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Combine Lean with Green Paradigm as an enabler for an environmentally sustainable supply chain

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Dissertation proposal presented as partial requirement for obtaining the master's degree in Information Management

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COMBINE LEAN WITH GREEN PARADIGM AS AN ENABLER FOR AN ENVIRONMENTALLY SUSTAINBLE SUPPLY CHAIN

by

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ABSTRACT

The incorporation of sustainability and the shift to Sustainable Supply Chains has forced companies to rethink their entire business and simultaneously, improve their environmental performance and efficiency. Lean paradigm has often been associated with Green practices/strategies since both have similar goals. However, the junction of Lean and the Green paradigm is still a recent topic and due to that, it is not yet clear how the Lean paradigm can contribute to an organization's environmental sustainability.

This thesis has the objective of performing a literature review of how the implementation of Lean strategies can contribute to an environmentally sustainable business and, how can these strategies be combined with Green practices to make a company's supply chain sustainable. This thesis also includes an analysis of Lean and Green paradigms and of their practices and techniques. After this analysis, the objective of the investigation is to identify which are the main differences between the Lean and Green paradigm so that, later,

it is possible to identify the synergies between the two concepts in order to be able to define a strategy that encompasses both Lean and Green paradigms with the goal of achieve a Sustainable Supply Chain.

KEYWORDS

Environmental Sustainability; Sustainability; Lean Paradigm; Green Paradigm; Supply Chain.

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LIST OF ABBREVIATIONS AND ACRONYMS

SC Supply Chain

SCM Supply Chain Management

LSC Lean Supply Chain

GSC Green Supply Chain

JIT Just in Time

VSM Value Stream Map

DSR Design Science Research

1.INTRODUCTION

In the last years, due to climate change, depletion of natural resources and pollution, environmental concerns have increasingly gained the attention of the world and society. As the attention for these concerns increases, business world environmental concerns start also to be discussed.

Companies have been pressured to adjust and align their internal practices with environmentally sustainability principles because of the exponential growth of environmental concerns and the growing pressure from the government, regulatory bodies and society (Caldera et al., 2017). The extremely competitive and rapidly changing business environmental requires that companies must be flexible when needed. This in turn have forced organizations to adjust their supply chain (Duarte, 2013).

Supply chain promotes interdependency between all the entities of the supply chain management which are linked by information, material and cash flow (Kainuma & Tawara, 2006). The main goal is to deliver value to the end customer at the lowest possible cost for all entities involved. This is accomplished with the right product or service, in the right quantities, in the right time and in the right place, assuring a continuous flow through the supply chain (Carvalho & Cruz-Machado, 2011).

Nowadays, for an organization to stay competitive in the market it must achieve a product or service with high quality, reduced cost and in less time but they must be aware of the supply chain operations impact on the environment (Mollenkopf et al., 2010; Zhu et al., 2008). In the past, environmentally friendly goods or services were always viewed as a huge problem for the organizations, bringing additional costs in place of bringing competitive advantage (Dimaggio et al., 2012). This, together with the idea that sustainable practices are not profitable in a short term, prevented most companies from finding the adoption and diffusion of sustainable practices a viable pathway (Dimaggio et al., 2012). All things considered, there is a long and exhaustive path until environmental responsibility becomes an important paradigm in the business world (Chen et al., 2013).

Research has recognized that for companies to survive and be stable in the long-term, it is critical that they integrate sustainability issues on their businesses (Porter & Kramer, 2006). So, opportunities are being developed for supply chain improvement: studying new paradigms as Lean, agile, resilient, and Green in supply chain may modify practices in order to achieve a more efficient and sustainable supply chain (Duarte, 2013).

The Lean paradigm or methodology has been considered one of the most used philosophies by organizations in their supply chains (Silva, 2014). A Lean Supply Chain (LSC) ensures low costs, reduced lead times, increased productivity, and quality, at the same time that guarantees the elimination of all wastes caused by the operations. The Lean paradigm is focused in optimizing the processes of all the supply chain and allows organizations to do more with less resources.

The Green paradigm seeks to reduce environmental impacts of all the supply chain operations while eliminating environmental waste in organizations (EPA, 2007). The main goal of the Green paradigm is to reduce the environmental risks and impacts while increasing the environmental

efficiency of the organization and respective partners, and achieving profits and market share objectives (Zhu et al., 2008).

The two strategies are very similar, however, the relationship between Green and Lean paradigms has not been fully explored, existing only a few examples of how Green practices can be integrated with Lean practices (Dües et al., 2013) and which synergies arise from their different characteristics (Carvalho & Cruz-Machado, 2011).

There are numerous recent studies that focus on Lean and Green paradigm, however, there are not so many investigations about the relationship between the two paradigms in supply chain. While the Green paradigm is concerned with the environmental risks of operations and the elimination of negative impacts on the environment (Carvalho et al., 2011), Lean paradigm is focused on eliminating waste, providing greater value to the end customer while using fewer resources and reducing costs (Larsson & Greenwood, 2004).

The supply chain can be considered as an integration of two paradigms, developing a number of principles, practices, techniques, and tools. Some researchers find that Lean paradigm has a positive connection with environmentally sustainable principles (Chiarini, 2014) so, the implementation of an integrated Lean-Green supply chain may be possible to achieve and crucial for the organization stay competitive. Although, there is a lack of research on the integration of Lean and Green supply chain strategies because of the many contradictory aspects between them. To establish the best integration of Lean and Green paradigms, it is crucial to understand each paradigm's characteristics (Dües et al., 2013) and be aware of their compability on each supply chain phase.

This research work aims to study how Lean and Green paradigms can be compatible in a supply chain context and to find how to develop an integrated strategy with the two paradigms in order to achieve an environmentally sustainable supply chain. The relationship between Lean and Green paradigms in a supply chain context will be explored, and the conflicting areas between the two paradigms will be identified as well as identified the conflicting areas between the two paradigms. This will provide insights of what synergies arise between the integration of the two concepts.

Also, this research is focused on developing a framework to combine Lean with Green paradigm in all the supply chain phases and, to propose a set of guidelines to implement the combination of the two paradigms proposed.

We expect to answer the following research questions:

- Is it possible to apply and integrate Green and Lean paradigms in the supply chain context?
- What are the actions needed to switch from Lean to "Lean-Green" supply chain?
- How can companies implement the Lean-Green combination?
- Lean paradigm combined with Green paradigm is an enabler for an environmentally sustainable supply chain?

For most of the organizations that have a Lean supply chain, this study will be a huge contribution to help them starting to adopt Green practices and principles in their operations. This will lead Lean organizations to have an environmentally responsibility and to achieve an environmentally sustainable supply chain.

To answer these questions, the thesis is organized as follows:

- In chapter 2 the literature and theoretical background will be presented
- In chapter 3 the methodology and the research model will be presented
- In chapter 4 the strategy proposed, and the results will be presented
- In chapter 5 the conclusion will be presented along with a discussion about the limitations for future research and recommendations.

2. LITERATURE REVIEW/ THEORETICAL FRAMEWORK

To introduce the problem behind this study there was the need for a theoretical background review to understand what the works were already done in this topic and what kind of concepts are needed to explore a new strategy to combine Lean and Green paradigms.

To be more familiar with all these concepts, we started by studying the main topics behind this master's thesis, Supply Chain Management, Sustainability, Lean paradigm, and Green paradigm.

2.1 Supply Chain

From raw materials acquisition stage to the delivery of the final product to the end customer, supply chain encompasses all activities related to the transformation and flow of products or services, as well as their associated information flows (Kainuma & Tawara, 2006). Chopra and Meindl (2001) defined supply chain (SC) as: "A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves" (Chopra & Meindl, 2001).

Any SC's main goal is to optimize the total value produced, which is the difference between the final product's value in customer's perspective and the effort the SC expends in fulfilling the customer's order, by balancing demand with supply with the least amount of inventory possible (Castro, 2014).

2.1.1 Supply Chain Management

Another term frequently used when talking about SC is the term "supply chain management (SCM)". SCM is a set of processes which an organization executes in order to control its supply chain behaviors and achieve its predefined goals (Nikbakhsh, 2009). SCM is also recognized as a supply network because of its branched structured with multiple intervenients, it can be defined as a set of interdependent organizations that are engaged, upstream and downstream, and act together to control, manage, and improve the flow of materials, products, services, and information, in the all the processes and activities, from the origin point to the delivery to the final customer (Duarte, 2013; Stadtler, 2005).

According to the *Council of Supply Chain Management Professionals (CSCMP)*, SCM includes coordination and collaboration with all the chain partners, who can be suppliers, intermediaries, and customers. Moreover, it comprises every effort concerning producing and delivering a final product or service, from the supplier's supplier to the customer's customer. Mentzer et al. (2001) refer that SCM integrates downstream and upstream management within and between organizations and links the principal business functions and processes (logistics management, manufacturing, marketing, sales, product design, financial control, information technologies, and others) to the achievement of an efficient network.

All flows of information, product, or funds generate costs within the SC, so the appropriate management of flows is essential to SC success (Castro, 2014). SC success is important for organizations because, nowadays, the competition between organizations is no longer between the individual businesses but between network of co-operating organizations along the entire supply chain (Li et al., 2006).

