2024, Vol. 2, No. 1, pp. 26-35
E-ISSN: 3025-9444

Lean Manufacturing Implementation to Reduce Waste in Small-Scale Manufacturing Enterprises

Ahmad Rizky Pratama [1]✉, Amr Dahab [2], Savindi Caldera [3]
(1) Department of Industrial Engineering, Universitas Brawijaya, Malang, Indonesia
(2) Department of Mechanical Engineering, Cairo University, Cairo, Egypt
(3) School of Engineering and Built Environment, Griffith University, Brisbane, Australia

Abstract: *Small-scale manufacturing enterprises (SMEs) face persistent challenges related to inefficiency, high operational costs, and excessive waste generation, which threaten their competitiveness and long-term sustainability. Lean manufacturing has been widely recognized as an effective managerial and operational approach to reduce waste and enhance productivity; however, its implementation in small-scale manufacturing environments remains uneven and context-dependent. This study aims to analyze the implementation of lean manufacturing practices in small-scale manufacturing enterprises and evaluate their effectiveness in reducing operational waste. Using a qualitative case study approach supported by descriptive quantitative indicators, this research synthesizes empirical evidence from multiple manufacturing SMEs. Data were collected through direct observation, semi-structured interviews, document analysis, and performance measurement tools such as Overall Equipment Effectiveness (OEE) and Value Stream Mapping (VSM). The results demonstrate that the systematic application of lean tools—particularly 5S, VSM, Kaizen, and standardized work—significantly reduced non-value-added activities, shortened lead time, and improved equipment efficiency. Comparative analysis with previous studies confirms that lean implementation in SMEs contributes to measurable waste reduction and operational performance improvement, despite constraints related to resources and organizational culture. The study concludes that lean manufacturing is a viable and scalable strategy for small-scale manufacturing enterprises, provided that managerial commitment and continuous improvement culture are effectively cultivated.*

Article history:
Received: 09 November 2023
Revised: 18 November 2023
Accepted: 26 January 2024
Published: 31 January 2024

Keyword:
lean manufacturing, waste reduction, small-scale manufacturing, value stream mapping, continuous improvement

How to cite: Pratama, A. R., Dahab, A., & Caldera, S. (2024). Lean Manufacturing Implementation to Reduce Waste in Small-Scale Manufacturing Enterprises. *RESWARA: Jurnal Riset Ilmu Teknik*, *2*(1), 26–35. https://doi.org/10.70716/reswara.v2i1.377

INTRODUCTION

The manufacturing sector continues to play a central role in economic development by generating employment, supporting industrial supply chains, and contributing to national productivity. Within this sector, small-scale manufacturing enterprises constitute a significant proportion of industrial actors, particularly in developing and emerging economies. Despite their importance, these enterprises frequently face persistent operational challenges related to low productivity, inefficient resource utilization, and high levels of process waste. Such challenges are exacerbated by limited capital, simple production technologies, and managerial constraints, which collectively reduce competitiveness and threaten long-term business sustainability (Dahab et al., n.d.; Mullisa & Kader, 2023).

Waste in manufacturing processes represents one of the most critical issues affecting small-scale enterprises. Waste manifests in various forms, including overproduction, waiting time, unnecessary transportation, excess inventory, defects, overprocessing, and excessive motion. These non-value-added activities consume resources without contributing to customer value and directly increase

✉ *Corresponding author: ahmad.rizkyp@ub.ac.id*

production costs. Empirical studies conducted in diverse small manufacturing contexts consistently indicate that waste-related inefficiencies account for a substantial proportion of total operational losses (Sood & Belokar, n.d.; Sharma, n.d.). Consequently, systematic waste identification and elimination have become essential priorities for improving operational performance in small-scale manufacturing environments.

Lean manufacturing has emerged as a widely recognized operational philosophy aimed at maximizing value while minimizing waste. Rooted in the Toyota Production System, lean manufacturing emphasizes continuous improvement, respect for people, and the systematic elimination of non-value-added activities. Numerous studies have demonstrated that lean implementation contributes to reduced lead time, improved process flow, enhanced equipment efficiency, and better quality performance (Grewal, 2008; Zahraee et al., 2017). Through the application of structured tools such as Value Stream Mapping, 5S, standardized work, and Kaizen, organizations are able to visualize inefficiencies, redesign processes, and sustain performance improvements.

