LEAN SIX SIGMA IMPLEMENTATION IN WASTE REDUCTION, ENVIRONMENTAL SUSTAINABILITY AND SAFETY RISK MANAGEMENT.

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ABSTRACT
The main goal of this article is to illustrate how the application of lean six Sigma may reduce waste, enhance environmental sustainability, and control safety risks in a manufacturing company. Lean manufacturing seeks to decrease/eliminate waste, whereas Six Sigma aims to reduce defects by reducing variability in the system. The goal of this article is to propose a model for Lean Six Sigma that will allow using the tools of Six Sigma and Lean manufacturing to reduce waste by reducing the percentage of returns, sustain the environment by reducing the empty contaminated return packages, and control the safety risk by using FMEA (Failure – Mode and effect analysis) in risk assessment. A DMAIC (Define – Measure – Analyze- Improve – Control) project is used to carry out the empirical case study. This Lean six sigma DMAIC methodology is used in parts to gather and examine data about the present process.

Keywords
Lean; Six Sigma; Waste; Environment; Safety.

1. INTRODUCTION
Throughout history, the role of continuous improvement within organizations has changed and adapted, from the first improvements made through the invention of machines that sped up production to using empirical or statistical methods to analyze processes. People and organizations have looked for better operational procedures. Increasing the quality of their goods and services is where some industries concentrate the majority of their efforts on continual improvement. Some people see cost reduction as a goal of ongoing progress. Successful continuous improvement projects ultimately alter an organization's culture in addition to reducing costs and raising quality. The motivation and desire of the organization's members to continuously enhance company procedures and policies are the main emphases of the culture change; an organized strategy or program of continuous improvement is needed to stimulate this fundamental shift in running and managing processes. Combining Lean and Six Sigma, two well-known continuous improvement approaches, creates Lean Six Sigma. Lean and Six Sigma often concentrate on enhancing an organization's transactional and production processes. Both have complementing effects despite using different approaches and guiding ideas to bring about improvement. As a production methodology, lean manufacturing attempts to reduce waste, simplify processes, and accelerate workflow.

The goal of Six Sigma, on the other hand, is to significantly reduce the number of errors that occur in manufacturing or service activities. Small and medium component manufacturing companies need efficient, low-cost methods and procedures to address serious issues with productivity and quality. Successful deployments of each of these approaches at organizations like Toyota, General Electric, and Raytheon each contributed to their own popularization. Now that many businesses are aware of the significant synergy created by combining these two approaches, Lean or Six Sigma has been successfully applied. **[1]**.

2. STUDY HYPOTHESES

The focus of this research effort is to investigate the research hypothesis. The Null hypothesis of this study is:

- $H_{o\,(1)}$: Lean six sigma implementation does not affect reducing waste.
- $H_{o\,(2)}$: Lean six sigma implementation does not affect environmental sustainability.
- $H_{o\,(3)}$: Lean six sigma implementation does not affect safety risk management.

3. LEAN MANUFACTURING

Lean manufacturing is often understood as the elimination of waste from a process in order to speed up the process and enhance quality. The Toyota Production System (TPS), often regarded as the father of the Lean methodology, was the foundation from which the lean production methodology was built. The Toyota system's primary goal has been to boost production efficiency by thoroughly and consistently reducing waste, according to Ohno (1988), who further confirms the connection between better business outcomes and waste elimination. The majority of Lean technologies are applied in brief periods of work that involve careful and thorough planning and application phases. Most Lean tools are implemented in short bursts of activity that include focused and intensive planning and implementation phases. **[2]**

Table (1): Lean tools.

Tool	Description
5S (or 6S)	A clean and organized workspace may be created and maintained using the systematic 5S technique. 5Splus Safety considerations are referred to as 6S.
Just-in-Time Production	A production schedule concept known as "just in time" requires that every material required at a production operation, including raw materials, completed goods, and anything in between, be created and made accessible just in time.
Kaizen	According to the kaizen concept, regular application and maintenance of minor, incremental adjustments over an extended period produce noticeable benefits. Kaizen events, which are 2–5 days rapid process improvement events, are frequently used to introduce lean.
Kanban	Work in progress and inventory levels are managed using Kanban (signals).

