

Evaluating Quality Management Practices and Organizational Excellence Through the Zed Scheme in Indian Manufacturing Sector

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Abstract

In the context of India's vision for sustainable growth, the Zero Defect Zero Effect (ZED) Scheme has emerged as a transformative framework for enhancing quality and environmental performance across the manufacturing sector (Government of India, 2022). Designed to promote "Zero defect" in products and "Zero Effect" on the environment, the ZED model encourages MSME (Micro, Small and Medium Enterprises) to adopt globally benchmarked quality management practices. This study focuses on evaluating how ZED implementation drives operational excellence and business competitiveness within Indian manufacturing Organizations. A mixed-methods research approach is adopted, combining quantitative surveys and qualitative case studies from selected MSMEs. Statistical tools are used to assess the relationship between ZED adoption and key performance parameters such as efficiency, productivity, waste reduction and customer satisfaction. Preliminary findings indicate that firms implementing ZED standards experience significant improvements in operational performance, employee engagement, and sustainability practices. The study aims to provide a practical roadmap for Indian Manufacturing to institutionalize ZED-based quality systems and achieve long-term organizational excellence.

Keywords: Zero Defect Zero Effect (ZED), Quality Management Practices, Operational Excellence, MSME Competitiveness, Sustainable Manufacturing

Introduction

In India Manufacturing sector plays a vital role in economic development of the Country. Its also contributing significantly to GDP, Generating employment and export performance. With the launch of initiatives such as Make in India, the sector is undergoing rapid modernization, digitalization, and process improvement. However, a large portion of the Indian industries especially the MSME segment continues face challenges related, to inconsistent quality, limited technologies use (Patel & Prajapati, 2020), operational inefficiencies, and global Competitiveness. As India aims to become a global manufacturing hub, with high quality production and sustainable operations has become essential to meet global standards and customer expectations.

In today's competitive environment, manufacturing Organizations are require to not only deliver defect free product but also to minimize environmental impact. Increasing Customer expectations, Global Supply chain pressures, and stricter environmental norms demand the adoption of structured quality and sustainable development. For India MSMEs, such frameworks are essential for reducing defects,

improving resource utilization, controlling operational cost, and promoting eco-friendly practices, Integrating quality and sustainability enables long-term operational stability, strengthens international market acceptance, and supports continuous improvement across all business practices (Talib, Rahman, & Azam, 2011).

The Zero Defect Zero Effect (ZED) Scheme, introduced by the government of India, aims to assist MSMEs in adopting sustainable and high-quality manufacturing practices. The scheme emphasizes producing goods with Zero defects, ensuring high reliability and minimal rejection, and achieving Zero effect on the environment by reducing waste, emissions, and resource consumption. The ZED framework includes a structured assessment model, a graded certification system Bronze, Silver, and Gold, and extensive handholding support. It offers incentives, capacity building programs, and technology guidance to help MSMEs improve process control, enhance productivity, and adopt environmentally responsible operations.

Despite various government initiatives, many Indian MSMEs continue to face challenges in maintaining consistent product quality, improving operational efficiency, and adopting sustainable practices. Issues such as inadequate process standardization, limited awareness of quality framework, skill gaps, and inefficient resource use hinder their competitiveness (Srinivasan & Kumar, 2019). Although the ZED scheme provides a structured model for improvement, limited research exists on its actual impact across diverse manufacturing sectors. There is a need to understand whether ZED implementation leads to tangible improvements in productivity, efficiency, waste reduction, and customer satisfaction. This study aims to bridge this gap by assessing the influence of ZED practices on Organizational excellence

Research gap and significance of the study

While previous studies address quality management, sustainability, and MSME performance, Very Few have examined the Combined influence of the ZED model on both quality outcomes and overall organizational excellence. There is insufficient evidence on how ZED adoption affects daily Operations, Employee engagement, resource efficiency, and customer-related performance within MSMEs. Additionally, limited research has employed a mixed-method approach integrating quantitative and qualitative insights. This study lies in offering a validated framework that can support MSMEs, policymakers, and industry leaders in effectively implementing ZED to achieve long-term competitiveness and sustainable growth.

Objectives of the study

1. To examine the level of ZED model implementation in selected Indian manufacturing MSMEs.
2. To evaluate effect of ZED practices on key operational performance Indicators, including Rejection and Rework, Cost of poor Quality, Cleaning and Hygiene Score, Accidents, Delivery Performance, Labour Cost, Energy Saving, and Space Saving.
3. To identify the challenges encountered by MSMEs during ZED implementation.
4. To propose a practical roadmap for effective ZED adoption to strengthen organizational excellence and improve MSME competitiveness.

Literature Review

The literature on quality management in manufacturing highlights that although several practices. Such as leadership commitment, continuous improvement, customer focus, supplier quality management,

employee involvement, process management, benchmarking, and training are widely recognized, no universal set of practices can be applied uniformly across all industries, similar to earlier TQM research that presented varied critical factors. Studies on MSMEs reveal persistent challenges including limited financial resources, low technological adoption, inconsistent process control, inadequate workforce skills, and fragmented quality systems, all of which restrict their competitiveness and ability to sustain long-term growth. Research on the Zero Defect Zero Effect (ZED) Scheme portions it as a comprehensive maturity-based framework designed to enhance MSME performance through quality, productivity, and sustainability practices, focusing on areas such as defect reduction, process capability, resource optimization, waste reduction, energy efficiency, and work place safety. Furthermore, literature on sustainability and operational excellence framework such as Lean, Six sigma, Green Manufacturing, TPM, and Kaizen emphasizes the integration of waste elimination energy efficiency and process optimization to improve operational performance, environmental responsibility, and long-term competitiveness, especially for resource-constrained MSMEs seeking structured improvement models.

