Critical Success Factors of Implementing Green Lean Six Sigma for Developing a Specific Framework

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Abstract— **Research has shown that implementation of Green and Lean Six Sigma make a positive impact on economic, environmental and social performance. Many organizations have already started to integrate the two approaches. However, evidence suggests that these organizations find their implementation challenging, and in many cases they are unsuccessful. The purpose of this paper is to present an analysis of research on Green Lean Six Sigma focusing on success factors in its implementation through a systematic literature review combined with the lesson learned from authors' experiences and verified by a survey of organizations. The findings have led to the identification of five success factors and their ranking according to the organizations that had implemented this initiative. The findings also have led to development of framework for implementing Green Lean Six Sigma.**
Both academicians and professionals will find this paper useful, as it explore critical success factors for successful Green Lean Six Sigma implementation and provides a concise description of each success factors that will be very helpful for organizations to understand and implement Green Lean Six Sigma.

Keywords— Lean Six Sigma; Sustainability; Green; Critical Success factors

I. INTRODUCTION

Recently, with the increase competitive business environment the globalization and the weight on stakeholder's orientation, the market dynamic has changed. Traditionally, efficiency, profitability, responsiveness and customer satisfaction have been the key concern for organizations [1] [2]. However, with the public's growing environmental awareness, increasing requirements of customers, regulators, and other stakeholders about sustainability, the organizations have been forced to change their way of working [3] [4]. Different management systems, such as Lean Manufacturing, Six Sigma and Green, have been explored by a growing number of companies to become more competitive and meet market, environmental and social demands [5] [6] [7]. Many studies have confirmed that Lean Six Sigma can be seen as new opportunities for business sustainability improvement [7] [8] [9] [10]. Lean Six Sigma and Green initiatives are often seen as compatible strategies because of their joint focus on waste elimination, efficient use of resources and focus on satisfying customer needs [11] [12] [13] [14] [15] [16] [17] [18] [19]. Some researchers have suggested that Lean Six Sigma and Green are synergetic approaches that can improve the sustainability performance [20] [21] [9] [22] [23] [24]. In this context, the use of the DMAIC methodology can provide a proven framework for helping organizations to identifying, defining, prioritizing, conducting, managing, achieving, sustaining and improving sustainability projects [25]. However, there are some difficulties in the understanding of the basic mechanisms through which the two strategies can be integrated. Only few organizations have been success to implement Green Lean Six Sigma [26]. The Green Lean Six Sigma implementation faces many challenges and barriers. There are many factors that can enable the Green Lean Six Sigma implementation process. This paper aims to identify the critical success factor (CSFs) for the successful implementation of the Green Lean Six Sigma .The secondary goals is to prepare a platform for further studies, specifically for Green Lean Six Sigma implementation strategy development and analyzing the interactions between Green Lean Six Sigma success factors.

The present paper is structured into six sections, in addition to this introduction. The subsequent sections present the literature review, the research methodology, the success factors for successful Green Lean Six Sigma implementation and survey results and discussions which are followed by conclusions, limitations and future work.

II. LITERATURE REVIEW

Many organizations have implemented Lean Six Sigma initiative in order to increase efficiency, reduce costs, improve customer response time and contribute to improve quality [9]. Others have implemented Green manufacturing resulting in reduced waste generation, energy and raw material consumption, and in the use of hazardous materials [9][27]. Green manufacturing is defined by [28] as a system to "develop technologies to transform materials without emission of greenhouse gases, use of non-renewable or toxic materials or generation of waste". According to [12], Green manufacturing is defined as

"the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources. Green manufacturing also enhances employee, community, and product safety".

On the other hand, Lean Six Sigma is defined as a combination of Lean and Six Sigma philosophies [29]. It is a business improvement methodology that aims to maximize shareholder value, and bottom line results by improving quality, customer satisfaction, speed and costs: it achieves this by using principles and tools from both Lean and Six Sigma [30][31].

The relationship between Lean Six Sigma and Green manufacturing has been well examined in recent studies [11]. Researchers suggest that Lean Six Sigma and Green manufacturing are concurrent and thus can be effectively integrated [11] [23]. They have a lot of elements and end results in common related to waste reduction, product design, lead time reduction, and use of various techniques and approaches to manage supply chain relations, organizations, and people [8][11][23][32][33]. Thus, the Green Lean Six Sigma has emerged as an initiative to improve the environmental efficiency of organizations while still achieving their economic objectives [34][35][36] [37].