Although lean manufacturing was initially developed and widely implemented in large-scale manufacturing organizations, its applicability to small-scale enterprises has received increasing scholarly attention. Research indicates that lean principles are not inherently dependent on organizational size, but rather on managerial commitment, workforce involvement, and systematic execution. Simmons et al. (n.d.) demonstrated that lean practices could be effectively implemented in low-volume manufacturing environments, resulting in measurable efficiency gains. Similarly, Sood and Belokar (n.d.) reported significant waste reduction and value creation in agro-parts manufacturing SMEs following lean adoption.

Despite these positive findings, the implementation of lean manufacturing in small-scale enterprises remains challenging. Structural limitations such as financial constraints, limited access to lean expertise, insufficient training, and resistance to organizational change frequently hinder effective implementation. Dombrowski and Crespo (n.d.) emphasized that SMEs often struggle to translate lean concepts into practical actions due to the absence of formal management systems. Furthermore, the lack of a supportive organizational culture reduces the sustainability of lean initiatives, leading to partial or short-term improvements rather than continuous performance enhancement (Caldera et al., n.d.).

Recent empirical studies have highlighted the importance of integrating lean manufacturing with complementary improvement frameworks to strengthen implementation outcomes. Lean Six Sigma and DMAIC-based approaches, for example, provide structured problem-solving mechanisms that enhance process control and data-driven decision making. Sodhi et al. (n.d.) proposed a conceptual Lean Six Sigma model that improved process stability and waste reduction effectiveness. Hassan (2013) and Arafeh (2015) further confirmed that combining lean tools with the DMAIC framework leads to more systematic and sustainable improvement results in manufacturing processes.

From a geographical perspective, lean manufacturing implementation has been extensively documented across both developed and developing economies. Studies conducted in Peru, Kosovo, India, and Indonesia demonstrate that lean principles are adaptable to diverse industrial, cultural, and economic contexts. Kaneku-Orbegozo et al. (2020) reported substantial waste reduction in Peruvian

manufacturing firms through lean process redesign. Azemi et al. (2020) found that SMEs in Kosovo experienced operational and financial benefits following lean adoption. Similarly, empirical evidence from Indian and Indonesian manufacturing enterprises confirms improvements in productivity, lead time, and equipment utilization after lean implementation (Kumar et al., 2014; Effendi et al., 2023).

Within the Indonesian context, small-scale manufacturing enterprises face intensified competitive pressure due to globalization and regional market integration. Limited production efficiency and high operational waste place these enterprises at a disadvantage compared to larger and more technologically advanced firms. Empirical studies conducted in Indonesia demonstrate that lean manufacturing offers a practical approach to addressing these challenges. Santosa and Sugarindra (2018) and Lesmana (2020) showed that the application of Value Stream Mapping, Kaizen, and waste assessment models significantly reduced waste and improved process performance in Indonesian manufacturing settings. However, many studies remain context-specific and focus on single-case implementations.

Another critical issue identified in the literature concerns the development of a lean culture within small-scale enterprises. Sustainable lean implementation requires not only the application of technical tools but also behavioral and cultural transformation at the organizational level. Flores Benítez and Núñez Silva (2023) emphasized the role of employee participation and management support in fostering continuous improvement behavior. Without a shared understanding of lean principles and active workforce involvement, lean initiatives risk becoming isolated projects rather than integrated management practices.

Furthermore, recent research has increasingly linked lean manufacturing with broader production management and sustainability objectives. Production management models that integrate lean principles with systematic layout planning and workflow optimization have been shown to enhance efficiency in small manufacturing firms (Anchayhua et al., 2022; Zamora-Gonzales et al., 2021). Sedelnikova (n.d.) also highlighted that lean-based production management systems improve enterprise-level performance by aligning operational processes with strategic objectives.

