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Review Article

Six Sigma Adoption in Karnataka: A Review of Success Factors and Six Sigma Challenges in Manufacturing and Service Industries

Deepak Kothari[1*], Sunil Kumar D[2], Venkatesh N[3]

[1]*Department of Mechanical Engineering, Alva's Institute of Engineering & Technology, Karnataka, India.*
[2]*Department of Mechanical Engineering, Bahubali College of Engineering, Karnataka, India.*
[3]*Department of Mechanical Engineering, Canara Engineering College, Karnataka, India.*
[1,2,3]*Visvesvaraya Technological University, Belagavi, Karnataka, India.*

[1]*Corresponding Author : dr.deepak2948@gmail.com*

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Abstract *- Six Sigma is a sound quality improvement technique that seeks perfectionality almost to the letter in organisational procedures. It is also efficient in the sense that it reduces the non-value adding activities and thus maximises resource utilisation. In business sectors like manufacturing, Six Sigma has greatly led to a minimization of flawed products and an enhancement of the working processes. Equally, its use in the service industry has increased customer experiences and reduced IT downtimes. Using the statistical means and the data-based analysis of defects, businesses can detect the areas of improvement and provide specific solutions. Effective communication, employee involvement, and top management commitment are critical success elements in Six Sigma deployment. Nevertheless, resistance to change, resource availability, and insufficient training are among the issues that can act as obstacles to the process. These challenges notwithstanding, the successful implementation of Six Sigma has resulted in significant improvement in various sectors, such as improved customer satisfaction, cost savings, and improved revenue. An example is Motorola, which developed Six Sigma, and it claimed to save over 17 billion dollars within the initial five years of its application. An example of sugar plants in Karnataka shows that Six Sigma enhanced the efficiency of processes and minimized the level of defects, which ultimately led to increased financial performance and customer satisfaction. The research showed that 49 percent of the respondents had realized financial benefits, whereas 55.5 percent had seen an improvement in productivity due to Six Sigma programs. This is in line with the research findings in other sectors where poor quality costs have been reduced and operations streamlined using Six Sigma to facilitate economic growth.*

Keywords - *Six Sigma, Quality Improvement, Process Improvement, Manufacturing and Service Industry, Critical Success Factors (CSFs).*

1. Introduction

This evaluation provides an examination of Karnataka's Six Sigma implementation due to the elements that contributed to its success as well as the challenges it faced in the industrial and service industries. This claim emphasizes how businesses in the region apply Six Sigma techniques to boost productivity, cut errors, and raise customer satisfaction [1]. In Six Sigma, the goal is to keep a process under control so that there are no defects recorded. Six Sigma provides a methodical strategy to enhance the efficacy (i.e., fulfilling the desired service qualities) and efficiency (i.e., time and cost) of services. With the use of Six Sigma approaches, this may be achieved, and the way healthcare is provided in modern hospitals and clinics can be revolutionised. Reduced variability and waste through Six Sigma can lead to happier and more productive employees, higher patient satisfaction rates, improved processes, and fewer errors overall. In recent years, Six Sigma has become increasingly popular in the healthcare sector [2]. With the current competitive business world, organisations are being forced more than ever to embrace systematic quality improvement approaches as a form of promoting efficiency in operations, reducing defects, and enhancing customer satisfaction. One of these methodologies has become the most popular and widely used, data-driven methodology of attaining process excellence, based on systematic, data-driven defect reduction and variability control, known as Six Sigma. First introduced as a manufacturing-focused quality instrument by Motorola in the mid-1980s, Six Sigma has since become a universal managerial ideology to be applied to manufacturing, service, healthcare, IT, hospitality, and public-sector organizations.

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The Six Sigma implementation has been accelerated in the Indian environment and can be attributed to increasing global competition, escalating customer expectations, and increasing pressure to enhance cost-effectiveness and quality services. The area of the diversified industrial ecosystem, like the state of Karnataka, is a specific environment where the implementation of Six Sigma is particularly relevant. Karnataka boasts a diverse range of industries such as automotive production, sugar mills, textiles, information technology services, healthcare, hospitality, and major public infrastructures. This industrial heterogeneity is what makes the state act like a laboratory in terms of examining the variation in Six Sigma success factors and challenges in industries that perform under the same economic and cultural setting.

The remainder of the document is organized as follows: A thorough overview of the literature on Six Sigma adoption, success factors, and problems in the industrial and service sectors is provided in Section 2. Section 3 talks about sector-by-sector and case evidence in Karnataka. In Section 4, a critical discussion will be made to connect the empirical findings with the theoretical knowledge. Lastly, Section 5 wraps up the study by giving a conclusion and recommendations on future research. Origin of Six Sigma at Motorola- Matsushita, Japan, took over one of Motorola's household appliance detachments in 1974 [3]. This division made TVs, among other things. After that, Matsushita started making TVs with only 1/20 of the problems from this section. When Motorola saw this accomplishment, it started to understand how important quality is. After that, in 1981, Bob Galvin, CEO of Motorola, set the goal of improving performance ten times over the next five years. Following this, Mikel Harry and Bill Smith worked together to provide a plan for getting rid of defects [4].

Based on these attempts, a four-step problem-solving method, MAIC, was developed. Mikel Harry and Bill Smith came up with MAIC after being inspired by Deming's PDCA cycle. In 1986, Bob Galvin made sure that Motorola's leaders knew about and agreed with the Six Sigma idea [5]. Motorola started the Six Sigma program on January 15, 1987, with the goal of getting fewer than 3.4 Defects Per Million Openings (DPMO). After Motorola was the first company to receive MBNQA, Bob Galvin talked about his journey of continuous improvement [6]. The Six Sigma Technical Institute at Motorola was set up in 1990, and Mikel Harry was named Director. After that, Six Sigma was put into place across the whole of Motorola. Table 1 shows the stages of life that Six Sigma went through at Motorola.

Table 1. Evolution of Six Sigma at Motorola [7]

Stage No.	Year	Stages of Six Sigma Evolution
1	Late 1970	A portion of Motorola that produced home items was acquired by Matsushita (Japan). From that point on, this sector produced televisions with a mere 20% fewer issues. Motorola was forced to focus on quality as a result.
2	1981	Bob Galvin, the CEO of Motorola, set a goal to increase performance dramatically over the next five years.
3	1984	Mikel Harry started his PhD fellowship with Motorola following his graduation from Arizona State University. Bill Smith, a long-time Motorola engineer, was his boss.
4	1985	Bill Smith used the internal quality report to offer details on the consequences of modifications and non-conformances.
5	1986	A useful four-step MAIC method for mistake elimination was created by Bill Smith and Mikel Harry.
6	1987	Reaching a maximum DPMO of 3.4 in products, processes, services, and management is the long-term goal of Bob Galvin's Six Sigma Quality program. Motorola set a new objective: "zero defects."
7	1988	MBNQA was purchased by Motorola.
8	1990	The Six Sigma Research Institute was founded by Motorola. Afterwards, Motorola started using Six Sigma throughout the board.

