

Impact of the implementation of the Lean Six Sigma process within Moroccan environmental SMEs

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Abstract. Lean Six Sigma is a management approach used to improve the efficiency, quality and performance of processes within companies. When applied to environmental businesses in Morocco, Lean Six Sigma can bring several significant benefits. Lean Six Sigma aims to eliminate waste, inefficiencies and non-essential processes. By applying it to Moroccan environmental companies, it is possible to optimize operations, improve productivity and reduce costs. That can contribute to more efficient use of resources and better management of projects. Environmental companies have the primary mission of minimizing their impact on the environment. Applying Lean Six Sigma can help identify sources of pollution, reduce waste, improve energy efficiency and promote sustainable practices. That helps build their environmental credibility and meet stakeholder expectations. Lean Six Sigma emphasizes customer satisfaction and product or service quality. By integrating this approach, Moroccan environmental companies can improve their production processes, eliminate defects and errors, and provide better quality products and services to their customers. That can promote customer loyalty and increase their competitiveness in the market. The application of Lean Six Sigma within environmental companies in Morocco can bring significant benefits, such as improved operational efficiency, reduction of environmental impacts, improving the quality of products and services, strengthening the culture of continuous improvement and developing employee skills. This is the case that we have dealt with in This article in order to measure the Impact of the implementation of the Lean Six Sigma process within Moroccan environmental SMEs. By adopting That approach, Moroccan environmental companies can strengthen their competitiveness, environmental sustainability and ability to meet stakeholder expectations.

Keywords : Lean management, sustainable development, lean six sigma, environmental companies.

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1 INTRODUCTION :

Lean Six Sigma is an approach aimed at combining the advantages of the Lean Management method and Six Sigma. Of course, it won't happen on its own. Beyond the seductive theory, it is more prudent to assess the cost of obtaining them and the inevitable human impacts at their fair values before embarking on such an ambitious undertaking. Lean Six Sigma aims to identify and eliminate sources of waste, defects and inefficiencies in processes. By applying it to Moroccan environmental SMEs, it can optimize operations, reduce costs, improve productivity and maximize the use of available resources. The main objective of environmental SMEs is to reduce the negative impact on the environment. Implementing Lean Six Sigma can help identify sources of pollution, minimize waste, improve energy efficiency and promote sustainable practices. That helps to strengthen their ecological environment and meet regulatory requirements. Lean Six Sigma emphasizes customer satisfaction and the quality of products or services. By integrating This approach, Moroccan environmental SMEs can improve their production processes, eliminate defects and errors, and provide better quality products and services to their customers. That can promote customer loyalty and increase competitiveness in the market. In This article, we will attempt to measure the impact of the implementation of the Lean Six Sigma process within Moroccan environmental SMEs, taking into consideration the available data.

2 LEAN SIX SIGMA AT THE SERVICE OF ENVIRONMENTAL MANAGEMENT:

In an environment characterized by uncertainty and led by those who have the power to innovate and continually adapt to their changing environment, companies are looking for new ways to increase their productivity and the quality of their products while reducing costs to achieve stakeholder satisfaction. Industrial companies are constantly facing many challenges such as changing customer demands such as shorter delivery times, better product quality, increased competition, loss of market share, financial crisis and recession (1). With increasing competition, production companies are faced with controlling and improving the performance of all their processes in order to guarantee their sustainability and competitiveness (2). On the other hand the high cost of energy resources and the challenges of protecting the environment against waste of all types and involves the fight against all types of waste. Lean Six Sigma fosters a culture of continuous improvement within organizations (3). By encouraging employee participation and engagement, it can stimulate innovation, creativity and involvement at all levels of the company. That allows Moroccan environmental SMEs to adapt more quickly to market changes and to remain competitive. The implementation of Lean Six Sigma requires specific training for employees (4). That can help develop skills in problem solving, data analysis and project management. These enhanced skills can be beneficial for both employees and the company, by promoting professional development and improving the overall performance of the organization. It is therefore recommended to put in place tools and approaches in terms of continuous improvement to achieve operational excellence such as the Lean-Six Sigma approach which combines increased process speed and improved product quality (5). They are essentially based on the principle of eliminating waste (Lean management) and continuous product improvement (six sigma). The objective is to obtain the best quality at the lowest possible cost and with minimum waste of resources, in order to boost quality management systems and integrate the customer satisfaction process approach (6).