Although the existing body of literature provides substantial evidence regarding the benefits of lean manufacturing in small-scale enterprises, several research gaps remain. First, many studies focus on isolated lean tools rather than examining lean implementation as an integrated system. Second, comparative synthesis across different small-scale manufacturing contexts remains limited, particularly in terms of identifying common waste patterns and improvement mechanisms. Third, there is a need for studies that explicitly link empirical implementation results with established lean performance indicators such as lead time reduction and equipment effectiveness.

Based on these gaps, this study aims to analyze the implementation of lean manufacturing in small-scale manufacturing enterprises with a specific focus on waste reduction and operational efficiency improvement. By synthesizing empirical evidence from multiple manufacturing contexts and explicitly applying established lean assessment tools, this research contributes to a more comprehensive understanding of lean implementation in small-scale environments. The findings are expected to provide practical insights for practitioners and theoretical contributions for scholars interested in operational improvement and manufacturing systems management.

RESEARCH METHOD

Research Design

This study employed a qualitative case study design supported by descriptive quantitative indicators to analyze the implementation of lean manufacturing in small-scale manufacturing enterprises. The case study approach was selected to enable an in-depth examination of operational processes, waste characteristics, and improvement outcomes within their real organizational context. This design is consistent with prior lean manufacturing research that emphasizes contextual understanding and process-level analysis in small manufacturing environments (Grewal, 2008; Lesmana, 2020).

Research Setting and Timeframe

The research was conducted in selected small-scale manufacturing enterprises operating in metal processing, textile, and agro-parts sectors. These sectors were chosen because they commonly exhibit repetitive production processes and observable waste patterns suitable for lean analysis. Data collection was carried out over a six-month period to ensure adequate observation of operational routines before and after lean implementation activities. The selected timeframe allowed for the stabilization of improvement actions and reduced the influence of short-term operational fluctuations.

Units of Analysis and Participants

The primary units of analysis were production processes within each enterprise, including material flow, machine utilization, and operator activities. Research participants consisted of production managers, supervisors, and shop-floor operators who were directly involved in daily operations and improvement initiatives. Participants were selected using purposive sampling based on their roles and direct knowledge of production processes. This sampling strategy ensured the relevance and reliability of information obtained while maintaining consistency with SME-focused lean studies (Sood & Belokar, n.d.; Simmons et al., n.d.).

Data Collection Techniques

Data were collected using multiple techniques to enhance credibility through triangulation. Direct shop-floor observation was conducted to document actual work practices, material movement, waiting times, and layout conditions. Semi-structured interviews were carried out with key personnel to capture insights related to operational challenges, waste sources, and perceptions of lean implementation. In addition, document analysis was performed on production records, standard operating procedures, and maintenance logs to support observational and interview data.

Lean assessment tools were systematically applied as part of the data collection process. Value Stream Mapping was used to visualize the current-state production flow and identify non-value-added activities across processes. Overall Equipment Effectiveness was employed as a performance indicator to assess machine availability, performance efficiency, and quality rate. Waste classification matrices were utilized to categorize observed waste types according to established lean manufacturing frameworks. These instruments are widely used in SME-oriented lean research and provide practical yet rigorous assessment mechanisms (Dahab et al., n.d.; Zahraee et al., 2017).

Data Analysis Procedures

Qualitative data obtained from observations and interviews were analyzed using thematic analysis. Data coding focused on recurring patterns related to waste sources, operational constraints, and improvement actions. Thematic categories were developed iteratively to maintain alignment with lean manufacturing concepts and research objectives. Quantitative indicators derived from Value Stream Mapping and Overall Equipment Effectiveness were analyzed using descriptive before-and-after comparisons to evaluate changes in operational performance following lean implementation. No inferential statistical testing was applied, as the study aimed to emphasize practical improvement outcomes rather than hypothesis testing.

Research Validity and Reliability

To ensure research validity, data triangulation was applied by cross-verifying findings from observations, interviews, documents, and performance indicators. Methodological consistency was maintained by using standardized lean assessment tools and clearly defined analysis procedures. Reliability was strengthened through repeated observations and validation of findings with key participants to confirm the accuracy of process descriptions and improvement outcomes. These measures are consistent with best practices in qualitative manufacturing research and support the trustworthiness of the study results (Santosa & Sugarindra, 2018; Mullisa & Kader, 2023).

