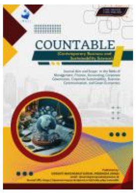

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Total Cost of Ownership (TCO) and Value Stream Mapping (VSM) Analysis for Cost Added Optimization in the Sunflower Supply Chain

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Abstract

PT XYZ faces a crucial problem stemming from the inefficiency of its sunflower supply chain, particularly the lack of clarity regarding the structure of additional costs associated with specific activities. The high frequency of partial deliveries from farmers triggers an accumulation of storage and production costs, alongside a decline in seed quality due to repeated handling. Furthermore, insufficient coordination with seed suppliers leads to harvest delays and additional storage costs, a situation compounded by factors of scarcity. This research utilizes a quantitative integration method of Total Cost of Ownership (TCO) and Value Stream Mapping (VSM). TCO analysis results demonstrate the significant impact of raw material scarcity: the TCO per ton of oil reaches Rp 38.5 million under normal conditions, but this value surges by 65.4% to Rp 63.7 million per ton during periods of scarcity. Following optimization scenarios, this value was successfully reduced to Rp 52.4 million per ton. Meanwhile, VSM identified hidden time waste valued at Rp 117.3 million per month (equivalent to 8.3% of total costs), with procurement (48%) and receiving (31%) identified as the main contributors to time waste. Through Value Stream Costing (VSC)-based optimization, the total potential savings could reach Rp 176.2 million per month (12.4% of total costs), sourced from lead time efficiency (Rp 37.6 million) and yield improvement (Rp 138.6 million). This achieved efficiency of 12.4% theoretically affirms the superiority of integrating TCO and VSM within lean cost management in agribusiness, while offering concrete managerial implications for enhancing the resilience and profitability of the sunflower supply chain.

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INTRODUCTION

The global sunflower supply turmoil is rooted in military conflicts in major producing regions. Russia and Ukraine, which have been the backbone of the world's

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exports of sunflower seeds and oil, are hampered by completely inaccessible agricultural land, transport ships stranded in blockaded ports (Bakrie et al., 2022). Weather anomalies have also worsened the situation, with crop failures spreading to other producing centers such as Canada due to the crazy extreme dry weather. The congestion in the flow of global goods plus soaring shipping costs makes it more difficult to distribute existing stocks. Governments in various countries then took protective measures by limiting the export of strategic commodities, including vegetable oil, to ensure domestic adequacy. Meanwhile, the market demand for sunflower raw materials continues to creep up, especially when the world's supply of palm oil is also stagnant. This condition is also supported by the increasing need for sunflowers in the *biofuel* process to increase efficiency (Helbawanti et al., 2023). It is this deadly combination that narrows the availability of sunflowers on the market.

PT XYZ is a major player in the sunflower agribusiness industry in Indonesia, focusing on the production of sunflower oil for the domestic and export markets. In recent years, global market competition and fluctuations in commodity prices have squeezed the company's profit margins. Internal observations reveal that supply chain operational costs ranging from seed procurement, farmer partner cultivation, seed processing, to the distribution of final products have increased significantly. However, management has difficulty identifying the source of waste holistically due to the fragmentation of hidden *cost data*, such as inefficient logistics costs, product damage during transportation, or *downtime* of processing equipment (Arifin & Sriyono, 2022)

The crucial problem faced by PT XYZ is the unclear structure of *value-added costs versus non-value-added activities* in the supply chain. For example, the high frequency of partial shipments from farmland to mills leads to accumulated transportation costs and deterioration in seed quality due to repetitive handling. On the other hand, the lack of coordination with seed suppliers results in delayed harvesting and additional storage costs. This phenomenon shows the need for a systematic approach to mapping value *streams while* calculating total cost ownership (TCO) that includes all direct and indirect costs.

The background of the previously known problems encourages the researcher to reveal and analyze *the total cost of ownership* and *value stream mapping* for the optimization of added costs in the sunflower supply chain. This research is expected to be able to identify the hidden cost components in the PT XYZ sunflower supply chain using the *Total Cost of Ownership* method(TCO) to get the accuracy of the total cost calculation. Then followed by mapping the flow of materials and information from upstream to downstream with *Value Stream Mapping* (VSM) to uncover worthless activities and waste points. TCO is explicitly designed to address *hidden costs* and risks that cross corporate boundaries, which are weaknesses of traditional cost models (Jaelani & Purnama, 2022)

RESEARCH METHODS

This research approach integrates the concepts of *Total Cost of Ownership* (TCO) and *Value Stream Mapping* (VSM) to analyze cost efficiencies in the sunflower supply chain. The main focus is to identify and optimize added costs by first understanding the actual cost structure and the process flow that occurs (Khunaifi et al., 2022). TCO is used as an analytical lens to capture the entire cost component, not only the direct acquisition