To achieve these objectives, Lean six sigma has become a new management tool in large international industrial companies. The Lean Six Sigma approach is a combination of two concepts Lean and six sigma (7).

Lean is based on the systematic eradication of waste, variability and inflexibility. It essentially starts from the idea that to improve performance, losses must be understood and eliminated relentlessly, it is the hunt for waste. Lean production is nicknamed lean because it uses the necessary human effort, the necessary space, the necessary investment, and tooling (8).

Lean management uses a set of tools and philosophies that positively impact quality and productivity and reduce manufacturing costs (9), including Value Stream Mapping (VSM), just in time (JIT), Kanban, Jiduka, among others. The LM method has been widely applied by large companies to improve business performance, including reducing waste and costs, improving customer satisfaction and improving process efficiency (10). Although Lean has proven its ability and support for process optimization and operational performance by eliminating waste and improving daily processes, it does not take into account the analysis of process variability and the causes of defects covered by the LSS methodology (11). It is a philosophy of quality improvement based on facts and data. This method was developed by Motorola, in the United States, at the end of the 1980s. Its application enabled it to save more than two billion dollars over a period of four years (12).

The Six Sigma method offers the possibility of ensuring that the process is controlled statistically, generating a minimum of defects with a level of quality acceptable to the customer, it allows a statistical measurement of the performance of the processes which makes it possible to determine with a great precision the quality of the products or service(13).

3 ENVIRONMENTAL SMES IN MOROCCO:

Environmental SMEs in Morocco play an important role in promoting sustainable development, environmental protection and natural resource management. Environmental SMEs operate in various sectors related to the environment, such as waste management, renewable energy, energy efficiency, water management, biodiversity preservation, ecosystem restoration, pollution air, etc. They thus contribute to solving environmental problems while creating economic opportunities (14). Moroccan environmental SMEs play a key role in the transition to a green and sustainable economy. They promote the use of clean technologies, the reduction of greenhouse gas emissions, the conservation of natural resources and the promotion of responsible business practices. They also contribute to the creation of green jobs and local development. Morocco has a regulatory framework that encourages the development of environmental SMEs. Environmental SMEs (Small and Medium Enterprises) in Morocco play a crucial role in promoting sustainable development, addressing environmental challenges, and contributing to the country's green economy (15). Environmental SMEs are businesses that operate in sectors related to environmental protection, conservation, and sustainable resource management. These sectors include renewable energy, waste management, water treatment, eco-tourism, green construction, sustainable agriculture, and environmental consulting, among others. Environmental SMEs in Morocco actively contribute to protecting the environment by offering products, services, and solutions that minimize negative impacts and promote sustainability. For example, renewable energy companies provide clean energy alternatives, waste management firms implement recycling and waste reduction measures, and eco-tourism enterprises focus on sustainable tourism practices. Environmental SMEs contribute to job creation and economic growth in Morocco. They provide employment opportunities, particularly in rural and peri-urban areas, where many eco-friendly activities are based. These businesses also attract investment, foster innovation, and promote the transfer of environmentally friendly technologies. The Moroccan government has recognized the importance of environmental SMEs and has implemented policies and initiatives to support their growth. That includes financial incentives, tax breaks, access to funding, capacity-building programs, and the establishment of dedicated agencies and institutions to promote green entrepreneurship. These significant contributions, environmental SMEs in Morocco face various challenges. These include limited access to financing, high upfront costs for green technologies, regulatory complexities, inadequate infrastructure, and limited market demand for sustainable products and services. Overcoming these challenges requires continued government support, increased collaboration, and the development of a supportive ecosystem for green entrepreneurship. Environmental SMEs in Morocco actively engage in international collaborations and partnerships. These collaborations facilitate knowledge exchange, technology transfer, and market access. Additionally, participation in international conferences, exhibitions, and networks helps raise the visibility of Moroccan environmental SMEs and create business opportunities. Environmental SMEs in Morocco play a vital role in addressing environmental challenges, promoting sustainable development, and contributing to the country's green economy. Through their innovative approaches, they contribute to job creation, economic growth, and the preservation of Morocco's natural resources. Supporting and nurturing these enterprises is essential for achieving long-term sustainability goals and transitioning to a greener and more resilient economy. Policies, tax incentives and support mechanisms are in place to promote investment and innovation in environmental sectors. That creates a favorable environment for the emergence and growth of these companies (16). Environmental SMEs in Morocco face various challenges, such as access to finance, availability of technical skills, public awareness, regulatory and administrative constraints, as well as market competition. However, they also benefit from opportunities, including the strong growth potential in environmental sectors, partnerships with local and international actors, and the growing interest in sustainable solutions. The Moroccan government, in collaboration with national and international institutions, is setting up support and assistance programs for environmental SMEs. That includes funding initiatives, specialized training, management consulting, networking platforms and incubation programs. These measures aim to strengthen the capacities of environmental SMEs and promote their growth and competitiveness. Environmental SMEs in Morocco are therefore key players in the transition to sustainable development, contributing to environmental protection, the creation of green jobs and economic growth. Their development and continued support are essential to achieving national and international environmental sustainability goals.