RESULTS AND DISCUSSION

Identification of Waste in Production Processes

The initial assessment revealed that waste was predominantly observed in the form of waiting time, unnecessary motion, excess inventory, and minor rework activities. These waste types were mainly caused by unbalanced workloads, non-optimized workstation layout, and the absence of standardized work procedures. Similar waste patterns have been reported in small-scale manufacturing enterprises across different sectors, indicating that operational inefficiencies are often systemic rather than incidental (Sood & Belokar, n.d.; Sharma, n.d.). The use of Value Stream Mapping enabled clear visualization of material and information flow, making non-value-added activities explicitly identifiable.

Table 1. Dominant Waste Types Identified in Small-Scale Manufacturing Processes

WASTE TYPE	PRIMARY SOURCE	OPERATIONAL IMPACT
Waiting	Machine idle time, unbalanced process flow	Increased lead time
Excess motion	Poor workstation layout	Operator fatigue, productivity loss
Inventory	Overproduction and batch-oriented scheduling	Space utilization inefficiency
Defects/Rework	Lack of standardized work procedures	Quality loss and reprocessing

The findings confirm that waste in small-scale manufacturing environments is closely linked to basic operational design issues rather than advanced technological limitations. This reinforces the argument that lean manufacturing tools focusing on process simplification and flow improvement are suitable for SMEs.

Effects of Lean Tool Implementation

Following the identification phase, lean tools were applied in a structured manner, focusing on 5S, standardized work, Kaizen activities, and preventive maintenance. The implementation of 5S improved workplace organization and reduced unnecessary motion, while standardized work minimized process variability. Preventive maintenance activities contributed to improved equipment availability, which aligns with previous findings that link lean implementation with enhanced equipment performance (Dahab et al., n.d.; Mullisa & Kader, 2023).

Table 2. Lean Tools Applied and Observed Improvement Outcomes

LEAN TOOL	APPLICATION FOCUS	OBSERVED OUTCOME
5S	Workplace organization	Reduced motion and search time
Standardized work	Process consistency	Lower variability and fewer defects
Kaizen	Continuous improvement initiatives	Incremental process efficiency gains
Preventive maintenance	Equipment reliability	Improved machine availability

These outcomes demonstrate that even basic lean tools, when applied consistently, can generate meaningful operational improvements in small-scale enterprises without requiring significant capital investment.

Improvement in Process Flow and Equipment Effectiveness

The application of Value Stream Mapping before and after improvement actions showed a clearer and more continuous process flow. Bottlenecks caused by waiting time between operations were reduced through workload balancing and layout adjustments. Improvements in Overall Equipment Effectiveness were mainly driven by increased availability and reduced minor stoppages, supporting prior studies that emphasize the role of maintenance and standardization in improving OEE in SMEs (Grewal, 2008; Zahraee et al., 2017).

These findings are consistent with empirical evidence from Indonesian manufacturing case studies, where lean implementation resulted in shorter lead times and improved production stability (Santosa & Sugarindra, 2018; Lesmana, 2020). The results indicate that performance improvement in small-scale manufacturing does not require complex automation but rather disciplined execution of lean fundamentals.

Employee Involvement and Organizational Response

Employee participation emerged as a critical factor influencing the effectiveness of lean implementation. Kaizen activities encouraged operators to identify problems and propose practical improvement solutions based on daily operational experience. This participatory approach strengthened ownership of improvement initiatives and facilitated behavioral change at the shop-floor level. Similar observations were reported by Flores Benítez and Núñez Silva (2023), who emphasized the role of workforce engagement in sustaining lean practices within small manufacturing firms.

Management support was equally important in ensuring continuity of improvement actions. Clear communication of improvement objectives and consistent follow-up reinforced employee commitment and reduced resistance to change. These findings align with studies highlighting organizational culture as a key determinant of lean sustainability in SMEs (Caldera et al., n.d.; Dombrowski & Crespo, n.d.).

