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SIX SIGMA IMPLEMENTATION AND IMPACT IN SMALL SCALE INDUSTRY PRODUCTIVITY WITH SPECIAL REFERENCE TO GREEN WHEEL AUTO COMPONENTS AT HOSUR.

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ABSTRACT :

Six Sigma is a data-driven quality improvement methodology aimed at reducing defects and enhancing productivity. While its implementation has been widely studied in large-scale industries, this paper explores its application and impact within a small-scale industrial setup Green Wheel Auto Components, located in Hosur, Tamil Nadu. The research focuses on how Six Sigma strategies can streamline operations, minimize waste, and improve overall efficiency in small-scale sectors, which typically lack extensive resources. The findings indicate significant productivity gains and defect reductions following the adoption of Six Sigma tools.

Key words: Six Sigma, Process Optimization, Quality Improvement, Small-Scale Industries, Operational Efficiency and Continuous Improvement

INTRODUCTION

Small-scale industries (SSIs) play a crucial role in India's industrial landscape, contributing significantly to employment generation and regional economic development. However, these industries often face constraints such as limited capital, skilled manpower shortages, and outdated processes. In this context, quality improvement methodologies like Six Sigma become increasingly relevant. Six Sigma, pioneered by Motorola and popularized by General Electric, is a set of techniques and tools for process improvement. By systematically identifying and eliminating defects and variation, Six Sigma aims for near-perfection in manufacturing and service processes. The methodology follows a structured approach called DMAIC (Define, Measure, Analysis Improve, Control).

RESEARCH BACKGROUND

Small-scale industries (SSIs) are vital to India's economic growth but often face challenges in maintaining quality and productivity due to limited resources. Six Sigma, a data-driven methodology using the DMAIC framework, has proven effective in improving process efficiency and reducing defects, primarily in large organizations. Recent studies show its successful adaptation in SSIs, leading to improved performance. Green Wheel Auto Components in Hosur, a small-scale manufacturer, has encountered issues like
high rejection rates and process variability.
This study explores how Six Sigma can be implemented effectively in such a setting to enhance productivity and ensure consistent product quality.

IDENTIFIED PROBLEM

A small-scale manufacturing unit in Hosur, has been experiencing persistent issues related to high defect rates, process variability, and inconsistent product quality. These challenges have led to increased rework, production delays, and customer dissatisfaction, ultimately impacting overall productivity and profitability. Despite having skilled labor and adequate machinery, the absence of a structured quality management system has hindered process optimization. The lack of data-driven decision-making and root cause analysis further aggravates the situation, highlighting the need for implementing Six Sigma methodologies to address these inefficiencies systematically.

OBJECTIVES OF THE STUDY

- To understand the need and scope of Six Sigma implementation in small-scale industries.
- To analysis the existing production challenges at Green Wheel Auto Components.
- To examine the impact of Six Sigma tools in improving productivity and reducing defects.

- To provide suggestions for sustaining quality improvements.

REVIEW OF LITERATURE

Agrawal & Kumar (2023) This comprehensive study evaluates the effectiveness of Lean Six Sigma (LSS) tools in enhancing productivity within manufacturing industries. Employing the DMAIC framework alongside tools like Value Stream Mapping and Pareto analysis, the research demonstrates significant improvements, including a 20% reduction in non-value-adding activities and a 15% increase in production output.

Baritto (2020) Baritto and colleagues proposed a methodology to support SMEs in transitioning towards Industry 4.0. While not exclusively focused on Six Sigma, their study provided insights into how SMEs can integrate advanced technologies and quality management practices to enhance productivity and competitiveness.

Bhat. (2021) This action research explores the deployment of Lean Six Sigma (LSS) in micro, small, and medium enterprises (MSMEs) in India, focusing on a case study in the printing industry. Utilizing the DMAIC approach, the study achieved a reduction in turnaround time from 1541.2 to 1303.36 minutes, improving the sigma level from 0.55 to 2.96.

Chaudhary & Rani (2023) emphasized Six Sigma's role in improving product quality in SSIs. Their research found that Six Sigma's DMAIC methodology helped reduce defects and increase product consistency. SSIs that tailored Six Sigma to their needs saw significant quality improvements and better customer satisfaction.

Chaudhary & Yadav (2022) highlighted the role of Six Sigma in improving product quality within SSIs. They found that Six Sigma's DMAIC framework significantly reduced defects and enhanced product consistency, resulting in higher customer satisfaction. Tailored approaches to Six Sigma enabled SSIs to meet industry standards more effectively.

