IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Sustainable Lean Manufacturing Practices For Indian Smes: Pathways To Eco-Efficiency And Competitiveness

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Abstract

This study explores sustainable lean manufacturing practices tailored for Indian small and medium-sized enterprises (SMEs), which play a vital role in the nation's economic growth. Despite their potential, Indian SMEs encounter significant barriers in implementing efficient and sustainable manufacturing practices due to limited resources, technological constraints, and cultural challenges. Lean manufacturing, emphasizing waste reduction and process optimization, is posited as a pragmatic solution. By integrating sustainability principles within lean methodologies, SMEs can enhance operational efficiency, reduce their environmental footprint, and boost competitiveness. The research identifies specific challenges faced by Indian SMEs in adopting these practices and aims to develop a sustainable lean manufacturing framework tailored to their unique contexts. Data collected from 46 SMEs revealed a gap in awareness and expertise regarding lean practices, though there is optimism regarding their potential benefits. Recommendations for enhancing the adoption of sustainable lean practices include employee training, technological integration, stakeholder collaboration, and leveraging government support. Overall, this study contributes valuable insights and practical strategies for facilitating sustainable industrial practices among Indian SMEs and fostering a balance between economic growth and environmental responsibility.

Keywords: Sustainable Manufacturing, Lean Practices, Indian SMEs, Environmental Impact, Operational Efficiency

1. Background of the Research

Small and medium-sized enterprises (SMEs) play a critical role in the global economy, particularly in developing nations like India, where they contribute significantly to industrial output and employment. However, SMEs often face substantial challenges in implementing efficient and sustainable manufacturing practices due to limited resources and technological capabilities (Alayón et al., 2022). Kumar et al. (2022) wrote that lean manufacturing, known for its focus on minimising waste and optimizing processes, presents

a viable solution for these enterprises to enhance their operational efficiency. By integrating sustainable practices within lean frameworks, according to Panizzolo et al. (2013), SMEs can not only reduce costs but also minimize their environmental impact, aligning with global sustainability goals.

In India, where SMEs are pivotal to economic growth yet operate in an environment marked by resource constraints and regulatory pressures, adopting sustainable lean manufacturing practices is especially crucial (Jaiswal et al., 2021). This approach can lead to improved productivity, reduced environmental footprint, and enhanced competitiveness in both domestic and international markets. The amalgamation of lean and green practices offers a strategic pathway for Indian SMEs to achieve economic and environmental sustainability, ensuring long-term viability and resilience in an increasingly eco-conscious global marketplace (Yadav et al., 2019).

2. Justification of the Study

The study on sustainable lean manufacturing practices for SMEs in India is justified by the critical role these enterprises play in the nation's economy (Jaiswal et al., 2021). SMEs account for a significant portion of industrial output and employment, driving economic growth and innovation (Shelly et al., 2020). However, they face numerous challenges, including resource constraints, technological limitations, and competitive pressures. Traditional manufacturing methods often lead to inefficiencies and substantial waste, exacerbating environmental concerns and increasing operational costs (Jaiswal et al., 2021). Lean manufacturing, with its emphasis on waste reduction and process optimization, offers a promising solution (Panizzolo et al., 2012). However, there is a need to adapt these principles to the specific context of Indian SMEs, considering their unique constraints and opportunities. This study aims to bridge this gap by providing tailored sustainable lean practices that align with the resource capabilities and strategic goals of Indian SMEs, thereby enhancing their operational efficiency and environmental performance.

3. Significance of the Study

The significance of this study lies in its potential to transform the manufacturing landscape for Indian SMEs, fostering a balance between economic growth and environmental stewardship. By integrating sustainable practices with lean manufacturing principles, SMEs can achieve significant cost savings through improved resource utilization and waste reduction (Yadav et al., 2019). This dual focus on efficiency and sustainability can enhance their competitive edge in both domestic and global markets, where eco-friendly practices are increasingly becoming a critical criterion for business partnerships and consumer preferences (Saini & Singh, 2020). Moreover, the study provides valuable insights and practical frameworks that can guide policy makers and industry leaders in promoting sustainable industrial practices. The findings can also serve as a blueprint for other developing nations facing similar challenges, thereby contributing to a broader global movement towards sustainable industrialisation (Panizzolo et al., 2012). Ultimately, this research underscores the vital importance of equipping SMEs with the tools and knowledge necessary to thrive in a sustainable and competitive industrial ecosystem.

4. Aim and Objectives of the Study

The aim of this study is to explore and develop sustainable lean manufacturing practices tailored for small and medium-sized enterprises (SMEs) in India, to enhance their operational efficiency, reduce environmental impact, and improve their competitiveness in the market.