According to Duarte et al. (2011), cited by Castro (2014), the main goal of managing all the flows, since the first point of SC to the last one, is to satisfy the requirements of the final customer at the lowest possible cost for all intervenient. To have an efficient SC, it is crucial to deliver to the

customer the correct product and service at the right place and at the right time, in the right amounts and with the required specifications (Carvalho & Cruz-Machado, 2011).

SCM has become a new and promising way of obtaining competitive advantages in the market (Duarte, 2013). To achieve a competitive advantage with SCM, it is necessary that the organizations that are part of the SC do not think about competing with each other but have a close collaboration (Ferreira et al., 2019).

According to Seuring and Muller (2008), cited by Duarte (2013), the focal company is who rules the supply chain, provides the direct contact to the customer, and designs and produces the product or service offered.

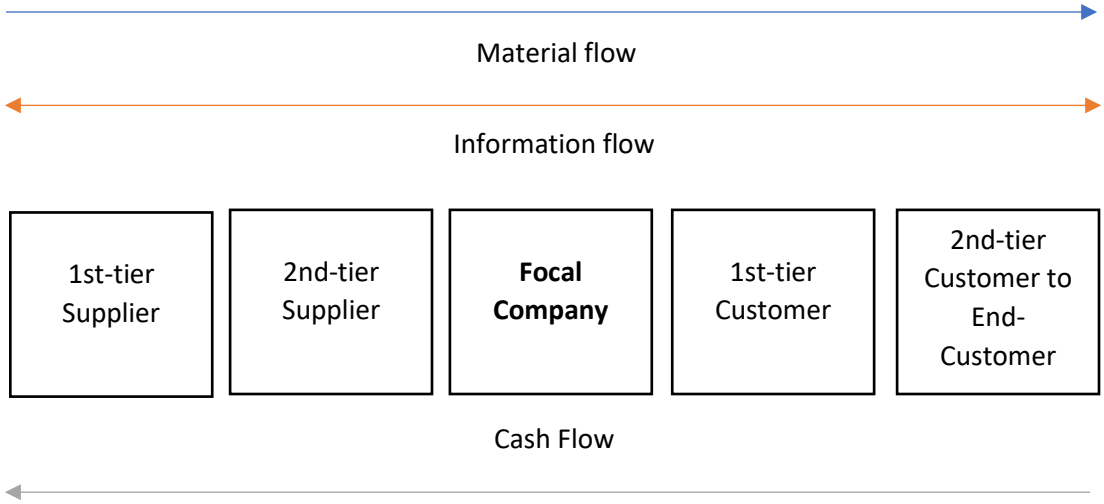

Figure 1-Supply chain, adapted from Duarte (2013)

To make a good management of the SC, all the processes and activities that compose a SC must be viewed as a single system in order to make a good management of the SC (Duarte, 2013). According to Kim et al. (2004), cited by Duarte (2013), the full strategy in SCM has three points of focus: 1) structure, which is related to the facilities localization and processes by stage within the SC, 2) organizational, which includes the determination of which organization takes direct responsibility for each stage of the supply process and the inter-organizational relationships; and 3) process, which covers the issues of planning, performing, controlling operations and processes that need to be coordinated.

SCM has been a subject of concern among organizations. In the SC definition it is possible to identify a number of subjects such as cost, time, and quality. Therefore, many organizations have adopted management paradigms like Lean or Green, to manage and have an efficient SC and, consequently, optimize performance and get competitive advantage (Castro, 2014).

So far, these paradigms have been explored from a separately perspective in isolated contexts but can be integrated in the SC, this is, each paradigm can influenced the SC in different ways (Duarte, 2013). According to Ravet (2012), cited by Castro (2014), Lean and Green SC's are able to satisfy the demands of customers and consequently achieve sustainable development. These two paradigms can be combined to have a better way of work where the materials flows, the information flows and cash flows are optimized (Duarte, 2013). These paradigms recognize new opportunities for SC improvement.

Considering the relevance of these two paradigms in SCM, the question of how these two paradigms can be incorporated within the SC context has not yet sufficiently investigated.

2.2 Lean Paradigm

2.2.1 Lean Paradigm origin

When we think about Lean, the first name that comes to our minds is Toyota. Despite that, the Lean concept started to be used back in 1450s, and Henry Ford was the first person to integrate the Lean concept in the manufacturing system. However, Lean paradigm is a management concept primarily derived from the Toyota Production System (TPS) (Womack & Jones, 1996).

This approach aims to provide a sustainable ecosystem for work, where they are capable of reducing the waste and its subsequent cost, improving the quality of products, guaranteeing efficiency in their processes, and delivering value to the customers (Cabrita et al., 2016). Lean paradigm is frequently linked with the basic expression "doing more with less" (Stone, 2012).

This methodology allows a company to provide more value in the final product delivered to the end customer by increasing the value-added activities, quality and service while focusing on waste reduction (Mollenkopf et al., 2010).

2.2.2 Lean Paradigm principles

According to Womack and Jones, Lean paradigm is defined as a process that includes five principles: defining value from the customer perspective, map value stream, create flow, establish pull and, at least, pursuit for perfection (Womack & Jones, 1996).

Figure 2-Lean principles

- **Define Value**- The value of a product/service is defined from the customer's point of view (Gupta & Jain, 2013) by the specific capabilities offered at a specific cost and time (Womack et al., 2007).

- **Map Value Stream**- Mapping value stream is identifying the entire value stream for each product, this is, the entire product life cycle from raw materials to delivering the final product to the customer (Womack & Jones, 1996). This principle is useful for eliminating waste because with the product life cycle identified we have access to all the activities that make up the production process, which will allow us to identify value added activities, non-value-added activities and the waste identified in these activities (Womack et al., 2007).

- **Create Flow**- This principle suggests that the value creation steps (the value stream) should be made to flow (Hicks, 2007). Making the value steps identified flow is crucial because it means working on each design, order, and product continuously from the beginning to the end so that there is no waiting, during the production, or production of scrap within or

between the steps (Womack & Jones, 1996). This is an important step in searching to avoid interruptions, delays, or bottlenecks.

- **Establish Pull**- The Lean principle of pull ensures that nothing is made ahead of time and the flow does not stop. This means designing and providing what the customer wants only when the customer wants it, which requires a massive flexibility to achieve the desired delivery times (Womack & Jones, 1996).

- **Pursue perfection**- This principle consists of the "continuous process improvements". Considering that the four initial principles interact with each other in a virtuous circle and need to be continuous implemented looking for waste reduction, redefining the definition of value and try to always have perfection in the value chain activities (Womack & Jones, 1996).

2.2.2.1 Value and Waste

In the Lean literature, the value concept is related to adding value because end consumers is only willing to pay for goods and products that add value to them and will not pay for non-adding activities. So, these activities must be drastically deleted (Helmold, 2011).

As explained before, Lean thinking has its roots in TPS and focuses on waste reduction. The very first definition of waste has its origins in Ohno (1988) of Toyota and Ohno also had identified seven types of wastes that were lately reported by Womack & Jones (1996). The seven wastes are:

Waste	Description
Overproduction	Making too much, too early or "just in case", resulting in an excess of production and an increased inventory.
Waiting	Production stops because of periods of inactivity in a downstream process because an upstream activity has not delivered on time.
Transport	Unnecessary movement of materials, such as work in progress (WIP) being transported from one operation to another, not adding value to the product.
Overprocessing	Operations that were not requested (Rework/Reprocessing).
Inventory	All the inventory that is not directly required to fulfil current orders.
Motion	Unnecessary or extra movements refers to employees and equipment.
Defects	Rework relative to correct finished goods or services that do not conform with the customer expectation.

Table 1- Seven Lean wastes

Adding to the seven wastes identified by Ohno (1988), Womack and Jones (1996) identified an eight waste. This waste arose as the underutilization of people capabilities, for example not

listening to people ideas or creative suggestions that might improve the processes (Womack & Jones, 1996). Also, adding to these eight wastes, some authors, such as Vinodh (2011), identified a ninth waste as "environmental waste" regarding to the unnecessary use of resources or inappropriate resources, as well as air, water or land-released pollutants that could affect human or environmental health (Vinodh et al., 2011).

When adopting Lean paradigm, a company hopes to eliminate these wastes within its production processes and apply methods to eliminate these wastes, for this to happen it is necessary consistency on production processes and that they work correctly. To mitigate inconsistency or changes in a process, the company should use the Lean tools (Rei, 2016).