Chiarini & Kumar (2021) Chiarini and Kumar analysis the integration of Lean Six Sigma and Industry 4.0 in Italian manufacturing SMEs. Their study highlights that combining these methodologies can lead to operational excellence, but requires overcoming cultural resistance and investing in employee training.

De Silva et. (2025) This study investigates the barriers to implementing Lean Six Sigma (LSS) in small- and medium-sized enterprises (SMEs) within the construction industry. Using a fuzzy TOPSIS analysis, the research identifies 15 significant barriers and proposes ten strategies to overcome them, including hiring LSS specialists and forming strategic planning committees.

Gandhi & Singh (2025) This study introduces a sustainability index integrating Lean, Green, and Six Sigma tools to assess the economic, social, and environmental performance of Indian manufacturing SMEs.

Gandhi & Thanki (2024) This study proposes a sustainability index by integrating lean, green, and Six Sigma tools to assess the economic, social, and environmental performance of Indian manufacturing SMEs. The index serves as a vital tool for monitoring progress in triple bottom line dimensions, tracking diverse indicators, and encouraging sustainable organizational practices.

Gram (2024) This research introduces an ensemble machine learning approach for root cause analysis of productivity losses in manufacturing systems. By analyzing data from sensors and programmable logic controllers (PLCs), the method identifies system elements responsible for inefficiencies. The approach enables real-time analysis and decision-making, reducing dependency on technical experts and enhancing the responsiveness of manufacturing operations to productivity issues.

Hiregoudar & Soragaon (2021) Focusing on Indian manufacturing SMEs, the authors develop a conceptual model for Six Sigma implementation, emphasizing the human element as a critical factor. The study suggests that addressing human-related issues is essential for reducing defects and enhancing process capabilities in SSIs.

Islam. (2023) This study explores the application of federated learning in manufacturing, addressing challenges and future directions within the context of Industry 4.0 and 5.0 visions. The research highlights the potential of federated learning to facilitate collaborative learning among small-scale industries without compromising data privacy. By enabling decentralized data analysis, federated learning can help small manufacturers overcome resource constraints and enhance productivity through shared insights and models.

Jimi. (2020) This field experiment investigates the impact of access to credit on productivity among microenterprises, specifically rice farmers in Bangladesh. The study finds that access to credit leads to a 14% increase in yield, with 11% attributed to technological changes and 3% to improvements in technical efficiency. The research underscores the importance of financial access in enhancing productivity

and technological adoption in small-scale agricultural enterprises.

Kumar & Desai (2024) This study investigates the application of the Six Sigma DMAIC approach in small-scale manufacturing industries. By systematically identifying and addressing process inefficiencies, the research highlights the importance of setting precise objectives and measuring success based on those goals.

Kumar. (2023) studied the adoption of Six Sigma in SSIs, highlighting benefits like cost reduction, improved product quality, and enhanced customer satisfaction. Despite challenges such as limited resources, SSIs successfully implemented Six Sigma, especially in quality control, yielding operational improvements and competitive advantages.

Lean Six Sigma in 2025: Transforming the Service Industry This article discusses how Lean Six Sigma is revolutionizing the service sector by addressing challenges like process inefficiencies and customer satisfaction.

Luciano-Apolinario (2021) This paper presents a productivity improvement model tailored for small and medium metal extruding companies, integrating Total Productive Maintenance, Six Sigma, and process standardization. The model aims to reduce production losses and enhance productivity.

Mehta (2021) studied Six Sigma implementation in small-scale manufacturing industries. His research found that Six Sigma helped reduce production defects, optimize processes, and improve quality standards. SSIs that customized Six Sigma tools for their size saw significant improvements in operational efficiency, demonstrating its relevance even in smaller-scale operations.

Orlov. (2024) This research examines the amalgamation of Circular Economy concepts with Lean Six Sigma approaches to enhance manufacturing operations, emphasizing waste minimization, resource efficiency, and economic performance. The study assesses the influence of Lean Six Sigma on production efficiency and environmental sustainability through empirical analysis and process optimization methodologies.