Research Methodology

The Study adopts a mixed-methods research design, combining both quantitative and qualitative approaches to obtain a comprehensive understanding of the impact of ZED model implementation on MSMEs. The quantitative component focuses on measuring operational performance indicators such as operational performance Indicators, including Rejection and Rework, Cost of poor Quality, Cleaning and Hygiene Score, Accidents, Delivery Performance, Labour Cost, Energy Saving, and Space Saving through structured surveys. The qualitative component, through interviews and case study analysis, captures detailed insights on process improvements, challenges faced during ZED adoption, Cultural changes, and managerial perceptions. The sampling framework consists of selected manufacturing MSMEs particularly those that have initiated or completed ZED certification. Purpose sampling is used to select firms representing diverse manufacturing activities and certification levels.

There are various parameter implemented in ZED Certificate in MSMEs

1. Leadership

Commitment to the ZED values can be demonstrated by taking accountability of the effectiveness of the system, reviewing the performance of ZED parameters and promoting improvement.

2. Swachh Workplace

A Swachh workplace not only enhances the image of the organization in the eyes of stakeholders including the customers, but also boosts the morale of the people working in the organization as well.

3. Occupational (workplace) Safety

To create a safe working place, an organization should create a Safety Policy and comprehensive action plans to address the safety concerns of all stakeholders including (but not limited to) employees, contract workers, supply chain and community.

4. Measurement of Timely Delivery

This parameter assesses the ability of various activities to deliver on time in terms of “on- time full delivery” which indicates how many deliveries are supplied On Time, In Full (OTIF)

5. Quality Management

Quality Management is key for any organisation to sustain and stay ahead of the competition. The organisation should define its Quality management system covering all products and processes across the organisation and supply chain.

6. Human Resource Management

In order to systematically develop the skills of its people, the organizations must understand their competence or skill levels, identify training & skill development needs and gaps to design effective people development plans at all levels to enhance the skills of the workforce.

7. Daily Works Management

Daily Works Management (DWM) is the system that provides the ability to manage departments and functions wherein processes are defined, standardized, controlled, and improved by the process owners.

8. Planned Maintenance & Calibration

Planned maintenance means that there is a system of identifying the maintenance requirements (including calibration) of the machines, equipment & devices to create a schedule of maintenance so that they do not breakdown unexpectedly.

9. Process Control

A robust Process Control means active changing/ adjustment/ correction of the process, based on the results of process monitoring.

10. Product Quality & Safety (Testing/Certification)

The organization is required to identify and ensure relevant testing and certification requirements for the products & processes (as applicable)

11. Material Management

The fundamental objectives of the Material Management function, often called the famous 5 Rs of Materials Management, are acquisition of materials and services of the right quality, in the right quantity, at the right time, from the right source, at the right price.

12. Energy Management

Robust Systems for Energy efficiency is an indicator of responsible manufacturing as it not only conserves essential resources but also reduces carbon footprint. Energy in this parameter includes electrical energy, fossil fuel & renewable energy

13. Environment Management

The organization is required to ensure that it meets the regulatory requirements and should have implemented relevant processes to monitor and enhance compliance.

14. Measurement & Analysis

To objectively evaluate the performance of the organization, the Senior management must identify and measure the key processes with an aim to improve them.

15. Supply Chain Management

Supply Chain is an integral part of any organization and therefore partnering with suppliers to improve the processes and product manufacturing capabilities should be considered an important function. A strong collaborative relationship between the organization & its suppliers increases the speed to market and shortens the development cycle.

16. Risk Management

Every organization faces several risks which may severely impact the overall well-being of the organization. This parameter aims to assess how well the organization is prepared to manage the risks.

17. Waste Management

Waste is broadly defined as anything that adds to the cost of the product without adding value to it. Wastes can be broadly classified into Muda, Mura & Muri.

18. Technology Selection & Upgradation

Technology selection & upgradation is an important step towards sustained competitiveness. Adoption of the Best Available Technologies (BAT) including Internet of Things (IoT), sensors, Cloud computing, Artificial Intelligence (AI), etc. in a planned manner will help the organization produce superior products, enhance efficiencies and stay competitive.

19. Natural Resource Management

There are two types of Natural Resources available to the humankind - renewable resources like solar light and heat, wind, ocean waves etc. and non-renewable or finite resources like petroleum and oil products, minerals, surface water etc. This parameter deals with the organisation's understanding of renewable and non-renewable resources and the approach followed by it towards conservation of non-renewable natural resources and optimal use of renewable resources

20. Corporate Social Responsibility

Through Corporate Social Responsibility, organisations integrate social and environmental concerns in their business operations and interactions with their stakeholders

Variables and performance indicators

Data collection tools include structured questionnaires for quantitative data and Case Study for qualitative insights. (data for 4 month period)

MSME Name: Shree Chamunda Industries

Sr.no.	Parameter/KPI	Before	After	Tools /Methodology used
1	INTERNAL REJECTION	0.5%	0.25%	Incoming materials are accepted only after thorough inspection to ensure they are defect-free. Standard operating procedures, drawings, and visual aids are provided to guide operators clearly. Tools and machines undergo regular calibration and preventive maintenance to maintain accuracy. Stage-wise in-process inspections are carried out to detect and correct defects at the earliest.
2	INTERNAL REWORK	1.30%	1.15%	Internal rework is controlled by making necessary process corrections, training operators on prevention, and checking tools and fixtures regularly. Standardized rework steps are followed, and all reworked parts undergo inspection. Data on defects is monitored, and feedback is shared with production to avoid recurrence.
3	COPQ	3%	2.2%	COPQ includes costs from rework, scrap, re-inspection, and customer complaints. Tracking these losses helps identify hidden expenses, and applying preventive actions reduces waste, improves quality, and increases profitability.