2.2.2.2 Lean Paradigm Tools

There are several tools in the Lean Paradigm that are effectively used for reducing wastes in the organization helping it to always be able to meet the customer's needs. Some of these tools include Just-in-Time (JIT), Value Stream Mapping (VSM), Kaizen, Material Requirement Planning, 5s, among others (Womack & Jones, 1996). I will briefly explain each one:

a) **Just-In-Time (JIT)**- This tool holds on the pillars of effective planning and the execution of events required to produce a product (Gupta & Jain, 2013). Karlsson & Ahlström (1996) claimed that each event and process should be treated in the correct manner, with the correct need to produce products and with the correct timing (Karlsson & Ahlstrom, 1996). This tool aims to constantly adjust the production plan correctly to the speed imposed by the customer derived from the pull system (Rei, 2016). The main objective of this tool is to reduce wastes as well as reduce lot sizes, buffer sizes, and order lead times. The pull system allows that waste such as waiting, overproduction or inventory is avoided because of the integration of clients and suppliers in the production process (Kannan & Tan, 2005).

b) **Value Stream Mapping (VSM)**- VSM is a graphical tool and provides a visual map of all the activities that compose the product life cycle. This helps to enlighten and analyze the work-flow and to find the value-added and non-value-added activities that contribute to the final product (Gupta & Jain, 2013). Besides, the tool also helps the company to have a macro layout of the current general panorama of company, which will allow the company to make better decisions aimed at improving a productive system (Rei, 2016). With this layout, it is expected to identify more easily the constrains in the value creation flow, the value-added activities and non-value-added activities (Pattanaik & Sharma, 2009). Due to this tool, it is possible to identify the waste activities, along with the resources allocated to them. Value Stream Mapping has four stages: preparation, current map, future map, and an improvement plan (Folinas et al., 2013). After the VSM of a product is carried out, an improved future state of the value stream of the product is created which is mainly dedicated on the reduction of wastes, the decrease in lead times, and improvement in the material flow (Gupta & Jain, 2013).

c)**Kaizen**- Kaizen is a Japanese term used for continuous improvement, "Kai stands for change and Zen stands for the better" (Singh & Singh, 2009). This is a fundamental tool of Lean paradigm and it means improvement initiatives that increases success, reduces failures and aims the continuous improvement of everyone (Sundar et al., 2014). According to the Kaizen Institute (2013), companies that implemented the Kaizen tool in their daily lives became more competitive than the others (Kaizen Institute, 2013). Kaizen is used to eliminate problems step by step by collecting data, analyzing the root causes, finding and picking the best solution from

various options (Gupta & Jain, 2013). Also, the *Plan-Do-Check-Act* (PDCA) methodology can be used (Rei, 2016), PCCA is a document that tell us all the information about the identified problem and means:

- Plan- Identify the problem, collect relevant data, and understand the problem's root cause, develop solutions, and decide the best one to test
- Do- Test the solution and measure results
- Check- Review and check the results by comparing the before and after data
- Act- Document the results and make recommendations.

d)**Material Requirement Planning (MRP)**- MRP is a company's day-to-day tool that converts the requirements of end products into a detailed schedule of raw materials, allowing to estimate correctly the requirements for inventories and the raw materials that will help the company to make and manage a better production plan without failures (Gupta & Jain, 2013). The material plans and production schedules are based on the lead times of a supply chain. The inputs needed to create an MRP system are: the production schedule outlining the exact quantities of product to be made, the current inventory holding, and the list of materials for each finished product line (Vargas, 2009). After obtaining all the inputs, the MRP system collects all of this information and generates purchase/production orders. There are two MRP systems, the MRP I and MRP II, and they are part of the planning function within an ERP (Enterprise Resource Planning) system.

e)**5s**- The 5S tool owes its name to the words: sort, set, shine, standardize and sustain. These five words define the five concepts of this methodology (Omogbai & Salonitis, 2017):

- Sort- Select the tools, materials, equipment, etc. needed to be present to carry out the work and determine what can be removed, which will help to organize the workspace.
- Set- Define and clearly label where everything should be stored, which will help reduce the time dispended to search for things.
- Shine- Make efforts to keep the workspace clean and organized, which will increase the motivation.
- Standardize- Create documents for organizing the workspace and to help make the 5s methodology part of the organization's culture.
- Sustain- Create routines of continuous improvement practices that will help ensuring the discipline.

This tool aims to improve the company's performance by making the company more organized and standardized, at the same time that helps to decrease non-value adding time, increase productivity and improve quality by increasing the safety levels and cleaning of the workplace (Gupta & Jain, 2013).

According to Vonderembse et al. (2006), the application of these tools and techniques brings improvements such as: a) decreased lead times, b) reduced inventories, c) increased process understanding, d) less process waste, e) less reworking and f) financial savings.

2.2.3 Lean Supply Chain

Lean practices, when applied in an enterprise, have as an objective the improvement of the company's value by reducing all of the waste generated in the production of final products and fulfill the customer's need to improve their satisfaction (Womack & Jones, 1996).

Companies are increasingly under pressure to reduce their delivery times, lower their costs and, at the same time, improve the quality of their service / product. Because of this, Lean principles began to be adopted by companies and incorporated into supply chains (Tortorella et al., 2018). Today, the Lean paradigm is dominant in manufacturing and reaches from customer needs right back to raw material sources (Venkat & Wakeland, 2006).

Melton (2005), cited by Duarte (2013), refer that Lean changes businesses completely, by changing how the SC operates, how the directors direct, how the managers manage and how employees go about their daily work. This author also defines that Lean can be applied to all the SC aspects. To create a LSC it is necessary to analyze each process and identify all the unnecessary resources that can be measured in cost time or inventory as well as the elimination of all waste and non-value added activities along the SC and the delivery of a low-cost product (Carvalho & Cruz-Machado, 2011; Vonderembse et al., 2006; Womack et al., 2007).

In resume, LSC reduces waste in the downstream supply chain, while making the correct product available at the right time and place to end user (Engin et al., 2019). The main purpose of a LSC is based on cost reduction and flexibility, while maximizing the profits earned (Carvalho & Cruz-Machado, 2011) through continuous improvements efforts that focus on reduction or elimination of all the waste produced or non-value added activities (NVA) along the entire supply chain (Mollenkopf et al., 2010).

This type of supply chain is supported by efforts to achieve product efficiency and reduction of preparation times, which allows the production of small quantities, reduces costs and increases profitability and production flexibility (Vonderembse et al., 2006). Vonderembse et al. (2006) in their work also refer that applying a LSC results in competitiveness.

LSC encompasses all the processes through the product life cycle, from product design to product selling, from the customer order to the delivery of the goods (Carvalho & Cruz-Machado, 2011). All these processes and their respective activities are mapped in the Value Stream Map (VSM) in order to identify the wastes and the non-value-added activities.

The lean product design strategy consists of maximizing product performance while minimizing costs (Dües et al., 2013), in addition to enhancing cost minimization, the product design strategy is constantly changing due to the flexibility of the LSC, which allows companies to make constant improvements in their products and their quality, searching for customer's satisfaction (Vonderembse et al., 2006).

The procurement strategy assents on an approach of choosing suppliers that have the same characteristics as the Lean paradigm, for example, low costs and high quality materials (Dües et al., 2013).

The Lean production is motivated by real customer orders, instead of forecasts that try to predict what will be the market demand. Lean creates a new approach in terms of demand variation: the pull approach. This approach is all about waiting for the customer's order because nothing is done until the customer's demand for a product and the order "pulls" the product through production, in place of the typical forecasts that were pushing the product into the shop floor

(Carvalho et al., 2017). The Lean manufacturing approach is also supported by Lean techniques such as: just in time practices (JIT), 5s, material requirement planning (MRP), and many others (Vonderembse et al., 2006).

The distribution and transport of goods is influenced by the fact that Lean manufacturing is based on techniques such as JIT, which means that materials handled during production are limited, which encourages deliveries of small amounts of finished products, increasing the amount of relative transportation drives of goods (Carvalho & Cruz-Machado, 2011).

Regarding the end-of-life management, in the Lean paradigm, the concern and the scope of the supply chain only goes on until the sale of the final product. What happens from that moment onwards, such as the evaluation of the product use impact or te recovery of the product at the end of its life, is not considered by the Lean approach (Srivastava, 2007).

2.3 Sustainability

The term “Sustainability” started to gain attention through a publication made by the World Commission on Environment and Development (WCED) in 1987, with the objective of setting an agenda with the changes urgently to be made on United Nations. In the publication made by WCED, they aligned sustainability with development, creating the following definition for sustainability development: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland et al., 1987).

The concept of Sustainability or Sustainability Development is well recognized today and, although it started to emerged over 30 years ago, it has still not been fully grasped (Mulvihill & Milan, 2007).

It can be said that Sustainability is the capacity to endure and a set of different dimensions is often referred, fundamentally: human, environmental, social, and economic dimensions (Goodland, 2017). It can also be said that sustainability is a business approach to creating long-term development, considering the way an enterprise works in an ecological, social, and economic climate (Haanaes, 2016).

2.3.1 Environmental Sustainability

Awareness and use of the term "environmental" appear to be correlated with human effect on natural environments quite frequently. “Environmental” is used to describe the human interaction with the ecosystem. According to Morelli, the term “environmental sustainability” is connected with the ecological concept, becoming a subset of ecological sustainability. The same author defends that “environmental sustainability” gives it even more strength to the definition present by Brundtland in WCED publication, on sustainability development by taking a new definition “meeting the resources and services needs of current and future generations without compromising the health of the ecosystems that provide them” (Morelli, 2011) (Brundtland et al., 1987). Basically, the term “Environmental Sustainability” means the constant concern with whether environmental resources will be protected and preserved for future generations, or not.

When authors refer to the concept of environmental sustainability in the business context, they refer to a "win-win" relationship because the main objective of this concept, when applied in a company, is to increase the value delivered to the final customer, while not harming the environment by reducing the company’s ecological footprints (Stubbs & Cocklin, 2008).

A company that integrates or wants to integrate environmental sustainability into its business model, will now have to incorporate environmental problems into its objectives and always have to promote environmental sustainability, even if it is through environmental projects, policies, or partnerships (Brennan et al., 2011). The company, in its entirety, must respect the environment, whether through its production, internal processes, distribution or acquisition of raw materials.