Overview of Six Sigma - Motorola tried to cut down on mistakes in 1986 by tracking metrics and reducing differences in the way things were done. This is where the six-sigma way of managing things began. Bill Smith, their mechanic, came up with this idea to make sure the quality of their work was better. The Greek sign σ is made up of two words: "Six" and "Sigma." In math and statistics, it is used to talk about the standard deviation. The standard deviation, or σ, of a set of facts or a process tells us how different they are from each other. The Sigma scale tells you how many mistakes are in a unit or how likely it is that something will not work. Using numbers to figure out why mistakes happen in all areas of management and then getting rid of those reasons is a planned and creative process. What Six Sigma Academy says about it is: "a business process that helps companies dramatically improve their bottom line by planning and overseeing daily

business activities in a way that reduces waste and maximises customer satisfaction". It is used to appraise and improve how well a business or group runs its operations. It is a way to see a problem as a fault from the manager's or user's point of view and figure out what went wrong so it can be fixed.

Things that get in the way of a service or process are called flaws. Six Sigma is a way to improve quality by getting each step that affects a customer's product or service cleaner and cleaner until it is perfect. Six Sigma is a planned, sharp, and data-driven method for getting rid of all sorts of mistakes, waste, and problems with quality control in business activities like management, service delivery, production, and more. Six Sigma is a method for managing quality that helps companies make more money by lowering the costs of quality problems and warranty issues. The main goal is to keep process and product quality factors that matter to the customer from being too different. These days, this word means getting a better product, lower prices, more loyal and happy customers, and results that affect the bottom line. Six Sigma aims to get rid of or cut down on waste, make customers happy, and make more money. Following a measurement-based technique to focus on process improvement and variation reduction is what Six Sigma is all about. The main goal of a six-sigma improvement project is to improve customer satisfaction [8]. DMAIC and DMADV are two essential methods used in Six Sigma.In Six Sigma, an opportunity is a process's potential for error or malfunction. The manufacturing and service sectors have been using the Six Sigma methodology for more than 20 years, and its instruments aid in comprehending and enhancing process sigma [9]. It was first used in manufacturing. Some Indian libraries do this process, but not many of them do it. That does not mean it cannot be used in libraries. People have always thought that quality was an important part of both making things and giving services. What makes a group important and how it will grow in the future depends only on how well it works. No matter what you do, quality is important. But in libraries, quality is getting more attention from management, users, and staff because of new technologies, high expectations from users, high costs of upkeep, rising prices of information resources, and a shrinking budget [10].

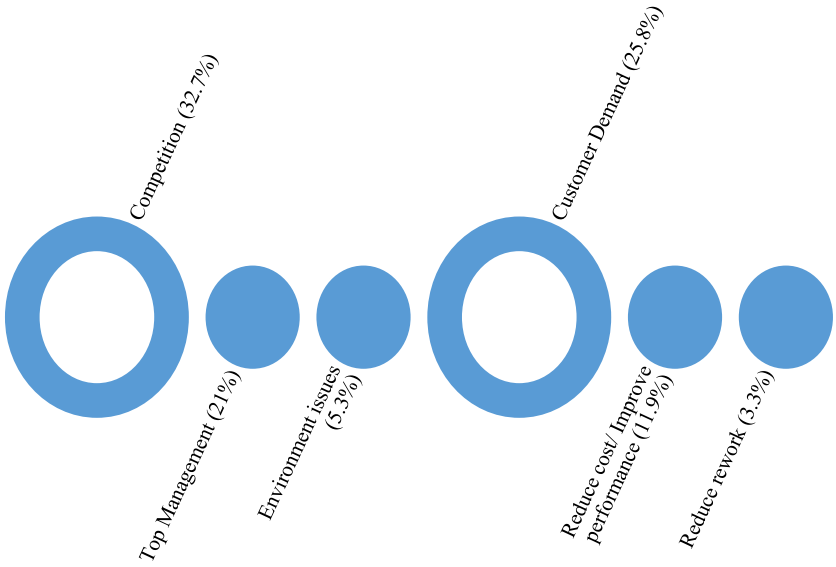

Fig. 1 Motivation factors to start Six Sigma [11]

Defining Six Sigma: "The very first definition of Six Sigma is that it is a defect rate metric, specifically, it means 3.4 DPMO. This is actually the origin of the name Six Sigma. Statisticians have used the Greek letter Sigma to refer to standard deviation. Six Sigma is simply six standard deviations.

What it truly means is that a process is highly capable, that customer specifications are actually six standard deviations away from the process centre. Since a product will only be considered defective if it is produced outside of customer specifications, a process with such a high capability will almost produce no defect [12]." Two methods are used by LSS (Lean Six Sigma) in India. These are DMAIC and DMADV. These methods are used in business for the following reasons:

1. To meet the specific needs of each customer
2. Lessen process variation
3. Make the customer happier
4. Get rid of tasks that do not add value.

LSS is not just useful for manufacturing or big companies; it is also useful for small and medium-sized businesses. A lot of writing has been written about how Six

Sigma can be used in small manufacturing units, all kinds of service businesses, hospitals, and labs. This method is very structured and usually has four steps: "Define, Measure, Analyse, Improve and Control". Sometimes, an initial step is added (DMAIC), shown in Figure 2. To put it briefly, these steps are: [13]

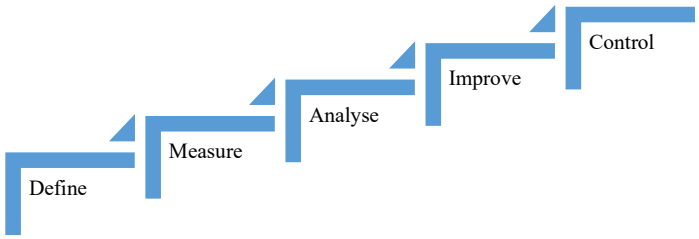

Fig. 2 DMAIC approach steps [14]

- Define (D): Describe the issue that needs to be fixed, mentioning how it affects customers and the possible benefits.
- Measure (M): Mark the features of the goods or service that are important for quality (CTQs). Check the ability to measure. Find out what the current failure rate is and make plans to make it better.
- Analyse (A): Figure out the "root causes" of defects and the key process factors that cause them.
- Improve (I): Find out how much the important process variables affect the CTQs, what the accepted ranges are for these variables, and then change the process to stay within these ranges. This will lower the number of defects in the CTQs.
- Control (C): To keep the gains over time, make sure that the changed process now keeps the key process factors within acceptable limits.

It is used to create new products that are meant to meet Six Sigma standards. Here are the steps in the DMADV method. Figure 3 is a diagram that shows how the DMADV method works.

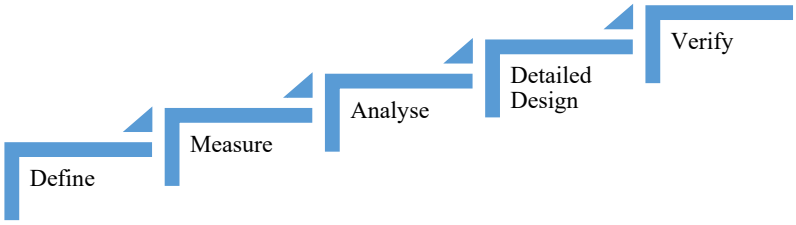

Fig. 3 DMADV Approach Steps [15]

Step 1: Define: This phase involves the identification of the goals of organisations as well as customers.

Step 2: Measure: In this step, measurement is done by using data collected from customers as well as from management, to find out the problems and statistically analyze the causes of the problem.

Step 3: Analyse: In this step, investigate when and where the defect occurred. These are statistically analysed, and the problems are documented.