Panayiotou et al. (2020) Panayiotou and colleagues presented a case study on implementing Lean Six Sigma in a Greek SME. Their research demonstrated that SMEs could achieve significant process improvements with minimal investment by focusing on critical success factors and employee involvement in LSS initiatives

Patel & Desai (2023) found that Six Sigma enhanced

operational efficiency in SSIs by reducing defects and optimizing processes. Their research showed that SSIs adopting Six Sigma methods achieved lower operational costs and improved production timelines, directly contributing to better business performance and competitive positioning.

Reddy & Kumar (2022) examined Six Sigma's adoption in SSIs, noting improvements in process efficiency, cost reduction, and quality control. Despite resource challenges, they highlighted that SSIs benefit from focused Six Sigma applications, such as reducing defects, leading to enhanced competitiveness and customer satisfaction.

Sakib. (2025) Conducting a systematic literature review and bibliometric analysis, this study explores the role of Lean Six Sigma (LSS) in promoting continuous improvement and organizational efficiency. Utilizing tools like Bibliophagy, VOS viewer, and RStudio, the research analysis nearly two decades of scientific literature, offering valuable insights into the practical implications of LSS tools from economic and social contexts to boost organizational performance.

Sharma & Rani (2022) focused on the role of leadership in Six Sigma success in SSIs. They emphasized that strong leadership is key to overcoming challenges, securing necessary resources, and fostering a continuous improvement culture. Leadership commitment was crucial for ensuring the long-term sustainability of Six Sigma initiatives in SSIs.

Sharma & Singh (2023) discussed challenges faced by SSIs in implementing Six Sigma, including financial constraints and a lack of skilled professionals. They suggested that SSIs adopt a flexible approach to Six Sigma, focusing on essential areas like training and process optimization to overcome resource limitations and improve effectiveness.

Singh. (2024) The study prioritizes solutions to overcome challenges in implementing Lean Six Sigma 4.0 (LSS 4.0) in small and medium enterprises (SMEs). Using fuzzy-SWARA and fuzzy-WASPAS methods, the research identifies 23 challenges and corresponding solutions. Key recommendations include strong management participation and long-term strategic planning.

Tampubolon & Purba (2020) Tampubolon and Purba performed a systematic literature review on Lean Six Sigma implementation across various industries. Their study confirmed that LSS remains a relevant and effective methodology for improving business

performance and customer satisfaction, emphasizing its applicability in diverse organizational contexts

Tampubolon et al. (2021) This paper presents a productivity improvement model tailored for small and medium metal extruding companies, integrating Total Productive Maintenance, Six Sigma, and process standardization. The model aims to reduce production losses and enhance productivity. Applied in a pilot plan, the approach achieved a 2.5% reduction in production losses and an 11% improvement in productivity. The study underscores the effectiveness of combining these methodologies to enhance operational efficiency in SMEs within the metallurgical sector

Wankhede. (2024) This empirical analysis explores the integration of Lean Six Sigma (LSS) and Industry 4.0, identifying key operational characteristics essential for successful implementation. The study highlights the top principles, workforce skills, critical success factors, challenges, and performance measures associated with LSS and Industry 4.0 integration. Yadav. (2022) This research identifies barriers to Six Sigma implementation in Indian SMEs, highlighting challenges such as limited financial resources, lack of skilled personnel, and resistance to change. The study suggests that tailored strategies are necessary to overcome these obstacles and successfully implement Six Sigma in SSIs.

RESEARCH GAP

Small-scale industries in production, there are several specific research gaps related to the application of Six Sigma. These gaps focus on how the methodology can be adapted and optimized to fit the unique constraints and characteristics of smaller manufacturing setups. To increasing the productivity and quality of the product by implementing six sigma methodology. Creating a farmwork based on industrial needs. Methodologies can complement each other and lead to better resource utilization, waste reduction, and quality improvement in small-scale industries. Exploring the relationship between Six Sigma driven improvements in production processes and customer satisfaction in small scale industries.

RESEARCH METHODOLOGY

The research design follows the DMAIC (Define, Measure, Analyze, Improve, Control) framework, which serves as the foundation for process improvement analysis. Primary data is collected through structured questionnaires, interviews, and direct observations involving employees, supervisors, and quality control personnel. Secondary data is sourced from company records, previous case studies, and industry reports. Key performance indicators such as defect rates, productivity levels, cost reduction, and customer satisfaction are analyzed using basic statistical tools and control charts.

A purposive sampling method is used to respondents from small manufacturing units. Additionally, tools like Fishbone Diagrams, Pareto Charts, and SPC are applied to identify root causes and process variations. This comprehensive methodology ensures a practical and data-driven assessment of Six Sigma's effectiveness in small-scale setups.