2.4 Green Paradigm

The concept of Green paradigm appears at a stage when the planet's environmental situation has been facing constant degradation. The worrying environmental situation on the planet has been causing many problems for companies as they have been forced to rethink their business model and reformulate organizational culture to cover environmental concerns. The same goes for governments that, given the growing environmental degradation, had to create laws and standards for companies to meet certain requirements to reduce their environmental footprint. Thus, the concept of "Green paradigm" begins to be a company philosophy (Engin et al., 2019).

Since environmental concerns are part of society's thoughts, the population began to look at companies differently. Society started to worry about whether companies integrate environmental and sustainable concerns in the production of their goods or not. This has led companies to integrate environmental concerns on their business models in order to achieve a strength when compared to other companies (Cabrita et al., 2016).

It is normal for companies to be afraid of integrating new practices into their business because they do not know what to expect. Although, according to Porter & Linde (1995), adopting Green paradigm principles and practices can be an important competitive advantage for the company (Porter & Linde, 1995). The same authors defended such affirmation by saying that adopting Green practices into businesses can lead to companies saving their resources, eliminating all the waste caused and, at the same time, increasing productivity. In other words, what these authors argued was that if a company adopts Green and sustainable practices, it is not only reducing the impacts that its business model has on the environment, but also improving its productivity, which, consequently, increases its efficiency and allows the company to stand out and gain a competitive advantage over other companies (Pejić et al., 2016).

The general purpose of the Green paradigm is to reduce environmental risks and impacts while increasing the environmental efficiency of the organization and their partners (Zhu et al., 2008), focusing on reducing the environmental impact of manufacturing activities through elimination of resource waste and pollution (Mollenkopf et al., 2010). This paradigm aims is that companies, in the long run, can minimize the adverse environmental impacts of production (air pollution, water and soil) and try as much as possible to minimize the resources used, from the acquisition of raw materials to the final use of the product by the end consumer (ElTayeb et al., 2010)

2.4.1 Green/ Environmentally Sustainable Supply Chain

Organizations started to be aware of environmental needs that are important to consider in the businesses. These needs became more complicated when the SC is considered (Venkat & Wakeland, 2006). Due to the increasing pressure on companies to reduce the negative impacts of their SCs on the environment (ElTayeb et al., 2010), the SCM started to experience a paradigm shift with the growth of environmental movement by intregating environmentally choices into supply chain management practices (Srivastava, 2007).

According to Vachon and Klassen (2006) there is an increasing need for integrating environmentally choices into SCM research and practice. The Green supply chain management concept (GSCM) (Srivastava, 2007) or environmentally sustainable supply chain management concept (ESSM) (Zhu et al., 2008) have origin on the same publication made by the WCED, in 1987, when it defined the concept of sustainability and sustainable development.

An ESSM is about operationalize environmentally conscious practices throughout the supply chain activities (Hervani et al., 2005) and has emphasis on complying with government environmental regulations and policies, embrace practices and support performance measures to meet the regulations (Coyle et al., 2015) . Incorporating environmental aspects into the Supply Chain is more than considering environmental concerns but also productivity and profits. The ESSM concept has emerged as an organizational philosophy that seeks, at the same time, to achieve corporate profit and market share objectives by reducing environmental risks and impacts, while making the business and its partners more environmentally effective (Carvalho & Cruz-Machado, 2011).

Srivastava (2007) define ESSM as "the integration of environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as the end-of-life management of the product after its useful life" (Srivastava, 2007). Greening the Supply Chain has numerous benefits to a company, ranging from improving their ecological efficiency and competitiveness (Zhu et al., 2007), cost reduction (Amemba et al., 2013) and increasing the company's competitive advantage (Ortas et al., 2014).

The strategies adopted for this type of supply chain are based on implementing measures and procedures that allow controlling environmental impacts during all phases of supply chain and, in addition, ESSM is also involved in fundamental changes in product and process designs that make managing the closed-loop supply chain simpler (Hervani et al., 2005; Klassen & Vachon, 2003). To achieve a GSC, it is essential to integrate organizational Green management practices along the supply chain and these practices should cover all of the supply chain activities (Carvalho et al., 2011) from Green purchasing to intregrated life-cycle management supply chains flowing from the supplier to the manufacturer and then the customer, closing the cycle with reverse logistics (Zhu et al., 2008). This type of supply chain requires collaboration between customers an suppliers, analysis of internal processes and environmental concerns into the product development process (Mollenkopf et al., 2010).

GSC focuses on reducing environmental risks and impacts of manufacturing activities through the elimination of resource waste and pollution, while enhancing environmental efficiency (Carvalho & Cruz-Machado, 2011; Zhu et al., 2008).

Green design was defined by Fiksel (1996) and cited by Nikbakhsh (2009) as the systematic consideration of design issues related to environmental health and safety over the product life cycle during new product design and production process design (Nikbakhsh, 2009). According to Zhu et al. (2008), "eco" is a crucial factor governing the environmental impact of a manufactured product, since the materials and processes are selected at the design stage. The product design strategy used by GSCM is called eco-design or Green design and it is concerned with development of products that are healthier and energy-efficient and, that avoid the use of harmful materials and can be easily disassembled for recycling (Gottberg et al., 2006). This method avoids the generation of wastes and improve the efficiency of resource usage by adjustments in product size, service life, recyclability and characteristics of use (Carvalho & Cruz-

Machado, 2011). At this phase, the life-cycle analysis of the product is made through the life-cycle assessment (LCA) tool which is a tool for assessing environmental impacts and resource consequences of a product through all the stages of the product life-cycle, from procurement phase through production, use and disposal (Srivastava, 2007), it evaluates the environmental impacts of your product or service from the very first to the very last or from cradle to grave.

The procurement strategy, material sourcing and selection, assents on "Green purchasing". Green purchasing can be described as an environmental sourcing activity meant to ensure that the purchased goods and materials meet the environmental goals set by the purchasing company, such as reducing waste resources, promoting recycling, reuse and material replacement (Younis et al., 2016). The materials purchased must be either recyclable or reusable or have already been recycled (Sarkis, 2003).

The manufacturing strategy assents on "Green manufacturing" and aims to reduce the environmental burden by utilizing proper material and technologies, while remanufacturing refers to an industrial process for restoring products that are longer fit for use and turning them into new ones (Srivastava, 2007). Sarkis (2003) said that GSCM is influenced by some production process characteristics, namely, the process capability to use particular materials, the possibility to incorporate recyclable or remanufactured components into the system and design for waste minimization (water, energy, raw masterials, non-product output) (Sarkis, 2003). The operations are intended to reduce, recycle, production planning and scheduling, inventory management, remanufacturing, reuse, and product and material recovery (Srivastava, 2007).

Product distribution and transportation activities are operational activities that have a major impact on the GSC. These two activities are influenced by a series of decisions such as location of distribution points, type of transport to be used, control systems and JIT policies, decisions that in themselves will also affect reverse logistics (Sarkis, 2003). When the whole supply chain is considered, the incorporation of environmental concerns becomes difficult because, with the fast increase of long-distance trade, supply chains are consequently covering larger distances, consuming significantly more fossil fuel energy for transportation and producing much more carbon dioxide, which is very bad for environmental performance (Venkat & Wakeland, 2006). Carbon dioxide emissions can be a key indicator of both energy use and pollution in supply chains and to achieve low levels of fuel energy consumed and C02 emissions it is important to keep a reduced replenishment frequency on Green supply chain (Venkat & Wakeland, 2006).

Lastly, the end-of-life management of the product after its useful life or, more abbreviated, the reverse logistics process, from an environmental point of view, emphasizes on the return to the forward supply chain of recycable or reusable goods and materials (Sarkis, 2003) and, considering the impact of produte use (Srivastava, 2007). Reverse material and information flows need to be integrated into the supply chain in order to reintroduce recycled materials, components and products into downstream production and distribution systems (Carvalho & Cruz-Machado, 2011).

Packaging is another characteristic that has impact on the distribution and affects the transport characteristics of the goods such as size, shape and material content (Sarkis, 2003). Sarkis (2003) also affirm that better packaging will minimize the use of materials, increase the use of space in the warehouse and in the trailer and decrease the amount of handling needed.

GSCM promotes efficiency, synergy among business partners, and that it helps to enhance environmental performance, eliminate waste and achieve cost savings, resource saings and productivitiy improvements (Srivastava, 2007), and ecological efficiency (Zhu et al., 2008).

Despite the shift of focus, the goals of visibility, efficiency and cost reduction do not have to be discarded (Rao and Holt, 2005), cited by Duarte (2013). For example, in order to be accepted as preferred suppliers, companies have strict requirements with recognized standards (ISO 14001), technical and performance specifications that their suppliers must follow. It is expected that the environmental risk associated with these manufacturers will be reduced (Sarkis, 2003), so Green practices must be implemented into the entire SC (Zhu et al., 2008). The perspective changes from greening as a "burden" to greening as a potential huge source of competitive advantage (Srivastava, 2007; Zhu et al., 2008).