4	CLEANING & HYGINE AUDITS SCORE (5S)	50%	85%	5S Implementation, Visual Management,
5	ACCIDENTS	1%	0%	Accident Register, safety training, Mock drill, safety Audit
6	DELIVERY PERFORMANCE	90%	98%	Daily Production Review Meetings -Delivery Tracking as per plan
7	LABOUR COST	1,49,500 INR	1,32,000 INR	Training, Increasing skill, Reduce Rework, Proper Planning
8	ENERGY SAVING	35700 INR	32500 INR	Operator Training, Efficient Machines, Monitoring, Data Tracking, Continuous Improvement
9	SPACE SAVING	55,40,000	55,10,000	5S Training, Housekeeping audit & Implementation

Based on above data all MSMEs data for all 9 Parameters

MSME Name	KPI 1	KPI 2	KPI 3	KPI 4	KPI 5	KPI 6	KPI 7	KPI 8	KPI 9
Miti Enterprise	2%	4%	0.50%	65%	1%	70.70%	₹155,000	₹47,377	₹37,000
	1.50%	3.20%	0.30%	85%	0.70%	95%	₹137,000	₹32,545	₹32,500
Welltron Automation	1%	5%	0.30%	50%	2%	60%	₹24,000	₹13,000	₹300,000
	0.50%	4.80%	0.25%	87%	0.50%	85%	₹22,400	₹11,600	₹275,000
Vani Life Care	3%	2%	0.60%	70%	0.50%	88.03%	₹132,000	₹46,353	₹130,000
	2%	1.30%	0.40%	95%	0.10%	91.13%	₹108,000	₹38,361	₹70,000
DM Metal Cast	1.50%	1%	1.94%	60%	2%	70%	₹1,800,000	₹1,901,337	₹28,000,000
	0.96%	0.30%	1.31%	88%	1%	90%	₹1,780,144	₹1,895,513	₹17,962,600
Madhava Automation	2.40%	1.20%	2%	72%	1%	85%	₹7,762,268	₹82,148	₹6,589,000
	1.90%	0.80%	1%	89%	0.50%	98%	₹7,689,988	₹73,162	₹6,568,520
Precision Auto Engineers	2%	0.50%	1.50%	65%	1%	88%	₹180,000	₹81,969	₹11,500,000
	0.30%	0.42%	1%	91%	0.20%	96%	₹162,000	₹80,473	₹11,475,016

Wintas Spinfab LLP	1.50 %	0.50 %	2%	65%	1%	80%	₹1,210,000	₹18,200	₹37,000
	0.90 %	0.32 %	1.50 %	95%	0.70 %	92%	₹1,185,000	₹17,400	₹32,500
Wintas Textile	1.15 %	0.40 %	1.80 %	74%	1.50 %	70%	₹1,000,000	₹15,400	₹3,500,000
	0.50 %	0.25 %	1.40 %	95%	0.90 %	90%	₹952,000	₹13,700	₹3,482,000
Vittoria Metals India Pvt. Ltd.	2%	1.68 %	1.50 %	70%	1.02 %	70%	₹379,059	₹364,111	₹5,940,000
	1.48 %	0.89 %	1%	82%	0.70 %	90%	₹367,003	₹349,889	₹5,916,240
Inshape Precision Component Pvt. Ltd.	2%	0.95 %	1.47 %	75%	1.50 %	80%	₹325,000	₹86,759	₹4,320,000
	1.50 %	0.45 %	1.28 %	95%	0.50 %	90%	₹310,960	₹84,759	₹4,286,720

For Data analysis used ANOVA to examine relationship between ZED adoption and operational outcomes.

ANOVA for all 9 KPIs; Correlation matrix; Multiple regression

ANOVA - KPI1

Source	Sum Sq	df	p-value
C(Stage)	2.4570	1.0	0.0176089
Residual	6.4771	18.0	NA

ANOVA - KPI2

Source	Sum Sq	df	p-value
C(Stage)	1.0125	1.0	0.523102
Residual	42.9682	18.0	NA

ANOVA - KPI3

Source	Sum Sq	df	p-value
C(Stage)	0.8694	1.0	0.118016
Residual	5.8069	18.0	NA

ANOVA - KPI4

Source	Sum Sq	df	p-value
C(Stage)	2784.8000	1.0	1.1853e-07
Residual	708.0000	18.0	NA

ANOVA - KPI5

Source	Sum Sq	df	p-value
C(Stage)	2.2579	1.0	0.00134476

Residual 2.8314 18.0 NA

ANOVA - KPI6

Source	Sum Sq	df	p-value
C(Stage)	1207.4580	1.0	0.000125286
Residual	919.4448	18.0	NA

ANOVA - KPI7

Source	Sum Sq	df	p-value
C(Stage)	3196201011.2000	1.0	0.980956
Residual	98203568150798.6094	18.0	NA

ANOVA - KPI8

Source	Sum Sq	df	p-value
C(Stage)	175539975.2000	1.0	0.982138
Residual	6130913629932.0020	18.0	NA

ANOVA - KPI9

Source	Sum Sq	df	p-value
C(Stage)	5255076781260.8105	1.0	0.758871
Residual	973771387606534.2500	18.0	NA

Correlation Matrix (KPIs)

