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Optimizing CPO Shipping Supply Chain Efficiency Using VSM and VALSAT Integration

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ABSTRACT

Objective: The palm oil industry plays an important role in Indonesia's economy, with Crude Palm Oil (CPO) widely used across industries. However, inefficiencies in the shipping process may cause delays and operational waste. This study aims to identify the types and root causes of waste in the CPO shipping process at PT XYZ and propose improvement strategies using Lean supply chain tools.

Methods: Value Stream Mapping (VSM) was used to visualize the current shipping process, while Value Stream Analysis Tools (VALSAT) were applied to select the appropriate tool for detailed waste analysis. Process Activity Mapping (PAM) was then used for activity-level analysis, and Fishbone analysis was applied to identify the root causes of the dominant waste.

Results: Waiting time was identified as the dominant waste, with an average score of 1.67, while PAM obtained the highest VALSAT score of 32.62. PAM showed a total standard time of 296.48 hours, consisting of 250.35 hours of value-added activities, 16.47 hours of necessary non-value-added activities, and 29.66 hours of non-value-added activities. The projected future-state analysis indicates a reduction in total standard time to 276.56 hours, corresponding to a potential saving of 19.92 hours or 6.72%. The proportion of NVA time is projected to decrease from 10.00% to 5.08%.

Conclusion: Lean-based improvement strategies can reduce waiting time and improve operational efficiency in bulk commodity logistics. The proposed recommendations provide practical guidance for reducing non-value-added activities and improving similar supply chain operations.

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1. Introduction

The palm oil industry plays a pivotal role in Indonesia's economic development, serving as one of the nation's most significant plantation commodities. Indonesia's oil palm plantation area reached approximately 16.01 million hectares in 2024, with crude palm oil production of approximately 45.44 million tons, highlighting the substantial scale of the country's palm oil industry (BPS-Statistics Indonesia, 2025). Crude Palm Oil (CPO) is one of the major products derived from oil palm and is widely used in various industries, including food, chemicals, livestock, and cosmetics. CPO consumption in Indonesia is expected to continue increasing, driven by both domestic utilization and international market demand (Mayandi & Suharjito, 2024).

Efficient logistics management is important for ensuring the timely and safe delivery of commodities such as CPO. Delays in shipping may disrupt supply chain activities, increase operational costs, and reduce customer satisfaction (Rossini et al., 2023). The accumulation of waste within the supply chain can also reduce a company's ability to compete in a market where efficiency and responsiveness are important (Gargalo et al., 2021). Waste minimization in supply chains has therefore been addressed through several approaches (Iqbal et al., 2020; Sarkar et al., 2022; Rossini et al., 2023). The Lean supply chain approach focuses on increasing value-added activities while reducing non-value-added activities throughout the supply chain flow (Gargalo et al., 2021). This approach is applicable not only to manufacturing activities but also to storage, warehousing, transportation, and shipping processes (Rossini et al., 2023). Recent evidence also shows that Lean logistics has expanded beyond manufacturing into logistics services, supply chains, digital technologies, construction, and sustainability-related applications, with increasing integration of analytical and optimization tools (Aygun et al., 2026).

Value Stream Mapping (VSM) is a Lean tool used to visualize material and information flows and identify inefficiencies, bottlenecks, and waste within a process (Batwara et al., 2023; Qin & Liu, 2022). Its relatively simple application has supported its use across different operational contexts (Lee et al., 2021; de Jesus Pacheco et al., 2023). Previous studies have shown that VSM can contribute to reductions in lead time, work-in-process inventory, and other operational inefficiencies. Similar applications have also been reported in manufacturing and agro-industrial supply chains, indicating the broad applicability of VSM for process improvement (De Steur et al., 2016).

To provide a more detailed analysis of the identified waste, Value Stream Analysis Tools (VALSAT) can be used to select an appropriate mapping tool according to the characteristics of the waste identified (Hines & Rich, 1997). The combination of VSM and VALSAT allows the process to be viewed at two levels: VSM provides an overall representation of the value stream, while VALSAT supports the selection of a more detailed analytical tool for specific waste categories (Hines & Rich, 1997).

Despite the growing application of Lean approaches in manufacturing and logistics, studies focusing on the shipping stage of agro-industrial bulk commodities, particularly barge-based CPO shipping, remain limited. Previous logistics studies have mainly focused on process visualization or specific transportation problems, while integrated analysis linking waste identification, detailed activity analysis, root-cause identification, and future-state development has received less attention. CPO shipping also involves both physical and information flows across several parties, including factory operations, transport providers, port operations, vessel services, inspection activities, and administrative coordination. Therefore, inefficiency may arise not only from physical transportation but also from waiting, information delays, and coordination problems.

Accordingly, this study applies VSM and VALSAT to analyze the CPO shipping process at PT XYZ. Rather than proposing the combination of VSM and VALSAT itself as a new method, this study applies a sequential Lean diagnostic approach to a bulk commodity shipping context by linking current-state mapping, waste identification, Process Activity Mapping (PAM), root-cause analysis, and future-state development. The study aims to identify the types and root causes of waste in the CPO shipping process and propose improvement strategies to improve operational efficiency.

2. Literature Review

Lean thinking has evolved from a manufacturing-oriented philosophy into a broader operational improvement approach applicable across supply chains and logistics systems. The fundamental principle of Lean is the systematic identification and reduction of activities that consume resources without creating value for customers, while improving process flow and operational responsiveness (Womack & Jones, 1996). In supply chain environments, inefficiencies may occur not only in production activities but also in transportation, warehousing, information exchange, and coordination among supply chain actors (Rossini et al., 2023). In logistics systems, waste may appear in the form of excessive waiting, unnecessary movement, delays in information processing, inefficient resource utilization, and poor synchronization among operational stakeholders. Therefore, Lean implementation in logistics requires analytical approaches that can evaluate both physical and information flows. A recent systematic review further shows that Lean logistics has expanded across logistics services, supply chains, digital technologies, construction, and sustainability-related applications, with increasing integration of analytical and data-driven tools (Aygun et al., 2026).

Value Stream Mapping (VSM) is widely used to identify process inefficiencies by providing an overall representation of material and information flows throughout a value stream (Rother & Shook, 2003). VSM allows organizations to evaluate the relationship among process activities, waiting time, information exchange, and overall process time. Previous studies have applied VSM across manufacturing, process industries, distribution, and logistics systems (Hines et al., 1999; Seth et al., 2008; De Steur et al., 2016). In logistics-related applications, VSM has also been used to identify transportation waste, delivery inefficiencies, and flow-related problems (Kihel et al., 2022; Qin & Liu, 2022). Reviews of VSM applications further indicate that the method has been extended to sustainability-oriented and logistics-related contexts beyond traditional manufacturing environments (Lee et al., 2021).

However, VSM mainly provides an overall view of where inefficiencies occur and does not always determine which detailed analytical approach should be used to investigate the identified waste. Different types of waste may require different analytical perspectives. Value Stream Analysis Tools (VALSAT) provide a structured approach for selecting detailed mapping tools according to the characteristics and importance of identified waste (Hines & Rich, 1997). Through VALSAT, analysis may be continued using tools such as Process Activity Mapping (PAM), Supply Chain Response Matrix (SCRM), Quality Filter Mapping, or other value-stream analysis tools. Therefore, VSM provides overall visibility of the process, while VALSAT supports the selection of a more detailed analytical tool for further waste analysis.

Previous studies have examined Lean and value-stream approaches across different operational contexts using various analytical methods. De Steur et al. (2016) systematically reviewed VSM applications for reducing food losses and waste across agri-food supply chains. Qin and Liu (2022) applied VSM to e-commerce logistics, while Kihel et al. (2022) extended VSM to downstream distribution activities involving warehousing, road transportation, and sea transportation. de Jesus Pacheco et al. (2023) developed a multi-method approach integrating VSM with complementary process-improvement methods to reduce operational waste in distribution warehouses. From a broader perspective, Lee et al. (2021) reviewed sustainability-oriented VSM applications, while Rossini et al. (2023) examined Lean supply chain management through a systematic literature review. More recently, Aygun et al. (2026) identified increasing cross-sectoral applications and analytical integration in Lean logistics research. These studies demonstrate the increasing application of Lean principles beyond manufacturing, but their operational contexts and analytical scope differ from those of bulk commodity shipping. To clarify these differences and position the present study within existing literature, previous studies are systematically compared in Table 1.

The comparison in Table 1 shows that Lean and value-stream approaches have been increasingly applied across manufacturing, distribution, transportation, logistics, and broader supply chain contexts, including more recent supply-chain-level and cross-sector Lean logistics applications. However, two limitations remain relevant to the present study. First, logistics-oriented VSM studies generally focus on process visualization or specific transportation problems, while waste prioritization, detailed activity analysis, and root-cause investigation are not always integrated within the

same analytical sequence. Second, integrated VSM–VALSAT applications have been more commonly reported in manufacturing and internal operational processes than in bulk commodity logistics.