According to Craig et al. (2009), cited by (Duarte, 2013), the most important agreement with the objective to combat climate change was the Kyoto Protocol where limits were established, and certain industrialized countries were enforced to measure their gas emissions. Other environmental performance metrics include scrap or non-product output, materials use, hazardous materials use, energy use, water use, air emissions, hazardous waste, and water pollution (Venkat & Wakeland, 2006).

Without sacrificing quality, value, reliability, performance or energy consumption efficiency, Green supply chain management may reduce the ecological effect of industrial activity, compliance with environmental regulations to not only mitigate ecological harm, but also contribute to overall economic benefit (Srivastava, 2007). It is necessary to integrate the Green paradigm into the SCM to achieve a sustainable supply chain and maintain a competitive advantage (Carvalho et al., 2011).

2.5 Integrated Supply Chain

Organizations nowadays are facing a huge pressure to comply with SC lead times and to answer to the actual market pressures and unpredictability. In today's business environment the challenge is to combine and integrate the previous paradigms explained (Duarte, 2013).

Organizational systems are composed of subsystems and internal processes that are related to each other. As a result, although various parts of a company perform different tasks, they all work together to achieve the strategic goals set by senior management (Castro, 2014), thus, it is required that all the internal processes are integrated with each other (Samaranayake, 2005).

In literature it is possible to find a comprehensive set of practices associated to Lean and Green paradigms, as well as some works comparing both paradigms.

Venkat and Wakeland (2006) in their work studied if LSC has actually been Green, focusing on a key performance indicator- carbon dioxide emissions. These authors concluded that the main factor of conflict between the two paradigms is the fact that the Lean paradigm leads to an increase in delivery trips, which clashes with the Green principle of reducing carbon emissions.

Kainuma and Tawara (2006) analyzed both paradigms extending the scope of SC to include reuse and recycling throughout the life cycle of products and services in a reverse SC. Dües et al. (2013) in their work investigated how to use Lean practices as a catalyst to greening SC based on a extent literature review focused on the relationship and links between Lean and Green SCM practices. Larson & Greenwood (2004) concluded that the implementation of Lean paradigm in SCM generates significant improvents in resource productivity, reducing the quantities of energey, water, raw materials, and non-product output associated with production processes, minimizing the ecological footprint of industrial activity.

Mollenkopf et al. (2010) examine the relationship among Green, Lean, and global SC strategies. Carvalho and Cruz-Machado (2011) also studied the integration of Lean, agile, resilient, and Green paradigms in SCM and make a comparison between the four paradigms concluded that those paradigms may help organizations and their SC to become more competitive and sustainable.

According to Ravet (2012), cited by Castro (2014), Lean and Green paradigms should not be considered alone or in isolation within the SC. Also cited by Castro (2014), Vasconcelos et al. (2013) refer that the use of different management srategies may help to get better operational results when combining the best practices, of different strategic models, in key areas of the organization. Thus they suggest that by combining the tools of Lean and Green paradigms, the achievement of better business results can be promoted and improve the service of customer needs.

As refferred before, the challenge is to combine and integrate Lean and Green paradigms on the same SC. Consequently, it is important to investigate and increase knowledge of the trade-offs between these two paradigms.

The U.S. Environmental Protection Agency (EPA) created a document called "The Lean and Environmental Toolkit" based on practical experiences from a group of partner organizations that have knowledge with managing Lean implementation and environmental management. This document present and adds environmental metrics to the Lean paradigm, referring that "using environmental metrics in Lean efforts will allow organizations to document the environmental benefits that are part of Lean implementation, as well as identify targets for future improvement efforts" (EPA, 2007).

2.5.1 Lean and Green synergies, similarities, and differences

2.5.1.1 Synergies

Lean paradigm goals are to increase efficiency, reduce costs, reduce wasted time, maximize performance, and eliminate waste. At first glance, the benefits seem to be the same as of turning Green, so it makes total sense to study and investigate some of the similarities and synergies, where Green paradigm intersects with Lean paradigm.

To achieve a synergy, all partners have to influence positively each other, increasing the benefits of the relationship (Dües et al., 2013). Dües et al. (2013) mention that a synergy is frequently described with the equation 1+1=3, and it means that combined practices have better results than the sum of the individual performances. There are few studies about the relationship between Lean and Green paradigm but, according to Bergmiller and McCright (2009), cited by Dües et al. (2013), organizations that have already implemented Lean paradigm and then include Green practices achieve better Lean results than those companies which do not. Dües et al. (2013) also debate in their work the synergies between the two paradigms, claiming that setting targets for Leanness would serve as an enabler for effectively adopting Green practices and achivieng Green goals (Dües et al., 2013). Bergmiller and McCright (2009) have found that only when both paradigms are executed simultaneously, Lean and Green can unfold their full potential and generate greater benefits than when implemented individually and that is a synergy.

Carvalho e Cruz-Machado (2011) also describe Lean and Green paradigms as a synergistic joining of environmental and operations managements.

Hansen et al. (2004), cited by Dües et al. (2013), affirm that "while Lean practices can lead to environmental benefits, inversely environmental practices often lead to improved Lean practices". So, in a synergy of the Lean and Green paradigms, Lean has to enhance Green practices while the Green has to be synergistic for Lean (Castro, 2014).

Castro (2014) in his work refers an example found in literature about Bergmiller and McCright's (2009) work, showing that they concluded that moving towards Green paradigm is more than just a coincidental side-effect but rather a natural extension. This means that Green practices are partially a natural extention to Lean withouth the absolute intention of being Green (*All Answers Ltd.*, 2018). Bergmiller and McCright (2009) also affirms that Green practices will improve Lean efforts and adress even further urgent environmental issues that organizations need to deal with, they state that Green practices serve as a catalyst to Lean results, which indicates the huge potential for integration (Castro, 2014).

2.5.1.2 Similarities and Differences

Similarities

The combination of Green and Lean paradigms in Supply Chain Management was studied by a few number of authors (Castro, 2014) but some researches have investigated various aspects of Lean and Green paradigms and came to the conclusion that Lean and Green connection goes beyond waste reduction (Dües et al., 2013).

Carvalho and Cruz-Machado (2011) explore the integration of Lean, agile, resilient and Green paradigms and describe the causal relationship with supply chain attributes and key performance indicators (KPIs) (cost, service level and lead time) in a conceptual model. Their investigation had provide understanding of synergies and discrepancies between them, having the synergies arising from the different characteristics of Lean and Green paradigm on the SC attributes of capacity surplus, integration level, inventory level, production lead time and transportation time (Carvalho & Cruz-Machado, 2011). Mollenkppf et al. (2010) in their work study the relationship of Green, Lean, and global supply chain strategies. They concluded that Lean and Green strategies are similar in that they both require efficient structures to reduce the output of unwanted by-product and have a significant effect on supply chain functional processes (Dües et al., 2013; Mollenkopf et al., 2010).

In their work, Dües et al. (2013) made a comparison of Lean and Green paradigms on purpose, focus, customers, structre and on specific SC characteristics like the relationship with suppliers and customers, and all stages of the SC, from product design, raw materials acquisition, manufacturing, distribution, usability and enf-of-life management. They also compare the waste reduction techniques and some tools that are employed for each paradigm (Dües et al., 2013).

Table 2 shows an overview of the comparison of both paradigms, based on the work done by all these authors highlighted above, being possible to identify some similarities and divergences between the two paradigms.

Characteristic	Lean Paradigm	Green Paradigm
General Purpose	Focus on cost reduction and flexibility, through continuous elimination of waste or non-value added activities (Vonderembse et al., 2006).	Focus on sustainable development and on reduction of environmental impact of industrial activity (Carvalho & Cruz-Machado, 2011).

Target	Customer driven by reduced costs (Dües et al., 2013).	Customer driven by eco-friendly products (Dües et al., 2013).
Approach to choosing suppliers	Supplier attributes involve low cost and high quality (Vonderembse et al., 2006).	Green purchasing (Zhu et al., 2008).
Product Design strategy	Maximize performance and minimize costs (Vonderembse et al., 2006).	Eco-design and LCA for evaluate environmental impacts (Zhu et al., 2008)
Manufacturing focus	High average utilization rate (Vonderembse et al., 2006). Use of JIT practices.	Focus on efficiency and waste reduction and developing remanufacturing capabilities (Sarkis, 2003).
Distribution Strategy	Frequent small deliveries of finished products (Carvalho & Cruz-Machado, 2011)	Reduce replenishment frequency in order to reduce fuel consumption an C02 emissions (Venkat & Wakeland, 2006).
End-of-life management	No conern for impact of end-of-life recovery (Srivastava, 2007).	Concerns with product's use impact as well as end-of-life recovery in form of reuse or recycling (Srivastava, 2007).
Relationship with suppliers and customers	May participate in traditional alliances such as partnerships and joint ventures at the operating level (Vonderembse et al., 2006).	Inter-organizational collaboration involves activities of transferring or disseminating Green knowledge to partners (Cheng et al., 2008).
Inventory strategy	High turns and minimizes inventory (Vonderembse et al., 2006).	Reduced product dimensions; making products foldable for storage and transport (Gottberg et al., 2006). Introduce remanufactured or re-used parts in the material inventory (Srivastava, 2007).
Organizational structure	Few levels in the hierarchy (Vonderembse et al., 2006).	Approach that integrates environmental thinking (Srivastava, 2007). Internal environmental management (Zhu et al., 2008).
Lead time focus	Shorten lead-time as long it does not increase cost (Vonderembse et al., 2006).	Reduce transportation lead time as long it does not increase carbon emissions (Venkat & Wakeland, 2006).
Product life cycle	Long because of the production of standard products (Vonderembse et al., 2006).	The product life cycle is influenced by the design for environmental issues, the improvement of processes and having an efficient reverse logistics system in place (Sarkis, 2003).

