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Analysis of the Supply Chain Performance of Sugar palm fruit in Tasikmalaya Regency, West Java

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ABSTRACT

During Ramadan, demand for palm fruit (*kolang kaling*) increases by approximately 60%. However, fulfillment of this demand is constrained by the limited availability of palm trees, weak coordination among supply chain actors, and delivery delays. This study aims to describe the overall condition of the palm fruit supply chain and evaluate its performance. A mixed-methods approach was employed, utilizing qualitative analysis through the Food Supply Chain Network (FSCN) framework to map the supply chain, and quantitative analysis using the SCOR model to assess performance. Sampling was conducted through purposive sampling, targeting farmers and processors with consistent production, complemented by snowball sampling to reach actors not easily identified through formal data. The findings indicate that the target market for palm fruit extends beyond local consumption to regional markets. The supply chain structure consists of interdependent collaboration among farmers, artisans, intermediaries, wholesalers, and retailers, and is characterized by three principal flows: product, information, and finance. Constraints are evident in the limited availability of technological and equipment resources. Business processes employ push and pull strategies, depending on demand fluctuations. Performance evaluation reveals weaknesses in several indicators, particularly order fulfillment, compliance with quality standards, asset management, and supply chain cost efficiency. These limitations highlight the urgency of establishing an association of palm fruit supply chain actors to strengthen communication and coordination, thereby supporting the development, sustainability, and competitiveness of palm fruit farming.

1. Introduction

Sugar palm fruit (Sundanese: *cangkaleng*) is one of the flagship products of the sugar palm fruit (*Arenga pinnata Merr.*), which has high economic value and strategic potential for local agribusiness development. The sugar palm is a multipurpose plant, with nearly all parts usable. It is widely distributed in Indonesia from India to Eastern Indonesia, known by over 150 local names (Haryadi, 2020; Jannah, 2021; Soekotjo, 2019; Santosa, 2018).

The role of sugar palm in the national plantation sector continues to grow. In 2022, the sugar palm plantations in Indonesia reached 63,244 hectares with a total production of 106,486 tons (Ministry of Agriculture, 2023). West Java Province holds a central position with a production contribution of 68,421 tons. Tasikmalaya Regency contributed 11,374 tons in

2020 (BPS West Java Province, 2021). This commodity is marketed domestically and exported to several countries, such as Malaysia and Singapore, making it one of the local products with international market potential (Diskopdagin Tasikmalaya, 2024).

Most farmers in Tasikmalaya Regency do not sell palm fruit in its raw form, but process it into sugar palm fruit. According to data from the Tasikmalaya Regency Regional Regulation (2021), there are 1,912 palm processing businesses in this area, employing more than 10,000 workers. This commodity is highly sought after seasonally, especially during Ramadan, when demand can increase by up to 60% and prices surge from IDR5,000 to IDR8,000 per kilogram (Diskopdagin Tasikmalaya, 2024) (Abidin *et al*., 2024). The stable export demand of 60 tons per month further strengthens sugar palm fruit's position as a high-value product. However, an inefficient and unstructured supply chain management system is hampered by this high potential. In Tasikmalaya Regency, distribution of sugar palm fruit faces persistent challenges including delivery delays, misaligned supply and demand, and lack of integrated information systems among stakeholders (Pebrian *et al*., 2024). Coordination between farmers, collectors, processors, and distributors remains informal and undocumented (Wibowo, 2023). In addition, no structured data is available to assess logistics and distribution performance across the supply chain. At the same time, the contributions and interactions between artisans as producers and marketing institutions together with their marketing functions are mutually influential (Pebrian *et al*., 2024).

Most prior research on Indonesia's food supply chains has concentrated on national-scale commodities such as rice, palm oil, and coffee (Makkarennu *et al*., 2020). Locally based products, such as sugar palm fruit, which are rooted in household industries and community networks, are overlooked mainly (Apriliani *et al*., 2025). This represents a clear research gap: the distribution system and performance of local flagship commodities remain unmapped using systematic and measurable approaches.

In this context, the Food Supply Chain Network (FSCN) approach is important for comprehensively mapping the network of actors and the flow of products, information, and value added from upstream to downstream (Trienekens, 2011). This approach rooted in agri-food value chain and FSCN frameworks explicitly considers vertical and horizontal linkages among actors and the flows of products/information while accommodating seasonal harvest cycles and supply–demand uncertainties that shape distribution stability (Vorst, 2006). Long lead times and volatile demand/supply are documented drivers of distribution instability in fresh produce chains, underscoring the need to model seasonal patterns and coordination across tiers (Soto-silva *et al*., 2016). Moreover, agri-food production is inherently seasonal, and products are often highly perishable, conditions that directly affect network design and the robustness of distribution (Ministry of Agriculture, 2023).

However, mapping alone is insufficient evaluative frameworks are needed to assess each chain component. The Supply Chain Operations Reference (SCOR) model fills this need, offering a global standard for evaluating five core processes Plan, Source, Make, Deliver, and Return through performance indicators like delivery reliability, cost efficiency, responsiveness, and accuracy in logistics planning (Kusrini *et al*., 2019; Supply Chain Council, 2021). This study breaks new ground by applying both FSCN and SCOR to sugar palm fruit at the regional scale. It provides descriptive mapping and diagnostic performance analysis to inform strategic decision-making among local governments, businesses, and other stakeholders (Lee *et al*., 2012). While FSCN emphasizes the structural mapping of actors, flows, and governance without performance measurement tools, SCOR provides standardized performance

indicators but lacks structural mapping capacity. Therefore, this research addresses two main questions: (1) how the sugar palm fruit supply chain in Tasikmalaya Regency is structured and organized, as analyzed through the FSCN framework, and (2) how its performance can be evaluated using the SCOR approach. Accordingly, this study aims to produce an integrated analysis that maps the sugar palm fruit supply chain and evaluates its performance, thereby generating evidence-based insights to support the development of efficient, adaptive, and competitive local agro-industries responsive to national and international market dynamics.