Tool	Description
Production Preparation Process (3P)	Lean process and/or product design methodology 3P. Production procedures, tools, and machinery that support one-piece flow are simple to manufacture and achieve appropriate cost, quality, and lead times are devised and put into use by 3P. Likewise referred to as pre-production planning.
Standard Work	Standard work is the series of steps required to carry out a specific operation. To guarantee that every employee is aware of and regularly follows the new procedure, improvements made during kaizen events are promptly documented as standard work.
Total Productive Maintenance (TPM)	TPM is a strategy to involve operators in the design, choice, correction, and maintenance of equipment to guarantee that every machine or process is always able to execute its necessary functions without halting or delaying defect-free output.
Value Stream Mapping	A technique for mapping processes that is used to record the present and potential future states of information and material flows in a value stream (from supplier to customer)
Visual Controls	Visual controls are used to display the status of an activity so that every employee can see it and respond appropriately, as well as to reinforce standardized procedures. During kaizen events, visual controls are routinely used to streamline operations and provide visual feedback on process performance.

4. SIX SIGMA APPROACH

By implementing a number of small projects utilizing the five-step DMAIC (Define, Measure, Analyze, Improve and Control) process, Six Sigma is implemented. The Plan-Do-Check-Act issue-solving process developed by Walter Shewhart and W. Edward Deming and DMAIC are fairly comparable. Later, Six Sigma initiatives and procedures would blend into the organizational philosophy and daily operations. **[2]**

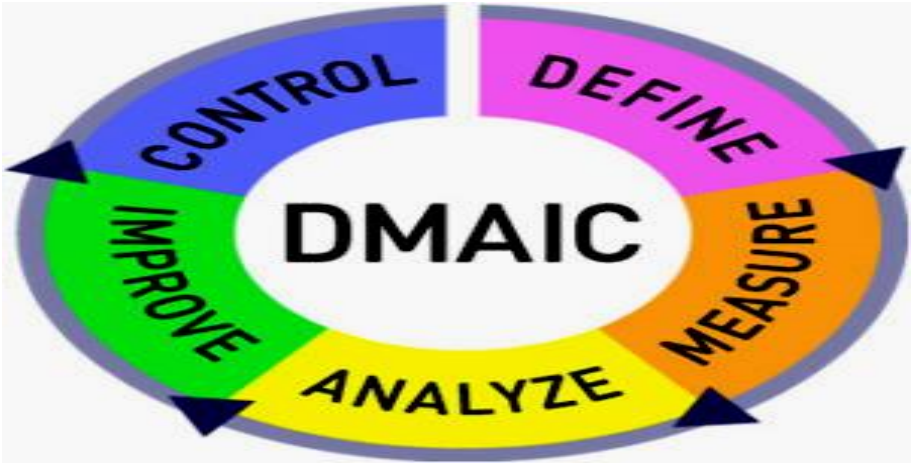

Fig. 1: DMAIC.

5. ROLE OF LEAN SIX SIGMA IN BUSINESS AND WASTE REDUCTION

Lean Six Sigma is a business approach that enables organizations to improve revenues by simplifying procedures, enhancing quality, and removing flaws. Companies that use the Six Sigma approach must lower process variation to a point where there are 3.4 defects per million opportunities (DPMO) produced. The organization's high-level goals are connected to Six Sigma initiatives and activities. Any organization's three main constituencies—customers, Owners, and employees-determine its objectives. These stakeholder-based goals are translated into the appropriate measurements by senior management. Then, a plan of action is matched to these objectives and metrics by considering all business procedures and viewing production as a component of a wider system. Numerous advantages of Six Sigma are offered to customers. The Owners will inevitably benefit more as the cycle time for product design shortens, and operations become more cost-effective. Naturally, employees' compensation will improve as they grow more productive. Therefore, implementing Six Sigma will increase the benefits to all organizational stakeholders. **[3]**

