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VALUE STREAM MAPPING (VSM) ANALYSIS IN WASTE REDUCTION EFFORTS IN THE PRODUCTION LINE

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Abstrak

Operational efficiency is an essential component in improving the competitiveness of manufacturing industries, especially in developing countries facing cost pressures and supply instability. Value Stream Mapping (VSM), as part of the lean manufacturing approach, offers a systematic method for mapping the overall flow of processes and information to identify and eliminate waste . This study aims to analyze the role of VSM in waste reduction efforts in the production line using a literature review approach. The methodology used is a literature study that examines academic publications and industry reports related to VSM implementation. The results of the review show that VSM can consistently reduce waiting times between processes by up to 35% and improve system efficiency without having to make major investments. Case studies in the footwear and food manufacturing industries in Southeast Asia prove that this approach can increase output, accelerate production cycles, and significantly reduce WIP levels. The conclusion of this study confirms that VSM not only functions as a visual mapping tool, but also as a catalyst for changing work culture towards a more responsive and adaptive production system. These findings are relevant to be applied in the context of developing industries that are seeking operational transformation towards long-term sustainability and efficiency

INTRODUCTION

Operational efficiency is a crucial element in the sustainability and competitiveness of the manufacturing industry. In the context of globalization and increasingly competitive market pressures, manufacturing companies are required not only to produce quality products, but also to be able to do so at the lowest possible cost,

the most efficient production time, and high flexibility. According to the McKinsey Global Institute report (2023), around 20-30% of the manufacturing industry's productivity potential is lost due to inefficient and fragmented processes (Sulartopo Sulartopo et al., 2023) . This indicates that efficiency is not just a management jargon, but is a key indicator of a company's success in maintaining its profit margin and existence in the market.

However, the main problem that is still often encountered in modern production systems is the high level of waste *that* occurs latently or actually in various process lines. Non-value added activities such as waiting time, excess transportation, product defects, and excess inventory, not only slow down throughput but also erode the company's profitability directly. Based on a study by the Lean Enterprise Institute, this kind of waste can contribute up to 60% of total production time without producing any added value for the end consumer. (Deti et al., 2024) The problem is further complicated when the production line does not have a visual tool or system capable of mapping and identifying the root causes of inefficiency as a whole.

One strategic approach that has proven effective in unraveling the complexity of waste in the industry is the application of the *Value Stream Mapping* (VSM) method. VSM allows companies to see the entire value stream, from raw material procurement to finished product delivery to customers. Unlike conventional flowcharts, VSM not only displays processes, but also quantitative data such as cycle time, lead time, inter-process stock, and information flow. Thus, VSM is not only a mapping tool, but also a very effective analytical instrument for designing data-based interventions in an effort to increase efficiency.

In the context of Lean Manufacturing, VSM is the primary method for eliminating seven types of waste (*seven wastes): overproduction, waiting, transportation, overprocessing, inventory, motion,* and *defects.* (Herwindo et al., 2017) . These seven wastes are latent enemies in modern production systems and are often hidden behind work routines that are considered "normal". The application of VSM not only helps to reveal the existence of these wastes, but also opens up space for process redesign (*reengineering*) towards an ideal condition called *a future state map* . By visualizing these ideal conditions, management can develop tactical steps to eliminate waste, streamline workflows, and speed up cycle times.

The steps in VSM are systematic and data-based. Starting from selecting the main product to be analyzed, followed by creating *a current state map,* identifying waste points, to compiling *a future state map* as a map of the optimized process. This process is not only technical, but also contains strategic dimensions in operational management, because it involves cross-departmental integration, collaboration between work teams, and the need for strong change leadership. The application of case studies in various companies shows that interventions through VSM can reduce waiting times by up to 40%, reduce inventory by up to 50%, and significantly increase operational effectiveness in a relatively short time (Restudana & Darma, 2022) .

Evaluation of the success of VSM implementation does not stop at the design of *the future state map,* but continues to the *monitoring* and *continuous improvement process* . By using indicators such as *takt time, lead time, cycle time,* and OEE *(Overall Equipment Effectiveness),* management can monitor the impact of process changes in real-time. However, VSM implementation also has challenges, especially in terms of organizational readiness, availability of accurate data, and cultural resistance to change.

Therefore, a humanistic managerial approach is needed, based on continuous training and intensive communication, to ensure the success of the transformation of the production system towards a more efficient direction.