2. Methodology

This study employed a convergent parallel mixed methods design, a mixed methods approach that collects and analyzes quantitative and qualitative data in parallel (simultaneously) (Creswell & Plano Clark, 2018). In this study, qualitative analysis was conducted using the Food Supply Chain Network (FSCN) framework to map supply chain conditions related to the structure, relationship patterns, and socio-economic dynamics of supply chain actors. Meanwhile, quantitative analysis used the Supply Chain Operations Reference (SCOR) model to provide standardized performance measures (reliability, flexibility, cost, etc.). These methods provide a comprehensive, complementary picture not only of the condition of the supply chain but also of how well it is functioning.

The research location was purposively selected in five sub-districts that are the main production centers of palm sugar in Tasikmalaya Regency Salawu, Karangjaya, Bantarkalong, Ciawi, and Leuwisari because these areas are the leading centers for sugar palm fruit processing. The data collected included primary and secondary data. Primary data was obtained through observation, in-depth interviews, and the distribution of questionnaires, while secondary data was obtained from literature reviews, scientific articles, and official documents from relevant institutions.

This study used a combination of purposive sampling and snowball sampling. Purposive sampling was chosen as a non-probability technique, where respondents were determined intentionally based on the researcher's considerations (Neuman, 2014). The criteria for selecting palm fruit farmers and artisans included having processed palm fruit for at least one year and producing consistently (not seasonally). These initial respondents, from farmers and artisans, then served as entry points to explore the connected supply chain network—including collectors, wholesalers, retailers, and exporters through snowball sampling. This technique helps reach small or informal business actors that are difficult to identify through official data, with the help of chain recommendations from initial respondents (Naderifar *et al*., 2017). By combining these two methods, the study obtained data from key actors while also involving hidden actors in the supply chain. In each sub-district, five farmers were selected as initial respondents, who were then traced downstream to downstream actors. Five farmers were selected from each sub-district and then traced back to downstream actors. The total number of respondents was 40. As an exploratory study of a unique commodity that is still rarely researched, this study faced limitations regarding time and human resources.

Data analysis was conducted using both qualitative and quantitative descriptive methods. The qualitative approach was analyzed based on the Food Supply Chain Network (FSCN) framework, which includes the following elements: target market, structure, resources, management, business processes, and supply chain performance (Trienekens, 2011). This analysis aims to understand the distribution flow, relationships between actors,

and the strategic role of local resources. Furthermore, a quantitative approach was used to measure supply chain performance using the Supply Chain Operations Reference (SCOR) model. The main objective of the SCOR method is to measure, compare, and improve supply chain performance.

SCOR was chosen because it can evaluate performance based on five main processes: plan, source, make, deliver, and return (Supply Chain Council, 2021). Performance attributes are grouped into two categories: (1) external which includes reliability, responsiveness, and agility/flexibility, and (2) internal which includes cost and assets (Bolstorff & Rosenbaum, 2011).

Reliability refers to the ability of supply chain actors to maintain the consistency of the quality of palm fruit (clean, not crushed, odorless, according to standard sizes, and fresh) and to deliver it according to the order schedule. Responsiveness refers to how quickly palm fruit artisans or wholesalers can distribute products from farmers to the market when demand arises by utilizing communication and transportation networks. Flexibility (Agility) is measured by the ability of supply chain actors to increase production and distribution (supply diversification, reserve labor, or production pattern adjustments) during seasonal spikes (Ramadan) or reduce supply when demand decreases. Control production costs (harvesting, transportation, and processing costs) through cooperation between supply chain actors to reduce costs per unit. Assets refer to the ability to manage palm fruit land, equipment, storage facilities, and capital.

Each attribute is measured using a performance matrix tailored to the characteristics of the supply chain processes. The measurement results are compared with benchmark standards called the Superior SCOR Card, which combines standards from the Supply Chain Council and the results of studies on companies with superior performance (Harrison, A. & van Hoek, 2008). Performance levels are classified into three categories: parity (industry average), advantage (above average), and superior (top 10%). This approach enables analysis that is not only descriptive but can also be used to design improvement strategies based on quantitative data and global industry standards.

Table 1. Criteria for Achieving The Performance Supply Chain

SCOR Attributes	Matrix/Performance Indicators	*Benchmark*		
		Parity	*Advantage*	*Superior*
	External Performance			
Reliability	Delivery Performance (%)	85.00–89.00	90.00–94.00	≥ 95.00
	Order Fulfillment Rate (%)	94.00–95.00	96.00–97.00	≥ 98.00
	Compliance with Standards (%)	80.00–84.00	85.00–89.00	≥ 90.00
Flexibility	*Flexibility* (days)	42.00–27.00	26.00–11.00	≤ 10.00
Responsiveness	Order fulfillment cycle (days)	14:00-12.00	11.00 – 9.00	≤ 8.00
	Internal Performance			
Assets	*Cash to cash cycle time* (days)	45.00–34.00	33.00–21.00	≤ 20.00
	Inventory days of supply	27.00–14.00	13.00–0.01	= 0.00
Cost	*Total Supply Chain Cost* (%)	13.00–9.00	8.00–4.00	≤ 3.00