4 MATERIALS AND METHODS

The implementation of the Lean six sigma approach in a Moroccan environmental SME, dismisses the idea that it is a process reserved for large companies and would set an example to others that it is feasible with the means they have. To this end, SMEs will invest in the project to implement the Lean six sigma process, which would allow them to adopt operational excellence, which has become a customer requirement.

The problem that we try to solve in That work is the following: What is the impact of the application of the Lean Six Sigma approach on the flow of production processes within Moroccan environmental SMEs?

Our work opts for the positivist paradigm. A current of thought which ensures that the only foundation of knowledge consists of the observation of facts, of experience, and the statistical processing of data, according to This paradigm each phenomenon (effect) would be explained by other phenomena (reasons). In order to display the way in

which the arguments must be presented, the reasoning taken into account is hypothetico-deductive, which consists of formulating research hypotheses, collecting data and then processing and analyzing them to confront them with realities. field to finally say whether these assumptions are confirmed or invalidated. It is the environmental SMEs that generate growth, create jobs, grow faster and are more innovative. But they are much less complex (in terms of structure) and more efficient and flexible than large companies. In fact, SMEs contribute around 50% to global gross value added (GVA). It is essential to strengthen their position, and to develop them by giving them the appropriate tools and the methodology for implementing these tools to enable them to increase their competitiveness and master modern management methods. In This sense, SMEs must reorganize and rethink their strategies in order to be ready to meet customer requirements. The objective is to quickly supply products that combine quality and a competitive price.

The savings and customer satisfaction obtained in That way translate directly into tangible benefits such as increased profit, development of staff potential, preservation of jobs and increased investment, not to mention the preservation of energy resources and contributing to efforts to combat global warming.

In order to answer our problem, the question of the subject we are dealing with is the following: What is the impact of the application of the Lean Six Sigma approach on the flow of production processes within Moroccan environmental SMEs?

Our case is based on the application of the Lean Six Sigma method by the implementation of the DMAIC approach, was carried out in a company specializing in the manufacture of products in which felt is the main material in the production process, The latter is an environmentally friendly product since it is the result of recycling plastic waste from bottles, waste clothing and all types of fabric, so it is an industry that contributes to the protection of the environment. Felt is an essential constituent in the manufacture of mattresses, lounges, duvets... The implementation of the DMAIC approach within the company specializing in the manufacture of products using felt as the main material can have several benefits in terms of improving efficiency, quality, and environmental sustainability. Applying the DMAIC approach allows for a systematic analysis of the production process involving felt. By identifying and eliminating non-value-added steps, reducing waste, and streamlining operations, the company can improve overall process efficiency and reduce costs. The DMAIC methodology emphasizes the importance of measuring and analyzing data to identify areas of improvement. By implementing rigorous quality control measures, conducting root cause analysis, and implementing corrective actions, the company can enhance the quality of its felt products. That can lead to increased customer satisfaction and loyalty. The company's use of recycled materials, such as plastic waste from bottles and fabric waste, contributes to environmental sustainability. The DMAIC approach can further support waste reduction efforts by identifying opportunities for waste minimization, recycling, and resource optimization. That not only reduces the company's environmental footprint but also aligns with its commitment to protecting the environment. Implementing DMAIC fosters a culture of continuous improvement within the organization. By engaging employees in problem-solving activities, encouraging their participation in data analysis and decision-making, and providing training on Lean Six Sigma principles, the company can cultivate a mindset of ongoing improvement. That can lead to innovation, increased employee satisfaction, and a more proactive approach to addressing challenges. Adopting Lean Six Sigma and the DMAIC approach can provide the company with a competitive edge. By enhancing efficiency, quality, and sustainability, the company can differentiate itself in the market, attract environmentally conscious customers, and potentially expand its market share. Applying the DMAIC approach within the company specializing in felt-based product manufacturing can lead to improved efficiency, enhanced product quality, waste reduction, and a stronger commitment to environmental sustainability. By leveraging the principles of Lean Six Sigma, the company can optimize its processes, deliver high-quality products, and contribute to a greener and more sustainable industry. The choice to carry out That research in a Moroccan SME specialized in That field of activity which contributes directly to the protection of the environment, through the introduction of waste that pollutes and harms fauna and flora (water, soil, air, etc.).