Step 4: Detailed Design: In this step, a detailed design of the process is made. This includes figuring out the smallest aspects and how to carry out the design. The Six Sigma team will look at all of the options before deciding on the best way to do things. Lastly, it is built into the system. This step lets you carry out test plans.

Step 5: Verify: Verification is the preceding step of the DMADV process. This is the creation of the correct control of the enhanced states and standardising the new approach [15].

2. Review of the Literature

Karnataka is one of the most important states in India, and there has been a high penetration of Six Sigma in its various manufacturing and service industries. This factual approach is focused on decreasing variability of processes and increasing quality, which is essential in attaining operational perfection and competitiveness. The industrial environment of the region, which is marked by major manufacturing sectors and developed service sectors, has its successes and obstacles to the implementation of Six Sigma that are predetermined by the specifics of the economic and cultural environment. This review studies the key success factors and issues faced during the process of adopting Six Sigma in Karnataka. Karnataka, India, is an important part of the Indian economy, with its contribution to the total national GDP reaching approximately

8.2% in 2023-24, with its economic production ranking it as the fourth largest state in the country. The GDP share of Karnataka has grown tremendously in the past half-century, since it was recorded at 5.4 percent in 1960-61 to the current amount, which means that the share has improved by 51 percent. This growth has significantly increased since economic deregulation in 1991, and this is remarkable because the growth is 38 percent in the last 10 years alone. Most sectors, such as information technology, biotechnology, manufacturing, and agriculture, drive the economy of the state, with Bengaluru recognized as a global IT centre. Karnataka has a remarkable per capita income as compared to the national average, which indicates that the region has a great economic potential and, as such, makes it an ideal location to study the contribution of industries to the GDP of India [16].

Examined the steps used in Smart Manufacturing (SM), which are quickly becoming more difficult. They have a lot of data, patterns that do not follow a straight line in places with a lot of dimensions, sources of variation that only last a short time, a lot of uniformity, and non-Gaussian pseudo-chaotic behaviour. The way quality control is usually done cannot handle all of these changes. So, quality engineers quit coming up with new ideas, which hurts the business of making things. AI, especially ML and DL, has been used to solve hard tech problems and come up with new ideas. The new age known as Quality 4.0, or Q4.0, combines computer science concepts with quality control to improve it. The five Six Sigma steps-define, measure, analyze, improve, and control-are used to address issues. They do not, however, function over the whole ML cycle. People discuss the limitations of Six Sigma approaches and paradigms in terms of increasing industrial innovation. An MLA can identify a 3D quality pattern with ease, but there are no other means to observe the process. The new age of Q4.0, which does not have the issues of Six Sigma and may be helpful like AI, is being built up by early findings [17].

Investigated what had already been written to examine the idea of Six Sigma and how it was used in factories. People all over the world knew about Six Sigma and used it in their businesses. This was especially true when they needed to fix problems with output by always getting better. To conduct this learning, some tutorials were presented that talked about how Six Sigma was used in different companies. The major aims of this revision were to discover the things that made Six Sigma implementation work, the best tools that could be used with the Six Sigma method, and the issues and limits of Six Sigma implementation. Results from the analysis of pupillages showed that while the general way to use Six Sigma was the same, the tools were used in very different ways based on the problem. Also, the time it took to finish depended on how complicated the process was [18]. Examined the CSFs of implementing LSS in Indian manufacturing companies within the framework of Industry 4.0 (I4.0). Following expert consultation and literature evaluation, twenty CSFs were found. A specially created questionnaire was used to poll manufacturing companies in India in order to assess the criteria's reliability. For every response, the Cronbach's alpha (α) value was calculated. Sixteen of the twenty CSFs that were examined turned out to be reliable. Furthermore, the sixteen components were levelled in accordance with the suggested model after being tested using the ISM method. Researchers determine the driving and dependence powers of the CSFs using the MICMAC technique. Using this method, researchers and practitioners can collaborate to use LSS in a way that takes the current I4.0 manufacturing paradigm into account. According to an ISM data analysis, "Organisational culture and belief," "Effective top management commitment and attitude," and "Motivated and skilled manpower" are the three key Success Factors (CSFs) for a successful LSS implementation in the Indian manufacturing business. Using this method, practitioners can plan how to use LSS as efficiently as possible, given Industry 4.0. [19].

Examined the CSFs affecting the implementation of LSS in the Indian manufacturing MSMEs. The study employed the BWM in ranking CSFs using an extensive literature review and a survey of 120 industry professionals using a questionnaire. The results showed that the most powerful ones are strategy-based CSFs and the bottom-line and supplier-related factors. The research offers a systematic decision-making framework to managers and policymakers in order to optimise LSS adoption. It adds original value in terms of its contribution to the scanty empirical attention to the issues of LSS implementation and priorities in Indian manufacturing MSMEs. [20]. Focused on the Indian healthcare industry, in particular, on the family planning services where the Six Sigma methodology might be applied. The review evaluated the available literature to determine the level of knowledge and practice of contraceptive methods among the populace and the efficacy of Six Sigma in enhancing healthcare procedures. The challenges mentioned in the study include the limited resources, awareness, and operational inefficiencies that impact the quality of services. It concludes that an application of Six Sigma can greatly boost productivity in processes, error reduction, and patient safety in a systematic approach, thus providing a worthwhile management solution to long-standing issues pertaining to the poor quality of services and poor governance [21].

Examined the feasibility of using LS by evaluating the CSF using the DEMATEL approach. The LS components were categorised into four distinct groups: TPs, WEPs, SPs, and EPs. The procedure of categorising was conducted by a field survey and supported by relevant works of fiction. The efficacy of the set of LS components was evaluated using the DEMATEL technique. The enquiry was carried out at the NSH located in Mangalore, Karnataka State, which is situated in the southern region of India. The NSH office only handled expedited mail packages. After LS was successfully

implemented at NSH Mangalore, it became compulsory for other Indian Postal Service organisations to use LS. Examining the fundamental factors necessary for effectively implementing LS in the postal service sectors is complex because of the diverse range of mail categories and intangible performance measurements that are involved [22].

Examined that Six Sigma was a strong technique that lowered costs, cut down on variation, raised customer satisfaction, and finally, made all of these things happen. Businesses were asked to rate how well Six Sigma had been used in this study to look at its pros and cons. To do this, poll data was gathered from 66 companies in a variety of areas. Different parts of a company's success were looked at different stages of putting Six Sigma into place. The people who used Six Sigma decided what kinds of projects were done most often and what kinds of problems arose when Six Sigma was used. Companies that did not use Six Sigma were also looked at in different ways to figure out why they did not. One of these was how much Six Sigma would cost, how much people knew about it, the risks, and whether Six Sigma was needed or whether the company already had enough. Another was whether Six Sigma was the right fit for the business. Kolmogorov–Smirnov tests were used to see if the performance scores of people who had gone through different steps of Six Sigma had changed. The new method, called exploratory factor analysis, backed up the main reasons why Six Sigma was not being used. The education helped managers make better plans for putting Six Sigma into action. Managers who did not already use the method might have been encouraged to start doing so in their businesses [23].