These limitations are particularly relevant to CPO shipping because the process involves several interconnected activities, including factory preparation, inland transportation, port handling, loading, inspection, vessel services, documentation, and coordination among internal and external parties. Therefore, inefficiency may originate not only from physical transportation but also from waiting, administrative processes, information delays, and resource availability. The interaction between physical and information flows requires an analytical approach that can identify waste at both process and activity levels.

Accordingly, the contribution of the present study does not lie in introducing a new Lean tool or in proposing the combination of VSM and VALSAT itself. Instead, this study applies a sequential Lean diagnostic approach to barge-based CPO shipping by linking current-state mapping, waste identification and prioritization, VALSAT-based tool selection, PAM, root-cause analysis, and projected future-state development within a single analytical sequence. This approach extends the application of integrated Lean analysis to a bulk commodity logistics context in which physical operations, information processing, and coordination among multiple stakeholders are closely interconnected.

3. Materials and Methods

This study used a case-study approach to identify waste and develop improvement strategies for the CPO shipping process at PT XYZ in Indonesia. The analytical procedure combined Value Stream Mapping (VSM), Value Stream Analysis Tools (VALSAT), Process Activity Mapping (PAM), and root-cause analysis to examine both physical and information flows within the shipping process. The research procedure is presented in Figure 1.

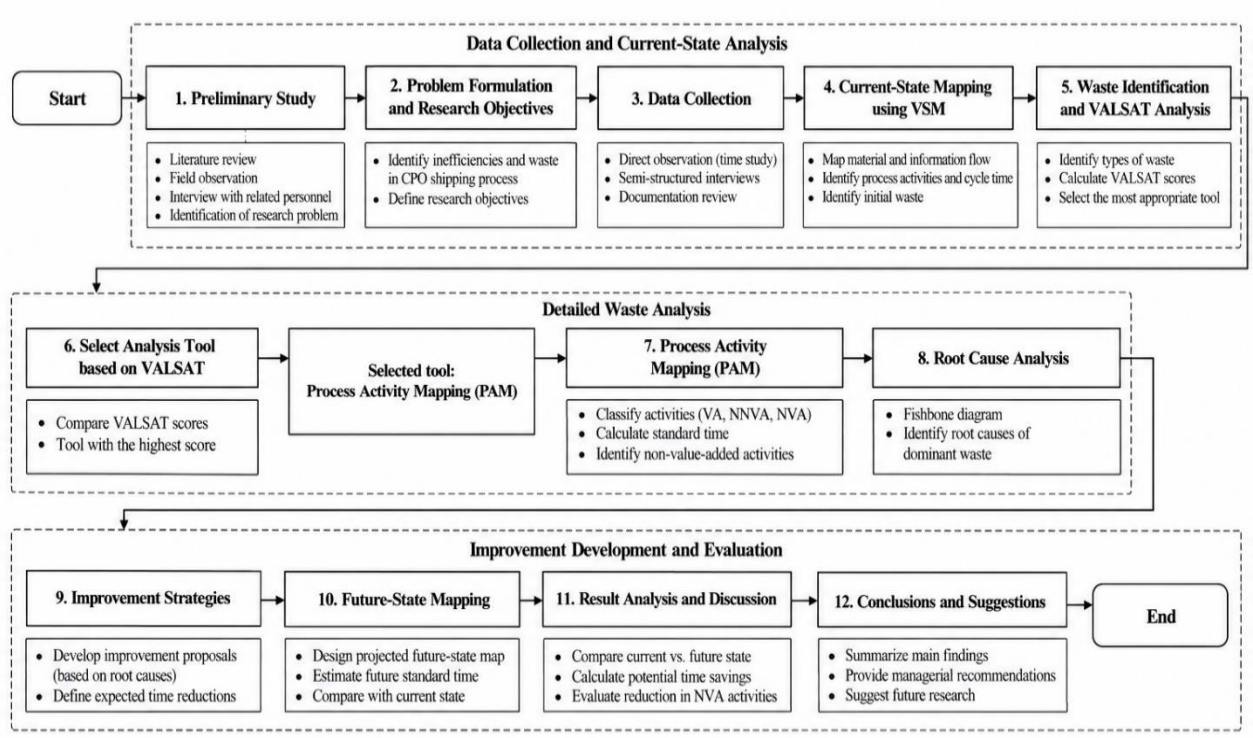


Figure 1. Research Flowchart

Table 1. Comparison of Previous Lean Studies and the Present Study

Study	Operational Context	Lean Approach / Analytical Focus	Research Method	Main Gap Relative to the Present Study
Hines & Rich (1997)	Manufacturing and supply chain	Seven value stream mapping tools / waste-based tool selection	Framework development	Provides a general framework for selecting value-stream analysis tools but does not examine an empirical bulk commodity logistics process.
Hines et al. (1999)	Distribution and supplier network	Value Stream Mapping	Applied case study	Applies VSM to improve a distribution and supplier network but does not integrate waste prioritization, activity-level analysis, and root-cause analysis within one analytical sequence.
Seth et al. (2008)	Cottonseed oil processing supply chain	VSM for waste identification and process improvement	Case study	Focuses on the processing side of an edible-oil supply chain rather than downstream bulk commodity shipping and multi-stakeholder logistics.
De Steur et al. (2016)	Agri-food supply chains	VSM for food-loss and waste reduction	Systematic literature review	Reviews VSM applications across agri-food supply chains but does not examine detailed operational waste and coordination problems in a specific bulk shipping process.
Lee et al. (2021)	Cross-industry sustainability applications	Sustainability-oriented VSM	Review and classification	Provides a broad classification of sustainability-oriented VSM applications rather than an integrated activity-level diagnosis of bulk logistics operations.
Qin & Liu (2022)	E-commerce logistics	VSM for process and waste improvement	Case study	Examines parcel-based e-commerce logistics rather than bulk commodity transportation involving vessel, port, and administrative coordination.
Kihel et al. (2022)	Automotive downstream distribution supply chain	Lean VSM 4.0 across warehousing, road transport, and sea transport	Case study	Covers road and sea logistics but emphasizes VSM 4.0 and digital technologies rather than VALSAT-based tool selection and detailed activity-level waste diagnosis.
Rossini et al. (2023)	Lean supply chain management	Lean supply chain and Industry 4.0 integration	Systematic literature review	Provides a broad supply-chain perspective but does not conduct activity-level waste diagnosis or root-cause analysis in a specific shipping operation.
Batwara et al. (2023)	Cross-industry VSM applications	VSM for sustainable process improvement	Systematic literature review	Synthesizes VSM applications across sectors but does not empirically examine operational and administrative waste in bulk commodity shipping.
de Jesus Pacheco et al. (2023)	Distribution warehouse	Multi-method waste reduction approach integrating VSM and other process-improvement methods	Exploratory case study	Focuses on operational waste within warehouse operations rather than multi-stakeholder bulk commodity shipping involving physical and information flows.
Aygun et al. (2026)	Cross-sector Lean logistics	Lean logistics tools and analytical and optimization approaches	Systematic literature review and science mapping	Provides a broad synthesis of Lean logistics applications but does not examine activity-level waste diagnosis in a specific bulk commodity shipping process.
Present study	Barge-based CPO shipping	VSM, VALSAT, PAM, Fishbone analysis, and Future-State Mapping	Case study using observation, time measurement, interviews, and expert assessment	Integrates physical and information flows through a sequential analysis from current-state mapping and waste prioritization to activity-level diagnosis, root-cause analysis, and projected future-state development.

3.1 Data Collection, Expert Selection, and Waste Assessment Procedure

Data were collected through direct observation, semi-structured interviews, time measurements, and expert-based waste assessment. A case-study approach was used to obtain an in-depth understanding of operational activities, coordination processes, and sources of inefficiency within the CPO shipping system (Voss et al., 2002; Yin, 2018).

Time measurements were conducted for the 15 activities identified in the CPO shipping process. Each activity was observed 30 times, and the observed times were averaged to determine the cycle time of each activity. Data variability was evaluated using standard deviation and control limits, while data normality and sufficiency were examined before the time data were used for further analysis. Data uniformity was assessed using the upper and lower control limits, calculated as UCL = $\bar{x}$ + 2σ and LCL = $\bar{x}$ − 2σ, respectively. Observations falling within these limits were considered to represent consistent process variation. Data sufficiency was evaluated at a 95% confidence level and 5% precision level. The required sample size (N′) was calculated using the standard work-measurement sufficiency equation, with k = 1.96 and s = 0.05.

$$N' = \left[\frac{\frac{k}{s}\sqrt{N \sum X_i^2 - (\sum X_i)^2}}{\sum X_i} \right]^2 \quad (1)$$

The observations were considered sufficient when N′ ≤ N.

