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Integrating Value Stream Mapping, Waste Assessment Model, and Root Cause Analysis to Improve Loading–Unloading Efficiency at PT XYZ

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Abstrak

Proses loading unloading sering menjadi hambatan dalam distribusi air minum dalam kemasan karena tingginya waktu tunggu. Penelitian ini bertujuan mengidentifikasi pemborosan waktu tersebut menggunakan Value Stream Mapping (VSM). Untuk memperkuat analisis, digunakan Waste Assessment Model (WAM) guna mengetahui hubungan hubungan antar pemborosan, serta Root Cause Analysis (RCA) untuk menemukan penyebab utama. Studi dilakukan di perusahaan air minum yang mengalami pemborosan signifikan pada tahap antrian dan pemeriksaan. Setelah penerapan perbaikan, efisiensi waktu meningkat sebesar 17.53%. Hasil penelitian ini menunjukkan bahwa identifikasi waste secara tepat dapat meningkatkan efisiensi operasional, mempercepat alur kerja, dan membantu perusahaan bergerak lebih produktif..

Keywords:
Loading unloadig;
Value Stream Mapping;
Waste Assessmen Model;
Root Cause Analysis;
Operational Efficiency

Abstract

The loading and unloading process often becomes a bottleneck in the distribution of bottled drinking water due to excessive waiting time. This study aims to identify and minimize such delays using Value Stream Mapping (VSM). To strengthen the analysis, the Waste Assessment Model (WAM) was applied to examine the interrelationships among different types of waste, while Root Cause Analysis (RCA) was employed to uncover the main contributing factors. The study was conducted at a bottled water company experiencing significant delays in queuing and inspection stages. Following the implementation of improvement measures, time efficiency increased by 17.53%. The findings demonstrate that accurately identifying waste can enhance operational efficiency, streamline workflow, and enable the company to operate more productively.

1. INTRODUCTION

Efficient loading and unloading operations are essential for ensuring smooth distribution flows in the bottled drinking water industry. However, these stages often experience prolonged waiting times, creating

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bottlenecks that disrupt delivery schedules, reduce productivity, and increase operational costs. In competitive supply chains, even small delays in downstream logistics can cause significant impacts on customer satisfaction and market responsiveness (Tyagi et al., 2015)(Kihel et al., 2022). Addressing these inefficiencies requires systematic process mapping to identify waste and improve workflow coordination through lean-based approaches.

Value Stream Mapping (VSM) has been widely recognized as an effective tool for visualizing workflows, identifying non-value-added (NVA) activities, and guiding process improvements (Arbelinda & Rumita, 2017; Yola et al., 2017). Numerous studies have demonstrated its success in manufacturing environments, including furniture production (Yola et al., 2017), automotive component manufacturing (Saraswat et al., 2015), textile industries (Fatma et al., 2022), and various assembly lines (Brilianto & Waluyowati, 2024). While these works highlight VSM's potential, most focus on upstream production processes. There is limited research exploring VSM in downstream logistics-specifically in loading and unloading operations within the bottled drinking water sector-where delays are often caused by coordination and scheduling rather than purely technical production constraints.

Furthermore, prior research has generally applied VSM as a standalone tool, with less emphasis on integrating it with complementary methods to strengthen analysis and solution design. The Waste Assessment Model (WAM) can be used to quantify and prioritize waste categories (Kihel et al., 2022) (Suryaningrat et al., 2022), while Root Cause Analysis (RCA) offers a structured approach to diagnosing systemic issues. Studies such as (Rusmawan, 2020) and (Khunaifi et al., 2022) show that combining VSM with other lean tools such as 5S, visual management, and standardized work can produce more sustainable operational improvements. However, few have systematically applied such integrated approaches in downstream logistics of the bottled drinking water industry.

This study addresses these gaps by implementing an integrated methodology combining VSM, WAM, and RCA to analyze and improve the loading and unloading processes at a bottled water company. The novelty lies in its logistics-focused lean application supported by quantitative waste prioritization and root-cause diagnosis. The findings show not only measurable efficiency gains-reducing process time by 17.53% but also underscore the importance of interdepartmental coordination and proactive scheduling. The results contribute to lean manufacturing literature while offering practical strategies for achieving responsive and sustainable logistics operations.