Researched that Six Sigma was the best way to keep getting better and stay ahead in the global market. It could also help them accomplish their work and team targets. What made a Six Sigma program work or not in a company? They explained how the amount of money saved is connected to the success of Six Sigma, which is what this tabloid was all about. On the other hand, they showed that the sigma level played a part in the success of implementing Six Sigma and finishing a single project. Reading this artefact helped to understand more about what businesses needed to do to make sure that Six Sigma worked well [24]. Examined that in the world we lived in then, businesses needed a stricter quality effort to stay in business. In the global market, it was necessary to make sure that our products and services were the best and that we could quickly meet customer wants. This was possible thanks to the many process improvement projects that were part of the Six Sigma effort. It was being looked at how a few small and medium-sized businesses used Six Sigma projects in their daily work. There were pros and cons to Six Sigma that they tried to figure out in order to see how it could be used in small businesses. They explore the gap between what Six Sigma said and how it was used was very large. There was a lot of information in different study papers about what the Six Sigma method was, how it worked, what its benefits were, and how to define it. When Six Sigma was used, there was a lot of work done, better methods, a better work culture, and everyone learned new skills [25]. This is a comprehensive review of LSS research done in India from 2010 to 2021. The researchers categorized the study trends based on the author profile, industry, methodology, and types of companies after reviewing 141 publications published in reputable journals. The article highlights the growing significance of LSS in India's industrial, service, and processing sectors. It is particularly helpful for academics, practitioners, MSMEs, and policymakers since it highlights research gaps and future directions. Additionally, the study supports national initiatives like Aatmanirbhar Bharat and Make in India [26].

Spoke about achieving quality and performance excellence in LSS by utilizing Industry 4.0 technology. The study provides a thorough framework for understanding this synergy by utilizing the golden circle notion. These findings suggest that integrating LSS with Industry 4.0 technology might result in the creation of smart factories, improved operational efficiency, and a paradigm change in India's outdated industrial clusters [27]. Assessed how well the National Sorting Hub in Mangalore and India's postal services performed in relation to lean service systems. The research demonstrates the applicability and use of lean ideas in improving workplace standards, productivity, and service quality in big public-sector organizations, as well as their relevance in several manufacturing-related fields [28]. Selected the key success factors and ranked them in order of significance. The results indicate strategic priorities and the challenges that organisations could encounter in the process of implementing green manufacturing. Turning qualitative CSFs into a quantitative index of intensity, the research can produce a useful decision-support instrument that should be used by managers and researchers who seek to achieve a compromise between manufacturing performance and environmental sustainability [29].

Investigated the obstacles encountered by an automobile component manufacturing business. A questionnaire survey was undertaken to identify 31 obstacles to the implementation of LSS. The manager's views were gathered using an online survey performed via email-based questions. The gathered replies were examined using statistical techniques such as Importance-indexed and CIMTC. The gathered replies exhibited a notable level of internal consistency, as shown by a coefficient of 0.971. The importance index and CIMTC enquiry revealed that the majority of Indian manufacturing enterprises encountered obstacles posed by LSSB-4 and LSSB-3. The identified Lean Six Sigma Black Belts (LSSBs) emphasised the challenges of applying LSS methodology in the automobile component manufacturing industry. The surviving literature has not extensively investigated the study of parts manufacturing organisations, which play a crucial role in producing distinctive components for vehicle units [30]. Examined a combinatorial strategy to allow the

customer/patient to pick from a variety of hospitals that have integrated LSS into their operations. The methodology used included identifying the pivotal indications or traits of LSS implementation at 5 hospitals located in Bangalore city. These signals showed a strong correlation with the advantages that a customer may get. The objective was to provide rankings for these institutions. The analysis yielded valuable insights into the advantages of implementing LSS for clients and aided in selecting a hospital based on client preferences. They performed a comprehensive assessment of five hospitals and assessed the implementation of eight indicators of LSS. It is feasible to expand this interpretation to include more facilities and a wider range of variables from diverse processes [31]. Researched on the benefits and challenges of implementing LSS in Indian MSMEs throughout or after the COVID-19 pandemic. The analysis used a descriptive methodology to analyse the elements that impacted the propensity or drive to embrace LSS in MSMEs, as well as the obstacles that hindered its implementation. In order to accomplish the objective, a thorough examination of the data in the relevant region was conducted to build a framework using inferential statistics, while taking into account the pivotal aspects that contribute to achievement.

The education was administered by disseminating a survey to companies, using "MS-Excel and SPSS 25.0 statistical software" for the purposes of planning and execution. The study used a purposive sampling approach to choose a total of 127 individuals who are considered experts in Lean Six Sigma, as well as owners or CEOs of MSMEs in India, to participate in the investigation. The conclusion may be considered as an authoritative reference for investigators conducting further investigations. Furthermore, it might provide valuable perspectives to MSME owners in determining whether to implement Lean Six Sigma amidst the COVID-19 epidemic. Several recommendations were put up about the techniques and concepts that would form the basis of an LSS institute [32].

LSS, also known as Lean Six Sigma, is a very prevalent and efficient approach for enhancing quality in several sectors. Several firms tried to apply LSS, but not all of them had success in enhancing their business processes and attaining their desired objectives. Gaining a deep understanding of the cause-and-effect links among the many components of LSS and gathering extensive information via the usage of the LSS method has been very beneficial for the fruitful application of LSS. Nevertheless, there is a dearth of studies regarding the causal connections that elucidate how the use of LSS enablers results in the intended consequences. They underscore the need for more exploration and development in this particular area. The analysis definitively elucidated the correlation between different components of LSS and their impact on quality performance, customer satisfaction, and corporate performance [33]. Studied industrial firms are more thorough in assessing the impact of their actions on many areas of sustainability. Enterprises were required by government rules and environmental agreements to implement sustainable practices in order to reduce their present levels of emissions and waste. In order to address these difficulties, it was crucial to create, embrace, and execute inclusive tactics such as GLS. GLS offered an industrial solution that facilitates significant growth by efficiently using resources and preventing the incidence of rejection, rework, waste, and pollution [34].

Investigated that Six Sigma was a way that was first used in manufacturing to cut down on product variation, increase customer satisfaction, and lower the number of defects. Fiction training was used to look at and compare all the verdicts, evidence, and investigation results from around the world that had been done on ISS. The results showed that Six Sigma was popular and had been used by many organisations of all sizes and in all kinds of industries around the world. It had helped improve quality, boost productivity, boost job satisfaction, cut costs, improve on-time carriage, and boost purchaser fulfilment, all of which led to more occupational progress, higher profits, and a strong base for the business to last [35]. Analysed the barriers and success factors that are critical to the implementation of Six Sigma in organizational systems and processes. The research examined 22 success aspects and 19 barrier variables of Six Sigma initiatives. The results found that communication/executive engagement and lack of Six Sigma awareness/low employee engagement were the most important success factors and barriers, respectively, evaluated [36].

Using the DMAIC framework, the research realized substantial changes in turnaround time and a rise in the level of sigma to achieve a cost saving per year. The study found leadership, validation through data, and technical expertise to be some of the key success factors. Although the study is a single case study, the results prove the viability of LSS application by inexperienced users in resource-based MSMEs [37]. Performed a systematic literature review to learn about the Kaizen approach and critical elements of a successful continuous improvement in Just-in-Time manufacturing. Out of 87 articles, 30 articles were analyzed in more detail, and the automobile industry was strongly focused. The review also found that excellent communication, training, education, and involvement of employees are essential facilitators of continuous improvement. Change management and organizational preparedness were also highlighted in the study, supporting the significance of human and managerial aspects in maintaining long-term improvement programs [38].