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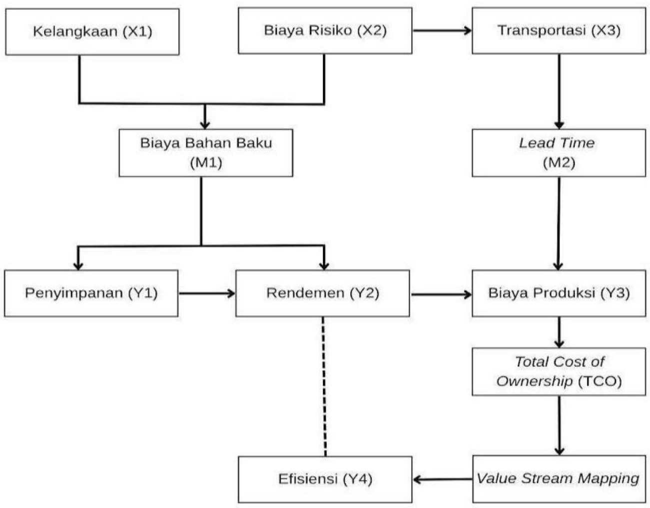
costs but also the hidden costs that arise throughout the raw material life cycle. The concept of calculation has been used in previous research, such as in the practice of tracing economic value even in the automotive sector (Pranatawijaya et al., 2019). Through TCO calculation, the impact of factors such as interest scarcity (X1), supply risk (X2), and logistics complexity (X3) on storage costs (Y1), damage/yield (Y2), and total production costs (Y3) can be quantitatively measured. The analysis also considers how variables such as input price fluctuations (M1) and lead *time* length (M2) reinforce or weaken the impact. Followed by VSM acting as a diagnostic tool to visualize the flow of materials and information from upstream to downstream. This value stream mapping reveals waste points, process inefficiencies, as well as the root causes *of long lead times* (M2) and excess inventory that trigger storage costs (Y1). Identifying activities through VSM is the basis for designing improvements.

The synergy of TCO and VSM is the key to the optimization strategy. The cost quantification results from TCO show the financial impact of any waste identified in the VSM. This combination allows prioritization of focus improvements on the activities that most significantly lower TCO while improving overall efficiency (Y4). The ultimate goal is to design a *leaner future state*, where waste-related costs (such as excessive storage, waiting time, or damage) are minimized, so that the added costs that customers really appreciate become more optimal in the context of perishable commodity supply chains (Karimah et al., 2025)

Figure 1 Research Thinking Framework



Even though *Activity Based Costing* (ABC) is an excellent tool for distributing costs *Overhead* to specific activities within the company and *Lean Six Sigma* Providing a structured methodology to suppress product variations and defects, the main focus of both often stalls within the company's internal boundaries. In contrast, the TCO-VSM hybrid approach is specifically designed to solve cost problems in the supply chain *end-to-end*; here the TCO is in charge of capturing and measuring all material ownership costs (including hidden ones such as risk and scarcity costs), while VSM visually maps the process flow to find time wastage (*Waste*) and activities that are not value-added. This combination is ideal for agribusiness cases because it directly links complex non-

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operational costs to *Lead Time* and *Waste* throughout the supply network, ensuring that the optimization carried out is not only production efficiency, but also a holistic increase in supply resilience.

RESULTS AND DISCUSSION

Calculation *of Total Cost Ownership*

The first data processing carried out by the researcher was by calculating *the Total Cost Ownership.* Then the following data was obtained:

Table 1 Initial Company Data

Component	Value	Unit
Seed Requirements	1.000	tons/month
Normal Seed Price	IDR 8,100,000	per ton
Oil Yield	26%	-
Processing Costs	IDR 1,300,000	/ ton of seeds
Logistics Costs	IDR 610,000	/ ton of seeds

Source : Data processed by the Author (2025)

Then the researcher obtained a number of trade risks that have been thoroughly examined in the company, taking into account various factors, including market instability, changes in global economic conditions, potential disruptions in the supply chain, as well as the impact of changes in regulations or trade policies that can affect the smooth operation, profitability, and sustainability of the business (Karimah et al., 2025)

Table 2 Trading Risk Data

Component	Change	New Values	Reason
Seed Prices	Up 45%	IDR 11,745,000/ton	Global supply crisis
Yields	Down 15%	22.1%	The quality of imported seeds has decreased
Logistics Costs	Up 30%	IDR 793,000/ton	Emergency routes. Risk premium
Cost of Risk	2% of seed costs	IDR 234,900,000	Penalty

Source : Data processed by the Author (2025)

The calculation is then processed based on the company's initial data, and scarcity conditions (trading risk) to find out the comparison of the two.