Previous research consistently identified waiting as a dominant waste, but the extent of efficiency improvement was generally below 15% when using VSM combined with conventional lean tools such as line balancing or manpower reallocation (Saraswat et al., 2015). However, little emphasis has been given to integrating scheduling and digital communication strategies into downstream logistics operations. This study differs by applying not only VSM, WAM, and RCA, but also incorporating staggered truck scheduling and digital reporting. This integrated approach aims to deliver greater efficiency gains by directly addressing interdepartmental communication delays, which were rarely explored in prior studies.

2. METHODS

This research was conducted over a period of three months, from January to March 2024, at PT XYZ, a bottled drinking water company operating in the East Java region of Indonesia. PT XYZ was selected as a case study because it faced recurring operational delays in the loading and unloading stages, which had a significant impact on distribution schedules, operational costs, and customer satisfaction. The company's openness to collaboration and provision of real operational data enabled a comprehensive on-site analysis.

This study utilized a descriptive approach with a qualitative lens, focusing on mapping and analyzing real operational practices at PT XYZ. The primary objective was to identify inefficiencies-particularly excessive delays in the loading and unloading area-by applying Value Stream Mapping (VSM) as a visual tool to track the actual flow of materials and information across processes (Yola et al., 2017). Observations were carried out by timing each activity using a digital stopwatch with an accuracy of 0.01 seconds, ensuring precise measurement of process durations and waiting periods. VSM was chosen for its ability to differentiate value-added (VA) and non-value-added (NVA) activities, offering a clear visualization of process bottlenecks (Arbelinda & Rumita, 2017).

Researchers began by observing and timing each activity within the workflow, especially those contributing to downtime. These observations were documented in a Current State Map, providing a real-time representation of operational flows. The map was then assessed using the Waste Assessment Model (WAM), which quantified and ranked the types of waste, identifying waiting as the most dominant (Kihel et al., 2022). WAM was selected to complement VSM by offering a structured prioritization of waste severity, ensuring improvement efforts targeted the most critical issues.

To further investigate the root causes behind inefficiencies-particularly long waiting times-the team applied Root Cause Analysis (RCA) techniques. Using the 5 Why's and Fishbone Diagram, underlying factors were traced logically, revealing issues such as uncoordinated scheduling, lack of real-time communication between production and logistics, and dependency on a single conveyor unit (Nowak et al., 2017). These findings guided the design of a Future State Map aimed at eliminating unnecessary steps, reducing time loss, and improving workflow coordination. The impact of proposed improvements was evaluated by comparing process performance between the current and future states, showing a projected time efficiency gain of 17.53% (Saraswat et al., 2015)(Rusmawan, 2020).

Once the analysis was complete, a redesigned workflow-the Future State Map-was developed. This improved model aimed to remove unnecessary steps, reduce time loss, and streamline operations. The difference between the current and future states was then compared to evaluate the projected impact, particularly in terms of time savings and process efficiency (Saraswat et al., 2015)(Rusmawan, 2020).

The integration of VSM, WAM, and RCA was intentionally chosen to achieve a holistic analysis: VSM identifies where waste occurs, WAM quantifies and prioritizes it, and RCA ensures that solutions address underlying causes. Prior research confirms that combining these tools leads to more sustainable process improvements in manufacturing and logistics contexts (Khunaifi et al., 2022)(Suryaningrat et al., 2022).

3. RESULT AND DISCUSSION

The initial observations at PT XYZ revealed that the loading and unloading process took a total of 14,480 seconds, with 4,260 seconds categorized as non-value-added (NVA) time, representing 29.4% of the overall process A significant portion of this time was consumed by non-value-added activities, primarily classified as waiting waste, caused by factors such as long vehicle queues, manual inspection delays, and occasional unavailability of tools. The breakdown of process time into value-added and non-value-added activities is presented in Table 1.

Table 1. Observation Loading Unloading Process at PT. XYZ

Process Time Category	Time (seconds)	Percentage (%)
Value-Added (VA) Time	10,220	70.59
Non-Value-Added (NVA)/Waiting Time	4,260	29.41

The data in Table 1 shows more than just numbers — it tells a story about how nearly a third of the total process time in loading and unloading at PT XYZ is spent on activities that add no value, mostly waiting. These moments of waiting are not abstract statistics; they are trucks idling in queues, workers holding back for manual inspections, and the occasional pause when tools are unavailable.