LIMITATION OF THE STUDY

The implementation of Six Sigma in small-scale industries faces several limitations. One of the primary challenges is resource constraints, including limited financial capacity to invest in training, technology, and expert consultation. Training employees requires time and effort, which can disrupt daily operations. Additionally, there may be resistance to change, with employees and management reluctant to adopt new processes due to fear of failure or lack of awareness about Six Sigma benefits. Data collection and analysis can be a challenge for small businesses that lack six sigma systems to track key performance indicators. Without accurate data, decision-making may not be fully optimized.

SIX SIGMA IMPLEMENTATION

Table 1. Six Sigma Implementation Process

PHASE	ACTIVITIES
Define	Identify problem areas, set objectives, and define project scope.
Measure	Collect baseline data (defect rates, process times, etc.).
Analysis	Identify root causes using statistical and visual tools.
Improve	Develop and implement solutions to address root causes.
Control	Establish monitoring systems and control plans to sustain improvements.

TOOLS USED FOR ANALYSIS

Table 2. Tools and Techniques Used

TOOL	PURPOSE
Process Flowcharts	Visualizing workflows to identify inefficiencies
Fishbone Diagrams	Root cause analysis of defects or failures
PPM Analysis	Measuring defect rates (Parts Per Million)
Statistical Process Control (SPC)	Monitoring process variation through control charts
Control Plans	Ensuring process consistency and corrective actions
Skill Matrices	Assessing employee capability and training needs