6. ROLE OF LEAN SIX SIGMA IN ENVIRONMENTAL SUSTAINABILITY

Because environmental effects are inherent in industrial wastes, lean implementation efforts can have a significant impact on environmental improvement. Therefore, cutting down on these Lean wastes benefits the environment. For instance, less over-processing activities and more effective transportation reduce emissions. Additionally, the establishment of the proper-sized manufacturing unit results in a reduction in the amount of materials, land, and energy consumed. While six Sigma focuses on minimizing variance, it also aids in improving the environment by removing faults. Efforts in Lean and six Sigma can significantly improve environmental performance. Organizations can leverage the potent forces underlying Lean and Six Sigma to increase business competitiveness while lowering environmental impacts and wastes by including environmental wastes in Lean's fatal wastes. **[2]**

7. ROLE OF LEAN SIX SIGMA IN REDUCING SAFETY RISKS

Risk is the term used to describe the unpredictability of future occurrences and results. It is an expression of the likelihood and effect of an event that could have an impact on the accomplishment of a goal. Risk can be best understood in its simplest form as something that could go wrong and prevent you from reaching your goals. Identification, evaluation, and prioritization of various risks are all steps in the risk management process. The risk manager will develop a strategy to lessen or completely avoid the effects of adverse events once the risks have been recognized. Various approaches can be used based on the risk type and the type of business **[4]**. Setting and reducing accidents is the department of health and safety's goal. In industrial organizations, safety is very important. Safety knowledge among employees is crucial to producing high-quality results. Reduces in the real health and safety of employees are associated with low levels of safety awareness and a bad safety climate. Any operations manager's responsibility is to find ways to boost employee productivity in general and quality results in particular. The current study aims to combine six sigma methodology and industrial safety. The safety, health, and welfare of workers in any industrial or non-industrial organization are a concern of the International Labor Organization (ILO) and **W**orld **H**ealth **O**rganization (WHO). Creating and supporting the appropriate safety culture is one of every manufacturing organization's main goals. **[5]**

8. RESULTS

This study used Lean Six Sigma (DMAIC approach) to successfully minimize waste, protect the environment, and lower safety risks. As a result, managers can use the paper as a roadmap to direct specific process improvement projects in their organizations.

The results revealed that:

1 - The percentage of returns for the specific product was 29.79 %, and six sigma level was 2.03 sigma and DPMO= 297848 in 2021; after applying lean Six Sigma, the percentage of returns for the same product became 0.255, and the six sigma level became 4.29 sigma in 2022.

So that:

- Lean Six Sigma reduced waste and enhanced environmental sustainability.
- The first and second null hypotheses were rejected.

2 - The number of accidents was 3, and the six sigma level was 4.05 sigma and DPMO= 5263 in 2021; after applying lean Six Sigma, the number of accidents **became** 2, and the six sigma level **became** 4.23 sigma in 2022.

So that:

- Lean Six Sigma reduces safety risks and accidents.
- The third hypothesis was rejected.

This demonstrates that as long as the organization continues embracing Lean Six Sigma within its continuous improvement culture and applies its concepts and principles to systematically solve quality problems, it is believed that benefits such as cost savings, sustaining the environment, reducing waste and reducing safety risks will be achieved.

9. RECOMMENDATIONS

- Training and awareness of the customer on the proper transportation, handling and storage methods of products at planned periodic intervals; this is because there are returns as a result of wrong transportation and storage.
- Establishing a cost center for returns to calculate the cost of rework and scrape through the financial department.
- Monitoring, measuring, analyzing and evaluating the percentage of returns monthly.
- Reassess the risks at planned intervals to decrease these risks.
- Applying lean six Sigma in different industrial companies.

10. REFERENCES

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