III. Research methodology

According to this paper objective, the research methodology followed was based on a combination of research methodology approaches. This includes systematic literature review, lessons learned from authors' experiences in the implementation of Green Lean Six Sigma and survey of organizations. The basic steps flowed are shown in Fig. 1.

The literature review was conducted using many sources, including peer reviewed journal articles and books from both academic and professional organizations and publishers; test-books, dissertations, conference papers and unpublished working were excluded. Relevant publications were identified in the main management databases (Elsevier ScienceDirect; Taylor & Francis, Springer, Emerald Database and Anbar International Management Database) using a number of keywords that are frequently used in the literature to describe the integration of Lean Six Sigma and Green strategies. The keyword combinations are indicated in Table I. The search was done for the period 1993 to present day. The reason for selecting 1993 as the starting point was the publication of the first article discussing the relationship between Lean and Green [38].

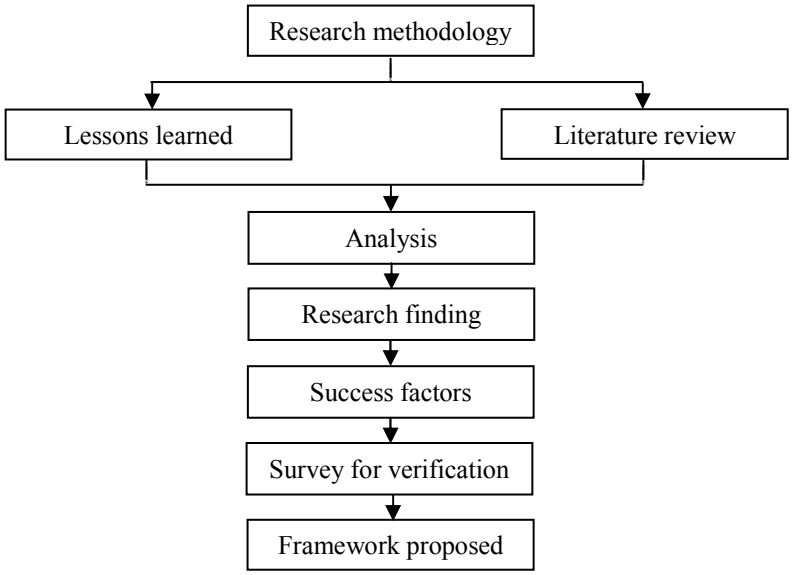

Fig. 1. Research methodology.

TABLE I. KEYWORD COMBINATIONS FOR THE LITERATURE SEARCH

Keyword combinations for the literature search
Lean Manufacturing
Six Sigma
Lean Six Sigma
Green Lean Six Sigma
Green
Sustainability

The preliminary finding of literature review has shown the existence of gaps in knowledge. The research conducted in this field has not provided sufficient information on issues that affect the successful integration of Green and Lean Six Sigma

within organizations. Therefore, we decided to include the lessons learned from our experience. This experience is based on an action research project developed from 2013 to 2015 by a team of Lean Six Sigma and sustainability experts from academia and industry. This project was applied in a group comprised four companies of different sizes operating in diverse range of industries (see TABLE II).

As shown in Figure 1, in order to verify whether organizations that had implemented Green Lean Six Sigma still recognize the same set of factors and which ones they would consider as more important, a survey was developed. A questionnaire was designed and distributed to 450 companies, from various countries and industries that have already integrate Green and Lean Six Sigma. The response rate was 25 per cent, with 113 responses received. In order to measure the consistency of our survey, a reliability test was conducted based on Cronbach's α coefficient and using JMP software. The results indicate that the alpha coefficients are between 0.72 and 0.94. According to [39] a reliability coefficient of 0.6 or higher is considered an acceptable level of internal consistency .Therefore; we can conclude that the data collected is reliable for analysis. The results of the survey are discussed in section V.

TABLE II. LIST OF ORGANIZATIONS INVOLVED IN THIS STUDY

Company	Size	Business sector
C1	SME	Agri-food
C2	Multinational	Automotive
C3	SME	Metal industries
C4	Multinational	Textile industries

For this paper, results obtained from the literature review, authors experience and survey was structured according to thematic synthesis. This method was selected due to its effectiveness. In addition, this article follows the introduction, methods, results, and discussion structure to report the findings. This structure, according to [40] [41], provides an easy and clear to follow flow for the readers of the paper.