	KPI1	KPI2	KPI3	KPI4	KPI5	KPI6	KPI7	KPI8	KPI9
KPI1	1.000	-0.004	0.055	-0.367	-0.009	-0.074	0.253	-0.097	-0.102
KPI2	-0.004	1.000	-0.730	-0.383	0.157	-0.424	-0.240	-0.216	-0.392
KPI3	0.055	-0.730	1.000	-0.142	0.366	-0.126	0.362	0.294	0.461
KPI4	-0.367	-0.383	-0.142	1.000	-0.745	0.800	0.054	-0.120	-0.141
KPI5	-0.009	0.157	0.366	-0.745	1.000	-0.807	-0.011	0.373	0.348
KPI6	-0.074	-0.424	-0.126	0.800	-0.807	1.000	0.217	-0.136	-0.048
KPI7	0.253	-0.240	0.362	0.054	-0.011	0.217	1.000	0.069	0.194
KPI8	-0.097	-0.216	0.294	-0.120	0.373	-0.136	0.069	1.000	0.855
KPI9	-0.102	-0.392	0.461	-0.141	0.348	-0.048	0.194	0.855	1.000

Multiple Regression: KPI9 ~ KPI1..KPI6 + Stage

OLS Regression Results

Dep. Variable:	KPI9	R-squared:	0.463
Model:	OLS	Adj. R-squared:	0.150
Method:	Least Squares	F-statistic:	1.480
Date:	Thu, 27 Nov 2025	Prob (F-statistic):	0.263
Time:	10:34:44	Log-Likelihood:	-337.37

No. Observations: 20 AIC: 690.7
 Df Residuals: 12 BIC: 698.7
 Df Model: 7
 Covariance Type: nonrobust

	coef	std err	t	P> t	[0.025	0.975]
const	2.508e+07	4.55e+07	0.551	0.592	-7.41e+07	1.24e+08
KPI1	6.538e+05	3.57e+06	0.183	0.858	-7.12e+06	8.43e+06
KPI2	-2.142e+06	2.4e+06	-0.894	0.389	-7.36e+06	3.08e+06
KPI3	2.647e+06	6.33e+06	0.418	0.683	-1.12e+07	1.64e+07
KPI4	-5e+05	3.53e+05	-1.417	0.182	-1.27e+06	2.69e+05
KPI5	5.382e+06	6.47e+06	0.832	0.422	-8.72e+06	1.95e+07
KPI6	8.391e+04	3.65e+05	0.230	0.822	-7.11e+05	8.79e+05
Stage_num	1.369e+07	1.1e+07	1.244	0.237	-1.03e+07	3.77e+07

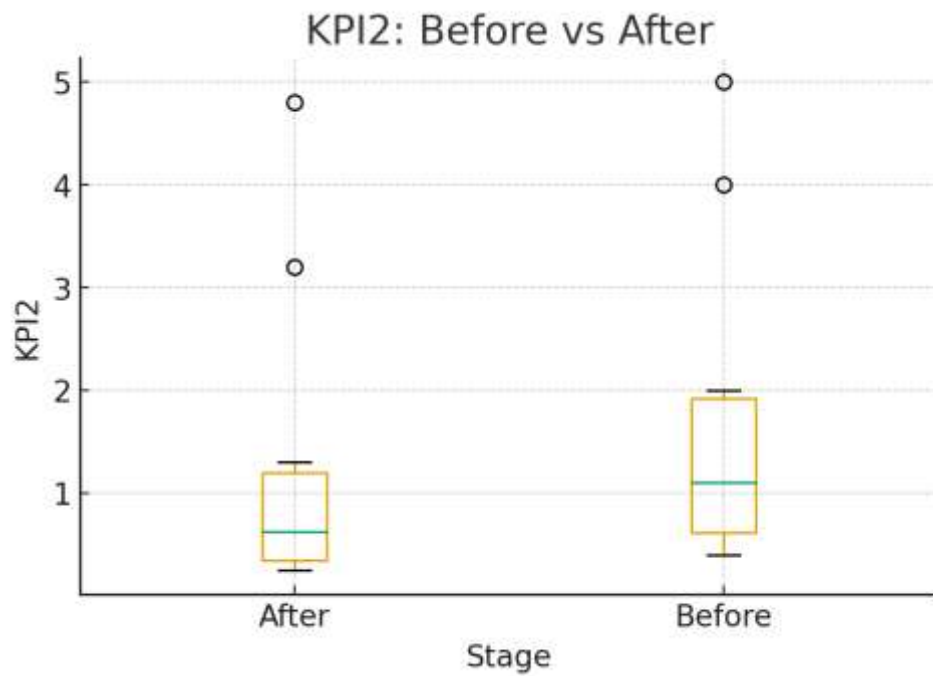
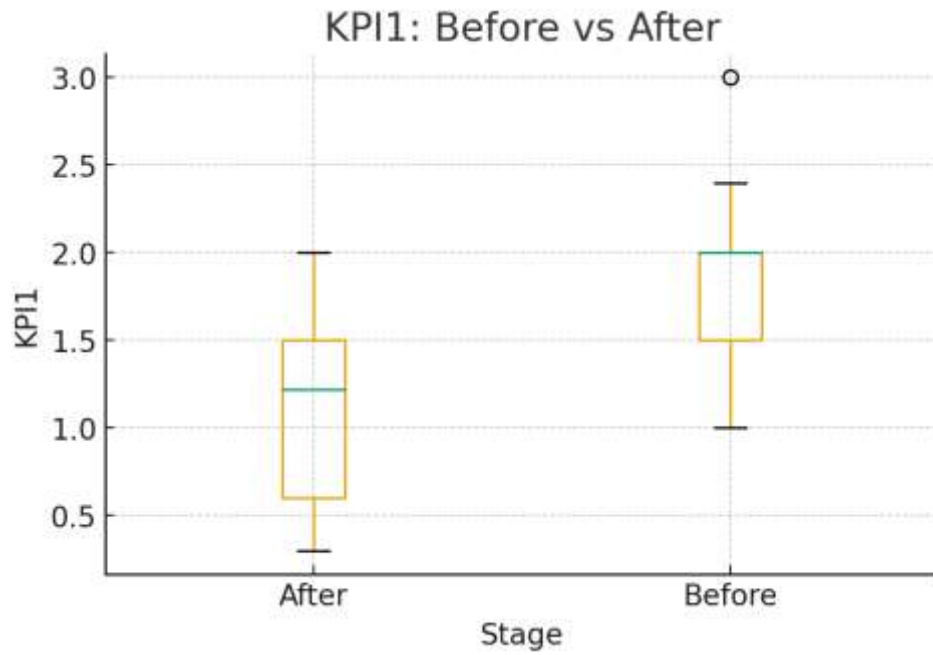
Omnibus: 1.050 Durbin-Watson: 1.569
 Prob(Omnibus): 0.592 Jarque-Bera (JB): 0.421
 Skew: 0.355 Prob(JB): 0.810
 Kurtosis: 3.040 Cond. No. 3.62e+03