Three expert respondents were purposively selected based on their direct involvement and operational knowledge as value stream managers in the CPO shipping process. The respondents had approximately 5–10 years of relevant experience and were involved in process flow, logistics coordination, and operational activities. Respondents with direct process knowledge were selected to ensure that the assessment reflected actual operational conditions (Campbell et al., 2020).

The waste-assessment questionnaire was developed based on the seven Lean wastes: overproduction, defect, unnecessary inventory, waiting, transportation, overprocessing, and unnecessary motion (Hines & Rich, 1997). Each waste category was assessed using a 0–5 scoring scale, where 0 indicated no occurrence, 1 very low occurrence, 2 low occurrence, 3 moderate occurrence, 4 high occurrence, and 5 very high occurrence. The respondents evaluated each waste category according to its occurrence and operational impact on the CPO shipping process. The scores from the three respondents were averaged for each waste category, and the resulting average scores were used to determine the dominant waste.

Because the waste-assessment instrument was used to prioritize distinct waste categories rather than to measure a single latent construct, internal-consistency reliability was not used. Assessment robustness was supported through methodological triangulation. Expert assessments were cross-checked with direct observations, measured process times, interview findings, PAM results, and subsequent root-cause analysis. This procedure was used to reduce potential evaluator bias and strengthen the consistency between expert judgment and empirical process evidence (Eisenhardt, 1989; Yin, 2018).

3.2 Current-State Value Stream Mapping

Value Stream Mapping (VSM) was used to construct the current-state representation of the CPO shipping process by integrating material and information flows. VSM enables process activities, waiting time, bottlenecks, material movement, and information exchange to be evaluated within the same value stream (Rother & Shook, 2003; Hines & Rich, 1997). In this study, the current-state map covered the shipping process from the preparation of shipping activities at the origin facility through the transportation of CPO to the destination port. The mapping included activity sequence, cycle time, waiting or delay time, material movement, and information exchange among the operational units involved. Data used for the current-state map were obtained from direct observation, interviews, and time measurements. The current-state VSM was used as the initial diagnostic stage to identify potential sources of inefficiency within the

shipping process. Tank storage time was recorded as part of the operational condition but was excluded from the active cycle-time calculation because it represented static storage rather than an actively performed process activity.

3.3 Waste Identification and VALSAT Prioritization

Following the current-state mapping, waste identification was conducted to determine the dominant sources of inefficiency within the CPO shipping process. The average scores obtained from the expert assessment were used to rank the seven Lean waste categories. Value Stream Analysis Tools (VALSAT) were subsequently applied to determine the most appropriate tool for detailed analysis. VALSAT provides a structured mechanism for selecting analytical tools based on the relationship between identified waste categories and available value-stream mapping tools (Hines & Rich, 1997). The average score of each waste category was multiplied by the corresponding VALSAT correlation weight, and the resulting values were aggregated to determine the priority score of each tool. Based on the VALSAT prioritization, Process Activity Mapping (PAM) was selected as the primary tool for detailed analysis. PAM enables detailed examination of activity sequence, processing time, transportation, inspection, storage, and delay. The use of VALSAT followed by PAM allowed the analysis to proceed from system-level waste identification to activity-level diagnosis.

3.4 Process Activity Mapping and Value-Added Classification

Process Activity Mapping (PAM) was applied to analyze individual activities within the CPO shipping process by evaluating activity sequence, processing time, transportation, inspection, storage, delay, and other operational characteristics. PAM is widely used in Lean studies to identify opportunities for waste reduction by examining how activities consume resources and contribute to overall process performance (Hines & Rich, 1997).

Each activity identified through PAM was first categorized according to its activity type as operation (O), transportation (T), inspection (I), storage (S), or delay (D). The activities were then evaluated according to their contribution to the shipping service and classified into value-added (VA), necessary but non-value-added (NNVA), and non-value-added (NVA) categories. VA activities refer to activities that directly contribute to fulfilling customer requirements or completing the required shipping service. NNVA activities do not directly create customer value but remain necessary because of operational requirements, regulatory compliance, safety considerations, quality assurance, or quantity verification. NVA activities consume time or resources without directly contributing to customer value and can potentially be reduced or eliminated without compromising the required shipping service (Womack & Jones, 1996; Rother & Shook, 2003).

To ensure consistency and reproducibility, predefined decision rules were applied to all activities. An activity was classified as VA when it directly contributed to the physical completion of the required CPO shipping service, including the transfer, loading, movement, or delivery of CPO toward the customer destination. Accordingly, core transportation activities were classified as VA because transportation constitutes an integral part of the shipping service.

An activity was classified as NNVA when it was necessary for operational continuity, quality assurance, quantity verification, safety, or compliance but did not directly deliver the shipping service to the customer. Mandatory inspection and verification activities, including pre-shipment inspection, weighing of empty and loaded trucks, and ship-figure measurement after loading, were therefore classified as NNVA. An activity was classified as NVA when it represented avoidable waiting or delay that did not contribute to the completion of the shipping service. This category included waiting for tugboat availability, delays associated with transport-truck preparation, and waiting for administrative readiness. Mandatory administrative processing would be considered NNVA if measured as active processing time; however, the activity measured in this study was the waiting time until the required documents and approvals were ready. Therefore, “waiting for administrative readiness” was classified as NVA.

The standard time of each activity was used as the time basis for PAM. Cycle time (W_s) was calculated as the average observed time:

$$W_s = \frac{\sum X_i}{N} \quad (2)$$

Normal time (W_n) was calculated by adjusting cycle time using the Westinghouse performance-rating factor:

$$W_n = W_s \times P \quad (3)$$

where the performance-rating factor was determined as:

$$P = 1 + (\text{skill} + \text{effort} + \text{working condition} + \text{consistency}) \quad (4)$$

The Westinghouse method evaluates operator performance based on skill, effort, working condition, and consistency (Cevikcan & Kilic, 2016). Standard time (W_b) was subsequently calculated by incorporating the allowance factor:

$$W_b = W_n \times \frac{100}{100 - A} \quad (5)$$

where A represents the allowance percentage. Performance rating and allowance determination followed established work-measurement principles (Freivalds & Niebel, 2014). Allowances were determined according to the working conditions of each activity and accounted for physical effort, work posture, movement, eye fatigue, workplace temperature, atmospheric condition, and environmental condition. The final allowance percentage for each activity was obtained by summing the applicable allowance percentages assigned to these seven factors. The resulting standard time was used for PAM and future-state analyses.

3.5 Root Cause Analysis and Future-State Development

After identifying the dominant waste and activity-level inefficiencies, root-cause analysis was conducted using a Fishbone diagram. Fishbone analysis was used to identify and organize potential causes of waiting-related waste and to examine the relationships between the observed problem and its contributing factors (Doggett, 2005).

Based on observations, interviews, and process analysis, the identified causes were grouped into four relevant categories: Man, Method, Machine, and Environment. The analysis considered factors related to operator performance and supervision, administrative and scheduling procedures, coordination with third-party service providers, equipment availability, road conditions, and port infrastructure. Each identified cause was linked to the corresponding waiting or delay activity so that the proposed improvement addressed the underlying cause of the inefficiency.

The root-cause analysis was subsequently used to formulate improvement strategies and develop the future-state map. The proposed actions included improvements in administrative coordination, earlier scheduling and preparation, coordination with external service providers, equipment availability, and selected infrastructure conditions.

The future-state map represents a projected improvement scenario rather than an empirically observed post-implementation condition. Projected activity times were estimated from the observed baseline times and the improvement assumptions developed from the root-cause analysis and operational observations, as summarized for each affected activity in Table 12. The projected future-state standard time was then compared with the current-state standard time to estimate potential time savings and changes in VA, NNVA, and NVA activities. Because the proposed improvements had not yet been implemented, statistical before-and-after significance testing was not performed.

4. Results and Discussion

4.1 Working Time Measurement

Work-time measurements were conducted for the 15 activities identified in the CPO shipping process, with 30 observations for each activity. The observed times were averaged to obtain the cycle time for each activity, following standard work-measurement procedures (Freivalds & Niebel, 2014). The resulting time data were subsequently

evaluated through normality, data uniformity and variability, and data sufficiency analyses before being used to calculate normal time and standard time.

4.2 Data Normality Test

The normality of the work-time measurement data was examined using the Shapiro–Wilk test. This test is appropriate for evaluating whether a dataset follows a normal distribution, particularly for relatively small samples (Ghasemi & Zahediasl, 2012). The results of the normality test for the 15 CPO shipping activities are presented in Table 2.