The objectives of the study are:

a) Identify the specific challenges Indian SMEs face in implementing lean manufacturing practices.
b) Develop a sustainable lean manufacturing framework tailored for Indian SMEs.
c) Evaluate the environmental and economic impact of sustainable lean practices in SMEs.
d) Provide practical recommendations and guidelines for effective implementation of sustainable lean manufacturing in SMEs.

5. Literature Review

5.1 Lean Manufacturing Practices: Concept and Principles

Lean manufacturing is a systematic approach to identifying the waste in manufacturing processes and eliminating it. It is also generally referred to as 'Lean'. The main objective of lean is to maximise value for the customers along with minimising the use of a resource (Čiarnienė & Vienažindienė, 2012). Yamamoto et al. (2019) mentioned that it originated from the Toyota Production System (TPS) in Japan. Whereas, Pinto et al. (2018) wrote that lean works on the principle of continuous improvement, known as 'Kaizen'. The key concepts used in lean are value stream mapping, Just-in-Time (JIT) production, and the 5S methodology (Thakur, 2016). The aim of such practices is to reduce lead times, and improve overall efficiency.

Lean focuses on identification and elimination of 'muda', which is another term for waste. There are seven types of waste categories- overproduction, waiting times, transportation, excess inventory, over-processing, unnecessary motion, and defects (Čiarnienė & Vienažindienė, 2012). The productivity and overall cost efficiency of an organisation can increase by working on these areas. Kumar et al. (2022) wrote that 'Lean' aims to foster a collaborative approach as it emphasises on involving employees at all levels. Such an approach helps in boosting the morale of employees and increases employee engagement. This leads to better operational efficiency.

The principles of 'Lean' are not limited to just manufacturing. They're being applied to many sectors like healthcare, services, and education (Dias et al., 2018; Alves et al., 2014). Lean practices are adaptable as their main focus is on creating value and reducing waste. This is what makes it highly relevant across different sectors and contexts. In order to successfully implement lean practices, it is important to understand the specific needs and challenges of the organisation. It also requires a commitment to sustained effort and cultural change (Singh & Rathi, 2019).

5.2 Sustainable Lean Manufacturing Practices

Sustainable lean manufacturing practices combine sustainability with the principles of lean methodology. This helps organisations in aligning operations with environmental and social responsibility (Iranmanesh et al., 2019). Hartini and Ciptomulyono (2015) mentioned that sustainable lean manufacturing aims at reducing resource consumption and waste. This is achieved by practicing energy-efficient production, using more renewable resources, and optimising supply chains in order to reduce the carbon footprint. For instance, by using Just-in-Time (JIT) inventory systems, organisations can reduce excess stock, as well as minimise the energy that is needed for storage and transportation (Pinto et al., 2018). When renewable energy sources are used during manufacturing, greenhouse gas emissions are cut down, which helps in contributing towards the climate initiatives (Iranmanesh et al., 2019).

Sustainable lean practices also emphasise on lifecycle thinking, wherein the focus is on the entire product lifecycle, and not just the production phase (Gecevska et al., 2012). Organisations can reduce waste and reuse materials if they have products that are designed by keeping recyclability in mind (Abualfaraa et al., 2020). Lim et al. (2022) opined that this can also be done by incorporating circular economy principles, which will align the organisation with its environmental sustainability goals. It will also help in creating economic value by reducing material costs and bringing innovation in product design. Therefore, sustainability in lean practices gives dual benefit to an organisation- better operational efficiency and fulfilment of CSR requirements (Dey et al., 2022).

In order to successfully implement sustainable lean manufacturing, according to Chen et al. (2020), employee engagement and stakeholder collaboration are necessary. To give a better understanding of the organisational objectives, employees should be given training about the sustainability principles and lean techniques. By partnering up with suppliers, government bodies, and NGOs, organisations can get easy access to resources, knowledge, and funding which can support their sustainable initiatives (Chen et al., 2020). Research done by Hartini & Ciptomulyono (2015), has shown that companies that adopt sustainable lean practices have a better brand reputation, regulatory compliance, and customer loyalty. This makes sustainable lean manufacturing practices an operational improvement move but also a strategic environment to sustain in the eco-conscious market.