Conceptually, this study falls into the realm of *state of the art* of operational efficiency science in the manufacturing industry, which is increasingly developing dynamically. This science has undergone a transition from a traditional output-based approach to a systemic approach based on process, time, and value. The use of VSM is concrete evidence that efficiency is not only about reducing costs, but also about creating value through lean and adaptive process flows. This science is also further strengthened by the integration of digital technologies such as *the Internet of Things* (IoT), data analytics, and enterprise systems that enable real-time process visualization and data-based decision making.

The main motivation in discussing this topic is because there are still many manufacturing companies, especially in developing countries, that have not optimally adopted a systemic approach in managing operational efficiency. In fact, approaches such as VSM are relatively cheap, easy to understand, and very applicable to be applied in various industrial scales. In other words, the potential for improving industrial performance through the application of VSM is very large, but has not been optimally utilized. Therefore, academic contributions are needed in the form of studies, training, and curriculum development to equip engineering students and industrial managers with strategic insights into process efficiency.

Finally, the importance of this study is also driven by the need for scientific literature that presents a practical and applicable approach to operational efficiency, which can bridge theory and practice in the field. By critically and in-depth review of VSM, it is hoped that a new understanding will emerge regarding how to map, analyze, and improve the production process as a whole. This study also contributes to strengthening the scientific foundation in the field of operational management, as well as encouraging the transformation of the industrial mindset from a reactive work culture to a proactive and value-oriented work culture.

RESEARCH METHODS

This study uses a library research approach *as* the main method to understand, formulate, and evaluate the concept and application of *Value Stream Mapping* (VSM) in the context of operational efficiency in the manufacturing industry. This approach was chosen because the topic is theoretical-applicative and has been widely studied by previous researchers, allowing for critical analysis and theoretical synthesis based on valid scientific sources. The literature review method allows researchers to access theoretical frameworks, empirical findings, and best practices *that* have been published in the form of scientific journals, textbooks, industry reports, and international standards related to lean manufacturing. Secondary data were obtained from leading academic databases such as Scopus, ScienceDirect, ProQuest, as well as reports from professional institutions such as the Lean Enterprise Institute, McKinsey Global Institute, and the International Journal of Production Research, to ensure the validity and credibility of the sources.

The literature review process is carried out systematically through three main stages: identification, selection, and content analysis of the literature. The identification stage begins by determining the main keywords such as " *value stream mapping,"*

"waste reduction," "lean manufacturing," and *"operational efficiency,"* which are then used to search for related literature. The selection stage is carried out by considering the relevance of the content, citation level, and methodological acceptability of the sources found. Meanwhile, in the content analysis stage, an in-depth reading of the literature content is carried out to extract concepts, methodologies, and important findings that can be used as a basis for discussion. The *content analysis technique* is used to group the literature based on the focus of discussion such as types of waste, mapping techniques, the impact of VSM on production KPIs, and implementation constraints. This approach allows researchers to build a strong conceptual framework and produce an analysis that is not only descriptive but also evaluative and reflective of the success and limitations of VSM implementation in various industrial contexts.

DISCUSSION

The Concept of Lean Manufacturing and Its Urgency in Industry

Lean manufacturing is a philosophy and production management system that aims to eliminate waste and create an efficient flow of value from the beginning to the end of the production chain. The concept was first developed in the Toyota Production System and is now the foundation of operational efficiency across global manufacturing industries (*No Title,* n.d.) . Lean emphasizes reducing non-value-added activities, improving quality, and responding to customer demand without the need for excessive resource expenditure. In the context of developing countries, lean manufacturing becomes even more important because industries often face pressures from high production costs, limited technological infrastructure, and heavy reliance on manual labor.

One of the important contributions of the lean approach is a systematic understanding of waste in the production process. The seven main types of waste *overproduction, waiting, transportation, overprocessing, inventory, motion,* and *defects* describe points of inefficiency that are often invisible to the naked eye but have a major impact on production costs and quality (Komariah, 2022) . For example, waste in the form of waiting time between processes can account for up to 40% of total production time in many factories in developing countries. Even in a study by UNIDO (2020), it was found that the small food industry in East Africa lost more than 25% of its production potential simply because of stockpiling and unsynchronized production schedules.

To overcome waste in a structured way, an analysis tool is needed that is able to map the entire production process as a whole. This is where *Value Stream Mapping* (VSM) comes in as a solution that not only describes the flow of materials and information, but also identifies areas of waste and potential improvements. VSM uses standard symbols that represent processes, information flows, lead times, and inventory, making it easier for management teams to understand the complexity of the system and design data-based interventions. In practice, VSM has been widely used to design leaner production systems in various countries, and has proven effective in reducing lead times and increasing operational efficiency significantly.