Comparative Discussion with Previous Studies

A comparison of the study results with prior international research demonstrates strong alignment in terms of waste reduction mechanisms and improvement outcomes. Studies conducted in Peru, Kosovo, and India reported similar improvements in process efficiency and waste elimination following lean implementation (Kaneku-Orbegozo et al., 2020; Azemi et al., 2020; Kumar et al., 2014). Furthermore, integration of lean practices with broader production management frameworks has been shown to enhance long-term performance, as reported by Anchayhua et al. (2022), Zamora-Gonzales et al. (2021), and Sedelnikova (n.d.).

Overall, the findings confirm that lean manufacturing provides a practical and adaptable improvement framework for small-scale manufacturing enterprises. When supported by managerial commitment and employee involvement, lean implementation contributes to systematic waste reduction, improved operational efficiency, and enhanced organizational learning.

CONCLUSION

This study demonstrates that the implementation of lean manufacturing provides a practical and effective approach to reducing waste and improving operational efficiency in small-scale manufacturing enterprises. The findings show that dominant waste types, including waiting time, unnecessary motion, excess inventory, and minor rework, can be systematically identified and mitigated through the consistent application of lean tools such as Value Stream Mapping, 5S, standardized work, Kaizen, and preventive maintenance. These interventions contributed to improved process flow, enhanced equipment availability, and more stable production operations without requiring substantial capital investment.

The results further indicate that the effectiveness of lean implementation in small-scale enterprises is strongly influenced by organizational factors. Active employee involvement in continuous improvement activities and sustained management commitment were essential in translating lean principles into daily operational practices. This confirms that lean manufacturing is not solely a set of technical tools, but a management approach that requires behavioral alignment and organizational discipline to achieve lasting performance improvements.

From a theoretical perspective, this study reinforces existing lean manufacturing literature by providing empirical evidence that lean principles are adaptable to small-scale manufacturing contexts across different industrial sectors. Practically, the findings offer actionable guidance for small manufacturing enterprises seeking to enhance efficiency under resource constraints. Future research is recommended to examine the long-term sustainability of lean initiatives and to incorporate longitudinal performance measurement to further validate improvement outcomes.

REFERENCES

Anchayhua, G., Cevallos, S., Peñafiel, J., et al. (2022). Production management model based on lean manufacturing and SLP to increase efficiency in the tapestry manufacturing process in Lima manufacturing SMEs. In Advances in Intelligent Systems and Computing. Springer. https://doi.org/10.1007/978-3-030-85540-6_74

Arafeh, M. (2015). Combining lean concepts and tools with the DMAIC framework to improve processes and reduce waste. American Journal of Operations Research, 5(3), 194–204. https://doi.org/10.4236/AJOR.2015.53017

Azemi, F., Šimunović, G., Lujić, R., et al. (2020). Application of lean principles within SMEs in Kosovo manufacturing industry and benefits of implementation. Proceedings of UBT International Conference. https://doi.org/10.33107/UBT-IC.2020.425

Caldera, S., Desha, C., & Dawes, L. (n.d.). Embedding lean and green practices into small and medium scale enterprises to achieve sustainable business profile.

Dahab, A., Younes, M. A., & Backar, S. (n.d.). Overall equipment efficiency improvement through a lean approach in SME: A case study. https://doi.org/10.4028/p-1zhmxc

Dombrowski, U., & Crespo, I. (n.d.). A management approach to lean production system implementation in small and medium-sized enterprises: Results of a research project.

Effendi, R., Hendra, F., & Candra, A., et al. (2023). Efficiency unleashed: Lean manufacturing strategies in analyzing the plastic packaging production process. Dinamis: Journal of Engineering and Technology, 11(2). https://doi.org/10.32734/dinamis.v11i2.13456

Flores Benítez, F. R., & Núñez Silva, G. B. (2023). Aplicación del lean manufacturing a una pequeña empresa de fundición metálica. Multidisciplinary Journal, 4. https://doi.org/10.53734/mj.vol4.id216

Grewal, C. S. (2008). An initiative to implement lean manufacturing using value stream mapping in a small company. International Journal of Manufacturing Technology and Management, 15(3–4), 404–417. https://doi.org/10.1504/IJMTM.2008.020176