To better understand where these inefficiencies occur, the process was mapped using a Current State Value Stream Mapping (VSM), as seen in Figure 1. Here, the red bars point to the exact stages where time is lost, while the green bars show value-adding activities. Together, the table and the VSM provide a complete picture: the table quantifies the problem, while the VSM shows exactly where it happens, turning data into a clear action map for improvement. The Current State Map highlighted long queues of trucks, manual inspection delays, and occasional conveyor breakdowns as primary contributors to the waiting waste. These delays contributed to almost one-third of the total processing time, a figure consistent with (Kihel et al., 2022) who observed waiting waste dominating downstream operations in the automotive wiring industry due to similar scheduling and equipment issues.

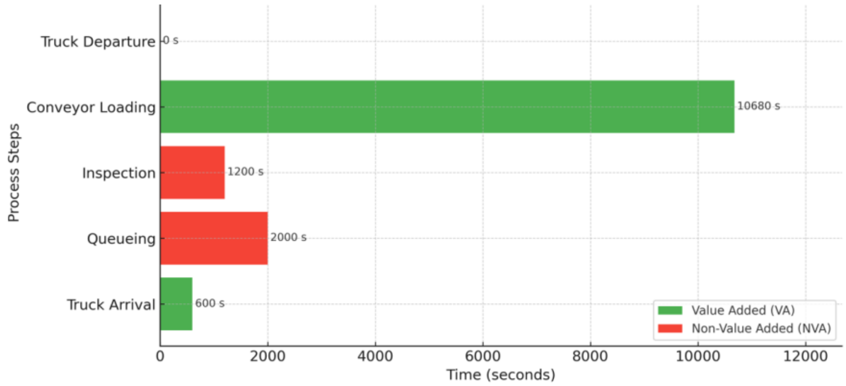

Fig. 1. Current State Value Stream Mapping

After constructing the Current State Map, the workflow was analyzed using the Waste Assessment Model (WAM) to quantify and prioritize the types of waste present in the loading and unloading process. The Waste Assessment Model (WAM) scoring identified waiting waste as having the highest weight (0.61), followed by transportation (0.17) and inventory (0.11). This prioritization mirrors the findings of (Yola et al., 2017) and Suryaningrat et al. (2022), highlighting that waiting waste frequently dominates in sequential, coordination-heavy processes, especially in industries where logistics rely on multiple handoffs between departments.

These results are visually summarized in Figure 2, where the red bar representing waiting waste clearly stands out, indicating its dominant role in process inefficiency. The WAM chart not only confirms the quantitative findings but also provides a straightforward visual reference that supports the prioritization of improvement initiatives aimed at reducing waiting time.

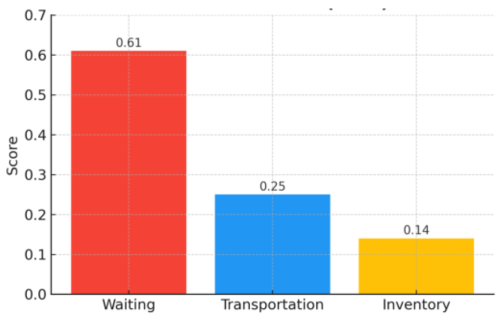

Fig. 2. Waste Assessment Model (WAM) Results

Root Cause Analysis (RCA), using both the fishbone diagram and 5 Why's technique, revealed systemic causes such as uncoordinated scheduling between production and logistics, lack of real-time information sharing, and reliance on a single conveyor unit. Similar patterns were documented by (Khunaifi et al., 2022) in manufacturing operations, where bottlenecks often stem from communication gaps and over-reliance on critical equipment.

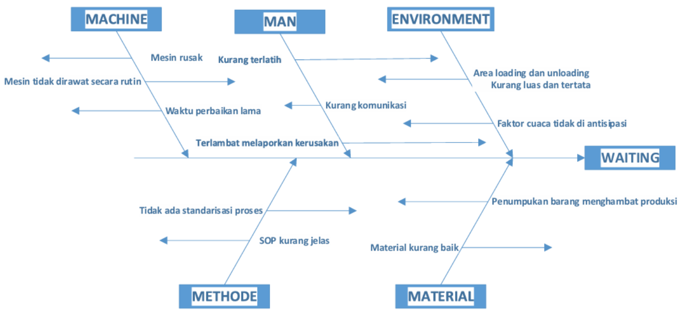

Fig. 2. Root Cause Analysis (Fishbone Diagram)

The identified root causes and corresponding improvement proposals are visually represented in the process mappings. The Current State Map depicts the initial workflow, revealing substantial non-value-added activities-particularly waiting waste-that significantly extended the overall process time. In contrast, the Future

State Map incorporates targeted improvements such as manpower reallocation, staggered loading schedules, and a simple visual kanban system to coordinate activities more effectively.