5.3 Adoption of Lean Manufacturing Practices by SMEs

Small and medium-sized enterprises (SMEs) can practice lean manufacturing to improve their overall efficiency (Yadav et al., 2019). One of the main practices is 5S, which emphasises on the workplace and caters to its productivity and safety (Panizzolo et al., 2012). The Just-in-Time (JIT) production is aimed at decreasing the costs of inventory by ensuring that production schedules are aligned with the demand and the principle of continuous improvement is followed by the employees (Pinto et al., 2018). Techniques such as cellular manufacturing streamline workflows by allowing smooth production flow through well sequenced work arrangements. This helps in reducing the lead times and overall waste. SMEs can optimise

their operations, minimise waste, and respond more agilely to market demands by implementing such practices (Sajan et al., 2017).

Lean manufacturing offers substantial benefits for the SMEs. They reduce costs by eliminating non-value-added activities and also help in enhancing resource utilisation. It also increases customer loyalty and satisfaction as a result of better product quality and reduced defects through continuous improvement (Sajan et al., 2017). Dey et al. (2022) wrote that lean methodologies also improve employee engagement and empowerment because employees are motivated to put forward their ideas for enhancing processes and workflows. In such a participatory environment, employee morale and productivity get boosted. In financial terms, lean implementation can result in higher profitability and competitiveness (Hartini & Ciptomulyono, 2015). This is because streamlined operations allow SMEs to offer better pricing along with faster delivery to the customers.

In India, some SMEs have successfully adopted lean strategies and practices which led to clear improvements in the manufacturing performance (Panizzolo et al., 2012; Sajan et al., 2017). Moreover, in Jordan, research highlights that manufacturing SMEs that have adopted lean management have seen a positive business performance (Al-Hyari, 2020). Studies on SMEs in Greece show that lean adoption has both challenges as well as successes (Psomas et al., 2018). These examples show that lean manufacturing is valuable for SMEs as it has many benefits. However, the degree of adoption and success of lean manufacturing depends on various factors like regional economic conditions, cultural aspects, and the availability of resources for the small and medium enterprises.

5.4 Environmental and Economic Impact of Sustainable Lean Practices in SMEs

Sustainable lean practices offer various environmental and economic benefits for SMEs. According to Abualfaraa et al. (2020), lean practices like waste reduction, energy efficiency, and pollution prevention have many benefits on the environmental front, like less resource consumption and reduced greenhouse gas emissions. Using energy-efficient equipment and renewable energy sources can help decrease the dependence on non-renewable resources, which aligns operations of a business with its sustainability goals (Hartini & Ciptomulyono, 2015). Lean practices also foster the use of life cycle assessment tools, which allows small and medium enterprises to evaluate the impact their products and processes have on the environment.

On the economic front, these practices reduce waste and energy consumption which results in cost savings that can be reinvested into business for innovation (Iranmanesh et al., 2019). The quality of products also increases by using lean practices, and the lead times are reduced. This increases the overall customer satisfaction and gives a competitive advantage. As per Singh and Rathi (2019), SMEs that use sustainable lean practices are better positioned to meet regulatory compliance requirements, thereby, they tend to avoid penalties and get green certifications for better opportunities.

These practices yield beneficial results only when they are effectively integrated with sustainability and implemented to the business strategies and operations. The realisation of these benefits can be hindered by factors like high initial investment costs and the need for organisational change. This is why SMEs can use a phased approach that starts with low-cost, high-impact initiatives, which will help them in gradually transitioning to sustainable lean manufacturing practices.

5.5 Challenges in Implementing Lean Manufacturing Practices in Indian SMEs

Indian SMEs have a significant contribution in the economy. They enhance the GDP and also bring various opportunities for employment. However, lean manufacturing practices are not widely adopted in this sector as they come with their unique operational and cultural challenges. Financial barriers also contribute to the limited implementation of these practices in SMEs because lack of ample financial resources restrict their ability to invest in the necessary technology and training required to implement such practices (Alayón et al., 2022). This issue is further exacerbated due to the lack of technical expertise and skilled labour. In order to successfully adopt lean manufacturing practices, a thorough understanding of processes and tools like value stream mapping, 5S, and Kaizen are required (Jaiswal et al., 2021).

Another challenge faced by organisations is the cultural resistance within organisations. Various studies show that Indian SMEs have a hierarchical organisational structure which limits open communication and employee participation. Jaiswal et al. (2021) emphasise that both these aspects are highly important for lean implementation. Moreover, many SMEs operate in highly competitive and fragmented markets, which shifts their focus to short term cost-cutting, instead of making strategic improvements for the longer run (Yadav et al., 2019). The challenges faced by SMEs are further compounded by the regulatory constraints and lack of proper support from government policies. SMEs often don't have the access to adequate incentives and frameworks which would help them in adopting lean manufacturing practices (Jaiswal et al., 2021). In order to address the challenges, a nuanced understanding of the Indian SME ecosystem is required. This will also help in developing tailored solutions for SMEs.