To That end, That work gives added value to the protection of the environment in the first place, and contributes to the performance of companies in That field of activity which falls into the category of societal companies.

The choice of company is not random. To the lack of skills, the cost of experimenting with the establishment of That process which requires the involvement and total commitment of the general management and all the stakeholders in the production process within the environmental SMEs.

In order to minimize losses and increase product quality to strengthen customer confidence, the Lean Six Sigma project will be structured according to the DMAIC method (define Method, Analyze, Innovate, control). This tool will identify the causes of losses and non-compliance of felts with the customer's request, which will generate waste and unnecessary and costly working hours for the company.

5 RESULTS AND DISCUSSION

The results of the measurements carried out by different operators, will be on the Minitab software dedicated to the analysis of the reliability of the measurements, The results of the measurements, processed by the Minitab software which is dedicated to the analysis of the reliability of the measurements and the process gave the following results:

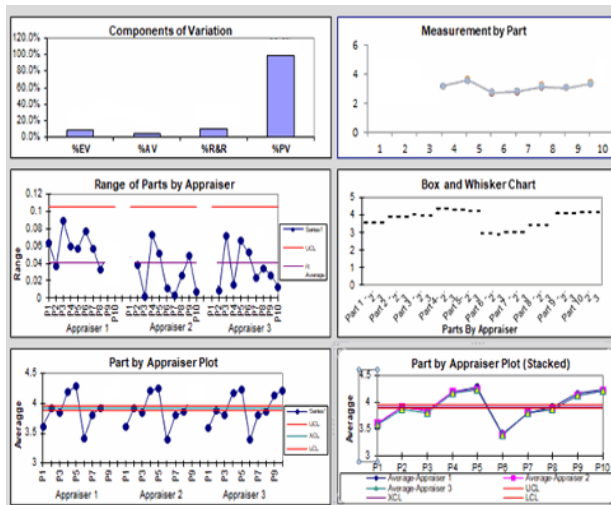


Fig. 1. Results Gage R&R of instrumentation for MATELMED case measurement

The analysis of the first graph shows the percentage variation of each source; the total R&R guarantee is very low compared to that of the parts, so we can conclude that the variation comes from manufactured parts, that the variation in the R&R (Repeatability and Reproducibility) guarantee is significantly lower compared to the variation in the parts. It's suggests that the measurement system used to assess the parts is less reliable and consistent compared to the R&R guarantee.

This conclusion raises concerns about the accuracy and consistency of the measurement system in assessing the quality of the parts. It indicates that there might be inconsistencies or errors in the measurement process, leading to unreliable results.

To ensure accurate and reliable measurements, it is crucial to address the issues with the measurement system. That could involve implementing improvements such as recalibrating the measuring equipment, providing additional training to the personnel involved in the measurement process, or identifying and resolving any systematic errors or biases.

By improving the measurement system, the company can enhance the reliability of the data used for quality control purposes, leading to more accurate assessments of the parts and potentially reducing variations in their quality. That , in turn, can help improve overall product quality, customer satisfaction, and process efficiency.

The R map depending on the operator; shows that operators measure consistently;

The Xbar chart according to the operators allows you to see if you have a wide measurement range; operator 1 has a wider measuring range than operator 2. The measurement map by parts shows if one operator measures more than the other; in our case, the difference is not significant in several measurements. In the measurement map depending on the operator; the width must be identical and the line joining the means as straight as possible. We notice that That is the case in our test. The interaction map shows if one operator measures more than the other. In our case there is no difference between the two. So we can conclude that the malfunction is not due to the measurement system; we must therefore analyze the manufacturing process. We will take samples during a production day at the same time interval and under the same conditions. These measurements are reported again on the Minitab software which will perform the processing and give the result in the form of a map and by calculating the indicators Pp, Ppk, Cp and Cpk which indicate the long-term performance and the short-term capability.