Table 3 Calculation of Normal Conditions

Component	Account	Total (Rp)
Seed Cost	1,000 × IDR 8,100,000	8.100.000.000
Processing Costs	1,000 × IDR 1,300,000	1.300.000.000
Logistics Costs	1,000 × IDR 610,000	610.000.000
Cost of Risk	-	0
Total Cost	-	10.010.000.000
TCO/ton of oil	IDR 10,010,000,000 ÷ 260	38.500.000

Source : Data processed by the Author (2025)

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The calculation of the normal conditions obtained oil produced 25% out of 1,000 is 260 tons.

Table 4 Calculation of Scarcity Conditions

Component	Account	Total (Rp)
Seed Cost	1,000 × IDR 11,745,000	11.745.000.000
Processing Costs	1,000 × IDR 1,300,000	1.300.000.000
Logistics Costs	1,000 × IDR 793,000	793.000.000
Cost of Risk	2% × IDR 11,745,000,000	234.900.000
Total Cost	-	14.072.900.000
Oil Produced	1,000 × 22.1%	221 tons
TCO/ton of oil	14,072,900,000 ÷ 221	63.679.185

Source : Data processed by the Author (2025)

The calculation of scarcity conditions shows that the oil produced is 22.1% out of 1,000 of 221 tons. This condition is 39 tons less than the normal period calculation.

Optimization Simulation

The researcher then made various strategic proposals in optimizing costs. in the following way:

1. Substitution of 20% seeds with *rapeseed* (IDR 7,200,000/ton. 25% yield)
2. +3% increase in yield (engine efficiency)
3. Logistics efficiency: 10% cost reduction
4. Risk mitigation: 50% discount on the initial risk cost

Table 5 Optimization Cost Calculation

Component	Account	Total (Rp)
Sunflower Seeds	800 × IDR 11,745,000	9.396.000.000
Rapeseed	200 × IDR 7,200,000	1.440.000.000
Processing Costs	1,000 × IDR 1,300,000	1.300.000.000
Logistics Costs	1,000 × IDR 793,000 × 90%	713.700.000
Cost of Risk	50% × IDR 234,900,000	117.450.000
Total Cost	-	12.967.150.000
Oil Produced	(800×22.1%) + (200×25%) + 3%	247.3 tons
TCO/ton of oil	IDR 12,967,150,000 ÷ 247.3	IDR 52,431,611

Source : Data processed by the Author (2025)

The results of the summary of the comparison under normal conditions, rarity, and optimization proposals by the researcher were found as follows:

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Table 6 Comparison of Calculations

Condition	Total Cost (Rp in Billions)	*Oil Output* (Tons)	TCO/ton Oil (Rp in Millions)
Usual	10,01	260	38,5
Scarcity	14,07	221	63,7
Optimization	12,97	24,3	52,4

Source : Data processed by the Author (2025)

Calculating *Value Stream Mapping*

This calculation is applied in the scope of Time & Cost Analysis in the Production Value Chain with sunflower raw materials to the *Lead Time* (LT) process, which is the waiting time or transit between activities.

a. Total Production Cost

The cost required in the processing of sunflower seeds by PT XYZ is IDR 14,072,900,000

b. *Average Inventory*

Storage costs are charged at half of the total production cost with a calculation of 50% × IDR 14,072,900,000 to IDR 7,036,450,000

c. Storage Fee/Month

The monthly storage fee is charged at 2% from the average storage of IDR 7,036,450,000 to IDR 140,729,000

d. Storage Fee/Day

The calculation of the cost is charged IDR 140,729,000 divided by 30 days (1 month and gets a fee of IDR 4,690,967). This cost will then be multiplied by various activities in the process of calculating costs and wasting time.

Table 7 Calculation of Wasted Time Costs

Activity	*Lead Time* (days)	Waste *Fee* (Rp)
Procurement	15	70.364.505
Transportation	3	14.072.901
Processing	2	9.381.934
Acceptance	5	23.454.835
Total *Waste*	25	IDR 117.274.175

Source : Data processed by the Author (2025)

The results of the summary of the VCS cost calculation were found as follows:

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Table 8 VCS Fee Calculation

Cost Component	Value (Rp)
Seed Cost	11.745.000.000
Logistics Costs	793.000.000
Processing Costs	1.300.000.000
Cost of Risk	234.900.000
Subtotal	14.072.900.000
Cost *of Waste* Time	117.274.175

Source : Data processed by the Author (2025)

Table 9 VSC Cost Analysis

Cost Component	Value (Rp)
Seed Cost	11.745.000.000
Logistics Costs	793.000.000
Processing Costs	1.300.000.000
Cost of Risk	234.900.000
Subtotal	14.072.900.000
Cost of Waste Time	117.274.175
TOTAL VSC	14.190.174.175