6. Data Findings and Analysis

6.1 Survey Demographics

This research surveyed 46 Indian SMEs using a structured questionnaire dispensed through a link of Google Form. The respondents were contacted through contacts. The results of the survey revealed that out of 46 responses twenty-eight (61%) were from manufacturing sector while eighteen (39%) were from the service sector. The responses received from each of these categories were analysed both combined and individually to determine the difference of opinion, if any, that existed among them. Majority of the respondents (31 responses) had more than 51 employees and over ten years of operations (35 responses) indicating that they had reasonably large scale of operations with considerable experience of their respective industries.

6.2 Awareness of the Concept of Lean Manufacturing, Benefits and Challenges

Majority of the respondents were aware of lean manufacturing process and its benefits however, when compared by industries, the manufacturing sectors seemed to have greater awareness. While majority of the service sector (9 responses) were not aware of lean manufacturing, majority of the manufacturing sector respondents (19 responses) agreed that they were aware of it.

The same was also reflected when majority of the respondents (both from service and manufacturing sector) agreed that the 'lack of knowledge and expertise' is preventing them from adopting lean manufacturing. The second most important factors that emerged as a challenge was the 'resistance to change from employees' followed by the 'lack of technological infrastructure' needed to practice lean manufacturing. While all these three challenges topped the respondent's list (both manufacturing and service sector), respondents also mentioned other challenges like limited financial resources and others in their responses. The Indian SMEs seemed to be struggling with adopting lean manufacturing because majority of respondents marked more than one option as their response.

It was interesting to note that when asked if their small size was one of the barriers majority of respondents marked either 'disagree' (8 responses) or 'strongly disagree' (16 responses) as their options however a closer look at the difference of opinions between service sector and manufacturing sector showed that service sector seemed to be neutral with the statement. Their responses were distributed almost evenly across the scale.

Sustainable lean manufacturing involves the integration of the lean manufacturing framework with sustainability goals. Hence, the SMEs practicing sustainable lean manufacturing should have clarity on not only the lean manufacturing processes but also their sustainability goals. It was interesting to see that the collective response on familiarity with sustainable manufacturing process seemed to be mixed while nearly equal number of responses were received for 'familiar' (15 responses), 'somewhat familiar' (16 responses) and not familiar' (15 responses).

At the same time, majority of respondents (21 responses) agreed that their respective companies had formally defined sustainability goals while twelve (26%) of them were working on developing these goals. Also, the SMEs in manufacturing apparently had greater clarity as a clear majority of them either had defined goals (14 responses) or were in the process of development (7 responses). In contrast, the service sector set of respondents were nearly evenly distributed among 'yes' (7 responses), 'no' (6 responses) and 'in development' (5 responses).

At the same time, both service sector and the manufacturing sector Indian SMEs either 'agreed' (26 responses) or 'strongly agreed' (6 responses) that integrating sustainability goals with lean management can benefit the company. This is a sign of optimism among the Indian SMEs towards integrating sustainability goals with lean manufacturing infrastructure.

6.3 Environmental and Economic Impact

It is widely argued that the integration of sustainability goals with manufacturing process reduces the company's environmental impact but at the same time, given the smaller scale of operations of the SMEs, the significance of their environmental footprint can be questioned. When the respondents were asked to state their opinion, the collective responses showed that majority of the respondents found that this integration is likely to affect the SME's environmental footprint only moderately (23 responses) or to a small extent (12 responses). The same was observed when studied separately for service sector and manufacturing SMEs.

At the same time, the results showed that the respondents noted a reduction in time, material waste and cost as a result of implementation of lean manufacturing. Majority of the respondents (23 responses) (both service and manufacturing sector) agreed that the application of lean manufacturing process has led to reduction in time and material needed in producing goods or services while at the same time, has saved cost (23 responses) for the company. It must also be noted that there were significant number of respondents which did not have any such process to measure process efficiency or cost saving as a result of lean manufacturing.

Comparing the responses to this section, it can be said that the Indian SMEs (both service and manufacturing sector) perceived economic benefits of lean manufacturing greater than the environmental benefits.

6.4 SMEs Recommendations to Enhance Adoption of Lean Manufacturing

As observed in the discussion so far, the Indian SMEs are struggling with adopting lean manufacturing due their lack of awareness, expertise and other reasons. Hence, the respondents were asked questions to understand their personal recommendations on how to improve the adoption of sustainable practices among them. Responses showed that majority of them recommended employee training (31 responses) for better adoption of sustainable practices.