Table 2. Data Normality Test

No.	Activity	p-value	Normality
1.	Set up the dock	0.368	Normally Distributed
2.	Waiting for the tugboat	0.198	Normally Distributed
3.	Assisting the vessel from Kendawangan to Banjarsari	0.188	Normally Distributed
4.	Preparing the fleet of transport trucks	0.262	Normally Distributed
5.	Pre-shipment	0.092	Normally Distributed
6.	Weighing the empty truck	0.108	Normally Distributed
7.	Pumping CPO from the tank to the truck	0.371	Normally Distributed
8.	Weighing the truck after loading	0.103	Normally Distributed
9.	Transporting CPO from the factory to the port	0.230	Normally Distributed
10.	Loading CPO into the hold	0.097	Normally Distributed
11.	Measuring the ship's figure after loading	0.127	Normally Distributed
12.	Waiting for administrative readiness	0.523	Normally Distributed
13.	Waiting for the tugboat	0.086	Normally Distributed
14.	Assisting the vessel from Banjarsari to Kendawangan	0.554	Normally Distributed
15.	Transporting CPO to the destination port	0.123	Normally Distributed

As shown in Table 2, all activities had p-values greater than 0.05, indicating that the observed work-time data did not significantly deviate from a normal distribution. Therefore, the measurement data were considered normally distributed and suitable for further analysis.

4.3 Data Uniformity and Variability Analysis

The variability of the work-measurement data was evaluated using standard deviation and control limits. The upper control limit (UCL) and lower control limit (LCL) were used to examine whether the observed data remained within an acceptable range. Data outside the control limits may indicate unusual variation in the observed process. Control limits are commonly used to evaluate process variation and data consistency (Montgomery, 2020).

4.4 Data Sufficiency Test

The data sufficiency test was conducted to determine whether the number of observations collected for each activity was adequate for further analysis. The required number of observations (N') was compared with the actual number of observations (N). The data were considered sufficient when the required number of observations (N′) was lower than the actual number of observations (N), following standard work-measurement procedures (Freivalds & Niebel, 2014). The results of the data sufficiency test are presented in Table 4.

Table 3. Data Uniformity and Variability Analysis

No.	Activities	Standard Deviation	UCL	LCL	Status
1.	Set up the dock	0.12	1.42	0.93	Uniform
2.	Waiting for the tugboat	0.13	1.26	0.75	Uniform
3.	Assisting the vessel from Kendawangan to Banjarsari	0.13	4.38	3.87	Uniform
4.	Preparing the fleet of transport trucks	0.15	1.41	0.82	Uniform
5.	Pre-shipment	0.14	2.27	1.71	Uniform
6.	Weighing the empty truck	0.12	4.25	3.75	Uniform
7.	Pumping CPO from the tank to the truck	0.20	6.93	6.12	Uniform
8.	Weighing the truck after loading	0.13	4.21	3.68	Uniform
9.	Transporting CPO from the factory to the port	0.05	0.46	0.27	Uniform
10.	Loading CPO into the hold	0.15	7.16	6.56	Uniform
11.	Measuring the ship's figure after loading	0.13	3.23	2.72	Uniform
12.	Waiting for administrative readiness	0.49	25.09	23.12	Uniform
13.	Waiting for the tugboat	0.12	1.21	0.72	Uniform
14.	Assisting the vessel from Banjarsari to Kendawangan	0.19	4.48	3.70	Uniform
15.	Transporting CPO to the destination port	0.63	197.32	194.79	Uniform

As shown in Table 3, all observed activity times remained within their respective UCL and LCL, indicating that no out-of-control observations were identified.

Table 4. Data Sufficiency Test

No.	Activity	N	N’	Description
1.	Set up the dock	30	18	Sufficient
2.	Waiting for the tugboat	30	26	Sufficient
3.	Assisting the vessel from Kendawangan to Banjarsari	30	2	Sufficient
4.	Preparing the fleet of transport trucks	30	8	Sufficient
5.	Pre-shipment	30	28	Sufficient
6.	Weighing the empty truck	30	2	Sufficient
7.	Pumping CPO from the tank to the truck	30	2	Sufficient
8.	Weighing the truck after loading	30	2	Sufficient
9.	Transporting CPO from the factory to the port	30	29	Sufficient
10.	Loading CPO into the hold	30	1	Sufficient
11.	Measuring the ship's figure after loading	30	3	Sufficient
12.	Waiting for administrative readiness	30	1	Sufficient
13.	Waiting for the tugboat	30	26	Sufficient
14.	Assisting the vessel from Banjarsari to Kendawangan	30	4	Sufficient
15.	Transporting CPO to the destination port	30	1	Sufficient

As shown in Table 4, all 15 activities had N'values lower than the actual number of observations ($N = 30$). Therefore, the collected work-time data were considered sufficient for subsequent cycle-time, normal-time, and standard-time calculations.

4.5 Calculation of Cycle Time, Normal Time, and Standard Time

The performance-rating and allowance factors described in Section 3.4 were applied to each activity to determine normal time and standard time. The final performance-rating factors and allowance percentages used in the calculations are presented in Table 5.

Table 5. Performance Rating and Allowance Used in Standard-Time Calculation

No.	Activity	Performance Rating, P	Allowance (%)
1	Set up the dock	1.12	25
2	Waiting for the tugboat	1.07	8
3	Assisting the vessel from Kendawangan to Banjarsari	1.19	8
4	Preparing the fleet of transport trucks	1.16	1
5	Pre-shipment	1.12	19
6	Weighing the empty truck	1.19	2
7	Pumping CPO from the tank to the truck	1.21	9
8	Weighing the truck after loading	1.19	2
9	Transporting CPO from the factory to the port	1.15	8
10	Loading CPO into the hold	1.15	11
11	Measuring the ship's figure after loading	1.12	18
12	Waiting for administrative readiness	1.07	1
13	Waiting for the tugboat	1.08	8
14	Assisting the vessel from Banjarsari to Kendawangan	1.17	8
15	Transporting CPO to the destination port	1.10	2

As an example, for the activity of assisting the vessel from Kendawangan to Banjarsari, the Westinghouse adjustments for skill, effort, working condition, and consistency were 0.08, 0.08, 0.02, and 0.01, respectively. Therefore, the performance-rating factor was:

$$P = 1 + (0.08 + 0.08 + 0.02 + 0.01) = 1.19$$

Using a cycle time of 4.13 hours, the normal time was 4.91 hours. With an allowance of 8%, the resulting standard time was 5.34 hours. The same procedure was applied to the remaining activities, and the resulting cycle time, normal time, and standard time for all activities are summarized in Table 6.

Based on the standard-time calculation, the longest activity was transporting CPO to the destination port, with a standard time of 220.06 h. Among the non-transport activities, waiting for administrative readiness required the longest standard time, at 26.05 h. This relatively long duration was mainly associated with the preparation of shipping documents and the need to obtain approval from multiple parties before the barge could leave the port. The shortest standard time was observed for transporting CPO from the factory to the port, at 0.45 h, which was attributable to the relatively short distance between the factory and the loading port.

4.6 Current State Mapping

Current-state mapping was developed to describe the existing CPO shipping process in terms of material flow, information flow, and activity time (Rother & Shook, 2003). Based on observations and interviews, 15 activities were identified and classified into value-added (VA), necessary but non-value-added (NNVA), and non-value-added (NVA) activities using the decision rules described in Section 3.4. The time values presented in this section are based on the observed cycle time of each activity and are distinguished from the standard times subsequently used in the Process Activity Mapping (PAM) analysis, which incorporate performance-rating and allowance adjustments. The current-state activity classification and observed cycle times are presented in Table 7.

Table 6. Cycle Time, Normal Time, and Standard Time

No	Activities	Cycle Time (Hours)	Normal Time (Hours)	Standard Time (Hours)
1.	Set up the dock	1.18	1.32	1.76
2.	Waiting for the tugboat	1.00	1.07	1.17
3.	Assisting the vessel from Kendawangan to Banjarsari	4.13	4.91	5.34
4.	Preparing the fleet of transport trucks	1.12	1.29	1.31
5.	Pre-shipment	1.99	2.23	2.75
6.	Weighing the empty truck	4.00	4.76	4.86
7.	Pumping CPO from the tank to the truck	6.53	7.90	8.68
8.	Weighing the truck after loading	3.94	4.69	4.79
9.	Transporting CPO from the factory to the port	0.36	0.42	0.45
10.	Loading CPO into the hold	6.86	7.89	8.86
11.	Measuring the ship's figure after loading	2.98	3.33	4.07
12.	Waiting for administrative readiness	24.10	25.79	26.05
13.	Waiting for the tugboat	0.97	1.04	1.13
14.	Assisting the vessel from Banjarsari to Kendawangan	4.09	4.78	5.20
15.	Transporting CPO to the destination port	196.05	215.66	220.06
	Total	259.30	287.08	296.48

4.6 Current State Mapping

Current-state mapping was developed to describe the existing CPO shipping process in terms of material flow, information flow, and activity time (Rother & Shook, 2003). Based on observations and interviews, 15 activities were identified and classified into value-added (VA), necessary but non-value-added (NNVA), and non-value-added (NVA) activities using the decision rules described in Section 3.4. The time values presented in this section are based on the observed cycle time of each activity and are distinguished from the standard times subsequently used in the Process Activity Mapping (PAM) analysis, which incorporate performance-rating and allowance adjustments. The current-state activity classification and observed cycle times are presented in Table 7.