Principal tool	VSM (Simons & Mason, 2003).	LCA (Kainuma & Tawara, 2006).
Waste reduction techniques	7 wastes: Elimination of waste in all operational processes (Dües et al., 2013).	Product redesign, dissassembly, remanufacturing, recycling, etc. (Bergmiller et al., 2009).
Tools/ practices	VSM, JIT, low inventory, shorter lead times (Carvalho & Cruz-Machado, 2011).	Reduction of unnecessary materials, Waste minimisation, Reduction of transportation lead time, Reduction of replenishment frequency (Carvalho & Cruz-Machado, 2011).

Table 2- Similarities between Lean and Green paradigm

It can be affirmed that the major similarity between Lean and Green paradigm is centred in the objective of waste elimination, even though the definition of "waste" is different for both paradigms. So far, Lean and Green paradigm were seen as "distinct collection of solutions addressing multiple sources of waste" (Bergmiller, 2006).

When speaking of waste in Lean paradigm, this usually relates with the seven or eight types of waste as referred by (Ohno, 1988), (Womack & Jones, 1996), respectively, and also with the non-value adding activities (Helmold, 2011).

When talking about waste in Green paradigm, this is related with environmental wastes regarding inefficient resource use, pollution or production of scrap (Mollenkopf et al., 2010). Even though the two concepts have different definitions for waste elimination, they focus on the same type of wastes (Dües et al., 2013).

In table 3, we can see the environmental impacts of the eighth Lean wastes.

Waste	Lean Paradigm	Environmental impact
Overproduction	Production in excess	Inefficient use of resources and production of scrap (Carvalho & Cruz-Machado, 2011).
Waiting	Production stops waiting for something (resource, task, etc.)	Deterioration of the material used (Herrmann et al., 2008).
Transportation	Unnecessary movement of materials	CO2 output from transport (Venkat & Wakeland, 2006).
Overprocessing	Putting more work into producing the product than the customer values	Waste of raw materials and waste of energy consumed (Herrmann et al., 2008).
Inventory	Holding excess of inventory	More space to store which needs to be heated or cooled or more packaging to store WIP (Herrmann et al., 2008).
Motion	Extra movements	Wasting the useful life of equipment (Dües et al., 2013).
Defects	Rework	More raw materials and energy consumed (Herrmann et al., 2008).

Underutilization	Underutilizing skills/ delegating tasks with inadequate training	Not knowing how to perform procedures, not knowing how to handle materials can lead to all previous waste.

Table 3- Environmental impact of Lean wastes

As mentioned before, Lean and Green paradigms have different definitions for waste elimination but, however, with this table we can see that the Lean wastes also integrate solid environmental impacts, which can mean an advantage for the Lean paradigm because, in addition to fulfilling its goal of generating zero waste, will also contribute positively to the organization's environmental performance (Herrmann et al., 2008). The U.S Environmental Protection Agency (EPA, 2003) refers that using lean principles and tools on a company can be a catalyst to achieve better environmental results.

Based on this table, we can affirm that Green paradigm does not restrict the fundamental of Lean wastes, instead, this table reveals that environmental wastes and Green initiatives foster opportunities for further waste elimination and promotes the implementation of Lean paradigm in companies (Dües et al., 2013; Herrmann et al., 2008). According to LMI (2005), the solution to generate even less waste in a supply chain is to merge Lean and Green paradigms to reduce waste, which can be labeled as the ultimate long-term objective of a Lean-Green supply chain (LMI, 2005).

Another similaritiy found between the two paradigms was the waste reduction techniques that, according to Bergmiller and McCright (2009), focus on business and production process practices. Mollenkopf et al. (2010) affirms that waste reduction through a change in business practices is achieved by an adaption of a company culture, which means that for integrating Lean and Green practices into business functions requires changing the organization's vision (Dües et al., 2013). Sarkis (2003) defends that both paradigms integrates waste reduction techniques that look into the integration of the product and the redesign of the process in order to prolong product use or enabling properly recycling as well as making processes more efficient.

Mollenkopf et al. (2010), Bergmiller and McCright (2009) and Vonderembse et al. (2006) in their works says that to simplify the adoption of Green practices into a Lean environment, organizations must employ few hierarchical levels, leading to a high involvement of the employees. When comparing both paradigms on the relationship with suppliers the two rely on close collaboration with SC partners. The goal of an integrated SC is to improve the information sharing along all the SC (Kainuma & Tawara, 2006), so combining the two paradigms will not be a problem in this aspect.

The analysis had concluded that implementing Green practices into a Lean environment is possible and it is not expected to require much investment of time or money (Dües et al., 2013). Also concluded that Lean practices can lead to environmental benefits, inversely, environmental practices ofthen lead to improved lean practices (Mollenkopf et al., 2010). Green practices needs to be incorporated with Lean to achieve maximum sustainability in all operations (*All Answers Ltd.*, 2018).

Differences

In spite of the similarities identified, the introduction of Green practices into already operational Lean companies will involve some trade-offs in some areas that are not 100% compatible (*All*

Answers Ltd., 2018). To overpass the differences between the Lean and Green paradigms it is necessary to analyze which areas of the Lean paradigm lacks in achieving Green benefits.

The divergences between the two concepts, accordingly to Dües et al. (2013), are based on: focus, definition of waste, the customer, product design and manufacturing policy, end of product-life management, principal tool used and some practices.

As studied before, the focus of Lean paradigm rely on cost reduction to increase profits and increasing the flexibility (Carvalho & Cruz-Machado, 2011) while Green paradigm focus on achieving a sustainable development and is concerned with reducing environmental risks and effects of operations (Mollenkopf et al., 2010). The Lean paradigm focus does not obstruct the focus of Green paradigm and the same to the contrary. According to Dües et al. (2013) it is possible to characterize the business environment generated by Lean paradigm as the ideal scenario for adopting green practices and, Bergmiller and McCright (2009) refer that Lean environment, to a certain extent, is Green through the mutual focus on waste elimination. We have already seen Green practices are in part a natural extension to Lean without the pure goal of being Green (*All Answers Ltd.*, 2018).

The biggest aspect in common between the two concepts is the elimination of waste and therefore, since the practice is quite common on both paradigms, it is easier to combine Green waste for environmental purposes with Lean waste. Adding Green practices to the waste elimination of Lean is a great advantage as they will help to reduce costs even more, which is due to better use of resources and not using unnecessary materials (Carvalho & Cruz-Machado, 2011). Although the two paradigms define waste forms differently, they can be combined, that is, we can add Green wastes to Lean wastes and obtain a huge synergy.

When it comes to the target public of these two concepts, the situation is relatively similar to the previously described. The Lean paradigm seeks to reach a public that is looking for a low-priced product but with high added value to them (Carvalho & Cruz-Machado, 2011), while the Green paradigm seeks to reach customers who have the same ecological thinking and who are looking for environmentally friendly products (Mollenkopf et al., 2010), this aspect is also a great synergy between both concepts because a customer looking for low prices will certainly not be concerned with whether or not the product incorporates Green practices as long as it remains at the same price. If the customer seeks sustainable products, they will not be bothered if they are cheaper as long as they maintain a Green ideology. With this, we can conclude that in this aspect the two concepts can be combined (Dües et al., 2013).

Regarding product design, the Lean paradigm focuses on high performance and minimization of costs while the Green paradigm applies the life cycle assessment (LCA) to outline the products so that each stage of the product's life cycle is optimized from the environmental point of view (Kainuma & Tawara, 2006). Using the LCA means that products are designed to allow fewer manufacturing processes, less by-product production, products that do not require as much packaging or storage or transportation space, and products that do not increase inventory levels (Simons & Mason, 2003). This shows us that the Green paradigm design does not disturb the focus of the Lean paradigm because less manufacturing steps and less-by products means less costs.

End of product-life management is a practice used by the Green paradigm and is concerned with considering the impact of using the product and obtaining it at the end of the product's life in the form of reuse or recycling. Contrarily, Lean paradigm does not apply this practice as it is not part of its purpose (Dües et al., 2013). As we know, Lean paradigm focus on removing waste

from all the activities, so reverse logistics is an ideal application for this philosophy because a company can use Lean principles to plan, implement and control the efficient flow of materials and information from the point of return back to the origin for renewing, collecting value or proper disposal and reverse logistics helps reduce the storage and distribution costs (Lee, 2019).

The principal tool used by the Lean paradigm is the Value Stream Mapping (VSM) which can be considered as a visual map of all the activities necessary to produce a product without concerning non-value activities (Pattanaik & Sharma, 2009), in Green paradigm the principal tool used is Life-Cycle Assessment (LCA) that recognizes all the activities necessary to produce a product considering product design, product use and end-of-life management, assessing also the environmental impacts through all the stages (Kainuma & Tawara, 2006). This difference will not be a problem for Lean paradigm because, as we saw earlier, the fact that the Green paradigm considers the LCA in product design phase means that less steps will be required in the production, less packaging or space in storage or transportation and deliver less scrap through considering remanufacturing possibilities (Simons & Mason, 2003) which, consequently, leads to a decrease in costs (lean focus).