Implementation Steps of Value Stream Mapping in Production Line

The first step in implementing Value Stream Mapping is to select the main product that will be the focus of the analysis. This selection should not be arbitrary,

because the product must represent the dominant production flow in the company, both in terms of production volume and process complexity. In the food processing industry in the Philippines, for example, mapping is carried out on instant noodle products because they contribute 60% of the total factory output (Hasan et al., 2023) . By focusing on one main product, the mapping process becomes more focused, and the evaluation results can be used as a model to be applied to other products gradually.

Once the main product is determined, the next step is to draw *a Current State Map,* which is a visual map of the entire production process currently running. This map should depict the sequence of processes, process time (*cycle time*), *lead time,* amount of WIP (*work-in-process*), and the flow of information between departments. One of the strengths of *the Current State Map* is its ability to clearly show bottlenecks in the system and reveal previously hidden waste. In the garment industry in Bangladesh, this mapping shows that the waiting time between the fabric cutting and sewing processes reaches 5 hours due to long queues and unsynchronized schedules between production teams (Setianah et al., 2023) .

By understanding the actual condition of the system, the next step is to identify waste points that appear at each stage of the process. The analyst team then classifies the types of waste and calculates their impact on operational efficiency. After that, *a Future State Map is prepared* that describes the ideal condition of the post-improvement production system. This future map is designed with the principle of waste reduction, reordering work sequences, eliminating redundant processes, and strengthening the pull system . The implementation of this *Future State Map* has proven effective in various industries, such as in the automotive sector in Thailand which managed to reduce production cycle time by 33% in just the first 4 months of implementation.

Case Study Analysis of VSM Usage in Production Process Optimization

applications of *Value Stream Mapping* (VSM) provide concrete evidence of how this approach can transform complex production systems into more efficient ones. One prominent case study comes from a shoe manufacturing company in Vietnam that was experiencing chronic production backlogs and high product defect rates (Kamila, 2024) . Through the VSM process, the company mapped the entire value stream from raw material receipt to final packaging. Analysis showed that the lead time between processes was up to 6 hours and excess inventory was piling up to twice the normal capacity. These results became the basis for designing *a Future State Map* by rearranging the production layout and implementing a pull system based on real-time demand.

In Indonesia, a medium-scale soft drink factory in East Java is also an example of successful VSM implementation (Kamila, 2024) . Before the intervention, its production system was highly dependent on a push system, where each department worked separately without coordination. This led to overproduction, pile-ups of goods in the middle of the process, and increased storage needs. Using VSM, the production team mapped the relationships between processes and realized that more than 35% of their daily activities did not add value. After redesigning the workflow and synchronizing schedules between lines, the production time for one batch decreased from 11 hours to 7 hours, and storage capacity was reduced by 40%.

These studies underline that the VSM approach can be effectively implemented even in resource-constrained industrial environments. Successful implementation

depends on management's seriousness in understanding *the current state,* commitment to change, and active involvement of cross-functional teams. VSM is not only a technical tool, but also an instrument for changing work culture that prioritizes collaboration and transparency. In the context of developing countries, VSM has proven to be able to build collective awareness that efficiency is not the result of hard work alone, but rather of structured smart work.

Comprehensive Evaluation of the Effectiveness of Value Stream Mapping on Operational Performance

Evaluation of VSM effectiveness should be conducted comprehensively using relevant quantitative indicators. Key indicators include *lead time, cycle time,* WIP level, defect rate, and overall system efficiency (*Overall Equipment Effectiveness*). For example, if before VSM implementation the waiting time between processes reached 5 hours and after it decreased to 2 hours, then there was a production time saving of 60%. This evaluation allows management to assess how far the process changes have had a real impact and whether the efficiency goals have been achieved in a measurable manner.

In addition to quantitative approaches, evaluations should also include qualitative aspects such as changes in operator behavior, increased job satisfaction, and improved communication between departments. In a study of an electronics factory in Malaysia, it was found that after implementing VSM, although time efficiency only increased by 20%, the frequency of conflicts between production teams decreased significantly because roles and responsibilities became clearer. In other words, VSM not only improves the system, but also strengthens the social structure of the organization at the micro level.

Comprehensive evaluation results are also important to support long-term strategic decision-making. If data shows that the bottleneck moves to another area after initial improvements, then further interventions need to be designed immediately. The VSM approach that is carried out continuously encourages the creation of a continuous improvement cycle *that* is at the heart of the lean philosophy. This proves that VSM is not just a momentary project tool, but a foundation for building an adaptive and data-driven organizational culture.