At the same time, nearly equal number of SMEs adopted sustainable practices with (20 responses) or without (26 responses) the external help (consultant or government programs). Also, majority of them (16 responses) were neither satisfied nor dissatisfied with the present state of adoption of lean manufacturing or sustainable production however, they either agreed (19 responses) or strongly agreed (17 responses) to promote lean production and sustainable production practices if they were provided external support in terms of expert advice or government programs. This could be because of the lack of awareness and/or expertise to implement or practice lean manufacturing or sustainable production.

Interestingly though, the collective response to the question on the impact of adopting lean management on SME's competitiveness were encouraging. Majority of the respondents (both service and manufacturing sector) with moderately or strongly agreed that this adoption can improve SME's market competitiveness.

6.5 Conclusion of Survey Findings

To sum up, Indian SMEs seemed to be struggling to adopt lean manufacturing and sustainable production despite their willingness to adopt them. They seemed to be lacking the knowledge and expertise needed to practice lean production and their employee were not trained enough. Despite these challenges, the SMEs were making efforts to promote lean production and sustainable production. Their work on their lean manufacturing process and sustainability goals showed their interest and willingness to play their part.

Interestingly enough, the SMEs found economic benefits (time, material and cost savings) of lean manufacturing more appealing that environmental benefits however were quite willing to contribute their part in promoting lean manufacturing. The findings also showed that they wanted better trained employees, government support and financial and expert advice to implement lean manufacturing and integrating it with sustainable production goals.

7. Developing a Sustainable Lean Manufacturing Framework for Indian SMEs

In recent years, integration of sustainability into lean manufacturing has become a well known concept. Organisations are increasingly understanding the importance of ensuring that their operational efficiency aligns with their environmental responsibility. For Indian SMEs, the dual objectives of optimising the use of resources along with environmental stewardship should be addressed by adopting a sustainable lean manufacturing framework. According to Sajan et al. (2017), such a framework should be guided by the principles of circular economy, wherein resources are reused and waste is minimised. The framework should also focus on energy efficiency and use of clean production technologies. This will help in reducing the overall environmental footprint.

To make this framework work for Indian SMEs, customisation is necessary. For example, it is important to develop cost-effective solutions that use local resources and technologies. Citybabu and Yamini (2024) mentions that by using digital tools like low-cost sensors for monitoring processes in real time, lean and sustainable practices can be implemented without a huge financial burden. Such a framework should also focus on employee training and engagement in order to create a culture that is guided by Kaizen (continuous improvement). Various studies highlight that organisations that invest well in their human resource development and incentivise innovation tend to be more successful in achieving their sustainability goals (Choudhury & Patel, 2020).

Another important aspect of this framework is the stakeholder collaboration. SMEs can get access to resources and funding by building partnerships with supply chain stakeholders, government bodies, and industry associations (Chen et al., 2020). A comprehensive and holistic approach that equally emphasises on technical, financial, and organisational strategies can enable Indian SMEs to successfully implement sustainable lean manufacturing practices.

8. Practical Recommendations for Implementing Sustainable Lean Manufacturing in SMEs

In order to effectively implement sustainable lean manufacturing practices in Indian SMEs, a strategic approach addressing both systemic and operational factors is required. In this context, organisational leaders play an important role in driving change. They must participate in sustainable practices and encourage employees to embrace continuous improvement, instead of just allocating resources for lean initiatives (Alayón et al., 2022). The existing skill gap among employees in SMEs can be bridge through training programmes tailored to the needs of the organisation. This will also encourage the employees to take ownership of lean practices.

According to Citybabu and Yamini (2024), the use of technology is another critical factor that plays an important role in successful implementation of sustainable lean practices. SMEs can use affordable digital solutions to monitor and optimise their processes in real-time. For example, SMEs can get insights into the usage of their resources and inefficiencies in their processes by using cloud-based manufacturing execution systems and IoT-enabled devices. SMEs can also take advantage of government schemes and incentives which are specially designed to promote the adoption of energy efficient practices as well as clean technologies.

For SMEs, it is equally important to embrace collaboration and get the required knowledge by engaging with industry associations, academic institutions, and non-governmental organisations (Psomas et al., 2018). An established network of peer SMEs that have successfully adopted lean practices can help in guiding other organisations and inspiring them (Dey et al., 2022). In addition to that, the development of clear performance metrics and regular audits can also help in ensuring the alignment of lean practices with sustainability goals to give measurable results.

To sum it up, it can be said that a comprehensive and customized approach is required for successful integration of sustainable lean manufacturing practices in Indian SMEs. Developing such a framework can help SMEs in addressing the unique challenges faced by them, along with offering environmental and economic benefits. This will allow SMEs to increase their competitiveness, while catering to broader sustainability objectives.

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