Regarding the practices used by both paradigms, those related to the replacement frequency are the main contributors to the conflict of practices between the Green and Lean paradigm (Dües et al., 2013). Lean paradigm works with JIT production principles so products are produced with the right timing and in the right quantity (Gupta & Jain, 2013). This elevates the replenishment frequency of raw material because the inventory levels are very low (Kannan & Tan, 2005), on the other hand, the Green paradigm has a very important premise that falls on the reduction of CO2 emissions, which cannot be achieved with a high replacement frequency of raw materials because a high frequency increases the transportations needed which, in turn, also increases CO2 emissions and goes against Green principles (Venkat & Wakeland, 2006). Dües et al. (2013) proposes that the solution to this conflict may be based on selecting suppliers that belong to the same geographic area in order to be able to share truck loads on delivery or, for example, when delivering small quantitities try to better manage the routes in order to supply multiple customers in the same area on just one route/trip (Dües et al., 2013). It is important that companies do trade-offs, so this difference does not make both paradigms incompatible.

In Carvalho and Cruz-Machado (2011) work, the discrepancies identified and analyzed between Lean and Green paradigms are only related to the “replenishment frequency”. Lean paradigm is characterized to the numerous deliveries of small quantities resulting in increase the number of transportations needed which also incentives an increase of the replenishment frequency (Mollenkopf et al., 2010). The high replenishment frequency is due to the pull system and JIT delivery (Castro, 2014) and goes against the principles of Green paradigm because the high frequency will consequently increase the carbon emissions due to transportation and, the Green paradigm imposes a SC with a reduced delivery frequency to reduce carbon emissions (Castro, 2014; Dües et al., 2013).

Like Carvalho and Cruz-Machado (2011) work, Dües et al. (2013) also says that Lean practices do not necessarily reduce carbon emissions because of the high replenishment frequency originated by the production of small batches. For this divergence founded, Carvalho and Cruz-Machado (2011) had propose some solutions like the selection of other transport modes more energy efficient and with low carbon emissions, reducing distancies, transport consilation and others.

In conclusion, Carvalho and Cruz-Machado (2011), Mollenkppf et al. (2010) and Dües et al. (2013) come to an agreement and find that the combination of Lean and Green paradigms will bring advantages to organizations, due to their synergies and potential when applied as one single model. The Lean paradigm definition, documented by Womack and Jones, does not explicity integrates environmental performance metrics, which theoretically leaves improvement opportunities on the agenda (Venkat & Wakeland, 2006) making a possible integration of the two paradigms possible.

3.METHODOLOGY

The research methodology that will be used throughout this work is the Design Science Research (DSR) methodology. DSR approach aims to produce an innovative artifact resulting from an informed and conceptual way of thinking.

In line manner, DSR can be split into products (IT artefacts) and into Processes (set of activities) (Weber et al., 2012), the latter will be the case of this dissertation. The main goal of DRS methodology is to create a new reality (Iivari, 2007). Some authors point out DSR uses the information learned to solve problems, establish improvements or reinforce existing solutions, creating new knowledge, perspectives, and theoretical explanations (Baskerville et al., 2015).

In summary, research carried out under the DSR paradigm has as objective the production of knowledge that can be applied in solving real problems (Van Aken, 2005).

3.1 Design Science Research Model

Design Science Research has been seen as the third shape of science “Artificial” adding to the natural and human sciences (Alturki et al., 2013). Design Science Research is a method that is performed under the paradigm of Design Science to operationalize research (Dresch et al., 2015).

Design Science Research is composed by two compound words, the “Design Science” and “Research Methodology”, due to that, it is important to clarify what each one means. It is the duty of Design Science to design and validate structures that do not yet exist, either through the development, negotiation or alteration of goods, procedures, software, and methods for improving existing locations (Amaral, 2017). For Bisandu (2016) Research Methodology deals with a way of thinking about and researching a particular phenomenon of interest by a researcher. Also, research methodology is often seen as an action plan, strategy, procedure, or design laying behind the choice of methods and connecting the choice of methods used (Bisandu, 2016).

According to Dresch et al. (2015), Design Science is the epistemological basis and Design Science Research is a method that operationalizes research when the desired objective is an artifact or a recommendation (Dresch et al., 2015). Design Science Research then appears as a process of research inherent to the design activity of an artifact, thus ensuring discipline, rigor, and transparency in research projects (Offermann et al., 2009).

In resume, DSR is a problem-solving approach that designs artifacts to solve the problems found or allow situations to be transformed by adjusting their conditions to better or optimal states, analyzing what was designed and communicating the results (March & Storey, 2014).

According to the authors (Lapão et al., 2017; Peffers et al., 2014), DSR methodology encompasses five main stages or activities. In this work, the chosen model is presented in detail, in figure 3, based on these author’s work.

Figure 3- Adapted DSR processes steps from Lapão et al. (2017) and Peffers et al. (2014)

The first step of DSR methodology is **"identification of the problem"**, where the research problem is defined, and the solution's value is justified. The first thing to do in this step is to identify the research question, that will lead to the research problem by explaining the importance of an efficient solution to the stakeholders and what they will earn with its outputs (Peffers et al., 2014).

The second step is "**definition of objectives for a solution"**, where the objectives and the requirements needed to achieve the solution of the problem identified are defined. Abductive logic should be used, based on creativity, imagination, previous knowledge, making inferences, and dismissing hypotheses (Peffers et al., 2014).

The third step is "**design and development of artifacts (constructs, models, methods, etc.)"**, where the artifacts proposed in the previous step should be developed, in order to solve the problem under study. This step of DSR methodology aims to generate knowledge by the design and development of the artifact itself (Gregor & Hevner, 2013) which can be reached by the division of the main problem of this research into easier ones (Hevner et al., 2004). The artifact developed must be supported with some theoretical background to have a coherent design in the next step (Peffers et al., 2014).

The fourth step is "**validation, results and discussion"**, where the objectives should be compared with the actual observed results derived from the use of the artifact, this is, to clear assess how efficient the solution created, it is necessary to evaluate what was defined in the beginning (starting point) with the practical application of the artifact (Peffers et al., 2014). After the development step, the artifact should be validated according to a clear definition of evaluation techniques that are appropriated to the problem in question and based on requirements formerly specified. This step's output is to understand if the artifact is fit to be applied or if improvements still need to be made to it, to make it more aligned with the initial problems (Peffers et al., 2014). At least, the results should be communicated, allowing a proper discussion about the topic.

The fifth and last step is "**conclusion"**, also known as the reflection phase, where results from evaluation are published, contributing to knowledge, and triggering new studies.

It is vital to remember that the result of the DSR project is always a purposeful artefact which "can be a product or a process; it can be a technology, a tool, a methodology, a technique, a procedure, a combination of any of these, or any other means for achieving some purpose" (Venable et al., 2012).

3.2 Research Strategy

According to the five DSR methodology phases, previously described, in this section the methodology phases will be applied to the present research, structured as follows:

Figure 4--DSR stages applied to the present research

As it was said before, the main objective of this research work is to propose a strategy to combine the Lean with Green paradigm to achieve an environmentally sustainable supply chain. So, according to this, it is possible to carry out the first step of DSR methodology, "**awareness of the problem",** by defining the research question. In this work, the research question will be: How Lean paradigm, aligned with Green practices, can be an enabler for an environmentally sustainable supply chain. This stage also consists in an analysis of the Lean paradigm, namely its origin, main tools, and supply chain strategy; the Green paradigm, namely its origin, main tools and supply chain strategy; and the comparison of the two paradigms, namely their similarities and differences.

The second step is about **defining objectives and a solution** around the research problem, identified in the previous step. Based on the similarities, differences and synergies identified, it can then be understood where Lean paradigm lacks in achieving sustainability and how the two paradigms can be combined.

The third step is the **design and development** and in this phase the framework structure was designed according to the research done in the previous stages. This phase results in proposing a strategy to combine Lean with Green paradigm to obtain an environmentally sustainable supply chain by defining what is essential (tools) to have on a Lean strategy to be able to have an environmentally sustainable supply chain.

In the fourth step, there is the need of **evaluate** the framework proposed. Due to the specificity of the topic, the evaluation of the artifact must be performed by experts. So, to do that, the evaluation phase will be supported by individual interviews with three relevant experts that will validate the work's output. By doing these interviews, it was possible to evaluate the assumptions and conclusions of the study, by confronting with the opinions of the experts on Lean and Green paradigms as well as on Environmentally Sustainable Supply chain.

The last step, **conclusion**, aims to discuss the results of the interviews and drawn the proper conclusions of the study. In this step is also addresses some limitations of the study as well as some recommendations for future research on the topic.

3.3 Individual Interviews

To validate both the study assumptions and the conceptual framework proposed, individual interviews were conducted, through Zoom meetings, with field experts of sustainability, Green paradigm, and the Lean paradigm having different academic and professional backgrounds, with the main goal of understanding the point of view of each of the interviewees about the proposed strategy and about how the Lean paradigm can be combined with the Green paradigm.