IV. CSFS FOR THE IMPLEMENTATION OF GREEN LEAN SIX SIGMA

According to [42], CSFs are those factors necessary to the success of any initiative or program, in the sense that, if goals associated with the factors are not achieved, the implementation of the initiative will perhaps fail catastrophically. The challenge to implement Green Lean Six Sigma is to recognize how to integrate Lean Six Sigma and Green as a systematic approach and identify the best way to sustain the results. Thus, the determination of CSF is critical as it helps organization to focus their efforts and resources on these factors to increase the chance of success.

The CSFs identified through literature review and several lessons that were learned during our experiences are summarizing in the following:

A. Organisational readiness to implement Green Lean Six Sigma

It is important to first understand the preparedness of an organization to implement Green Lean Six Sigma initiative. This action increases the probability of success of the project before an organization invests its resources heavily on the strategy. Based on our experience we suggest that organizations should realize a diagnostic in order to determine its weaknesses and strengths and understand its maturity level to evaluate their own positioning in the Green Lean Six Sigma journey. The results of the diagnostic will indicate whether or not an organization is in a position to implement Green Lean Six Sigma initiative.

B. Project selection and prioritization

Project selection and prioritization is the most challenging phase experienced during a Green Lean Six Sigma initiative. Project selection methodology helps organization to prioritize the project that will give the best return. In addition, selection of the right project will develop confidence in management and employees towards the Green Lean Six Sigma strategy. This in turn will encourage organization to invest and take future efforts into the initiative. It is important to take into consideration the following elements while selecting potential Green Lean Six Sigma projects:

- Selected project needs to be aligned with organizational strategic objectives and stakeholders issues.
- Selected project must be feasible to implement from a resource and technical standpoint.
- Project goals should be clear to the team members involved in the Green Lean Six Sigma initiative.
- Project selected should have the capacity to show measurable sustainability improvements in short time.

Other factors in project selection are having the right people. It is important to attract the best employees from all levels and departments. Team members are selected for their availability, skills and experience with the process under improvement.

C. Commitment of top management and employees

The involvement and commitment of top management and employees in the implementation of Green Lean Six Sigma initiative is critical for long-term success [43] [9] [44] [45] [46] [47] [48] [12] [26]. Without this commitment, it is absolutely a waste of time and energy. The authors believe that an observable commitment by the leadership was crucial to motivate employees and support the strategic role of the initiative. Top management must define the vision, strategic direction and develop an organization culture that promotes continuous improvement in order to improve sustainability performance. Furthermore, they must be able to lead and motivate employees to achieve the economic, social and environmental goals of the organization. In addition, organization must ensure the respect of people, empowerment of creativity; recognition plays a vital role in this context. In turn, employees must engage to ensure the successful implementation of the Green Lean Six Sigma projects according to company strategies and should act as a team [20] [26] [48].

D. Communication

One of the challenges identified by the authors' is that there is a poor communication during the implementation of Green Lean Six Sigma, especially during the early phases of deployment. Organization needs to establish a common language for change and improvement [12] [35] [49] [50]. Furthermore, different stakeholders may have misunderstanding about the Green Lean Six Sigma initiative and their impact on sustainability performance. Only through effective communication, stakeholders will be more engaged and the employees can work as a team for solving different sustainability problems which facilitate the Green Lean Six Sigma implementation.

E. Resource and skills to facilitate implementation

One of the most vital requirements for developing and sustaining process-improvement initiative such as Green Lean Six Sigma is to build human capital by developing the appropriate training and education to employees [12] [43] [45] [48] [51]. The employees should be able to understand and use the Lean Six Sigma tools and techniques into daily operations in order to improve sustainability performance. Team members should be given the necessary resources (financial and technique) and adequate time to implement and execute a project which results in improved economic, environmental and social performance.

F. Focus on measurement and results

Performance measurement is important for Green Lean Six Sigma efforts, it permits to organization to identify the sustainability problems, evaluate the effectiveness of an action plan, and monitor progress towards the goals [12] [20] [47] [48]. The measurement system allows any influencing parameters to be detected and can serve also as a basis for decision-making. In addition, organization should to keep in mind that Green Lean Six sigma is not about tools or methodologies. It is about improving sustainability performance and outcomes in order to achieve better results. In this context, top management should make sure results are the cornerstone of any messaging about the initiative.