Investigated Six Sigma is a methodical and demanding technique that seeks to decrease variability in processes and enhance quality by meticulously examining collected data using statistical tools. The Six Sigma approach has seen significant growth in several corporate sectors worldwide, including manufacturing, service, and process industries, in recent years. Nevertheless, Indian business practitioners were

not well-informed about the effectiveness of Six Sigma compared to its broad adoption in other regions. Thus, it was an opportune moment to acquaint them with the Six Sigma methodology and its execution [39].

The Six Sigma methodology was used in a case study of sugar refineries in Karnataka. The industry has invested a total of 1,250 crore rupees and employs 2,86 lakh people. Additionally, the 2.50 crore sugarcane growers benefit from it. A nation's economy is strong if its manufacturing sector is solvent. Industrial businesses have to control their spending because they have limited control over pricing. Reducing the fault rate is essential to keeping costs to an absolute minimum. The Six Sigma methodology approaches quality control in a data-driven and customer-centric manner. It is a thorough and rigorous method that aims to lower the failure rate, track and enhance performance, and gather and statistically evaluate data. Six Sigma was recognised for improving customer satisfaction, productivity, and financial stability. In any case, it does a commendable job of raising factory morale and output [40].

Research gave an in-depth look at how Lean Six Sigma could be used as a method to help a company change its business processes strategically. The company being looked at had grown steadily for almost twenty years. But in the former three ages, it had become clear that the company needed to look at its internal occupational progressions if it wanted to keep up with the competition and run at its best. The novelists of this revision tried to figure out how well the use of Lean Six Sigma helped get that goal accomplished. In-depth studies of the Lean Six Sigma technique and the things that might affect its use were also part of the study. A few people thought that the idea behind Lean Six Sigma could be used in any business. Studies, on the other hand, showed that many non-manufacturing companies still thought Six Sigma would not work best for them. The piece looked at a number of Lean Six Sigma projects that had been carried out. Some projects worked well when Lean Six Sigma was used in that company, but others did not go as planned. The issues that came up on the trip were looked at to find out what the Lean Six Sigma method could not do and how it could be fixed [41]. Evaluated the function of PPPs in the delivery of primary healthcare services in the Indian state of Karnataka. In the context of its target to achieve the goal of Health for All, the WHO pointed out the importance of primary healthcare facilities in its 2008 World Health Report. The state governments have been urging private businesses to spend more on healthcare, enhance the quality of their provision, and incur the incremental costs to the overall public health.

This strategy is in line with the current frenzy by the citizens and business sectors to invest in the best medical institutions. To enhance the accessibility of medical care to people, the Indian state of Karnataka pioneered the creation of a network of PHCs. Government representatives have initiated a public-private partnership to enhance the capability of PHCs to deliver good-quality care. A PPP in health care refers to collaboration between one or more commercial organizations and a government agency, the main aim of which is to improve the quality of the public health care by strengthening government control over the health facilities.

Evaluated the benefits and implementation of Six-Sigma at one automotive firm in Mysore, India. Businesses that are successful use Six Sigma as a technique to increase productivity, accuracy, speed, profit, and customer satisfaction. These days, achieving financial success, cutting expenses, improving customer loyalty, and improving quality are all linked to Six-Sigma. They include the results of the numerous adjustments made throughout implementation, as well as analysis and a comparison conducted both before and after the Six Sigma approach was used.

Table 2. Comparison of reviews

Study	Focus	Key Points	Success Factors	Limitations	Unique Contribution
[16]	Quality 4.0 & Smart Manufacturing	Highlights limitations of traditional Six Sigma in handling high-dimensional, non-Gaussian data; proposes AI-enabled Quality 4.0	AI/ML integration, data-driven quality intelligence	Six Sigma is not aligned with the full ML lifecycle	Introduces Quality 4.0 as an evolution beyond Six Sigma
[17]	Six Sigma in manufacturing	Reviews global Six Sigma adoption, tools, and outcomes	Tool–problem fit, continuous improvement culture	No sector-wise or regional comparison	Comprehensive synthesis of Six Sigma tools and practices
[18]	LSS CSFs in Industry 4.0	Identifies and ranks 16 reliable CSFs using ISM–MICMAC	Top management commitment, skilled workforce, culture	Manufacturing-focused	Integrates LSS with the Industry 4.0 framework
[19]	LSS in Indian MSMEs	Ranks CSFs using BWM; strategy and supplier focus are critical	Strategic alignment, cost orientation	MSME-specific	Decision-support model for MSME LSS adoption

[20]	Healthcare sector	Examines Six Sigma in family planning services	Process standardization, error reduction	Resource and awareness constraints	Demonstrates Six Sigma relevance in public healthcare
[21]	Lean Service Systems (Postal sector)	DEMATEL-based CSF analysis in Karnataka postal services	Process standardization, management support	Intangible performance measures	Public-sector Lean implementation case from Karnataka
[22]	Six Sigma effectiveness	Surveys 66 firms on benefits and adoption barriers	Cost–benefit clarity, project selection	Sample-size limitation	Explains why firms abandon Six Sigma
[23]	Six Sigma success	Links financial savings and sigma levels to success	Financial orientation, performance metrics	Conceptual emphasis	Connects sigma level with project success
[24]	SMEs & Six Sigma	Evaluates benefits and challenges in SMEs	Employee skill development, process discipline	The gap between theory and practice	Highlights Six Sigma applicability in SMEs
[25]	Indian LSS literature review	Reviews 141 studies (2010–2021)	Policy support, structured methodologies	Descriptive nature	Identifies research gaps and future directions
[26]	LSS + Industry 4.0	Uses the golden circle model to integrate LSS and I4.0	Technology integration, strategic vision	Conceptual framework	Framework for smart factories in India
[27]	Lean service (public sector)	Lean improves service quality in postal operations	Workplace standardization, process flow	Sector-specific	Validates Lean applicability in large public organizations
[28]	Green manufacturing	Ranks CSFs for green manufacturing adoption	Strategic prioritization, sustainability focus	Manufacturing-centric	Quantifies CSFs for green strategies
[29]	Automotive LSS barriers	Identifies 31 barriers using statistical tools	Skilled LSS belts, management commitment	Limited to the auto sector	Empirical barrier ranking in Indian manufacturing
[30]	Healthcare LSS	Ranks hospitals based on LSS indicators	Patient-centric quality metrics	Limited hospital sample	Consumer-oriented evaluation of LSS hospitals
[31]	MSMEs & COVID-19	Examines LSS adoption during the pandemic	Flexibility, expert involvement	Crisis-specific context	LSS relevance during disruptions
[32]	LSS enablers & outcomes	Explores causal links between LSS enablers and performance	Enabler–outcome alignment	Limited empirical testing	Establishes a causal performance model
[33]	Green Lean Six Sigma	Integrates sustainability with LSS	Resource efficiency, waste prevention	Sustainability-focused	Introduces GLS as a holistic strategy
[34]	Global Six Sigma review	Reviews worldwide Six Sigma benefits	Productivity and quality improvement	Secondary-data based	Confirms the universality of Six Sigma benefits
[35]	Six Sigma barriers & CSFs	Identifies 22 CSFs and 19 barriers	Communication, executive engagement	Cross-sector generalization	Balanced view of success vs failure factors
[36]	MSME case study	DMAIC improves sigma level and turnaround time	Leadership, data validation	Single case study	Proves LSS feasibility for small firms
[37]	Kaizen & CI	Reviews CI in JIT manufacturing	Training, employee involvement	Auto-industry bias	Human-factor emphasis in CI

[38]	Six Sigma awareness in India	Highlights low practitioner awareness	Training and dissemination	Awareness-focused	Advocates for wider Six Sigma education
[39]	Sugar industry (Karnataka)	Six Sigma improves productivity and morale	Data-driven quality control	Industry-specific	Karnataka-based manufacturing evidence
[40]	Strategic LSS	Examines LSS as a business transformation tool	Strategic alignment	Non-manufacturing skepticism	Identifies causes of LSS failure
[41]	Healthcare PPPs	PPPs improve service quality in Karnataka PHCs	Public–private collaboration	Policy dependency	Links quality improvement with governance

2.1. Problem Statement

Regardless of the increasing literature on the concept of Six Sigma, current research findings show a number of limitations. Most previous research has considered manufacturing organisations or service organisations separately, mostly using single case research or sector-based empirical research.