Table 7. Current-State Activity Classification and Observed Cycle Time

No.	Working Process	Category	Time (Hours)
1.	Set up the dock	VA	1.18
2.	Waiting for the tugboat	NVA	1.00
3.	Assisting the vessel from Kendawangan to Banjarsari	VA	4.13
4.	Preparing the fleet of transport trucks	NVA	1.12
5.	Pre-shipment	NNVA	1.99
6.	Weighing the empty truck	NNVA	4.00
7.	Pumping CPO from the tank to the truck	VA	6.53
8.	Weighing the truck after loading	NNVA	3.94
9.	Transporting CPO from the factory to the port	VA	0.36
10.	Loading CPO into the hold	VA	6.86
11.	Measuring the ship's figure after loading	NNVA	2.98
12.	Waiting for administrative readiness	NVA	24.10
13.	Waiting for the tugboat	NVA	0.97
14.	Assisting the vessel from Banjarsari to Kendawangan	VA	4.09
15.	Transporting CPO to the destination port	VA	196.05
	Total		259.30

Based on Table 7, the total observed cycle time of the CPO shipping process was 259.30 hours**.** VA activities accounted for 219.20 hours (84.54%), while NNVA activities accounted for 12.91 hours (4.98%) and NVA activities accounted for 27.19 hours (10.49%). The relatively high proportion of VA time is mainly attributable to the long transportation time from the loading port to the destination port. Nevertheless, the current state still contains substantial non-value-added time, particularly in activities associated with waiting. The cycle-time data in Table 7 were subsequently used to construct the current state map shown in Figure 2.

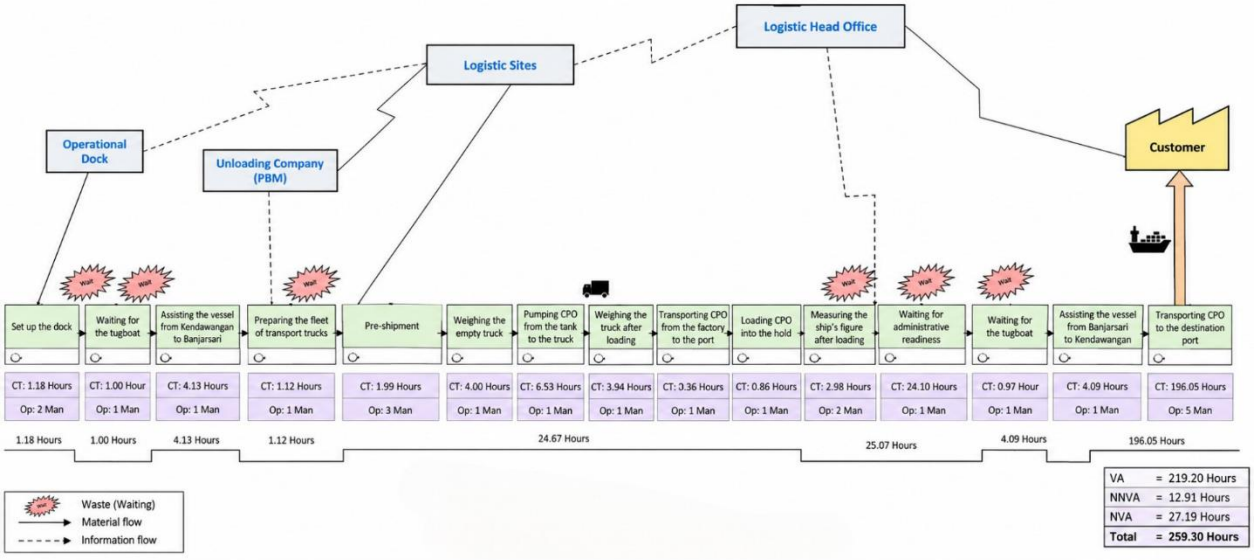


Figure 2. Current State Map of CPO Shipment

Figure 2 illustrates the current flow of information and materials throughout the CPO shipping process. The information flow begins when the customer communicates the required CPO quantity to the Head Office Logistics department. The Head Office then determines the shipment schedule and quantity and prepares the sales and purchase contract. This information is subsequently communicated to the Site Logistics department, which coordinates the operational preparation of the shipment.

At the site level, the logistics team coordinates with the stevedoring company regarding the required transport-truck fleet and stevedoring personnel and with the dock operations team regarding vessel berthing. Once the vessel and supporting facilities are ready, a pre-shipment inspection is conducted to verify the quality of the CPO. The CPO is then pumped from the storage tank into transport trucks, weighed, transported from the factory to the port, and loaded into the vessel. After loading, quantity and quality verification is conducted through the ship-figure measurement, followed by the completion of the required administrative documents and approvals. The vessel then receives tugboat assistance to leave the loading port and continues its voyage to the destination port.

The current state map also identifies several points at which non-value-added time occurs, particularly waiting for tugboat availability, preparation of the transport-truck fleet, and administrative readiness. These activities represent opportunities for reducing delays and improving the overall flow of the shipping process. Thus, the current state map provides the baseline for subsequent waste identification and detailed process analysis using VALSAT and PAM. This is consistent with the role of value stream mapping in visualizing the existing process and identifying opportunities to reduce non-value-added time and improve process flow (Rother & Shook, 2003).

4.7 Waste Identification

Following the development of the current-state map, waste identification was conducted to determine the dominant sources of inefficiency in the CPO shipping process. The assessment was performed using a questionnaire completed by three value stream managers who were directly involved in the shipping process. The questionnaire evaluated the seven Lean waste categories using a 0-5 scoring scale, where a higher score indicated a greater occurrence and operational impact of the identified waste. The scores provided by the three respondents were averaged and used to rank the waste categories. As described in Section 3.1, the expert assessments were also cross-validated with direct observations, measured process times, and interview findings to reduce potential evaluator bias. The waste-assessment results are summarized in Table 8 and subsequently used as input for the VALSAT analysis to determine the most appropriate detailed mapping tool.

Table 8. Waste Recapitulation Results

No.	Waste	Respondents			Avg	Rank
		1	2	3		
1.	Overproduction	0	0	1	0.33	4
2.	Defect	2	1	1	1.33	2
3.	Unnecessary Inventory	0	0	1	0.33	4
4.	Waiting Time	1	2	2	1.67	1
5.	Transportation	0	0	1	0.33	4
6.	Over processing	0	0	1	0.33	4
7.	Unnecessary Motion	1	1	1	1.00	3

As shown in Table 8, waiting time obtained the highest average score of 1.67 and was therefore ranked as the dominant waste in the CPO shipping process. Defect ranked second with an average score of 1.33, followed by unnecessary motion with an average score of 1.00. Overproduction, unnecessary inventory, transportation, and overprocessing each obtained an average score of 0.33. The dominance of waiting time is consistent with the current-state mapping results, which identified waiting-related activities at several stages of the shipping process, including waiting for tugboat availability, transport-truck preparation, and administrative readiness. These findings indicate that delays within the process flow require further investigation to identify their underlying causes and potential improvement opportunities. The aggregated waste scores presented in Table 8 were subsequently used as the weighting input in the VALSAT analysis to select the most appropriate tool for detailed waste assessment.

4.8 VALSAT Tool Selection

VALSAT tool selection was performed using a weighting procedure based on the waste-assessment results presented in Table 8. The average score of each waste category was multiplied by the corresponding VALSAT correlation weight, and the resulting scores were aggregated to determine the priority of the available mapping tools (Hines & Rich, 1997). The results of the VALSAT analysis are presented in Table 9.

Table 9. VALSAT Tool Selection Results

No	Tools	Total	Rank
1.	Process Activity Mapping	32.62	1
2.	Supply Chain Response Matrix	19.99	2
3.	Production Variety Funnel	3.65	6
4.	Quality Filter Mapping	12.63	3
5.	Demand Amplification Mapping	8.97	4
6.	Decision Point Analysis	7.32	5
7.	Physical Structure Mapping	0.66	7

As shown in Table 9, Process Activity Mapping (PAM) obtained the highest VALSAT score of 32.62, followed by the Supply Chain Response Matrix with a score of 19.99. Therefore, PAM was selected as the primary tool for detailed analysis of the CPO shipping process. The selection of PAM is also consistent with the dominance of waiting time identified in Table 8 because PAM enables detailed examination of activity sequence, processing time, transportation, inspection, and delay at the activity level. This allows the analysis to progress from system-level waste identification toward a more detailed diagnosis of where non-value-added time occurs within the shipping process.