Source: (Bolstorff & Rosenbaum, 2011) (Apriyani *et al*., 2018) (Pujawan & Mahendrawathi, 2017)

In measuring the performance of the sugar palm fruit supply chain, several indicators are applied based on the five main attributes of the SCOR model, adapted to the specific

characteristics of this commodity. The global SCOR benchmarks in Table 1 are used as an initial reference. However, their interpretation is carefully adjusted to the context of a supply chain dominated by smallholder farmers and constrained by local infrastructure.

a. Reliability includes three indicators:
   - On-time delivery, the percentage of sugar palm fruit shipments that arrive on the date requested by the buyer, both for local markets and for export;
   - Order fulfillment rate, the percentage of total consumer demand that can be met immediately without requiring additional production processes;
   - Quality conformity, the percentage of sugar palm fruit delivered that meets established standard specifications such as size, texture, and ripeness.

b. Flexibility is evaluated through response time to changes in demand, whether in the form of increases or decreases in order volume, without incurring additional costs or order rejections (e.g., during Ramadan or in response to sudden export demand).

c. Responsiveness is measured by the order fulfillment cycle, namely the time required by the business actor to process and send sugar palm fruit for one order.

d. Asset Management is analyzed through two indicators:
   - Cash-to-cash cycle time, which is the time difference between payment to palm fruit suppliers and receipt of payment from consumers (distributors, retailers, or exporters);
   - Inventory days of supply, which is the estimated length of time that sugar palm fruit inventory can sustain market demand in the event of a supply disruption, such as during a decline in palm fruit harvests. In addition, the Daily Supply indicator = 0.00 does not mean that supply has stopped completely, but rather reflects a condition where all products are immediately absorbed by the market on the same day so that there is no remaining stock.

e. Cost is measured through Total Supply Chain Management Cost (TSCM), which is the total cost incurred in all post-harvest and distribution activities of sugar palm fruit, including labor costs, packaging, transportation, and storage, expressed as a percentage of total business revenue.

In this study, the SCOR benchmarks are employed adaptively, serving primarily as evaluative guidelines rather than absolute standards compared with multinational supply chains. Such an approach acknowledges the contextual specificity of the sugar palm fruit supply chain, which is inherently informal, predominantly smallholder-based, and sustained by trust-oriented relationships. Consequently, deviations from global standards are both expected and analytically accommodated, ensuring that performance assessment remains relevant to the structural and socio-economic realities of the local context.

3. Results and Discussion

3.1 Description of the general overview of the sugar palm fruit supply chain in Tasikmalaya Regency based on the Food Supply Chain Network (FSCN) approach

3.1.1 *Supply Chain Objectives*

Supply chain performance can only be optimal if every actor involved consistently performs their functions and roles in accordance with established regulations. Thus, the

supply chain flow structure is a strategic factor that determines the success rate of the distribution system. This structure consists of members involved directly or indirectly, grouped according to their duties, functions, and roles. Identifying the supply chain structure is intended to map the actors involved and to determine critical points, namely, actors or elements that have the most significant influence on the smooth flow of products and coordination between members. This is in line with findings in the horticultural supply chain in China, where wholesalers play a dominant role in grading and determining product quality standards, thereby influencing the behavior of other actors in the network (Li *et al*., 2022). Similarly, studies on food systems in South Asia reveal that intermediaries not only serve as distribution links but also as controllers of prices and market access, thereby influencing the competitiveness of the entire supply chain (Mazhar *et al*., 2022) (Shareef *et al*., 2024). Therefore, identifying key actors and elements that can be optimized is a crucial prerequisite for enhancing the efficiency and sustainability of the supply chain

a. *Members of The Sugar Palm Fruit Supply Chain*

In this study, supply chain members are categorized into two groups: those directly involved and those not directly involved, but rather acting as supporters in maintaining the continuity of the supply chain flow.

Members who are directly involved in the supply chain flow play a crucial role at every stage, from production to marketing, and ultimately determine the success of the supply chain. These members are referred to as core members. Meanwhile, members who are not directly involved are members who do not participate in producing and marketing agricultural products, but whose existence supports the success of the supply chain flow.

The sugar palm fruit supply chain structure includes central actors such as palm tree owners, sugar palm fruit artisans, intermediaries, wholesalers, retailers, and supporting actors who indirectly influence product flow (Indriani *et al*., 2025; Handayati, 2015). A similar study on nipa palm commodities in Thailand, a regional analog, shows the involvement of suppliers, farmers, intermediaries, wholesalers, and consumers in the supply chain (Chanklap *et al*., 2025). Both commodities involve many local stakeholders, indicating that the development of the sugar palm fruit supply chain has the potential to provide a double positive impact on the community. Small agro-industrial activities are known to be able to absorb labor in rural areas (Fatmawati & Rahmawati, 2021). The following describes the roles of each actor in the sugar palm fruit supply chain in Tasikmalaya Regency.

