee processing. The KPI with the lowest value is the order fully delivered, and the delivery cycle time at business partnerships has a value of 0.374 and 0.497, which can be seen in Table 4. The order is fully delivered, and the delivery performance is assessed in complete and timely conditions according to the agreement. This KPI is not considered more

important than other KPIs because the business partnerships has formed functions to store and sell coffee before it is sold to consumer. business partnerships sends coffee to exporters twice a week and ships around 27 tons of green bean coffee. Business partnerships has limitations in storing coffee due to the smaller storage capacity of the warehouse. Therefore, the coffee storage stock owned by business partnerships is relatively small. Coffee stored in poor conditions can cause damage, such as increased water content and mold growth. The damage to the coffee occurs due to biotic factors (insects, microorganisms) and abiotic factors (humidity and temperature).

The second KPI with the lowest value is the delivery cycle time (in the responsiveness group). This KPI is considered no more important than other KPIs. Geographically, Tanggamus Regency, as a coffee-producing area, has a flat to hilly topography. In addition, business partnerships sends coffee from Ulu Belu to exporters in Bandar Lampung, which covers a relatively long distance of 99.5 km. The long-distance and narrow and slightly potholed road access results in the delivery of coffee from business partnerships to exporters taking a longer time, approximately 2 days. In addition, coffee farmers tend to sell coffee when they get a suitable price. If the selling price of coffee is low, farmers in the Ulu Belu store postpone sales activities, resulting in business partnerships having a shortage of coffee to send to exporters. Another reason is that the coffee harvest in Ulu Belu differs in each village; for example, Datarajan village has a different coffee harvest time from Sukamaju village by about 1 month. If a complete recapitulation occurs, the performance results of coffee agro-industry actors in Ulu Belu will get a performance value that falls into the very poor criteria (58.855), as seen in Table 4.

3.8 Strategy for Improving Robusta Coffee Supply Chain Performance in Ulu Belu District

Based on the results of performance measurements of 12 KPIs that require improvement. Recommendations for improvement are prepared to address problems in the coffee supply chain in Ulu Belu District. Based on the results of performance measurements, KPIs with poor performance values can be improved, and KPIs with reasonably good performance can be improved. Analysis of performance indicators and performance improvement strategies can be seen in Table 5.

Table 5. Analysis of Performance Indicators and Performance Improvement Strategies

Problem	Strategy	Description
Profit (RA-1) Low profits for farmers, collectors, and business partnership	a. Farmer: Implementation and supervision of Good Agricultural Practices (GAP) and Good Handling Practices (GHP). b. Collectors and Business Partnership: Facilitate communication and coordination among supply chain participants.	Providing training and coaching to farmer groups related to GAP and GHP
Total management cost (DC-1) High coffee agro-industry management costs	a. Farmers: Implementation of the Common Code for the Coffee Community (4C) and GAP certification b. Collectors and Business Partnership: Delivery scheduling planning	Using organic fertilizers gradually. Moreover, an integrated pest control (IPM) system should be implemented. Set the shortest delivery schedule and route for coffee to customers
On-time delivery (PR-1) Relatively low coffee quality	Farmers, Collectors and Business Partnership: Implementation of Good Agricultural Practices	The integration of GAP among these actors helps strengthen supply chain performance by improving efficiency, enhancing product quality, and promoting long-term sustainability in coffee production.

Problem	Strategy	Description
Adaptability of capacity increase (MA-1) Low availability of coffee owned by supply chain actors	Farmers, Collectors and Business Partnership: Implementation of GAP and increasing storage or warehouse capacity	a. Farmers: The implementation of replanting on coffee plantations is not done comprehensively but gradually. b. Collectors and Business Partnership: Making additions and expansions to the coffee storage warehouse to increase the amount of coffee inventory
Processing/Cultivation cycle time (SRe-1) Delays in coffee harvesting due to extreme weather.	a. Farmers:Planting of superior coffee seedlings and replanting b. Collectors and Business Partnership: Adding coffee processing equipment	Farmers carry out cuttings using local clones, implementing replanting in stages.
Cost of goods sold (DC-2) Fluctuating coffee prices and low-quality coffee produced by farmers	a. Farmers: Training and reachout on GAP. b. Farmers, Collectors and Business Partnership: Improving coordination and communication between supply chain actors	Coffee farmers work together with the plantation office and the private sector so that they can conduct reachout related to red picking and farmers get high prices.
Cash to cash cycle time (RA-2) Payment of supply chain actors is a relatively long	Farmers, Collectors and Business Partnership: Implementation of Collaborative Planning, Forecasting, and Replenishment (CPFR) in supply chain management in Ulu Belu.	Creating an information system to anticipate coffee supplies, production, and transportation can achieve safe stock and stable coffee prices.
Perfect condition of goods (PR-2) Farmers do not send coffee according to customer specifications.	Farmers, Collectors and Business Partnership: Implement CPFR Moreover, replenishment of stock in advance	Building good relationships between supply chain actors.
Orders fully delivered (PR-3) Farmers postpone sales or store coffee.	Farmers, Collectors and Business Partnership: Determining safety stock	Slowly increase coffee inventory to prevent delayed order deliveries from suppliers.
Flexibility of capacity increase (MA-3) Limitations of machines, human resource level in technology application and age of coffee trees more than 25 years	Farmers, Collectors and Business Partnership: Building partnerships between coffee farmers and the coffee industry	To address machine limitations, low technological capacity, and ageing coffee trees, farmers, collectors, and business partners should build strong partnerships with the coffee industry to support capacity enhancement.
Delivery cycle time (SRe-2) Each pekon has a different coffee harvest and long distances and narrow and potholed road access.	Farmers, Collectors and Business Partnership: Planning and scheduling of deliveries	Due to varying harvest times and poor road access in each village, farmers, collectors, and business partners need to plan and schedule deliveries effectively.