When placed side by side, the difference is evident: the waiting time was notably reduced, resulting in a 17.53% decrease in total process duration. This reduction not only improved operational flow but also minimized idle time, alleviating work pressure on staff.

Figure 3 below compares the total process time for each activity between the Current and Future States. The grouped bar chart clearly shows the efficiency gains across different stages, demonstrating how the application of VSM, RCA, and WAM successfully streamlined loading and unloading operations at PT XYZ.

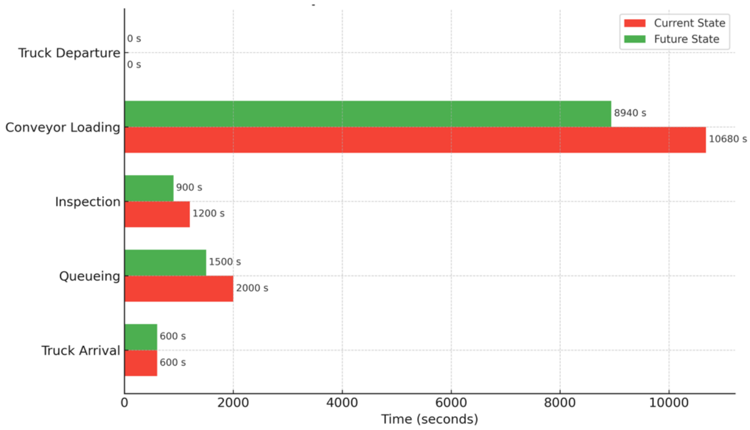

Fig. 3. Current vs Future State Process Mapping

The approach demonstrated in this study has potential applications in various industries beyond bottled water distribution. For example, sectors such as food processing, automotive parts delivery, and pharmaceuticals, where time-sensitive logistics play a critical role, can benefit from integrating VSM with WAM and RCA. By quantifying waste, tracing its root causes, and redesigning workflows, organizations can achieve measurable efficiency gains while fostering better coordination between departments. This combination of lean tools offers a structured yet adaptable framework suitable for diverse operational settings where bottlenecks impede performance.

These findings show both similarities and differences when compared to earlier studies. For instance, Kihel et al. (2022) observed that waiting waste also dominated in the automotive wiring industry, while Suryaningrat et al. (2022) reported similar pattern in frozen food production. In terms of efficiency gains, Saraswat et al. (2015) documented a 15% reduction in non-value-added time through VSM–RCA integration, which is slightly lower than the 17.53% achieved in this study. The difference lies in the specific solutions implemented: while earlier studies emphasized manpower reallocation and work standardization, this research introduced staggered truck scheduling and digital reporting to mitigate communication gaps. As a result, the magnitude of improvement was greater, showing that context-specific interventions can significantly influence outcomes.

4. CONCLUSION

This study demonstrated that the integration of Value Stream Mapping (VSM), Waste Assessment Model (WAM), and Root Cause Analysis (RCA) effectively identified and reduced waiting waste in the loading–unloading process at PT XYZ, where it accounted for 29.4% of total process time. The proposed improvements-manpower reallocation, staggered truck scheduling, and digital reporting-were projected to shorten process time by 17.53%, enhancing workflow efficiency and operational productivity. These findings confirm that combining visual mapping with analytical tools can address systemic inefficiencies in logistics and offer a transferable framework for similar industries.

In comparison with previous studies, this research achieved a higher improvement rate because it not only applied lean tools such as VSM, WAM, and RCA, but also complemented them with scheduling and digital-based solutions. This highlights the importance of tailoring lean methods to the operational context, as different industries and companies may require different sets of interventions to maximize efficiency. Future research should explore the application of IoT-based real-time monitoring to further optimize coordination and reduce delays

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