V. SURVEY RESULT AND DISCUSSION

The respondents to the survey were asked to score on a Likert scale their perceived importance of each CSF, with 1 – not very important; 2 – not important; 3 – important; 4 – very important; 5 – critical. The results of the survey are showed in Figure 2 and Table III, where the various factors have been classified accordingly to their mean score. A CSF with the highest mean score is considered as the most important factor. According to the respondents' "commitment of top management and employees" is considered the most important with an average of 4.7, followed by "organizational readiness to implement Green Lean Six Sigma", "project selection and prioritization" and "resource and skills to facilitate implementation". Furthermore, respondents do not consider "communication" and "focus on measurement and results" as important for a successful implementation of Green Lean Six Sigma.

TABLE III. AVERAGE IMPORTANCE SCORES FOR CSFS

CSFs	Average score
Commitment of top management and employees	4,7
Organisational readiness to implement Green Lean Six Sigma	4,1
Project selection and prioritization	3,8
Resource and skills to facilitate implementation	3,3
Communication	2,9
Focus on measurement and results	2,5

It is not a surprise the high score of "commitment of top management and employees". It is very important for the introduction of Green Lean Six Sigma in organization, and the results of the survey confirm the thinking process of authors and many experts and researchers [9] [12] [43] [44] [45] [26] [47] [48].

Organizational readiness to implement Green Lean Six Sigma has also been widely perceived by respondents as one of the most important CSF to implement Green Lean Six Sigma. This is because without organizational readiness, this improvement

effort may face barriers and problems during their deployment. It is appears that this factors is more important to practitioners than it was in the literature, where a small number of studies identified it [12] [20] [44] [47] [50].

However, it is surprising to see the low score of "communication" and "focus on measurement and results", as these were often mentioned in the literature as a two key elements that encourage team members to make more effort and focus on more important activities to achieve objectives of Green Lean Six Sigma project [12] [43] [47] [48].

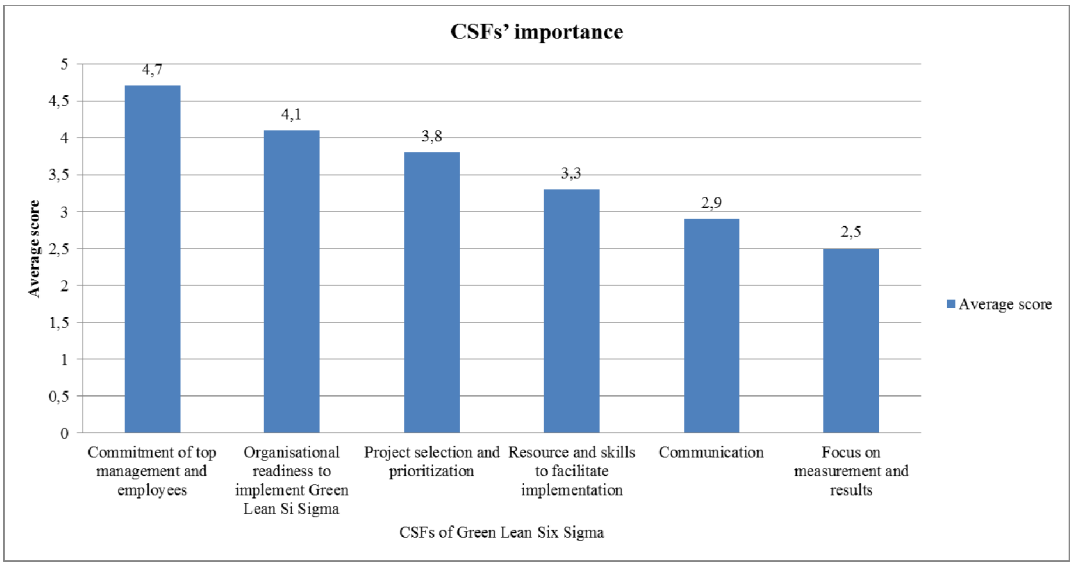

Fig. 2. CSFs' importance.