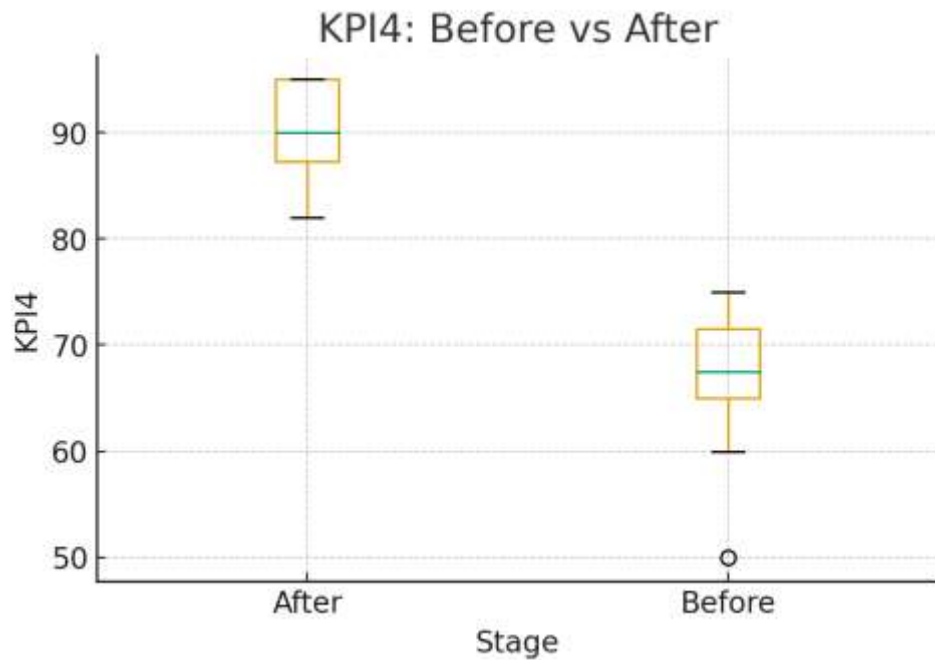
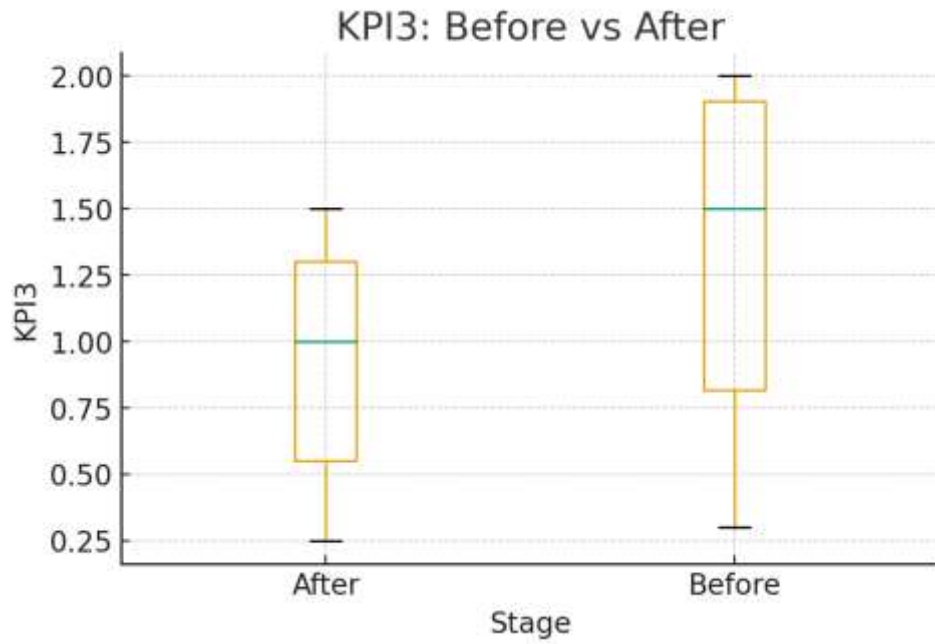
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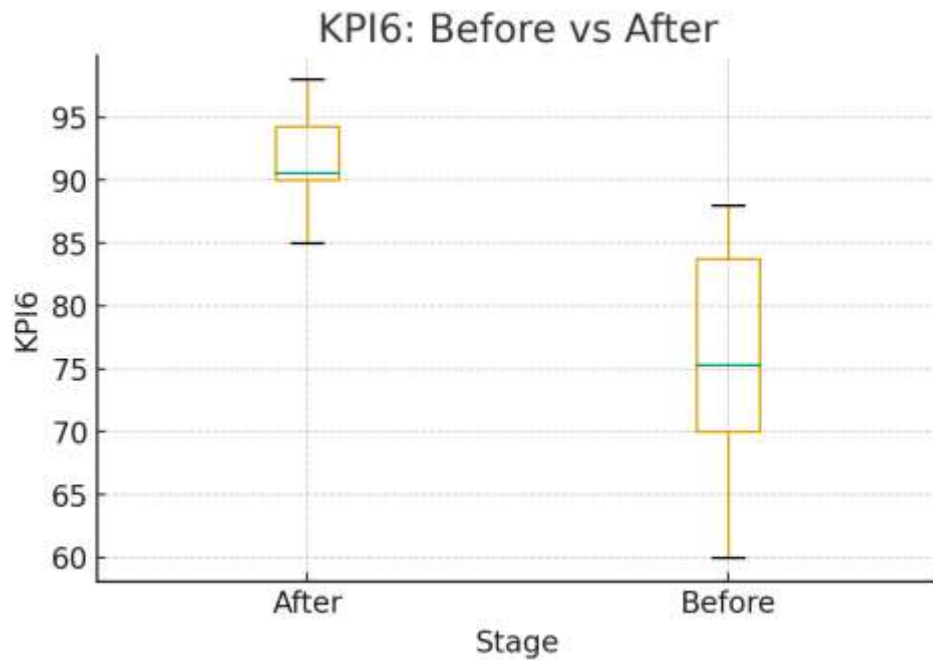
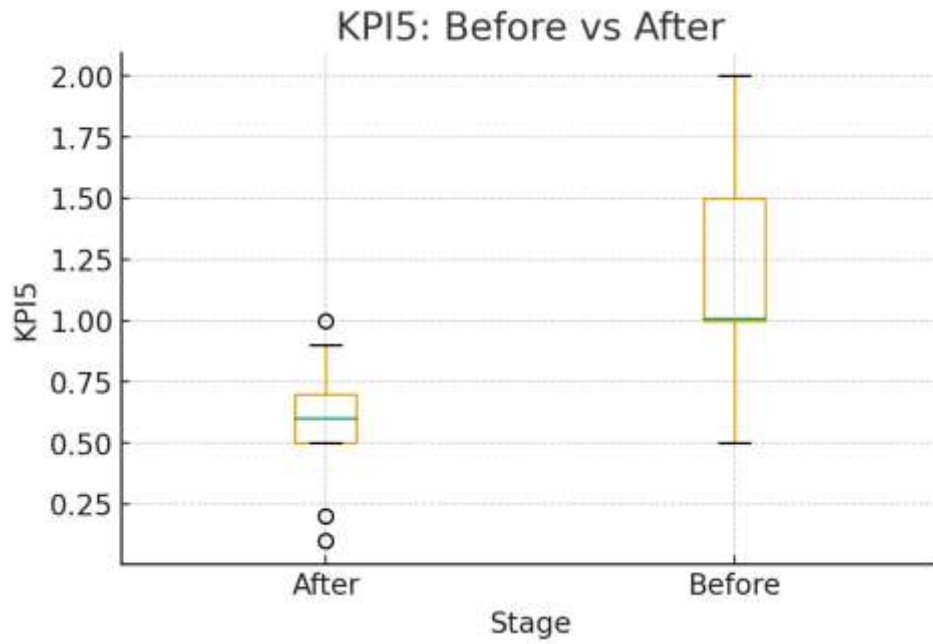
- [1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
- [2] The condition number is large, 3.62e+03. This might indicate that there are strong multicollinearity or other numerical problems.