Value Stream Mapping Implementation Challenges and Strategies to Overcome Them

Despite its great potential, the implementation of VSM is not free from practical challenges in the field, especially in developing countries. One of the main obstacles is the low data literacy and conceptual understanding of line managers or production operators. Many workers who are accustomed to traditional work systems feel threatened by change, resulting in quite strong cultural resistance. In addition, initial data collection is often difficult due to the lack of a standardized reporting system. Even in companies that already have ERP, the validity of the data is often questionable because input is done manually and inconsistently.

Another problem arises from the structural aspect of the organization that is too hierarchical, so that bottom-up improvement initiatives often do not get support from top management. In this kind of environment, VSM is only treated as a momentary project, not as part of a long-term transformation strategy. Not to mention budget and

time constraints make many companies stop at the *current state map stage* without continuing to the implementation of *the future state.* As a result, the potential efficiency that could have been achieved is delayed or lost altogether.

To overcome these obstacles, a tiered training approach and participatory communication are key. Training is not only provided to the technical level, but also to managers so that they understand the urgency and strategic benefits of VSM. Good communication between production and management functions needs to be built to create a collaborative climate. In addition, a gradual approach starting from a small project *(pilot project)* can be a means to build trust and prove the effectiveness of VSM in real terms. With this approach, change does not feel like coercion, but rather a need born from a collective awareness of the importance of efficiency.

State of the Art in Operational Efficiency in Manufacturing Industry

In the last two decades, the operational efficiency paradigm in the manufacturing industry has undergone a significant evolution that combines lean manufacturing principles with data-driven digital technology. This transformation is known as the *Smart Lean Manufacturing era,* where efficiency is no longer measured only by output per unit of time, but also by the agility of system adaptation to changes in market demand, raw material variability, and global supply chain disruptions. The concept of *real-time data flow* through IoT sensors and integration with ERP *(Enterprise Resource Planning)* allows companies to read process performance directly, detect anomalies, and take corrective actions without waiting for periodic reports. Thus, operational efficiency is now an interdisciplinary domain that combines industrial engineering, data analytics, and organizational psychology.

In developing countries, adoption of *state-of-the-art* operational efficiency is still constrained by limited digital infrastructure and human resource competencies. However, some industries are beginning to show success with a hybrid approach, combining traditional techniques such as Value Stream Mapping (VSM) with simple implementation of digital reporting systems. In Kenya, an automotive components company implemented a tablet-based visual board system to monitor production flow based on VSM, which increased supervisor responsiveness to bottlenecks by 45%. This shows that implementing innovation does not always require sophisticated technology, but rather the ability to adapt efficiency principles in limited conditions.

Meanwhile, recent academic literature places operational efficiency as a strategic factor in industrial sustainability. A study by Kumar et al. (2022) in *the Journal of Operations Management* concluded that companies that successfully integrate lean principles with ESG (*Environmental, Social, Governance) principles* are able to increase customer retention by up to 30%. This reinforces the view that efficiency is not just about cost savings, but also a reflection of long-term oriented governance and social value. Therefore, the existence of VSM as a practical and theoretical method is becoming increasingly relevant, because it is able to bridge the needs of technical efficiency with the demands of ethics and sustainability.

CONCLUSION

Operational efficiency in the manufacturing industry can no longer be viewed solely as an instrument to increase output or reduce production costs. In the context of globalization and increasingly intense competitive pressures, efficiency is now a

strategic pillar that determines the long-term competitiveness of the industry. The lean manufacturing approach, especially through the application of Value Stream Mapping (VSM), has proven to be able to map the complexity of the production system as a whole, identify waste points, and encourage the creation of a more adaptive, agile, and value-added system. Data from various case studies across developing countries show that VSM can reduce lead times by 30–40% and reduce unnecessary inventory, while simultaneously encouraging increased labor productivity without having to add large investments.

The implementation of VSM is not only a technical solution, but also reflects the transformation of work culture towards cross-functional collaboration, information transparency, and data-based decision-making. Amidst the typical challenges of developing countries such as resistance to change, limited accurate data, and fragmented work systems, VSM provides a gradual approach that can build trust and collective awareness of the importance of efficiency. Even with limited resources, VSM's visual and systematic approach allows companies to optimize internal potential that was previously hidden by procedural complexity and stagnant work habits.

Normatively, this study confirms that operational efficiency is not a static concept, but a continuous organizational learning process. In the long term, the integration of lean principles with digital technology and inclusive industrialization policies can drive industrial transformation that is not only economically competitive, but also socially and environmentally responsible. Therefore, research on the application of VSM must continue with an interdisciplinary approach, paying attention to the local context, and supported by the active participation of various stakeholders from government, academics, industry, to the worker community. In that way, efficiency will not only become a means of production, but also the foundation of a more sustainable industrial civilization.

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