Chart 1. Process Flowcharts

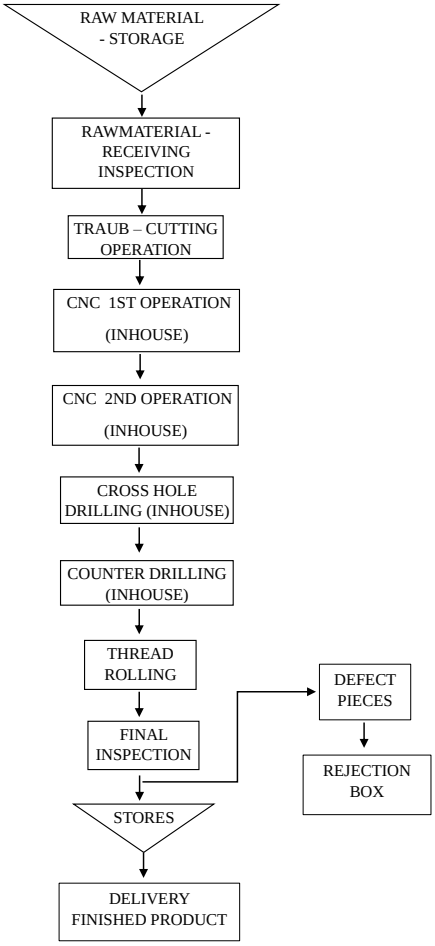

Chart 2. Fishbone Diagram

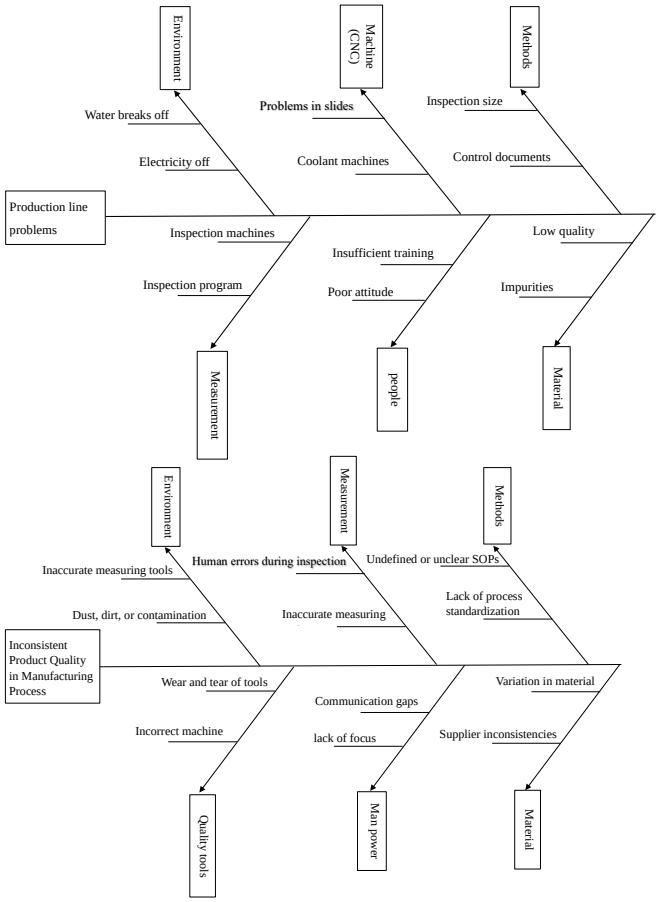

Chart 3. Ppm (Parts Per Million)

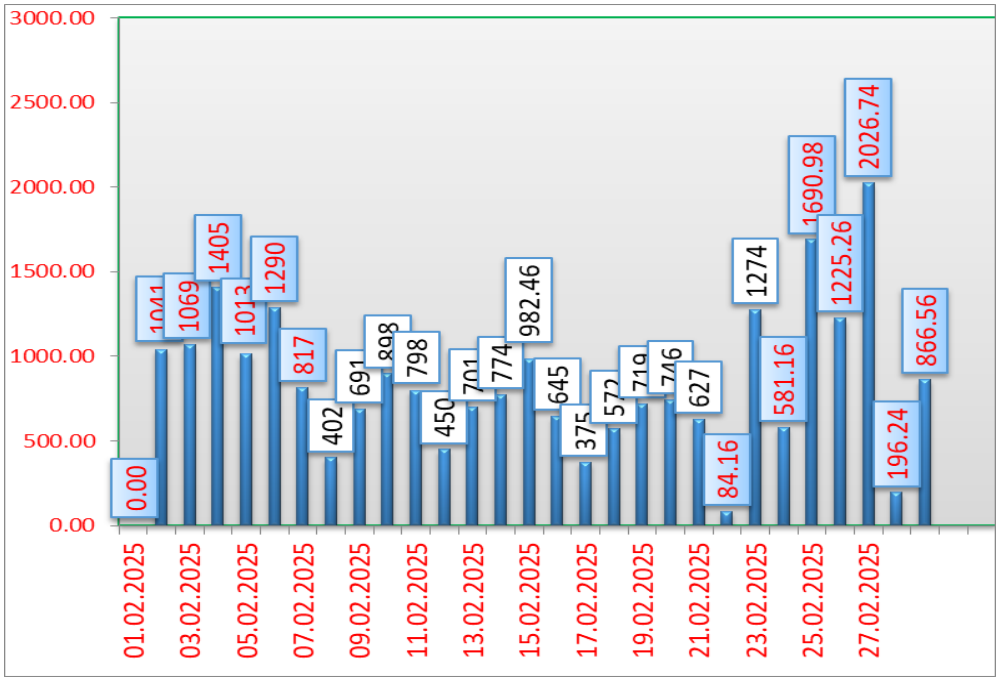

Table 3. Production Skill Matrix

S,NO	NAME	DEPARTMENT	DRAWING STUDY	WORK INSTRUCTION	INSTRUMENT HANDLING	DEFFECT IDENTIFY	DRILLING	SIDE CHAMFER	THREAD ROLL	FINAL INSPECTION	PACKING
1	SUDHAKAR.V	PROD	★	★	★	★	★	★	★	★	★
2	PIPASH	PROD	★	★	⊘	★	★	▲	▲	▲	★
3	ADHIR	PROD	★	●	★	★	▲	▲	▲	▲	★
4	SONATHAN	PROD	●	●	★	●	▲	▲	▲	▲	★
5	BOOPATHY	PROD	▲	●	★	●	▲	▲	▲	▲	★
6	BIKASH	PROD	★	★	★	★	★	▲	★	★	★
7	SUSHANTH	PROD	★	●	★	●	▲	▲	▲	▲	●
8	SUBOTH	PROD	★	★	★	●	★	▲	★	●	★
9	KALA	PROD	▲	★	●	★	★	★	★	★	★
10	GOMATHI	PROD	▲	●	●	●	★	★	●	▲	★
11	MALAR	PROD	▲	●	●	●	★	★	●	▲	★
12	SUSHKUMAR	PROD	▲	●	●	●	⊘	★	●	▲	★
13	AJAY.T	PROD	★	●	●	●	★	★	⊘	▲	★
14	UTTAM	PROD	●	●	★	★	★	★	●	▲	★
15	CHANDER	PROD	●	●	●	●	▲	▲	▲	▲	★
16	AJAY	PROD	●	●	★	●	▲	▲	▲	▲	▲
	▲ Begineer		● Can work under supervision			⊘ Can work independently			★ Can train others		