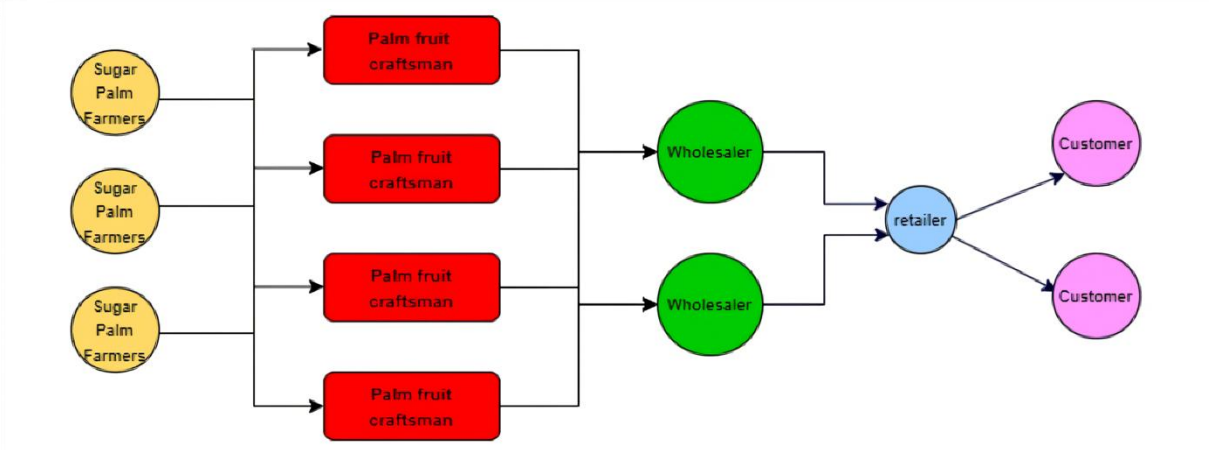

Figure 1. Core Structure of The Sugar Palm Fruit Supply Chain in Tasikmalaya Regency

(1) Farmers Who Own Palm Trees

Farmers who own palm trees own them because they manage them or because palm sugar artisans purchase them and their fronds. Their activities are seasonal, from harvesting palm sugar to utilizing male flowers for sap tapping. Research on mandarin farmers in Punjab, Pakistan, reveals that small-scale farmers tend to be part of traditional supply chains, resulting in limited access to modern supply chains and lower efficiency and profitability than large-scale farmers (Mazhar *et al*., 2022). Additionally, a study of the dairy sector in Punjab reveals that small-scale farmers who rely on informal chains and intermediaries face high transaction costs and weak coordination (Ziad *et al*., 2018).

(2) Sugar palm Fruit Artisans

The sugar palm fruit artisans in this study are located in Tasikmalaya Regency, where they process sugar palm fruit by boiling, peeling, and crushing it to produce a final product of high quality that meets market demand. As the leading actors, sugar palm fruit artisans are one of the important pillars in the local supply chain. Their role in supplying sugar palm fruit products is a determining factor in the next supply chain. For comparison, a study of the coconut sugar commodity supply chain in Purworejo found a similar flow, starting from artisans/processors, then collectors, to retailers and end consumers (Fatmawati & Rahmawati, 2021). Several artisan products (products made traditionally or semi-traditionally), such as Indonesian chocolate, involve a similar supply chain framework accompanied by demands for environmentally friendly and high-quality products (Nur *et al*., 2023). Additionally, artisanal products in Ukraine have a sustainable market structure that is based on the involvement of local communities (Danko *et al*., 2025).

(3) Middlemen/Intermediaries or Brokers

Middlemen/Intermediaries or brokers are tasked with purchasing products from farmers or artisans, then liaising with the market by managing access related to location, quality, and product criteria. They also provide capital financing to artisans and hold significant control over decisions related to the selling price, quantity, and quality of products that large traders desire. Additionally, middlemen handle the sorting and grading of production and arrange logistics for delivery to large traders. In many agricultural supply chains in various developing countries, intermediaries, such as middlemen, play a dominant role, and farmers often receive minimal profits because these intermediaries control prices (Oguoma *et al*., 2010).

(4) Wholesalers

Wholesalers purchase sugar palm fruit in large quantities from middlemen and then distribute it to small traders, retailers, or consumers. They serve as the main intermediaries between producers (artisans) and wider distribution channels (outside the city), and play a strategic role in ensuring the smooth flow of products to the final market. This finding is consistent with those in the agricultural commodity supply chain, where wholesalers aggregate products, provide market access, and perform sorting and distribution, despite the intermediary layer having the potential to cause inefficiencies and additional costs (Shareef *et al*., 2024). Furthermore, in international production networks, the existence of wholesale intermediaries has been shown to significantly increase aggregate productivity and welfare, reduce

market concentration and markups, and strengthen resilience to trade shocks (Blum *et al*., 2023).

(5) Small Traders (Retailers)

Retailers purchase sugar palm fruit from middlemen or wholesalers and then sell it in small quantities to end consumers. They serve as a direct bridge between the supply chain and consumers by providing products according to the daily needs of households and small businesses. The role of retailers is not only to ensure product accessibility, but also to serve as a channel for market feedback regarding consumer preferences, such as the size, color, and cleanliness of palm fruit, as well as the timing of demand. This finding aligns with research on the horticultural supply chain in China, where retailers serve as quality gatekeepers, tailoring products to meet the standards of urban consumers (Li *et al*., 2022). Similarly, a study in Pakistan shows that traditional retailers remain vital in traditional supply chains because they maintain direct relationships with consumers despite thin profit margins (Mazhar *et al*., 2022). Thus, retailers play a strategic role in ensuring smooth distribution, maintaining quality standards, and absorbing products to prevent accumulation at the producer level.

b. *Flow Patterns in the Sugar palm fruit Supply Chain*

In the supply chain, there are three primary flows that must be managed, the flow of goods, the flow of money, and the flow of information that moves from upstream to downstream (Nuraisyah *et al*., 2025; Handayati, 2015; Sukur *et al*., 2024). In the sugar palm fruit supply chain, the flow of goods begins with farmers as fruit suppliers, then moves to artisans as producers, continues to middlemen, and ends with wholesalers as the link to end consumers. The pattern of goods flow is highly dependent on the availability of harvests, so delivery schedules are inconsistent and follow the stock obtained by artisans. This condition differs from the horticultural supply chain in China, where contract mechanisms and harvest schedule coordination enable consistent distribution even when supplies fluctuate (Li *et al*., 2022).