Capability is measured by the ratio of the requested performance and the actual performance of a process. Following the results the process is not far from performance but it needs improvements in order to reduce variability and waste. The curves of X and r oscillate on each side of the average, the process is therefore under control but there is a higher trend which indicates that the short-term capability is deteriorating. We must find the origin of This deterioration

The analysis phase makes it possible to identify the causes of variability and the sources of waste issues, and generate hypotheses.

The brainstorming session facilitates collaboration and encourages a diverse range of viewpoints. It allows for the integration of different expertise and perspectives, fostering a comprehensive understanding of the problem at hand. By leveraging the collective intelligence of the team, valuable insights can be gained, leading to a deeper analysis of the issues. Following the brainstorming session, the team can prioritize the potential causes and hypotheses based on their relevance and impact. This prioritization sets the stage for further analysis, where the team can conduct root cause analysis, perform data-driven investigations, and apply appropriate problem-solving techniques. Overall, the brainstorming session during the analysis phase of DMAIC serves as a starting point to explore and understand the causes of variability and waste in the felt-based product manufacturing process. It allows the team to tap into collective knowledge and insights, setting the foundation for a more comprehensive analysis and problem-solving efforts. Our analysis is based on the data provided by the measurement phase. First, a brainstorming was done to discuss the results. Team members presented their views on the causes of process failure.

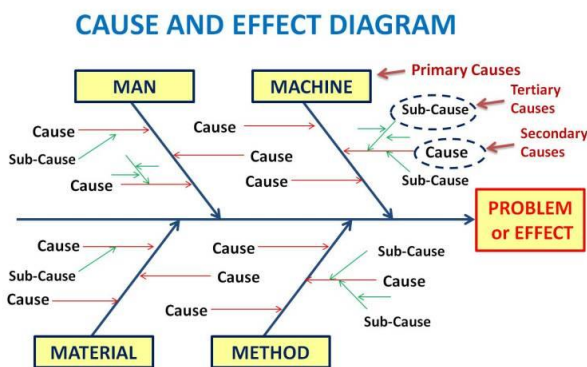


Fig. 2. Diagram of causes and effects of ISHIKAWA for MATELMED

Based on the analysis of the operation of the company, the voice of the consumer, the purpose of the project, and the findings of the diagram.

The implementation of the Lean Six Sigma process allowed us to identify the sources of dysfunction, starting from the need to prove the reliability of the measurement tools. The use of control charts makes it possible to identify the sources of the poor quality of the product.

The results show the need for recruitment in the Moroccan environmental company of specialists in the Lean six sigma process, not only in the production process but also in the management of the company in general, of the direction which must be inspired by the Lean Six sigma model in strategic decision making. The next research will aim to implement the Lean Six Sigma process in the management of the company in order to improve the purchasing process, purchase order, digitization of procedures to minimize travel (diesel) and use of papers. These approaches will have a great benefit on profitability and on the environment.

6 CONCLUSION:

The application of the LSS methodology, based on the successive stages of the DMAIC approach, has made it possible, on the one hand, to reduce the waste mentioned during the production of the current state map, by experimenting with solutions and improvements proposed within environmental SMEs in Morocco. On the other hand to analyze and reduce the variability's of the process demonstrated in the two phases Measure and Analyze by experimenting with the solutions proposed by the project team by exploiting the information collected through the face-to-face questionnaire administered to managers of production and quality functions in the company, and the use of a control chart tool using Minitab software, the results of which validate the two assumed hypotheses. DMAIC is a methodology used within the framework of Lean Six Sigma for the continuous improvement of performance. It can also be applied to environmental SMEs in Morocco to optimize their operations and results. The application of DMAIC in Moroccan environmental SMEs makes it possible to follow a structured approach to identify problems, solve them in an effective and measurable way, and improve environmental performance on a continuous basis. That can lead to better resource management, lower costs, greater regulatory compliance and improved stakeholder satisfaction.

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