PAM classifies process activities into five activity types: operation (O), transportation (T), inspection (I), storage (S), and delay (D) (Hines & Rich, 1997). In addition, each activity was classified according to its value contribution as value-added (VA), necessary but non-value-added (NNVA), or non-value-added (NVA), using the decision rules described in Section 3.4. Unlike the current-state time analysis in Table 7, which reports observed cycle time, the PAM analysis uses standard time, which incorporates the Westinghouse performance-rating and allowance factors. The results are presented in Table 10.

Table 10. Process Activity Mapping Results for the CPO Shipping Process

Activities	Types of Activities					Standard Time (Hours)	Distance (m)	Number of Operators	Category
	O	T	I	S	D				
Set up the dock	✓					1.76	–	2	VA
Waiting for the tugboat					✓	1.17	–	1	NVA
Assisting the vessel from Kendawangan to Banjarsari	✓					5.34	20,000	1	VA
Preparing the fleet of transport trucks					✓	1.31	–	1	NVA
Pre-shipment			✓			2.75	–	3	NNVA
Weighing the empty truck			✓			4.86	–	1	NNVA
Pumping CPO from the tank to the truck	✓					8.68	–	1	VA
Weighing the truck after loading			✓			4.79	–	1	NNVA
Transporting CPO from the factory to the port		✓				0.45	–	1	VA
Loading CPO into the hold	✓					8.86	–	1	VA
Measuring the ship's figure after loading			✓			4.07	–	2	NNVA
Waiting for administrative readiness					✓	26.05	–	1	NVA
Waiting for the tugboat					✓	1.13	–	1	NVA
Assisting the vessel from Banjarsari to Kendawangan	✓					5.20	20,000	1	VA
Transporting CPO to the destination port		✓				220.06	630,000	5	VA
Total	5	2	4	-	4	**296.48**	**670,000**	24	

Description: O = Operation; T = Transportation; I = Inspection; S = Storage; D = Delay

Based on Table 10, the total standard time of the CPO shipping process was 296.48 hours. Transportation accounted for the largest proportion of standard time at 220.51 hours (74.38%), primarily because the transportation of CPO to the destination port alone required 220.06 hours. Operation activities accounted for 29.84 hours (10.06%), while delay activities accounted for 29.66 hours (10.00%). Inspection activities represented 16.47 hours (5.56%), and no storage activity was recorded within the active shipping process. The distribution of standard time across PAM activity types is illustrated in Figure 3.

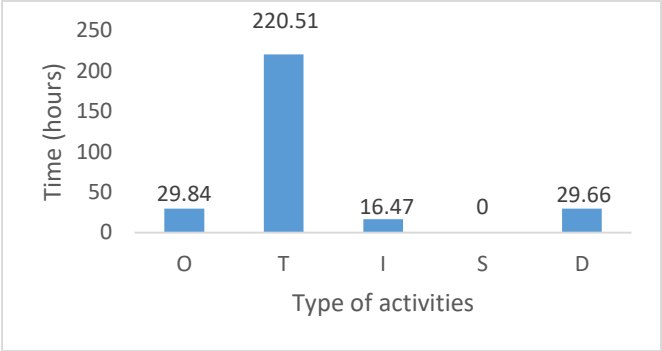


Figure 3. Standard Time by PAM Activity Type

Figure 3 shows that transportation dominates the total standard time, primarily because of the long-distance shipment from the loading port to the destination port. However, the dominance of transportation time does not necessarily indicate that transportation is the primary waste because most of this activity is required to fulfil the shipping service. In contrast, the 29.66 hours of delay represent non-value-added time and therefore constitute a more direct opportunity for process improvement. The largest component of delay was waiting for administrative readiness, which required 26.05 hours, followed by waiting for tugboat availability and delays associated with transport-truck preparation. This result is consistent with the waste-assessment findings in Table 8, where waiting time obtained the highest waste score. Therefore, waiting-related activities were selected for further root-cause analysis in the subsequent section. This interpretation is consistent with Hines and Rich (1997), who classify delay as a non-value-added activity that should be reduced or eliminated where operationally feasible.

4.9 Waste Cause Analysis

Based on the waste-identification and PAM results, waiting time was selected for further root-cause analysis because it was identified as the dominant waste in the CPO shipping process. The PAM analysis showed that delay activities accounted for 29.66 hours of standard time, consisting primarily of waiting for administrative readiness (26.05 h), waiting for tugboat availability (1.17 h and 1.13 h), and delays associated with the preparation of the transport-truck fleet (1.31 h). A fishbone diagram was therefore used to identify the underlying causes contributing to these waiting-related inefficiencies. The causes identified from observations, interviews, and process analysis were grouped into four relevant categories: Man, Method, Machine, and Environment. The resulting root-cause structure is presented in Figure 4.

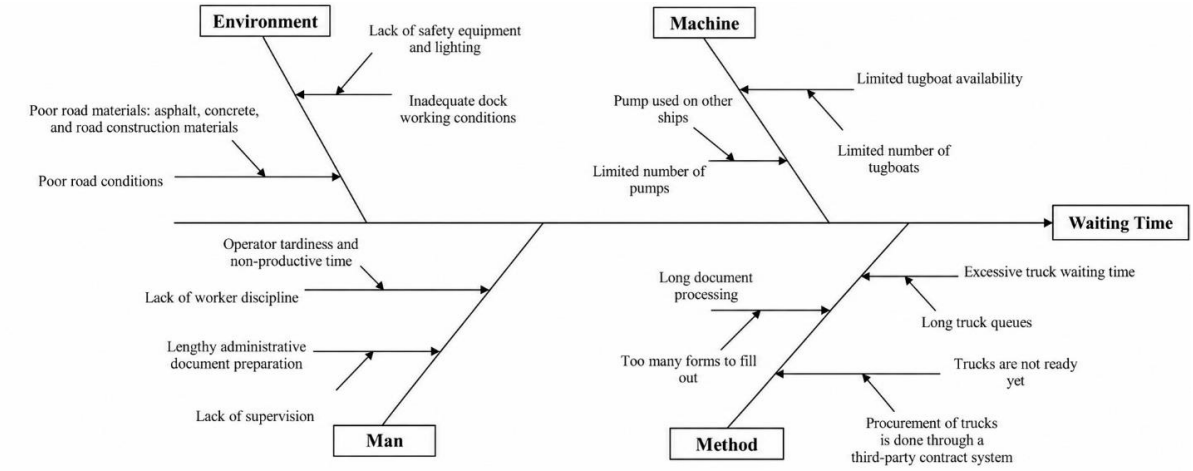


Figure 4. Fishbone Diagram of Waiting Time Waste

Figure 4 shows that waiting-time waste in the CPO shipping process is associated with a combination of human,procedural, equipment-related, and environmental factors. These causes are described as follows.

a. Man
   Human-related causes were mainly associated with administrative handling and operator work discipline. Delays in administrative processing were linked to inadequate supervision, limited filing capability, and the need for approval from multiple parties. In addition, operator tardiness, excessive breaks, and other unproductive behavior contributed to delays during loading and unloading activities. These conditions indicate that waiting time was influenced not only by physical process constraints but also by workforce management and administrative performance.
b. Method
   Method-related causes included long truck queues, extensive administrative procedures, dependence on third-party transport fleets, and lengthy manual documentation processes. The availability of transport trucks depended on external vendors, which limited the company's direct control over fleet readiness. In addition, ship-figure documentation required several manually completed forms, while the limited number of personnel involved in form completion increased processing time. Long truck queues were also associated with limited pumping capacity, which slowed the flow of trucks through the loading process.
c. Machine
   Machine-related causes were primarily associated with the limited availability of pumps and tugboats. Pumps used during loading were also required by other vessels, creating resource-sharing constraints and increasing truck waiting time. Similarly, the limited availability of tugboats, particularly during periods of high port traffic, resulted in delays before vessel docking and departure. These equipment and service-capacity limitations contributed directly to the waiting activities identified in the PAM analysis.
d. Environment
   Environmental causes included inadequate lighting, limited safety equipment, and poor road conditions along the transportation route. Poor road conditions reduced truck movement speed between the factory and the loading port, thereby extending transportation and queueing time. Inadequate working conditions at the dock could also reduce operational efficiency and contribute indirectly to process delays.