The flow of money in the sugar palm fruit chain is carried out directly in each transaction without a formal payment system. Farmers receive payment both when the fruit is young and after it is ready to be harvested. Artisans obtain cash capital from middlemen before starting production, while payments from wholesalers to middlemen are usually made via transfer after the products are received. This scheme reflects cash-based transaction practices that are common in developing countries, but differs from modern agribusiness supply chains that have adopted digital payment systems or formal contracts to reduce liquidity risk (Shareef *et al*., 2024).

The flow of information occurs through informal communication between actors, mainly using telephones and instant messaging applications. Large traders convey market information, prices, and consumer quality preferences to middlemen, who then pass this information on to artisans. However, information on quantity and quality is often not distributed evenly due to coordination limitations. This pattern is in line with the findings of Mazhar *et al*. (2022) in Pakistan, where limitations in the information system cause market uncertainty for small farmers. Conversely, the study Li *et al*., (2022) shows that in China's horticultural supply chain, information integration through digital systems helps reduce food loss by connecting urban consumer preferences with quality standards at the producer level. Thus, weaknesses

in the flow of goods, money, and information in the sugar palm fruit supply chain indicate the need for modernized coordination to improve efficiency and competitiveness.

3.1.2. *Supply Chain Resources*

Supply chain resources encompass all inputs required to produce products and distribute them to customers, comprising physical resources, human resources, technology, and capital (Perdana *et al*., 2023) . In the context of the sugar palm fruit supply chain, the physical resources of artisans include production sites, palm trees or palm plantations, simple equipment (stoves, drums, machetes), packaging (sacks), and transportation facilities. Infrastructure factors such as road conditions and distribution distances also affect the smooth flow of products. However, the most critical challenge lies in the availability of palm fruit, given that palm trees only bear fruit once in their lifetime, and some are cut down early for the production of aci. This is consistent with findings on other agroforestry commodities in Southeast Asia, where the limitations of crop production cycles can disrupt supply chain continuity and pose long-term supply risks (Perdana *et al*., 2023; (Promkhambut *et al*., 2023).

At the middleman level, the physical resources used are relatively straightforward, including storage drums, crushing tools, and vehicles for distribution. There are no significant obstacles in this aspect; however, limitations in storage and cooling infrastructure can impact product quality. A comparison with the horticultural supply chain in China shows that weaknesses in storage facilities at the intermediary level often increase the potential for food loss (Li *et al*., 2022).

Human resources at the artisan level generally range from 2 to 10 people, consisting of family and non-family workers. In contrast, at the middleman level, 3 to 4 workers are involved in the pounding activity. The majority of the crushing workforce involves women. The motivation for women to work is to fill their free time and increase family income (Hamidah & Wahyurini, 2023). Income as a driver of entrepreneurial interest (Arman *et al*., 2024). The relatively large number of workers suggests a labor-intensive production structure, similar to that of small businesses in other tropical commodities, such as cocoa and coffee (Bitzer & Glasbergen, 2015).

In terms of capital, most artisans rely on personal funds for the continuity of production, with a small portion obtaining loans from intermediaries, which are then repaid through the sale of their production. The middlemen themselves use personal capital to finance distribution. This informal financing scheme reflects a typical pattern in developing countries, where limited access to formal credit leads to high dependence on intermediary networks and weak bargaining power. Studies in Bangladesh and Pakistan reveal similar phenomena: financing based on socio-economic relationships with intermediaries, while playing a crucial role, has the potential to erode the profit margins of small producers and create power asymmetries in the supply chain (Mazhar *et al*., 2022; Shareef *et al*., 2024)

In addition to tangible resources such as physical assets, supply chain actors also have intangible resources such as local networks, traditional knowledge, and relationships of trust. Local knowledge and traditional skills have been proven to enhance the ability of small farmers to maintain access to food during disruptions, thereby playing a crucial role in the operational resilience of the supply chain (Munyoro, 2025). Furthermore, organizational networks and flexible relationships between entities are a source of competitive value that is difficult to replicate, where the ability to utilize social networks can drive performance even when physical resources are limited (Adetoyinbo & Mith, 2025)

3.1.3 *Supply Chain Management*

Supply chain management emphasizes the importance of coordination and collaboration among actors in utilizing resources to improve overall performance (Handayati, 2015). In sugar palm fruit, supply coordination is primarily controlled by the relationship between artisans/farmers and intermediaries. Intermediaries often offer a certain quantity that must be met. However, the limited availability of sugar palm fruit means that artisans continue to sell their harvest even if they do not reach the target quantity. This pattern indicates a lack of formal regulation, as cooperation is still based on trust and unwritten customs. Trust-based governance systems are commonly found in small-scale agricultural supply chains in developing countries; however, a significant difference from modern supply chains is the absence of formal contracts, which can reduce supply uncertainty (Fischer *et al*., 2008) (Mazhar *et al*., 2022). Trust is the foundation for adaptation and building mutual commitment, which leads to long-term collaborative relationships. Trust-based cooperative relationships in the supply chain encompass information sharing, honesty, partner competence, and long-term commitment (Ryciuk & Nazarko, 2020).