Although these studies affirm that Six Sigma is part of the reduction of defects, improvement of costs and productivity, they provide less comparative information about variations in the implementation dynamics of manufacturing and service industries, especially within the same region. Moreover, the interplay between Critical Success Factors (CSFs) and the operation-related issues unique to a sector has not been well studied, despite the common identification of the top management commitment, employee involvement, and training as the CSFs.

The second interesting issue is that a lot of the available Indian literature focuses on the operational or financial results in the short-term, and relatively little discussion is made about the implementation obstacles, change resistance, skill deficiencies, and sustainability of the implementation in the long-term, particularly in the organisations of the public and services. Moreover, emerging trends like digitalisation, Industry 4.0, and the advent of Quality 4.0 are also starting to supplant conventional frameworks of Six Sigma, but empirical and review-based research touching on such transitions (especially on the state or regional level) is weak.

2.2. Research Gap

According to a comprehensive analysis of the national and international literature, the following research gaps will be considered:

- Absence of region-specific comparative reviews of the adoption of Six Sigma in both the manufacturing and service industries in Karnataka.
- There are a few syntheses of success factors and difficulties in a wide range of industries, including IT, healthcare, hospitality, manufacturing, and public infrastructure.
- A lack of contextual effects, such as organisational culture, workforce preparation, and disparities in operational activities between the public and the private sectors.
- Little incorporation of new outlooks like LSS, Industry 4.0, and Quality 4.0 into the ecosystem of the Karnataka industrial sector.
- Lack of representation of evidence of the public-sector and service-sector cases in comparison with manufacturing-intensive studies.

2.3. Originality and Value Addition of the Study

The originality of the current study is its integrative and comparative review-based method that will pull together findings of manufacturing, service, hospitality, IT, healthcare, and public-sector organisations that work in Karnataka.

This is in contrast to previous research that is highly disjointed or industry-focused, as this study gives a comprehensive synthesis of Six Sigma success factors, issues of implementation, and quantifiable results of various industries within the same regional context.

In particular, the study can add to what is already known by:

- Comparison of manufacturing and service-sector Six Sigma adoption patterns in Karnataka.
- Determining the common and industry-specific CSFs.
- Bringing into focus the implementation issues of service and public-sector organisations that have been ignored in previous studies.
- Establishing Six Sigma as a part of modern quality paradigms, such as Lean Six Sigma and Quality 4.0.

Providing locally-based knowledge that can inform practitioners, policy makers, and researchers.

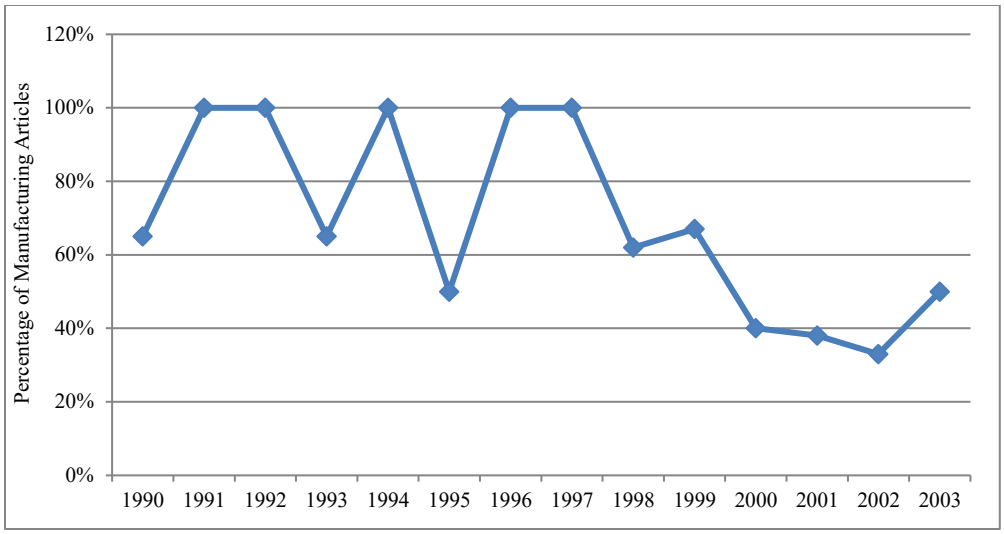

Fig. 4 Percentage of articles focused on the manufacturing sector [31]

2.4. Six Sigma in the Manufacturing Sector

People are getting more and more competitive in the modern age, so making sure customers are happy is important for businesses. Making your business or field competitive is one of the most important things you can do to keep it going [42]. To stay competitive in a business or industry, it needs to boost sales and output, market to more people, and keep customers by keeping and improving the quality of its goods [43, 44]. It is important for an industry to stay competitive and last a long time to keep customers happy and improve quality and efficiency. In the very competitive business world of today, quality is key [45].

People also choose the goods and services that companies offer because of how well they work. Making people happy is what quality is all about [46]. To give customers the good products they expect, a company must always find out what those customers want. This can be done through investigation and expansion to better create and make an artefact with features that make customers happy and meet their needs [47]. How productive a group, company, or country is shows how well it does [48]. When you think about efficiency, you think about how to use your resources in the best way to come up with more things and services. When a customer buys something, they rate how well it meets a number of factors before, during, and after use [49].

A business can make a customer happy if it can give them the features or qualities of a product that meet their wants. These traits or qualities should also affect how often used items are reused and help the brand by giving other buyers details about the items [50, 51]. There are many plans, methods, and strategies that can be used to expand quality, productivity, and customer happiness. One of these is the Six Sigma method. Six Sigma is a planned way for a business to make more money by improving quality, performance, and customer satisfaction [52-54]. This method from Six Sigma is called DMAIC, which means "Define, Measure, Analyse, Improve, and Control". As part of this step toward better quality, the goal is to cut the number of flaws by up to 3.4 parts per million. This method works well for current businesses that want to make their customers happier, be more productive, and make more money. The rules of Six Sigma say that to make processes better, you should use statistical methods, lower variation, put the customer first, pay close attention to processes, and use organisational systems that focus on high returns that make big, steady profits [55, 56].