Problem	Strategy	Description
Adaptive capacity decline (MA-2) Decrease in the quantity of coffee produced	a. Farmers: Farmers do coffee cuttings using local clones that are more resistant to weather changes. b. Farmers, Collectors and Business Partnership: Increasing the target market and providing training to increase the added value of coffee	A key strategy involves farmers using local coffee clones that are more resilient to climate change. In contrast, collaboration among farmers, collectors, and business partners focuses on expanding target markets and providing training to enhance the added value of coffee products.

3.9 Managerial Implications of GAP and GHP

Performance improvement strategies for the robusta coffee supply chain in Ulu Belu District as regulated in the Regulation of the Minister of Agriculture Number: 49/Permentan/OT.140/4/2014 concerning GAP (Good Agriculture Practices) and Regulation of the Minister of Agriculture Number: 52/Permentan/OT.140/9/2012 concerning GHP (Good Handling Practices) that need to be implemented. This is done to improve the quality, productivity, and selling price of coffee. Crop cultivation activities (GAP) include the post-harvest handling process, post-harvest infrastructure and facilities, quality standards, environmental preservation, and supervision. Post-harvest handling of coffee (GHP) with the scope of sustainable coffee production, good coffee cultivation, diversification in coffee cultivation, harvesting, and post-harvest handling. The principles of GAP and GHP in coffee plantations can assure consumers through efficient, productive, and environmentally friendly processes. Based on the problems in the robusta coffee supply chain in Ulu Belu District, improvements need to be made through counseling on the Implementation and supervision of GAP and GHP as follows:

1. Conducting technical guidance for robusta coffee GAP on selecting superior seeds appropriate for the planting environment to obtain maximum taste quality and productivity.
2. Carrying out a combination of clones that are specifically suited to the environment, it is better to use grafted clone seeds using the BP 308 clone rootstock that can survive parasitic nematodes.
3. Reducing dependence on chemical fertilizers by composting with coffee plantation waste (coffee skin and organic waste).
4. Intercropping plants are selected plants that do not have a canopy that is not too dense and have small leaves to provide good light.
5. Harvesting good quality coffee is indicated by a change in the color of the skin of the Robusta coffee fruit to red while harvesting unripe fruit (green and yellow fruit) will cause the quality of the beans to decrease and the taste to be less good.
6. Coffee beans that have been harvested and sorted must be dried immediately so that a chemical process that causes a decrease in quality does not occur. In the highlands, coffee is dried for 2-3 days until the water content reaches 25-27%, with a drying layer thickness of around 6-10 cm. Drying can be done using racks, tarpaulins, and drying floors.
7. Post-harvest coffee handling facilities and infrastructure are used to obtain high-quality post-harvest results (pulper machines, washing machines, drying machines, peeling machines or hullers, and sorting machines).

4. CONCLUSIONS

Based on the results of the coffee supply chain performance measurement, the following conclusions can be drawn. In the coffee supply chain structure in Ulu Belu District, there are several actors: farmers, collectors, collectors, business partnerships, ground coffee processors, domestic roasters, retailers, exporters, and consumers. The coffee supply chain has six types of distribution channels. The most common distribution channels are from farmers as the starting point of the supply chain (point of origin), collectors, business partnerships, exporters, and consumers (point of

destination). The measurement results based on 12 key performance indicators show that the coffee supply chain in Ulu Belu District is still performing poorly (58.855). The results of performance measurements at each tier of the coffee supply chain show that farmers (59.721) are in poor condition, collectors (62.888) are in deplorable condition, and business partnerships is in poor condition (53.957). Strategies needed to improve the performance of the coffee supply chain in Ulu Belu District include socialization related to the implementation of Good Agricultural Practices (GAP), implementation and supervision of GAP and Good Handling Practices (GHP), implementation of the Common Code for the Coffee Community (4C) certification, implementation of Collaborative Planning, Forecasting, and Replenishment (CPFR) in supply chain management in Ulu Belu, increasing storage warehouse capacity, determining safety stock and planning delivery scheduling.

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