The root-cause analysis indicates that waiting-time waste does not originate from a single activity or operational factor. Instead, it results from interactions among workforce performance, process coordination, equipment availability, third-party service dependence, and infrastructure conditions. Therefore, improvement strategies were formulated by linking each identified problem with its corresponding root cause and affected process activity. The proposed improvement strategies are summarized in Table 11. Among the proposed improvements, actions related to coordination, scheduling, supervision, and earlier administrative preparation can be implemented primarily through process-management changes, whereas improvements involving pumps, road infrastructure, lighting, and other physical resources require greater operational investment. These recommendations were subsequently used as the basis for developing the projected future-state map.

4.10 Future-State Mapping

The future-state map was developed based on the proposed improvement strategies identified from the root-cause analysis. The proposed changes focused on reducing or eliminating activities that were identified as non-value-added and on reducing the processing time of activities that still had improvement potential. Activities that were required to maintain the core CPO shipping process were retained. The projected future-state configuration is presented in Figure 5. Figure 5 represents a projected future-state condition and has not yet been implemented by PT XYZ. Therefore, the time reductions shown in the future-state map represent estimated improvements based on the identified waste, root causes, and proposed improvement actions rather than observed post-implementation results. The future-state map is used to illustrate how the CPO shipping process may operate if the proposed improvements are implemented. The effectiveness of these proposed changes is evaluated further in Section 4.11 using the same standard-time basis applied in the PAM analysis.

Table 11. Improvement Strategy

Activity	Problem	Factor	Improvement
Waiting for tugboat	Limited tugboat availability	Machine / Method	Improve coordination with tugboat service providers and submit tugboat service requests earlier
Preparing the fleet of transport trucks	Transport trucks are not ready when required	Method	Schedule truck requirements earlier and coordinate fleet allocation with third-party vendors
Transporting CPO from factory to port	Damaged road conditions reduce transport speed	Environment	Conduct regular road-condition inspections and improve damaged road sections
Loading CPO into the hold	Limited pump availability because pumps are shared with other vessels	Machine	Increase pump availability, including the provision of dedicated company-controlled pumping capacity
Loading CPO into the hold	Long truck queues	Method	Improve truck-flow scheduling and increase pumping capacity to reduce queue duration
Loading and unloading activities	Operator tardiness and unproductive behavior	Man	Strengthen supervision, work-discipline enforcement, and performance evaluation
Dock operations	Insufficient safety equipment and lighting	Environment	Improve dock lighting and provide adequate safety equipment
Measuring ship figure after loading	Measurement and manual documentation require considerable processing time	Method	Increase surveyor/operator support during measurement and documentation activities
Waiting for administrative readiness	Administrative document preparation and approval take excessive time	Man / Method	Strengthen administrative supervision, prepare documents as early as operationally possible, and improve coordination among approval parties

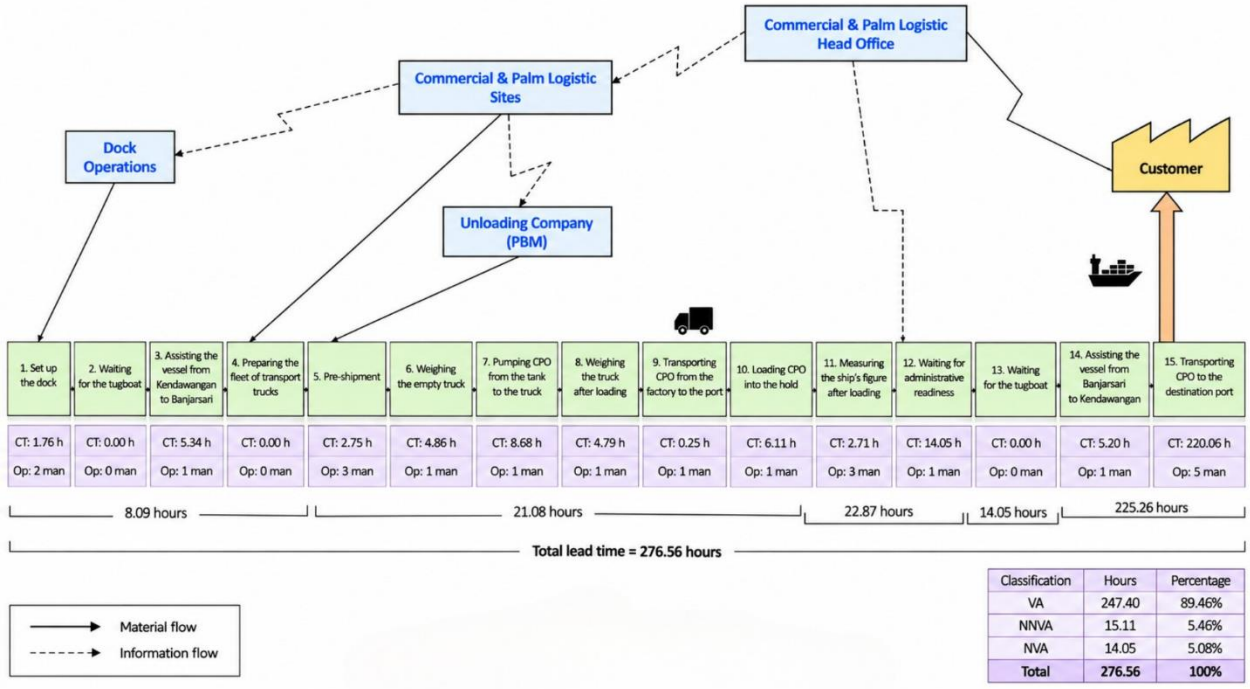


Figure 5. Projected Future-State Map of CPO Shipment

4.11 Projected Effectiveness of Lean Improvements

The effectiveness of the proposed improvements was estimated by comparing the current standard time with the projected future-state standard time. The same standard-time basis used in the PAM analysis was applied to maintain consistency between the current and future-states. The proposed changes focused on eliminating avoidable waiting and reducing activities that still had improvement potential. The projected changes for each activity are presented in Table 12.

Table 12. Proposed Future-State Improvement Scenario Based on PAM Analysis

No.	Process Activity	Current Classification	Current Standard Time (h)	Improvement Action	Future Standard Time (h)
1	Set up the dock	VA	1.76	–	1.76
2	Waiting for the tugboat	NVA	1.17	Elimination of unnecessary waiting	0
3	Assisting the vessel from Kendawangan to Banjarsari	VA	5.34	–	5.34
4	Preparing the fleet of transport trucks	NVA	1.31	Elimination of avoidable preparation delay	0
5	Pre-shipment	NNVA	2.75	–	2.75
6	Weighing the empty truck	NNVA	4.86	–	4.86
7	Pumping CPO from the tank to the truck	VA	8.68	–	8.68
8	Weighing the truck after loading	NNVA	4.79	–	4.79
9	Transporting CPO from the factory to the port	VA	0.45	Transportation efficiency improvement	0.25
10	Loading CPO into the hold	VA	8.86	Loading process improvement	6.11
11	Measuring the ship's figure after loading	NNVA	4.07	Measurement process improvement	2.71
12	Waiting for administrative readiness	NVA	26.05	Administrative coordination improvement	14.05
13	Waiting for the tugboat	NVA	1.13	Elimination of unnecessary waiting	0
14	Assisting the vessel from Banjarsari to Kendawangan	VA	5.20	–	5.20
15	Transporting CPO to the destination port	VA	220.06	–	220.06
	Total		**296.48**		**276.56**

As shown in Table 12, the proposed improvements are projected to reduce the total standard time from 296.48 hours to 276.56 hours, resulting in a potential time saving of 19.92 hours (6.72%). The largest reduction is associated with waiting for administrative readiness, which is projected to decrease by 12.00 hours. Other reductions are expected from eliminating tugboat waiting and truck-preparation delays and from improving loading, transportation, and ship-figure measurement activities. The comparison of the current and projected future-states based on activity classification is presented in Table 13.

Table 13. Comparison of Current-State and Projected Future-State Process Time

Activity Classification	Current State (h)	Future-State (h)	Time Reduction (h)	Reduction (%)	Current Share (%)	Future Share (%)
VA	250.35	247.40	2.95	1.18	84.44	89.46
NNVA	16.47	15.11	1.36	8.26	5.56	5.46
NVA	29.66	14.05	**15.61**	**52.63**	10.00	5.08
Total	**296.48**	**276.56**	**19.92**	**6.72**	**100**	**100**

To facilitate the comparison, the distribution of VA, NNVA, and NVA activities in the current and projected future-states is presented in Figure 6.