SUMMARY OF FINDINGS

1. The implementation of Six Sigma in small scale industries reduced defects, improved productivity, and enhanced quality control using tools like Pareto charts.
2. The Fishbone Diagram identified key inefficiencies poor raw material quality, lack of SOPs, outdated machinery, untrained staff, and inadequate workspace conditions all contributing to defects, delays, and reduced productivity.
3. The Skill Matrix revealed workforce strengths and training needs, enabling better task allocation and improved efficiency through employee specialization.
4. PPM analysis measured defect rates, revealing high initial values that indicated poor quality control and inconsistent processes, highlighting the need for improved production efficiency and monitoring.
5. SOP implementation improved consistency, reduced errors, and enhanced productivity by standardizing tasks, minimizing rework, and ensuring uniform execution across shifts and operators, including faster new employee training.
6. SPC improved real-time process monitoring using control charts, enabling early issue detection, reduced variability, enhanced consistency, and greater process stability, resulting in fewer defects and higher customer satisfaction.
7. Six Sigma improved small-scale industry productivity by eliminating inefficiencies using DMAIC, Fishbone Diagrams, and SPC, leading to streamlined, predictable workflows.
8. Six Sigma improved product and process quality by identifying defects, reducing variability, and enhancing consistency using tools like Pareto Analysis, Control Charts, and Cause-and-Effect Diagrams.
9. Six Sigma boosted employee awareness, accountability, and skills, encouraging involvement in problem-solving and fostering ownership, morale, and focus on quality and efficiency.
10. Six Sigma improved employee skills, accountability, and engagement, while fostering a data-driven, collaborative organizational culture that enhanced decision-making, strategic alignment, and overall operational effectiveness.

SUGGESTION

To ensure effective Six Sigma implementation in small-scale industries, a customized framework must be developed that adapts core tools to fit their limited resources and unique operational challenges. Emphasis should be placed on cost-effective solutions targeting process improvement and defect reduction. Basic employee training, such as Yellow or Green Belt certification, can raise awareness and build internal capabilities, promoting a culture of continuous improvement. Pilot projects allow small businesses to assess the feasibility and benefits of Six Sigma before full-scale adoption. Integrating Lean principles alongside Six Sigma helps minimize waste and optimize resources. Utilizing affordable digital tools enables real-time process monitoring

and data analysis without heavy investment. Moreover, aligning quality improvements with customer needs ensures better satisfaction and market relevance. To sustain improvements, regular performance evaluations and process refinements are essential. Together, these steps offer a practical, scalable approach for small enterprises to achieve productivity, efficiency, and long-term growth through Six Sigma.

CONCLUSION

The implementation of Six Sigma in small-scale industries offers a structured approach to improving productivity, quality, and cost efficiency. Despite challenges such as resource limitations and lack of expertise, a customized and practical Six Sigma framework can help small businesses achieve significant operational improvements. By integrating Lean principles, utilizing affordable digital tools, and fostering a culture of continuous improvement through

employee training, small-scale industries can optimize their processes and reduce defects. Moreover, aligning Six Sigma-driven improvements with customer expectations enhances product quality and market competitiveness. To ensure long-term success, businesses must regularly monitor performance metrics and refine their strategies for sustained efficiency and growth.

DIRECTIONS FOR FUTURE RESEARCH

Future research can explore the long-term sustainability and adaptability of Six Sigma practices in small-scale industries across diverse sectors such as services, textiles, processing. There is also scope to investigate the integration of Six Sigma with modern technologies like IoT, AI, and Industry 4.0 tools to enhance real-time monitoring and decision-making. Additionally, studies could focus on the cost-benefit analysis of Six Sigma implementation in micro and rural enterprises, where resources are limited. Comparative research between small and large-scale industries could reveal sector-specific challenges and best practices. Furthermore, the role of leadership commitment, organizational culture, and employee motivation in the success of Six Sigma initiatives remains a rich area for exploration. Finally, developing simplified or hybrid Six Sigma models tailored for small enterprises can make the methodology more accessible and impactful for broader adoption.

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