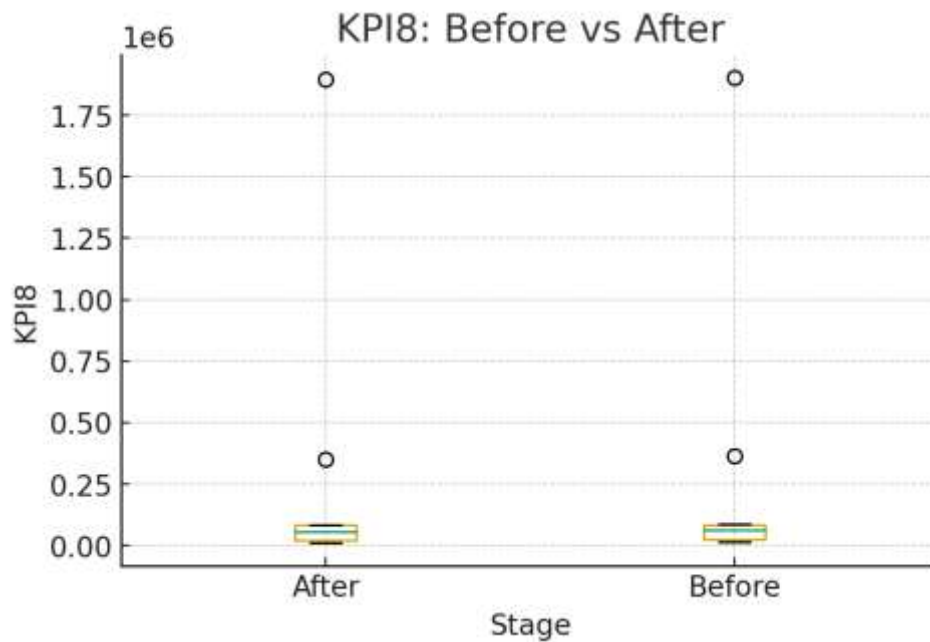
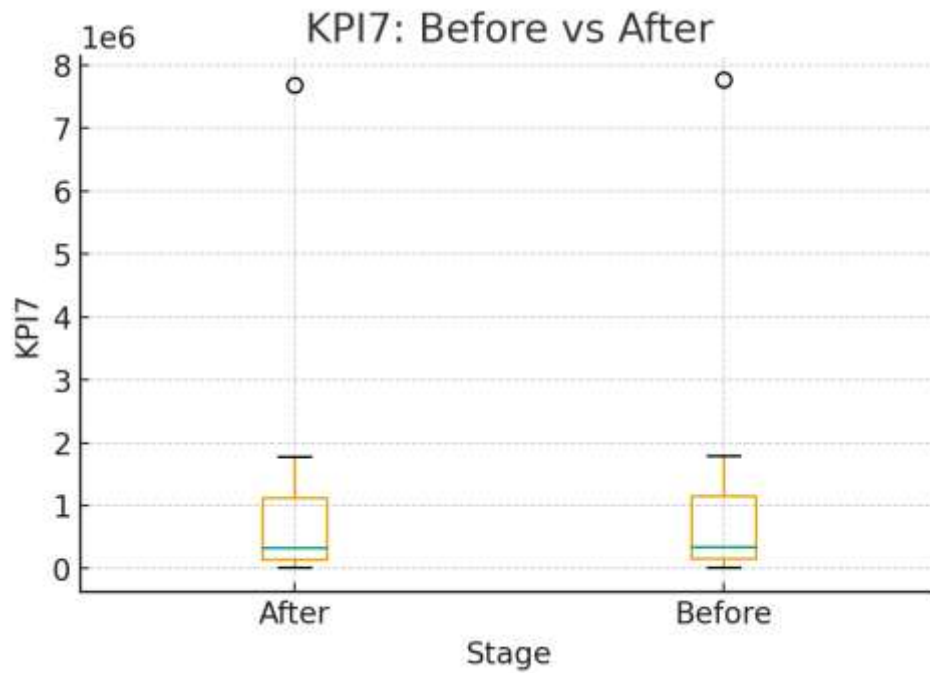
Visual Dashboard (Plots)