The selection of partners is also informal: The selection of partners in the sugar palm fruit supply chain remains informal. Artisans prefer intermediaries who offer flexibility in price and quality, while intermediaries tend to choose farmers who can supply them consistently. This pattern of cooperation reflects the high dependence on interpersonal trust relationships, which is also found in the horticultural supply chain in Thailand. There, small farmers use traditional markets to link to the modern supply chain and choose intermediaries based on supply reliability and transaction flexibility (Ørtenblad *et al*., 2023). This situation aligns with the horticultural supply chain in Pakistan, where small farmers choose intermediaries based on price flexibility. In contrast, intermediaries choose farmers with continuity of supply, even though this practice often pressures producers' profit margins (Mazhar *et al*., 2022). In contrast, studies on the horticultural supply chain in Europe show that formal contracts and quality standard mechanisms can increase supply certainty while strengthening farmers' bargaining position (Gellynck & Kühne, 2010). In agribusiness supply chains in developed countries, the adoption of more formal partner selection practices through structured evaluation mechanisms has been shown to increase supply stability and price fairness (Silva *et al*., 2023).

On the other hand, waste management at the artisan level remains weak. The production process generates waste in the form of shells, boiling water, stems, and burning ash, most of which is discarded into the surrounding environment. Although some artisans have utilized dry stems as firewood, waste management efforts have not been integrated. This finding is similar to those in small agro-industrial supply chains in South Asia, where agricultural waste is often disposed of without further processing, resulting in environmental impacts (Rai *et al*., 2025). In contrast, sustainable supply chain approaches in Europe and Latin America have promoted circular economy practices by utilizing agricultural waste as a source of biomass energy or secondary raw materials (Teigiserova *et al*., 2020). Thus, weaknesses in coordination, formal contracts, and waste management indicate the need for a transformation of the sugar palm fruit supply chain towards a more modern and sustainable model.

3.1.4 *Supply Chain Business Process*

The supply chain business process can be viewed from two main perspectives, the cycle view and the push or pull view (Chopra & Meindl, 2016). Based on data analysis, the sugar palm fruit supply chain tends to reflect a push-pull view pattern. This model separates the supply chain process into two: the pull process, which is reactive to actual consumer demand, and the push process, which is speculative based on demand predictions. In practice, sugar palm fruit artisans and intermediaries tend to rely on a combination. Production and distribution volumes are determined by experience-based estimates (push), but supply realization still follows actual demand (pull). This indicates that the sugar palm fruit supply chain coordination still relies on the intuition of actors and informal relationships, unlike modern supply chains in developed countries, which have utilized data-based forecasting systems and digital technology to reduce uncertainty. For example, in China's agricultural sector, the adoption of digital technology and IoT has been shown to improve supply resilience by improving forecasting accuracy and real-time responses to fluctuations in demand (Yu *et al*., 2025). More generally, a literature review has found that the integration of digital technologies such as predictive analytics, AI, and big data enhances the efficiency of the food supply chain through improved visibility, enhanced risk management, and more responsive decision-making (Panigrahi & Singh, 2025).

Some of the business processes carried out by sugar palm fruit businesses are still simple, particularly regarding demand management and customer order fulfillment. Demand management involves planning and controlling demand to match supply capacity. In the case of sugar palm fruit, a surge in demand occurs ahead of Ramadan. To anticipate this, farmers usually adjust their harvest schedules to coincide with this period and collaborate with other farmers to maintain product availability (Perdana *et al*., 2023). This pattern is similar to demand-driven planning practices for seasonal horticultural commodities in South Asia, where smallholder farmers time their harvests to meet peak market demand, despite often facing the risk of oversupply and falling prices (Mazhar *et al*., 2022). In contrast, the European horticultural supply chain has integrated collaborative planning based on market data, enabling a higher degree of accuracy in anticipating demand spikes (Gellynck & Kühne, 2010).

Meanwhile, the Customer Order Fulfillment process in the sugar palm fruit supply chain involves stages ranging from receiving order information from intermediaries to harvesting ripe palm fruit, boiling or burning it, peeling it, processing it into sugar, and then packaging and distributing it. This process typically takes 2-3 days, but it may take longer if the necessary raw materials are unavailable. Dependence on the limited availability of palm fruit prolongs the order fulfillment cycle. This condition aligns with Trienekens' (2011) findings, which indicate that supply chains in developing countries tend to be vulnerable to delays due to limited production inputs. Conversely, delays can often be mitigated in more integrated global supply chains by implementing modern logistics systems, formal contracts, and supply reserve mechanisms. For example, inventory management practices such as inventory pre-positioning, multiple sourcing, and flexible sourcing contracts have been shown to increase supply chains' resilience to disruptions (Guo *et al*., 2025) . Thus, the sugar palm fruit supply chain remains at a traditional stage, relying on informal flexibility. At the same time, international practices demonstrate the importance of integrating technology and collaborative planning to improve efficiency.

3.2 The performance of the sugar palm fruit supply chain in Tasikmalaya Regency using the Supply Chain Operation Reference (SCOR) approach

The SCOR model integrates three essential management elements into a cross-functional supply chain framework: business process reengineering, benchmarking, and performance measurement. This emphasis aligns with the fundamental principles of SCOR, which are designed to integrate strategy, operations, and continuous improvement throughout the supply chain (APICS / ASCM, 2022). In addition, the SCOR structure at the strategic level (Level-1) includes six main processes: Plan, Source, Make, Deliver, Return, and Enable, which serve as a hierarchical framework for analyzing and improving supply chain performance (Engelenhoven *et al*., (2023); APICS / ASCM, (2022)) . The use of SCOR analysis in this study is not intended as an absolute comparison with multinational supply chains, but rather as a benchmarking framework adapted to measure the relative position of the sugar palm fruit supply chain based on field observations.