Based on survey results, we propose a specific integrated framework for implementing Green Lean Six Sigma. The framework provides a comprehensive set of six categories used to assess an organization to integrate Green and Lean Six Sigma. It illustrates the cause and effect relationships between the CSFs on performance and the results achieved (Fig.3).

In the framework, there are six categories used to assess an organization. Commitment of top management and employees helps to set the strategic direction for the organization and drives the mindset of excellence. Project selection and prioritization are positioned after commitment of top management and employees to demonstrate the importance of selection of the right project. Communication is developed based on understanding external and internal stakeholder requirements, which guides the implementation of initiative based on resources and skills of people to achieve desired Results. Measurement is part of the system, which supports decision-making and drives improvements.

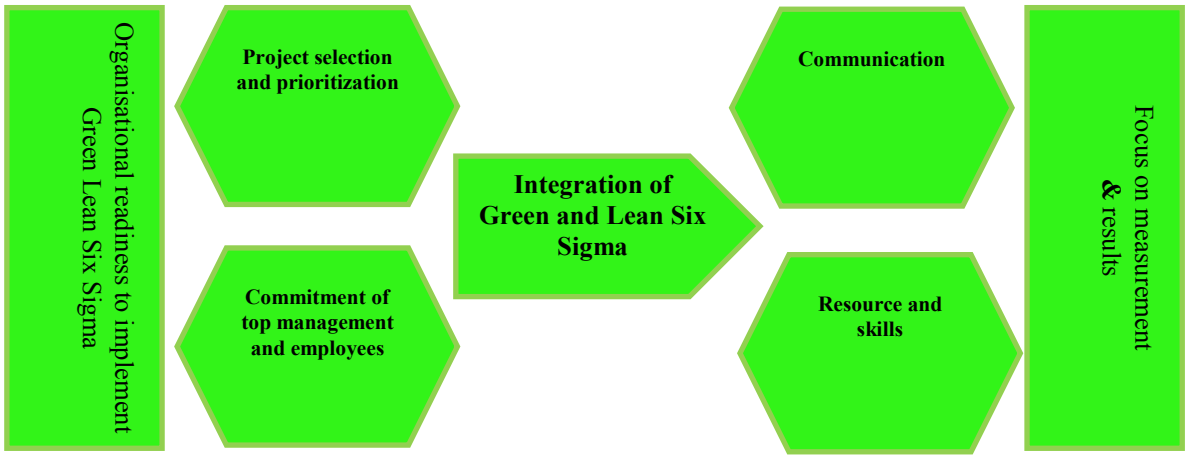

Fig. 3. Framework to implement Green Lean Six Sigma.

VI. CONCLUSION AND AGENDA FOR FUTURE WORK

Lean Six Sigma and Green are very powerful strategies that share common elements related especially to waste reduction. They are compatible and even synergistic and can be integrated to form a superior strategy to achieve economic, social and environmental performance.

This paper aims to identify the CSFs effecting Green Lean Six Sigma implementation. A characterization of each CSF is presented, based on literature review and lessons learned through authors experiences. Second, a survey was conducted in order to verify and rank these CSFs. Based on the results of this survey, the two factors of "commitment of top management and employees" and "organizational readiness to implement Green Lean Six Sigma" have been shown to be the extremely important CSFs for Green Lean Six Sigma implementation.

Through a better understanding of these CSFs, organization will have an idea about the way to deploy Green Lean Six Sigma as a systematic way and recognize the "success formula".

Academics and practitioners could use the results of this paper for future survey development, and as the basis for developing hypotheses for testing, as, for example, which factors are most widely impact the implementation of Green Lean Six Sigma initiative.

This is one of the first attempts to propose the identification of CSFs for implementing Green Lean Six Sigma initiative and for that there are many aspects that need to be investigated further. The experience acquired through four projects and is may be not sufficient to generalize our findings. In addition the data for the survey came especially from developed countries. Therefore, The Green Lean Six Sigma implementation may vary from geographic location and culture of the company. It will be pertinent to classify the CSFs using data from some other emerging and developing countries.

The next step of the study will be looking into the development of a Green Lean Six Sigma Readiness Index Model based on the CSFs for the successful deployment of Green Lean Six Sigma. The authors are interested also to study the structural relationship between Green Lean Six Sigma success factors and developing a model of these CSFs using modeling techniques such as interpretive structural modeling, analytical hierarchy process, and structural equation modeling.

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