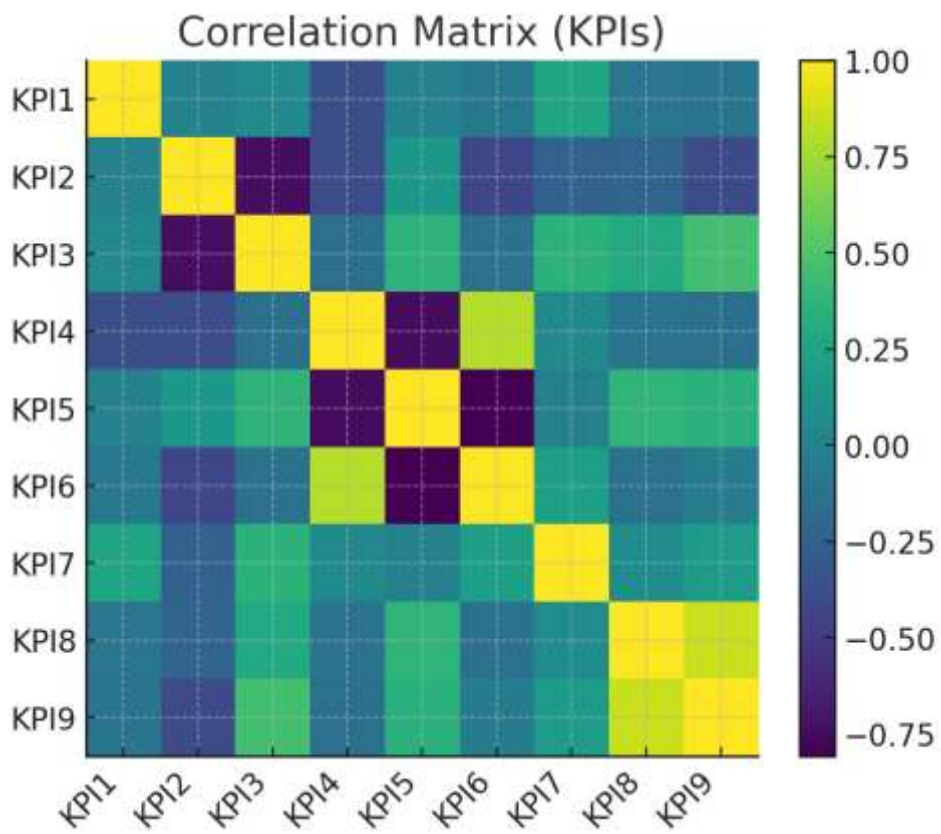
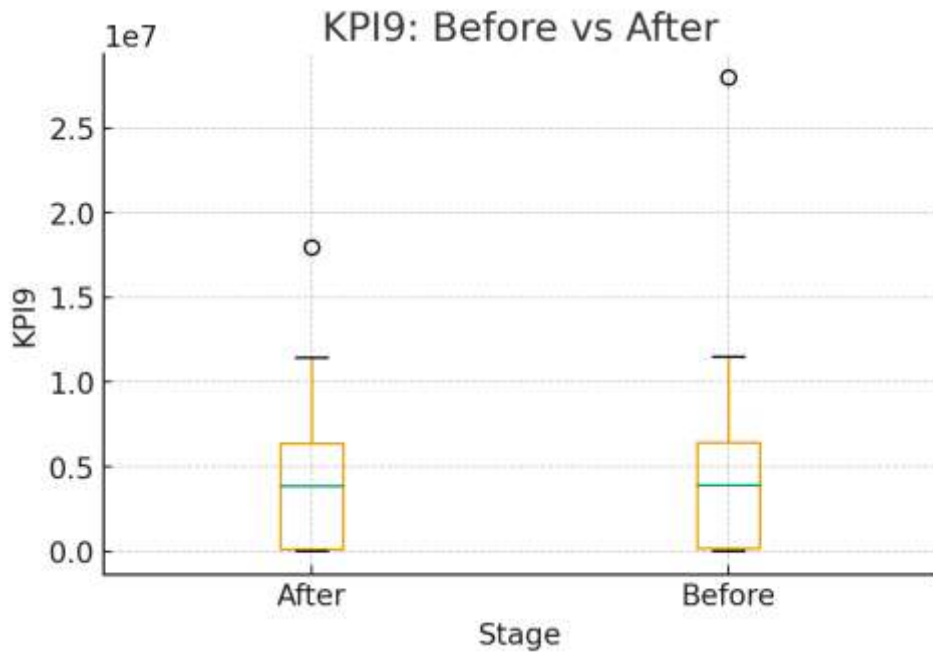
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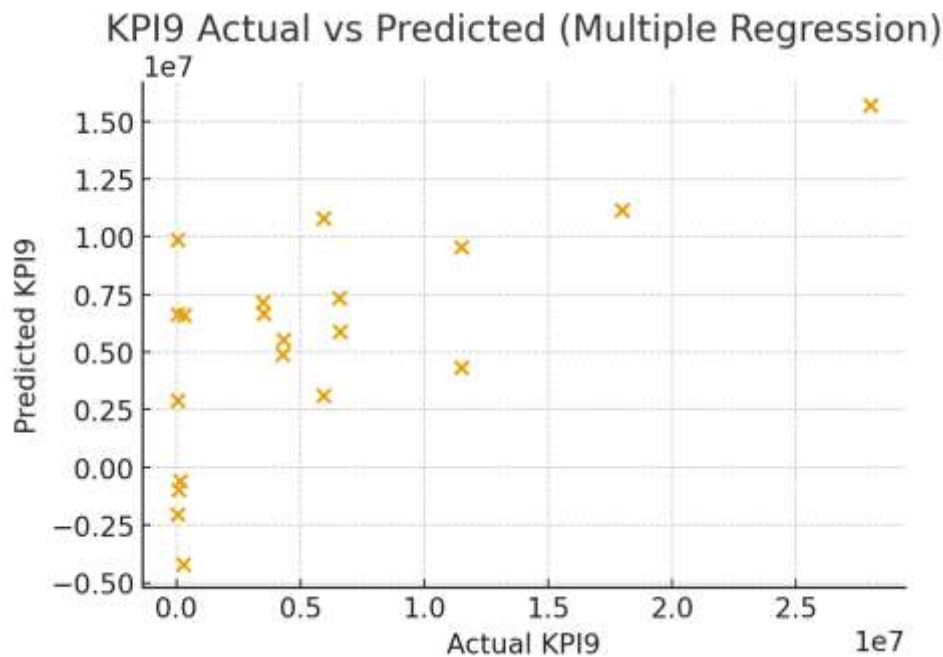