Table 2. Results of Measuring The Performance of The Supply Chain of Palm Fruit Farmers

SCOR Attributes	Matrix/Performance Indicators	*Benchmark*			**Average**	**Results**
		Parity	*Advantage*	*Superior*		
	External Performance					
Reliability	Delivery Performance (%)	85.00–89.00	90.00–94.00	≥ 95.00	99.32	Superior
	Order Fulfillment Rate (%)	94.00–95.00	96.00–97.00	≥ 98.00	88.60	Parity
	Compliance with Standards (%)	80.00–84.00	85.00–89.00	≥ 90.00	89.95	Advantage
Flexibility	*Flexibility* (days)	42.00–27.00	26:00–11:00	≤ 10:00	4	Superior
Responsive-ness	Order fulfillment cycle (days)	14:00-12:00	11:00 AM - 9:00 PM	≤ 8.00	7	Superior
	Internal Performance					
Assets	*Cash to cash cycle time* (days)	45.00–34.00	33.00–21.00	≤ 20.00	2	Superior
	Daily Supply (days)	27.00–14.00	13:00–0:01	= 0.00	5	Advantage
Cost	*Total Supply Chain Cost* (%)	13.00–9.00	8.00–4.00	≤ 3.00	18.75	Parity

Source: Primary data analysis, 2025

3.2.1 *Delivery Reliability*

This high reliability is influenced by a combination of factors, including human resource involvement, infrastructure conditions, and adequate transportation facilities, ensuring that supplies can be delivered on time. Artisans employ family and non-family workers in the processing stage to accelerate production. Most of the market segment is located within the district, resulting in relatively short distribution times that can be accomplished using two-wheeled vehicles. Additionally, intermediaries' location, typically near highways with good infrastructure, also facilitates the distribution process. Theoretically, delivery reliability is measured by the percentage of on-time and complete deliveries; the SCOR standard defines a value above 95% as the superior category (APICS / ASCM, 2022). This finding is higher than that of a horticulture study in Turkey, where the reliability of fresh product distribution often declines due to transportation and infrastructure constraints (Özkanlısoy, 2023) . Technological infrastructure utilizing real-time sensors can monitor distribution conditions and ensure products arrive on time, thereby consistently maintaining a delivery reliability rate above 95% (Plakantara & Karakitsiou, 2025).

3.2.2 *Order Fulfilment or Fill Rate*

Aramyan *et al*.'s study (2007) notes that a fill rate of 85–90% is the average standard in the agricultural supply chain. Based on Table 2, the average performance value of the palm fruit fill rate reached 88.60%, which falls into the parity category. This low value is influenced by the limited physical resources, specifically palm trees, which are decreasing due to competing industries, such as sago palm, which utilizes tree trunks as raw materials. Similar conditions are also observed in citrus commodities in Pakistan, where supply constraints at the farmer level lead to delays in order fulfillment (Mazhar *et al*., 2022).

In addition to supply factors, FSCN analysis shows that the cooperation system in the palm fruit supply chain is still based on trust without formal contracts, resulting in no guarantee of raw material availability. The absence of rules regarding obligations, rights, and sanctions leads to supply chain activities operating without certainty. In addition to the conventional cooperation system, the lack of coordination between supply chain actors also contributes to a lack of clarity regarding consumer preferences, prices, quantities, and quality requirements. However, the fill rate in the 88–90% range can still be improved through improved demand management, particularly by adopting modern forecasting capabilities based on predictive technology (big data analytics). This technology has been proven to improve forecast accuracy and reduce the risk of order shortages in the food supply chain (Rejeb *et al*., 2022).

3.2.3 *Quality Conformance*

The average product quality conformance reached 89.95%, which is advantageous. This means that a quality gap still exists because intermediaries use estimation-based standards. For example, in 1 quintal, it is considered that 5 kg of products do not meet standards due to small, defective, or crushed seeds. As a result, the consistency of the product's visual quality is not always maintained. Standard compliance performance is also hampered by limited storage and cooling infrastructure. The equipment used is still very conventional: burlap or plastic sacks. This storage method hurts the product, including rapid deterioration in quality, increased risk of contamination, failure to maintain optimal temperature, resulting in uneven texture, and shortening the shelf life.

Additionally, non-compliance with quality standards is also influenced by miscommunication between artisans and intermediaries, as quality criteria are not clearly agreed upon at the beginning of the order. This condition aligns with research on the horticultural supply chain in China, where the misalignment of quality standards between farmers and wholesalers is the primary cause of food loss (Li *et al*., 2022) . Furthermore, recent studies emphasize the importance of applying multi-capital metrics in the food supply chain, namely product quality measurements that are integrated with environmental and sustainability aspects (Amamou *et al*., 2025).

3.2.4 *Flexibility*

The average response time to changes in demand is 4 days, which is considered a superior performance. This flexibility demonstrates the ability of farmers and artisans to adapt to surges in demand, especially ahead of Ramadan. To anticipate this season, artisans implement several strategies, including: planning harvest times, purchasing palm fruit bunches from other farmers several months in advance of the fasting month, and collaborating with seasonal producers to ensure high production volumes. These mitigation measures enable the surge in demand to be met quickly, thereby maintaining supply continuity. Moazzam's research(2015) emphasizes the importance of volume flexibility in maintaining customer

satisfaction, despite response times often being longer in other industries. In line with this, the design of the agrifood supply chain network confirms that flexibility is a key factor in adapting to seasonal demand and a determining factor in the supply chain's competitiveness (Chokri *et al*., 2025).