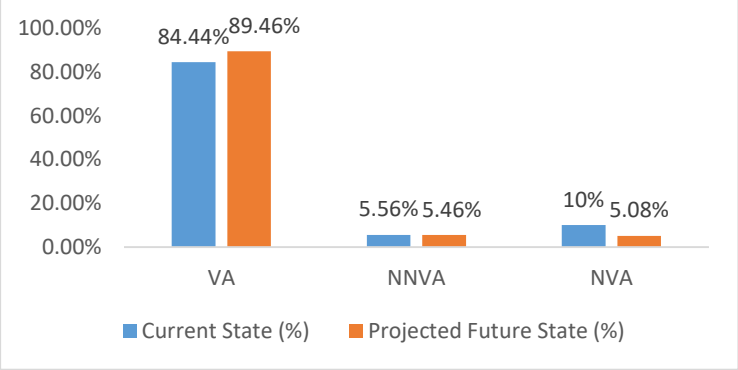


Figure 6. Comparison of Current-State and Projected Future-State Process Time by Activity Classification

Figure 6 shows that the proportion of VA time is projected to increase from 84.44% to 89.46%, although the absolute VA time decreases slightly due to improvements in transportation and loading activities. In contrast, NVA time is projected to decrease from 29.66 hours to 14.05 hours, representing a reduction of 52.63%. NNVA time is also projected to decrease from 16.47 hours to 15.11 hours due to improvement in the ship-figure measurement process. These results indicate that the largest potential improvement is obtained from reducing waiting-related NVA activities.

The identification of waiting time as the dominant waste is consistent with Lean principles, which emphasize the reduction of activities that consume time without creating value (Hines & Rich, 1997). In this study, waiting obtained the highest waste-assessment score of 1.67. The PAM analysis also showed that delay activities accounted for 29.66 hours or 10.00% of the total standard time, with waiting for administrative readiness representing the largest component. This indicates that inefficiency in the CPO shipping process is not caused only by physical transportation, but also by delays related to information processing, coordination, and resource availability.

Although transportation accounted for the largest proportion of the standard time, at 220.51 hours or 74.38%, most transportation activities were required to complete the CPO shipping service and were therefore classified as VA. Thus, a large time contribution does not automatically indicate waste. In contrast, waiting for tugboat availability, truck-fleet preparation delays, and administrative waiting did not directly contribute to the completion of the shipping service and were classified as NVA. This distinction is important in logistics processes because activities should be evaluated based on their function within the service process rather than only on the amount of time consumed.

The application of VSM provided an overall view of material and information flows and helped identify where inefficiencies occurred in the shipping process. VALSAT provided a more focused selection of the appropriate analytical tool, resulting in the use of PAM for activity-level analysis. The fishbone analysis further showed that waiting-time waste was influenced by several factors, including workforce performance, process coordination, equipment availability, and environmental conditions. These findings are consistent with recent Lean logistics research, which emphasizes the importance of integrating operational and inter-organizational logistics activities rather than treating individual process stages in isolation (Aygun et al., 2026).

The findings also show the importance of considering both physical and information flows in CPO shipping. Kihel et al. (2022) demonstrated the application of VSM across downstream distribution activities involving warehousing, road transportation, and sea transportation, while Chew et al. (2022) reviewed palm oil recovery processes and quality-enhancement technologies. In the present study, administrative waiting and coordination problems were also identified as important sources of inefficiency. Therefore, the contribution of this study does not lie in the individual use of VSM or VALSAT, but in their application within a sequential Lean analysis that connects current-state mapping, waste identification, PAM, root-cause analysis, and future-state development in a bulk commodity shipping process.

The future-state values presented in this study represent projected improvements rather than post-implementation measurements. Therefore, statistical before-and-after significance testing was not performed because empirical post-implementation data were not available. Applying statistical significance testing to estimated future-state values would not provide a valid measure of actual improvement. The proposed results should therefore be interpreted as potential performance gains derived from the current-state analysis. Further validation is required after implementation using actual post-improvement observations, including before-and-after performance comparisons and variability analysis.

4.12 Managerial Implications

The findings provide several practical implications for PT XYZ in improving the efficiency of the CPO shipping process. The proposed improvements differ in terms of expected time saving, implementation requirements, and feasibility. Therefore, the improvement actions should not be treated as having the same implementation priority. Improvements that mainly require better coordination, scheduling, and supervision can be implemented more quickly, while improvements requiring additional equipment or infrastructure need further investment and planning. Based on the expected time saving, implementation requirements, and feasibility of each proposed action, the managerial priority of the improvements is summarized in Table 14. Only improvement actions with directly quantifiable effects on the projected process time are included in the prioritization table. Other supporting actions, such as workforce supervision and dock safety improvements, remain relevant but were not assigned separate time-saving estimates.

Table 14. Managerial Prioritization of Proposed Improvements

Proposed Improvement	Main Activity Affected	Projected Time Saving (h)	Cost Requirement*	Feasibility*	Suggested Priority
Improve administrative coordination and prepare documents earlier	Waiting for administrative readiness	**12.00**	Low	High	Immediate
Improve coordination and early booking of tugboat services	Waiting for tugboat	**2.30**	Low	High	Immediate
Schedule and allocate transport-truck requirements earlier	Preparing transport-truck fleet	**1.31**	Low	High	Immediate
Improve ship-figure measurement and documentation support	Ship-figure measurement	**1.36**	Low–Moderate	High	Short term
Improve loading process and increase pump availability	Loading CPO into the hold	**2.75**	High	Moderate	Medium term
Improve road and transportation conditions	Factory-to-port transportation	**0.20**	High	Moderate	Long term
Total projected time saving		**19.92**			

*Cost requirement and feasibility are qualitative managerial assessments based on the type of resources required for implementation and are not based on actual investment-cost data.

As shown in Table 14, the largest projected time saving is obtained from improving administrative readiness, with a potential reduction of 12.00 hours. This improvement mainly requires earlier document preparation, better coordination among the parties involved in approval, and stronger administrative supervision. Because these actions mainly involve process and coordination changes rather than major physical investment, they can be considered an immediate improvement priority.

Improvements related to tugboat coordination and transport-truck scheduling also provide opportunities for relatively quick implementation. These actions primarily require earlier planning and communication with external service providers. Although their individual time savings are lower than those obtained from administrative improvement, they can reduce recurring waiting activities without requiring major changes to the existing shipping system.

In contrast, improvements involving pump availability and road conditions require greater resources and longer implementation periods. Increasing pump capacity may reduce loading and truck-queue time, but it requires additional equipment investment. Similarly, road improvement may support more reliable transportation between the factory and the port, but its implementation involves infrastructure expenditure and coordination beyond daily operational management. Therefore, these actions should be evaluated as medium- or long-term improvements.

A quantitative return-on-investment (ROI) analysis was not conducted because actual implementation costs, operating-cost savings, and monetary benefits were not collected in this study. Therefore, the cost and feasibility assessments in Table 14 should be interpreted as preliminary managerial considerations rather than financial evaluation results. Before implementing capital-intensive improvements, particularly additional pumping capacity and road infrastructure improvement, PT XYZ should conduct a detailed economic evaluation considering investment cost, expected operational savings, payback period, and ROI.

From a managerial perspective, the results suggest that PT XYZ can begin with low-investment operational improvements, particularly administrative coordination, tugboat booking, truck scheduling, and workforce supervision. These actions can be implemented before committing to larger infrastructure investments. This prioritization allows the company to address the main sources of waiting time while gradually evaluating the need for more capital-intensive improvements.

5. Conclusion

The study identified waiting time as the dominant waste in the CPO shipping process, with the highest waste-assessment score of 1.67. The main sources of waiting were administrative readiness, limited tugboat availability, transport-truck preparation, and other operational constraints. The integration of Value Stream Mapping (VSM) and Value Stream Analysis Tools (VALSAT) provided a structured approach for identifying waste and selecting Process Activity Mapping (PAM) for more detailed activity analysis.

The PAM analysis showed a total standard time of 296.48 hours, consisting of 250.35 hours of VA activities, 16.47 hours of NNVA activities, and 29.66 hours of NVA activities. Based on the proposed improvement scenario, the total standard time is projected to decrease to 276.56 hours, corresponding to a potential reduction of 19.92 hours or 6.72%. The largest reduction is projected for NVA activities, particularly waiting for administrative readiness. The proportion of NVA time is projected to decrease from 10.00% to 5.08%, while the proportion of VA time is projected to increase from 84.44% to 89.46%.

The findings indicate that improvements in administrative coordination, operational scheduling, resource availability, and infrastructure conditions can potentially improve the efficiency of CPO shipping. However, the future-state results represent projected improvements and have not yet been validated through actual implementation. This study contributes to Lean logistics research by applying a sequential VSM–VALSAT–PAM approach to bulk commodity shipping, where physical and information flows are closely interconnected. Further research should validate the proposed improvements using actual post-implementation data and evaluate their economic impact, including implementation cost, operational savings, and return on investment.

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