How ready a company or business is makes a big difference in how well Six Sigma works. An important part is played by operating systems, measurement systems, employee involvement, the work environment, and the idea of always getting better [57]. Two signs that Six Sigma is working to boost quality and output are the extra capacity (sigma levels) of the process and the money that is saved. Rahman et al. were able to increase sigma values from 1.7 to 3.4 and decrease flaws like open seams and broken stitches by 35% in the reading. Rana and Kaushik's work with Six Sigma has shown that it can help cut down on mistakes and get more done. The DMAIC data showed that in just four months, the width of the broken washer went from 1550 PPM to almost 100 PPM. Besides this, there were other perks that did not happen, such as initiative and competition. Used Six Sigma implementation (DMAIC) in their work and found that it reduced mistakes, raised the Quality Rate by 41%, from 19% to 60%, and made the Cp in the Bead Apex process higher than 1.33. With the help of the Six Sigma method, the four-wheel business raised its sigma level from 1.2 to 3.2 [58].

Through his study, the author was able to cut the time it took to make one item from 47 days to 20 days. [59] were able to make $18,394.2 a month and improve the process skill (sigma levels) from 2.2 to 3.1 in their study [60]. Also, say that the Six Sigma method is a way to run a business that leads to

excellence by making processes better. This method has been used by many industries to adapt to changes in what people want or need. The study was able to raise sigma levels from 3.1 to 3.7, lower the reject rate from 15.50% to 4.47%, which is a 71.2 % drop, and save INR 18,27,402. Six Sigma is a methodical, scientific approach to managing a corporation. Its objective is to cut waste in order to improve the efficiency of the production process. The investigation resulted in a gain of INR 12,56,640 as the number of cylinder block issues decreased from 28,111 to 9,708 DPMO. To increase sigma levels from 3 sigma with DPMO = 33333.00 to 6 sigma with DPMO = 0 and Cp value = 1.91, Pp = 0.53, Cpk = 1.88, Ppk = 0.52 to Cp = 3.79, Pp = 3.32, Cpk = 3.34, Ppk = 2.29. The study found that Six Sigma's DPMO number should be 3.4; it does not say in their study that the main idea behind Six Sigma is to make the process better by making changes that make it stronger so that it can make products that are defect-free and make the user happy [61].

The study found the issue and fixed it. It also raised the process's capacity from 1.5 to 4, cut down on process rework by 50%, and raised the quality of the whole output by 30%. All of these changes made between Rs 90 and 95 lakhs a year. By changing the way the company was set up to make it more productive, they were able to cut waste from 18% to 2% in their Six Sigma study [62]. CPFR can improve prediction accuracy by 10–40%, lower inventory costs by 10-40%, lower shipping costs by 0.3% to 1%, and improve customer service by 0.5% to 4%, according to [63].

CPFR is known as one of the best ways to get better predictions, lower prices, cut down on inventory, and improve service levels. The MAPE dropped from 19.37% to 5.26 % in one study that used Six Sigma. The amount of goods that are still being held would drop from 17.7% to 5.18 %. This would improve SCM, build trust between business partners, and make companies more competitive in a world that is getting more and more competitive. With the Six Sigma method, they were able to bring down the number of flaws (DPMO) from 609,302 to 304,651 and raise the Sigma level from 1.2 to 2.0 in their study of the casting industry [64].

It was used in the nozzle furnace business as well. They were able to raise the sigma level from 3.31 to 3.67 and save INR 0.125 million, which is about US$53,000 [65]. This proves that DMAIC can raise the amount of sigma and make products better, which cuts costs and makes a business more competitive. From the above studies, we can say that Six Sigma uses statistical methods to give us measurable signs. It can also be put together with other analysis tools that have been shown to lower the variability of both the product and the process, as well as improve process capability by cutting down on defects and process time. This can bring down the cost of production, make customers happier, and definitely raise company profits, which is what an industry or group needs to stay in business in the long run.

2.5. Six Sigma in the Service Sector

There is not much room for error in health care. Mistakes that do not seem dangerous can hurt a lot of people and even kill some. Here is an example of the hospital industry. In 2008, medical mistakes cost the US more than $19.5 billion, according to a study in the Journal of Healthcare Finance. There were 98,000 deaths that could have been avoided in 1998, according to the Institute of Medicine. In 2008, that number had grown to 200,000 deaths a year, or 548 deaths a day, or almost one death in the US every two minutes [66]. LSS can help stop a lot of these terrible deaths that could have been avoided. If someone works in healthcare and knows how to use the right tools and methods to fix hitches and rally care, they will quickly become a benefit to their company [67].

They not only keep people from dying, but they also improve patient care and help keep costs down. There are many things that could be done better in health care. Lean Six Sigma syndicates the ideas of Lean and Six Sigma. Making things better is what Six Sigma is all about [68]. Lean is all about getting rid of waste. Six sigma stands for the standard deviation. By combining these ideas, we will be able to eliminate waste and decrease differences. This will enhance the process in terms of quality and speed [69]. The lean approach is considered at the beginning to dispose of waste. The process is then made less diverse with the application of Six Sigma tools. Nowadays, these two approaches are combined [70]. You can also accelerate it in case you combine lean and six sigma [71]. The concepts of Six Sigma and lean have been interconnected in a variety of ways so that they can work together. The two make the customer and the business equal in value [72].

Both LSS belong to the industrial sector, and it is in the auto business where they originated. Anyway, it is used now in healthcare, customer service, the government, and many other places. People used to think in a linear way. His first mass production system that mixed workflow and standard parts lines was kind of the first one of its kind. During the 1990s, Kiichiro Toyota tried out new ideas. One thing they did was come up with the value stream and Kanban, which are now known as the Toyota production method [73]. A bigger group of people learned about it as a good answer. The idea for lean production came from James Womack, who works at Let Us Do Small Things. Most of the time, qualitative tools are used with the lean method. One reason most Lean Six Sigma projects begin with lean is that qualitative tools are easier to use. It can be understood that the idea behind LSS is better than you can use [74]. Every day, the cost of health care goes up, but the rates at which people can pay drop. In order to meet their bottom line, hospitals need to be efficient, keep their patients safe, and keep their workers interested. Get better service by cutting costs and waste when you use LSS together. This can be used to improve treatment (Rathi et al., 2021) [75]. LSS is not merely a method of making things better when we contemplate it. It is a lifestyle that may lead to

change. LSS is effective in the healthcare industry since the business is people-process oriented. LSS is used by a large number of businesses and service companies throughout the world. Nevertheless, the long-term advantages of the LSS strategy are unfamiliar to the majority of individuals working in the healthcare sector, particularly in developing countries such as India, Pakistan, and Sri Lanka. LSS in poor countries in healthcare organisations has already been researched a lot, and the focus of this study was to find out what could be done on the same.

3. Research Methodology

The study examines the application of Six Sigma in Karnataka's industrial and service sectors using the structured narrative review method. From reputable academic sources, including Scopus, Web of Science, SpringerLink, IEEE Xplore, Science Direct, and Google Scholar, we examined scholarly book chapters, conference papers, and peer-reviewed journal articles. Six Sigma, Lean Six Sigma, quality improvement, process optimization, important success factors, manufacturing, service industry, Karnataka, and India were among the keywords included in the methodical search methodology. Articles are written in English and are included in the study on the basis of being published no earlier than 2010 and the latest developments regarding the theme of Industry 4.0 and Quality 4.0, though older seminal articles were also included where needed to provide a conceptual basis. Only the studies where methodology description was properly given and were relevant to the quality management practices were taken, and the rest were left out, such as non-peer-reviewed sources or those articles that were not relevant in view of their context. A thematic synthesis and comparative data set had been used to extract and analyse data to establish the common and sector-specific success factors, challenges, and implementation outcomes. Since the study is review-based research, no primary data was collected, and the analysis was based on the existing literature (methodological rigor was ensured by the selection of the sources, comparison across studies, and critical analysis of results).