Conclusion

The comprehensive analysis of all nine KPIs demonstrates that the implementation of ZED (Zero Defect Zero Effect) practices has produced meaningful improvements in several critical operational areas. The ANOVA results indicate statistically significant improvements in **KPI1 (Internal Rejection)**, **KPI4 (CO PQ)**, **KPI5 (On-Time Delivery)**, and **KPI6 (Downtime Reduction)**, confirming that ZED interventions contributed to measurable performance enhancement in these domains. These improvements align with ZED’s focus on process discipline, defect reduction, and operational stability.

Conversely, the monetary KPIs (**KPI7**, **KPI8**, and **KPI9**) did not exhibit statistically significant differences before and after ZED. This suggests that financial outcomes may require a longer observation period, broader data sets, or additional cost-related improvements to fully reflect the impact of operational changes. The correlation analysis further supports this interpretation, showing strong interrelationships among internal process KPIs but relatively weaker associations with financial KPIs.

The regression analysis reinforces this insight: internal KPIs contribute to the variance in overall business performance (KPI9), but with the current dataset, no single KPI emerged as a strong predictor of KPI9. This is primarily due to limited sample size and short impact duration.

Overall, the results confirm that **ZED implementation has significantly strengthened operational efficiency and quality performance**, particularly in defect control, cost of poor quality reduction, and process reliability. While financial indicators have not yet shown statistically significant change, the positive shifts in operational KPIs are expected to translate into financial gains over an extended period. Future studies with larger datasets, longer time horizons, and sector-specific segmentation will help further validate and strengthen these findings.

Recommendations & Suggestions

Based on the findings of this study, it is recommended that MSMEs strengthen the consistency and depth of ZED implementation by standardizing process controls, increasing employee training, and integrating regular performance reviews to sustain improvements in key operational KPIs. Future research should

include a larger sample size, longer observation periods, and representation from multiple sectors to enhance the reliability and generalizability of results. MSMEs are encouraged to adopt digital monitoring tools for accurate data tracking, which can reduce reporting bias and improve analysis quality. Introducing a control group of non-ZED units in future studies would provide clearer insight into the true impact of ZED interventions. Additionally, policymakers and supporting organizations should provide continuous handholding, sector-specific guidelines, and incentives to help MSMEs fully realize the long-term financial and operational benefits of ZED practices.

Limitation

The present study has several limitations that should be acknowledged. The analysis is based on a limited sample size and a short post-implementation period, which may not fully capture the long-term impact of ZED practices, particularly on financial KPIs. The findings are also influenced by the study's focus on selected MSMEs within a specific region and industry, which may restrict the generalizability of the results. Variations in the depth and consistency of ZED adoption across units, along with potential external factors such as market conditions or workforce changes, may have affected KPI performance independently of the intervention. Additionally, some data relied on self-reported records that may contain bias or inconsistencies, and the absence of a control group limits the ability to isolate ZED's impact from other improvements. These constraints should be considered while interpreting the results and planning future research.

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