3.2.5 *Order Fulfillment Cycle Time*

The results of the FSCN analysis show that the sugar palm fruit product flow is relatively simple and still depends on direct relationships between actors. Artisans function as the primary producers, while middlemen and wholesalers act as distributors to broader markets. The vertical relationship between artisans and middlemen is built primarily on trust and long-term interaction rather than formal contracts. This condition aligns with the results of SCOR measurements, where the average order fulfillment cycle is only 7 days, which is categorized as superior. SCOR stipulates that a cycle time of less than 8 days is an indicator of high performance for fresh products (APICS / ASCM, 2022). These findings are comparable to those in the horticultural supply chain in Europe, where modern logistics integration enables order fulfillment in under a week (Aramyan *et al*., 2007). One of the key factors affecting order fulfillment efficiency is the selection of partners. Until now, the selection of partners has been informal, with artisans preferring flexible intermediaries in terms of quality and price, while intermediaries rely on regular artisans to obtain a continuous supply. Thus, the efficiency of order fulfillment is not only determined by the technical processes of harvesting and post-harvesting, but also by the pattern of relationships between actors based on the principle of trust.

3.2.6 *Cash-to-Cash Cycle Time*

The FSCN analysis reveals that cash flow in the sugar palm fruit supply chain is rapid due to its direct transactions-based nature. Farmers typically receive cash or advance payments from artisans, while artisans obtain capital from intermediaries who often provide advances to ensure a steady supply. This pattern results in a very short interval between supplier payments and buyer receipts. Based on SCOR measurements, the average cash-to-cash cycle time is only two days, which is considered superior. This efficiency occurs because there are no formal contracts or long-term credit mechanisms. However, this advantage also indicates vulnerability, as farmers and artisans are highly dependent on intermediaries as a source of liquidity. In contrast to modern agribusiness supply chains, which typically have 30–90 days' cash cycles due to contracts and administrative procedures, this situation is similar to findings among non-cooperative coffee farmers in Mexico who depend on intermediaries to maintain cash flow (Pech-Trejo *et al*., 2023).

3.2.7 *Inventory Days of Supply*

FSCN analysis shows that artisans often delay sales by storing palm fruit in simple sacks to increase their selling weight. This practice extends the storage period while maintaining supply continuity in a relatively short supply chain (from farmers to artisans to intermediaries). Based on SCOR, the average daily inventory is around 5 days, which is considered an advantage. This figure is comparable to the modern retail target for fresh commodities (<5 days) and is far more efficient than general food retail (15–30 days) (Kirci & Isaksson, 2022) . Thus, even though the storage system is still conventional, the inventory performance of sugar palm fruit can be considered quite competitive (Henry, 2024).

3.2.8 *Cost*

The FSCN reveals that the cost structure of the sugar palm fruit supply chain is still labor-intensive, with the majority of costs allocated to harvesting and post-harvest labor. Meanwhile, transportation and packaging costs are borne by intermediaries. This pattern reflects the characteristics of a traditional supply chain that has not been integrated with modern technology or logistics systems, resulting in suboptimal cost efficiency. Based on SCOR measurements, the total cost of the sugar palm fruit supply chain reaches 18.75% of revenue, which is categorized as parity. This figure is higher than the global benchmark in modern companies, which is only 5–10% (APQC, 2022). However, the analysis shows that the supply chain cost reaches 18.75%, which falls into the parity category.

4. Conclusion

This study produced comprehensive new findings related to the palm fruit supply chain in Tasikmalaya Regency using FSCN and SCOR integration for local commodities. The main market segment for sugar palm fruit is aimed at intermediaries or local markets. The sugar palm fruit supply chain structure involves local actors. It is traditional in nature, consisting of palm tree owners, artisans/processors, intermediaries, wholesalers, retailers, and supporting actors such as transportation and equipment providers. Limited supply chain resources, such as capital, storage media, and modern equipment, are weaknesses that affect the quality of palm fruit. Relationships between actors are dominated by trust-based and informal patterns, which are more flexible but vulnerable to supply uncertainty. SCOR measurement results show that the main strengths of the supply chain lie in delivery reliability (99.32%), flexibility (4 days), order fulfillment cycle time (7 days), cash-to-cash cycle time (2 days), and inventory days of supply (5 days), which are relatively efficient. These performance values reflect high responsiveness and a smooth cash flow system. However, due to quality inconsistency, major weaknesses are still found in fill rate (88.60%) and quality conformance (89.95%). In addition, the supply chain cost structure is also relatively high (18.75%), indicating inefficiency.

These findings confirm that even though the network structure is still traditional and relationships are informal, it has proven to produce superior performance in certain areas. However, deviation from global benchmarks is inevitable due to structural limitations. Therefore, SCOR needs to be applied adaptively in the context of traditional supply chains. This study reinforces the literature on trust-based governance and Resource-Based View (RBV), where intangible resources such as social networks and local knowledge have proven to be strategic assets despite limited physical infrastructure. Policy and managerial implications include (1) increasing the cultivation of palm trees to ensure a sustainable supply, (2) building storage and cooling infrastructure, and (3) providing simple contract facilitation or cooperatives to strengthen market certainty. In addition, (4) it is necessary to adopt predictive technologies and digitize information to improve forecasting accuracy and transparency among supply chain actors. Further research should explore the potential for integrating palm fruit into the regional agroforestry value chain.

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