Source : Data processed by the Author (2025)

The researchers propose improvements in the optimization of previous calculations to improve the efficiency of the production process. Based on the proposal, oil production is calculated at 1,000 tons with *a yield* of 22.1%, resulting in 221 tons of oil. The cost per ton of oil was set at IDR 14,190,174,175 divided by 221 tons, which is IDR 64,238,833, which shows an increase of 3.2% compared to the initial calculation without considering the time factor. In addition, the *flow efficiency* is calculated with the formula (*Total Cycle Time / Total Lead Time*) × 100%, in the calculation (800 hours / 25 days × 24 hours) × 100%, resulting in an efficiency value of 3.2%.

The advanced calculation carried out by the researcher, by reducing *the lead time* with all time optimization, in reducing the costs that follow in terms of production activities. This potential is by reducing procurement lead time from 15 to 10 days through negotiations with suppliers, followed by acceptance *lead time* from 5 to 2 days with the *Just In Time* (JIT) system (Goo et al., 2024). Data processing is also used to increase production yield from 22.1% to 24% with process optimization.

Table 10. Proposed Improvements

Metric	Before	After	Change
Total *Lead Time*	25 days	17 days	-32%
Flow Efficiency	3,2%	4,7%	+47%
Cost of Waste Time	IDR 117,3 million	IDR 79.7 million	IDR 37,6 million
Oil Production	221 tons	240 tons	19 tons
Cost per Ton of Oil	IDR 64,2 million	IDR 58,9 million	8,3%

Source : Data processed by the Author (2025)

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The analysis of the Value *Stream Costing* (VSC) calculation carried out previously, found the following descriptive results

1. Press *Procurement Lead Time*

At this stage, the researcher recommends implementing *vendor-managed inventory* (VMI), such as using a long-term contract with a supplier, with a potential savings of Rp 23.5 million/month (for a 5-day reduction)

2. Processing Process Optimization

To increase oil production efficiency, the researcher proposes to automate quality control by applying the SMED *(Single-Minute Exchange of Dies)* method to speed up the tool change process and minimize downtime (Siregar et al., 2022) This implementation has the potential to increase production by 19 tons of oil per month, which is equivalent to an increase in revenue of IDR 1.2 billion.

3. Inventory Reduction in the Reception Area

To optimize the production process, the researcher implemented a *Just-In-Time* system with the buyer, in order to align production with demand, thereby reducing waste (Gulo et al., 2023). Additionally, using Kanban for inventory control can ensure efficient stock management and minimize excess inventory. The implementation of these two strategies has the potential to result in cost savings of IDR 14.1 million per month.

4. Risk Cost Mitigation

To increase supply chain resilience, it is recommended to add strategic *safety stocks* to anticipate unexpected disruptions. Additionally, diversification of suppliers is recommended to ensure security of supply and reduce dependence on a single source. The implementation of these two steps has the potential to reduce risk costs by up to 30%.

CONCLUSION

Based on the analysis *Total Cost of Ownership* (TCO) and *Value Stream Mapping* (VSM) at PT XYZ, found that hidden costs stemming from wasting time (*Waste*) in the sunflower supply chain reached Rp 117.3 million per month (equivalent to 8.3% of the total cost). The largest waste of time is concentrated in the Procurement (48%) and Receipt (31%) processes. Value chain optimization through an approach *Value Stream Costing* (VSC) projects a total potential savings of IDR 176.2 million per month or 12.4% of overall costs, driven by efficiency *Lead Time* (IDR 37.6 million) and increased income (IDR 138.6 million). These findings result in measurable managerial recommendations, such as implementation *Vendor-Managed Inventory* (VMI) to reduce procurement uncertainty, implementation *Single-Minute Exchange of Die* (SMED) for process acceleration, and system usage *Kanban* for the optimization of raw material flow. These recommendations are crucial for managing strategic costs (*Strategic cost management*) and improve the resilience of PT XYZ's supply chain amid global challenges.

Theoretically, this study contributes to the cost management literature *Lean* by explicitly bridging the quantitative approach of TCO and the approach of VSM process mapping. This hybrid model provides a more holistic and robust framework for the identification of non-value-added costs in the time- and yield-sensitive agribusiness sector, which has rarely been integrated in previous research.

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The limitation of this study is its nature as a single case study, which limits generalization. The data has also not been validated with in-depth sensitivity analysis. Therefore, future research can expand the scope by comparing the efficiency of this TCO-VSM model with that of the *Activity-Based Costing* (ABC) or applying case studies across different types of commodities or companies to validate the proposed conceptual model.

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