4. Case Study

4.1. Manufacturing Sector Case Study [76]

4.1.1. Company Name: Quantum Motors

Background

Quantum Motors is an Indian-based manufacturing firm located in Karnataka, and it deals with the production of electric vehicles and parts. Quantum Motors also has difficulties in sustaining quality levels and reducing production costs, and thus, to improve their production processes, they chose to apply the Six Sigma techniques.

Implementation

Quantum Motors company initiated a Six Sigma program and provided their workers with Six Sigma techniques such as DMAIC (Define, Measure, Analyse, Improve, and Control). They assembled cross-functional teams to identify how they could do things better, and they also applied statistical tools to examine data and determine why their production processes were not working.

Results

Quantum Motors has achieved high-quality products and efficiency after adopting Six Sigma. The rate of defects reduced by 35% and this resulted in the reduction of rework cost and scrap. This saw improved customer satisfaction and market share in the electric vehicle market by Quantum Motors.

4.2. Service Sector [77]

4.2.1.Company Name: VirtualTech Solutions

Background

VirtualTech Solutions is an IT service firm located in Karnataka, and it offers IT consulting services and software development to its clients around the world. VirtualTech Solutions encountered difficulties in dealing with the project delays and unsatisfied customers, and therefore chose to implement the Six Sigma techniques in enhancing service delivery and customer satisfaction.

Implementation

Virtual Tech Solutions implemented the Six Sigma concepts in their project management procedures. They educated their project managers and subordinates in Six Sigma techniques and introduced mechanisms like the Lean principles and Statistical Process Control (SPC). They additionally created a project tracking system to sieve crucial dimension metrics and identify regions to expand upon.

Results

The research also brings out selected case reports where Six Sigma processes, including the DMAIC, have effectively been implemented to realize quantifiable increases in performance measures. The implementation of Six Sigma helped Virtual Tech Solutions to improve drastically on project delivery and customer satisfaction. The rate of on-time delivery rose by 25 percent, resulting in improved customer relations and more business repeat.

The levels of defects in software releases became lower, which meant the number of post-implementation problems decreased and increased customer satisfaction. On the whole, the implementation of Six Sigma contributed to Virtual Tech Solutions enhancing its reputation as a quality and trusted provider of IT services.

4.2.2. Company Name: Infosys

Background

Infosys is an Indian based IT services firm, which was established in 1981 and is based in Bengaluru. It has been a key factor in making Karnataka one of the world's IT hubs.

Results

Infosys has played an important role in the economy of the state and has brought in more than 13 billion dollars as revenue in 2020 alone. Another innovation brought by the company was the digital transformation efforts and employee training to improve competencies among the employees in the region.

4.3. Hospitality Sector

4.3.1. Company Name: Marriott Hotel, Whitefield

Background

The Six Sigma practices adopted by Marriott Hotel in Bengaluru aimed at improving the experiences of guests and streamlining the operation, aimed at reducing the time of service and increasing guest satisfaction.

Results

There was an accelerated check-in procedure, and delivery of room service was enhanced. Another area where Marriott improved customer satisfaction was matching services with the needs of the guests, decreasing the time spent by the room service by 24-19 minutes during peak seasons.

4.4. Public-Private Sector

4.4.1. Project Name: Karnataka Urban Water Supply Improvement Project (KUWASIP)

Background:

The KUWASIP program was initiated by the Government of Karnataka, aiming at improving water supply services in such metropolitan cities as Belagavi, Hubballi-Dharwad, and Kalaburagi. The project was a Public-Private Partnership (PPP) with the World Bank assistance and enacted by Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC). It was concerned with the sustainable delivery of water and better infrastructure to have a dependable supply of water.

Results

The implementation of Six Sigma techniques in water management resulted in quantifiable enhancement of water quality, service interruption mitigation, and efficiency. Such milestones as a 24/7 supply of water in certain areas and lessening the loss of water through pipeline leaks were also major successes. This increased the level of service reliability, customer satisfaction, and managed operational costs. KUWASIP served as an example of PPP-based programs in India.

5. Discussion

The discussion section explains further what the results entail and how Six Sigma can transform both the manufacturing industry and the service industry. It discusses the following.

- Implementation issues: The issues that are usually encountered are the reluctance by people to change, lack of training, and management support. To overcome these issues, you must have good leadership, communication, and a spirit of continuous improvement.
- Critical Success Factors: support by top management, adequate training, selection of appropriate projects, and utilization of appropriate Six Sigma tools and techniques are the key success factors of successful adoption.
- Specific Industries: The flexibility of Six Sigma to other industries is discussed, and examples of manufacturing, healthcare, and the auto industries are provided. Tailor-made Six Sigma software will be useful to each business with its issues and requirements.
- Integration with Other Methodologies: LSS, a combination of Six Sigma and Lean principles, is more applicable, as it enhances the speed and quality of the process.

The consequences of the research show that Six Sigma has been extensively implemented in various industries and organisations of all sizes in the world. Key findings include:

- Quality Improvement: Major decrease in defects and an increase in the quality of products.
- Productivity Proliferation: Improved productivity and efficiency in procedures.
- Fast Customer Satisfaction: More customer satisfaction because of the stable quality of products and their reliability.
- Cost Savings: decrease in operations costs through the decrease in the number of defects and rework.
- Tablet: Improved employee engagement views and participation in ongoing improvement programs.

The paper also brings out certain case studies that have seen successful application of Six Sigma procedures, i.e., DMAIC, in attaining measurable performance metrics. There are some observations:

- Karnataka has a manufacturing industry comprising textiles, automotive, and sugar manufacturing industries, with great emphasis being on production efficiency and cost optimisation of their industries.
- The service industry, with IT, hospitality, and healthcare being its leaders, focuses on customer satisfaction and rapidity of operations using models such as Six Sigma.
- The manufacturing industry focuses on streamlined processes and tangible deliverables, whereas the service industry is dependent on the correlative degree of employee involvement and interaction with the customer.
- The use of Six Sigma is more flexible in in-service businesses and manufacturing is able to make use of linear process enhancement and optimisation of the supply chain.

6. Conclusion

As the study concludes, Six Sigma is an important approach in enhancing quality, productivity, and operational efficiency among different sectors. The application of Six

Sigma assists organisations to simplify processes, cut down costs, and increase customer satisfaction by making use of data-driven problem-solving and a methodical removal of defects. The results also point out that Karnataka has seen a lot of gains in its public and private enterprises, including the hospitality, healthcare, software, and water management sectors, through the application of Six Sigma. These are attaining enhanced service provision, attainment of operational consistency, and sustainable growth. The research highlights that an effective Six Sigma program relies on the promotion of the culture of continuous improvement, effective top management, and employee participation on all levels. There should be proper communication systems to ensure that all the stakeholders are geared towards common objectives. Moreover, regular training should be invested in so that employees are prepared to use the principles of Six Sigma in the most effective way, and it is essential to achieve success in the long term. Going forward, the study recommends that organisations should consider new ways to apply Six Sigma in new industries and overcome certain industry issues, including supply chain optimization and waste minimization. It also suggests the need to conduct additional research to detect the best practice of implementing the Six Sigma with references to such variables as the involvement of employees and the support of leaders. In general, Six Sigma is a useful tool that can be utilized by a business that aims at improving its performance, competitiveness, and customer loyalty sustainably.

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