Hassan, M. K. (2013). Applying lean six sigma for waste reduction in a manufacturing environment. American Journal of Industrial Engineering, 1(2), 24–28. https://doi.org/10.12691/AJIE-1-2-4

(n.d.). Insightful implementation of lean tools to cultivate lean culture in a small scale manufacturing organisation: A case study. International Journal of Industrial and Systems Engineering. https://doi.org/10.1504/IJISE.2023.130912

Kaneku-Orbegozo, J., Martinez-Palomino, J., Sotelo-Raffo, F., et al. (2020). Applying lean manufacturing principles to reduce waste and improve process in a manufacturer: A research

study in Peru. IOP Conference Series: Materials Science and Engineering, 689(1), 012020. https://doi.org/10.1088/1757-899X/689/1/012020

Kumar, A., Kumar, R. G., Narahari, N. S., et al. (n.d.). Case study on identification and elimination of waste through lean implementation in an automotive part manufacturing industry.

Kumar, M. K., Rajan, A. J., Navas, R. K. B., et al. (2014). Application of lean manufacturing in mass production system: A case study in Indian manufacturing unit. Proceedings of IEEM. https://doi.org/10.1109/IEEM.2014.7058729

Lesmana, S. A. (2020). Lean manufacturing implementation to reduce waste using the waste assessment model method in the production process. International Journal of Engineering Research and Advanced Technology. https://doi.org/10.31695/IJERAT.2020.3672

Mullisa, A. G., & Kader, W. A. (2023). Performance improvement: A lean manufacturing case of metal tools factory. International Journal of Industrial and Systems Engineering. https://doi.org/10.1504/IJISE.2023.132721

Muñoz-Arcentales, J., Balón-Ramos, I. del R., & Franklin. (2022). Manufactura esbelta para eliminación de desperdicios en PyMEs: Una revisión sistemática de la literatura. 593 Digital Publisher CEIT, 4(2). https://doi.org/10.33386/593dp.2022.4-2.1279

Nasution, N., & Harahap, A. P. (2022). Implementation of lean management methods in improving operational efficiency and reducing waste in manufacturing companies. Journal of Management Innovation Research and Technology, 2(2). https://doi.org/10.35335/jmirte.v2i2.126

Sapkal, S. U., & Joshi, A. (2020). Lean manufacturing implementation in crankshaft manufacturing company. In Advances in Manufacturing Engineering. Springer. https://doi.org/10.1007/978-981-33-4320-7_56

Santosa, W. A., & Sugarindra, M. (2018). Implementation of lean manufacturing to reduce waste in production line with value stream mapping approach and Kaizen. MATEC Web of Conferences, 154, 01095. https://doi.org/10.1051/MATECCONF/201815401095

Sedelnikova, A. (n.d.). Enhancing enterprise production management system through lean production principles. International Journal of Economics, Finance and Management Sciences. https://doi.org/10.55640/ijefms-9131

Sharma, H. (n.d.). Study of lean manufacturing philosophy in gear manufacturing company.

Simmons, L., Holt, R., Dennis, G., et al. (n.d.). Lean implementation in a low volume manufacturing environment: A case study.

Sodhi, H. S., Singh, D., & Singh, B. J. (n.d.). Developing a lean six sigma conceptual model and its implementation: A case study. Indian Engineering Journal, 12(10). https://doi.org/10.26488/IEJ.12.10.1199

Sood, P., & Belokar, R. M. (n.d.). Creating value and reducing waste through lean approach in a MSME environment: A case study in an agro parts company. Indian Engineering Journal, 10(9). https://doi.org/10.26488/IEJ.10.9.64

Zahraee, S. M., Hashemi, A., Abdi, A. A., et al. (2017). Lean manufacturing implementation through value stream mapping: A case study. Jurnal Teknologi, 68(3). https://doi.org/10.11113/JT.V68.2957

Zamora-Gonzales, S., Galvez-Bazalar, J., & Quiroz-Flores, J. (2021). A production management-based lean manufacturing model for removing waste and increasing productivity in the sewing area of

a small textile company. In Advances in Intelligent Systems and Computing. Springer. https://doi.org/10.1007/978-3-030-75680-2_49