Individual interviews are the most widely-used data collection strategy in qualitative research and they are chosen to collect detailed reports of interviewees' thoughts, attitudes, beliefs, and knowledge about a specific topic (Lambert & Loiselle, 2008). There are three fundamental types of research interviews: structured, semi-structured and unstructured (Gill et al., 2008). Gill et al. (2008) refer that semi-structured interviews are based on several key questions that aims to identify the areas to be explored, but also allows the interviewer or interviewee to diverge in order to pursue an idea or response in more detail. Dicicco-Bloom & Crabtree (2006) refer that semi-structured interviews are organized around a set of predetermined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewee/s.

To conduct these individual meetings, a script was followed. The script was structured to meet both validation requirements and specifications and it followed a precise sequence in order to best obtain the information relevant to this study. It began with a general explanation about Lean and Green paradigm as well as Lean and Green supply chains, then moving to more specific questions to validate the conceptual model proposed. The questions were open-ended questions, and it was given space to the experts to express their personal views and experiences and for them to ask their own questions about the conceptual strategy.

Individual interviews allow the interviewer to delve deeply into social and personal matters (Dicicco-bloom & Crabtree, 2006) and to discover information that would not be possible to access using other techniques (such as surveys), not to mention that the data resulting from the interviews can be recorded and reviewed at different times, helping the reporting of results to be more accurate (Alshenqeeti, 2014).

For the purposes of this research, surveys would not have been suitable for validation purposes since only experts of Lean and Green paradigms could actually provide the level of knowledge required for the validation of the proposed model. So, individual interviews were conducted with four relevant experts and four questions were asked:

1. Do you consider the proposed model as useful in Lean Supply Chains and why?
2. Do you have any criticism towards the proposed strategy?
3. Would you consider implementing the proposed strategy?
4. Do you have any recommendation or suggestions for further improvements of the proposed model?

4. Framework to combine Lean with Green paradigm as an enabler to an environmentally sustainable Supply Chain

Nowadays, organizations are being pressured to insert Green principles into their operations, including their supply chains. They are aware that the market is continuously changing which means that organizations also have to continuously change and improve their supply chains processes. In this chapter, a framework is proposed to assist organizations integrate Lean and Green paradigms in supply chain. This framework shows what should be a Lean and Green supply chain, by describing a combination of the two paradigms, and also provides a set of guidelines to implement this integrated supply chain. Through literature review, it was possible to acknowledge and study extensively the literature regarding the topics of Supply Chain Management, Sustainability and Environmentally Sustainability, Lean paradigm and Lean Supply Chain, Green paradigm, and Green Supply Chain and, in a deeper and more conclusive detail, the principles and tools used by these two paradigms. After these deep understanding it was possible to have a clear acknowledgment on how an integrated Lean-Green strategy must look like in order to support and enhance the achievement of an environmentally sustainable supply chain.

Likewise, the relationship between the different strategies used by Lean and Green along the supply chain was studied and analyzed. Also, the areas in which these two paradigms are in syntony or in conflict were identified. It was also identified the synergies that arise through the combination of both paradigms and the solution to overpass the divergences founded.

The goal of the new strategy is to provide improvements to the Lean paradigm along the entire SC by adopting green practices and principles or by adjusting the current Lean tools used in each SC phase. This strategy will help organizations to turn their SCs more environmentally sustainable through the possible combinations of Lean and Green paradigm, that were studied from the extensive literature review.

4.1. Assumptions

Based on what was studied in the literature review, about supply chain management, sustainability, Lean paradigm, and Green paradigm, it was concluded that organizations can and must combine Lean paradigm with Green paradigm in supply chain because:

- Integration of Lean and Green paradigms help companies to improve efficiency and money (Bashkite & Karaulova, 2012);
- Only when the two paradigms are executed simultaneously, they can reach their fullest potential and generate even more benefits than when they are executed individually (Bergmiller and McCright, 2009);
- Lean organizations which implement green practices along the SC achieve better Lean result than the others Lean organizations that do not implement (Dües et al., 2013);
- Green practices will improve Lean efforts and adress even further urgent environmental issues that organizations need to deal with (Bergmiller & Mccright, 2009);
- Using lean principles and tools on a company can be a catalyst to achieve better environmental results (EPA, 2003);
- The elimination of environmental waste and the adoption of Green practices help to further promote waste disposal and promote the implementation of Lean paradigm in organizations (Herrmann et al., 2008);

- The solution to generate even less waste in a supply chain is to merge Lean and Green paradigms (LMI, 2005);
- Implementing Green practices into a Lean environment is possible and it is not expected to require much investment of time or money (Dües et al., 2013);
- Aligning Green and Lean practices across the SC drives the financial performance of the organization and incrases the respect from customers (Mollenkopf et al., 2010);
- Lean practices can lead to environmental benefits, inversely environmental practices often lead to improved Lean practices (Mollenkopf et al., 2010)
- Green practices are partially a natural extention to Lean withouth the absolute intention of being Green (*All Answers Ltd.*, 2018)
- Lean approaches help reduce waste and emissions and facilitate the use of tools for environmental management (EPA, 2003).

Each initiative planned to be done at the scope of achivieng an environmentally sustainable supply chain through the combination of Lean paradigm with Green paradigm, should always consider that they must end up with reduction of costs, increased efficiency , efficient use of resources, waste elimination and increase productivity and quality (Porter & Linde, 1995), as those factors are defined as what people expected to happen with the implementation of green practices along a Lean supply chain.

After studying environmentally sustainable supply chains and how it is possible to combine Lean paradigm with Green paradigm in supply chain context, it was concluded that a Lean supply chain to become more environmentally sustainable through the adoption of Green practices must:

- Have efficient integration and collaboration processes between all the SC links (Ferreira et al., 2019);
- Have all the business processes integrated (Samaranayake, 2005);
- Employ few hierarchical levels, leading to a high involvement of the employees (Mollenkopf et al., 2010; Vonderembse et al., 2006);
- Improve the information sharing along all the SC (Kainuma & Tawara, 2006);
- Adapt the company's culture to include Lean and Green principles, making it necessary to change the organization's vision (Dües et al., 2013);
- Incorporate environmental issues in the organization’s goals and promote always environmental sustainability (Brennan et al., 2011);
- Understand that the adoption of Green practices can be a huge competitive advantage for the organization (Porter & Linde, 1995);
- Analyze which areas of the Lean paradigm lack in achieving Green benefits in order to overpass the incompatibilities (*All Answers Ltd.*, 2018) by introducing environmental principles;

4.2– Framework proposal

In the third stage, one ought to find the solution to the question under analysis, by building the artifact. Trying to build a strategy that may fit all organizations with already a Lean supply chain, is proposing a strategy that considers every organization reality and that allows that every organization customizes the improvements proposed in this chapter in their own way to fit their problems and environmental needs.

4.2.1. Framework

At the scope of this study, a strategy for integrate Lean and Green paradigms in supply chain context was proposed, for Lean companies supply chain become environmentally sustainable. According to the assumptions described above it was proposed the following conceptual framework.

The main goal of the conceptual framework proposed is to turn a Lean Supply Chain environmentally sustainable through the combination of some Lean tools and principles with Green tools and principles. To be possible to propose a strategy that fits any Lean organization's supply chain, the framework will be presented in three parts, which are: the main concepts and participants, the improvements proposed to each Lean Supply Chain phase and the guidelines that each organization wants to apply the improvements must apply.

In figure 6 it is possible to see all the main concepts of the framework and who are the participants of each one.

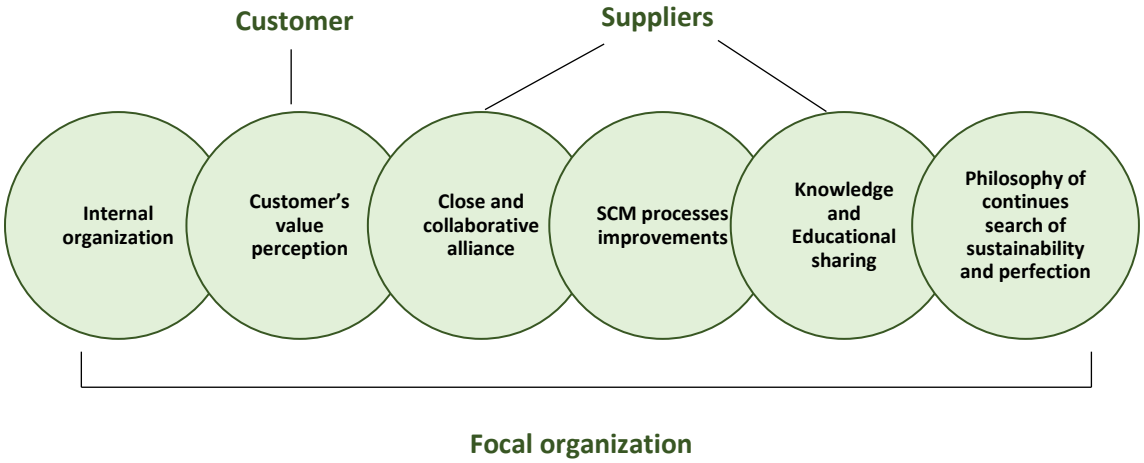

Figure 5- Framework main concepts and participants

Based on this, it was considered that to create a new LSC strategy that integrates Green practices and principles, changes must start from inside the focal organization. This is, it is important to understand first what are the goals that the organization wants to achieve with the new strategy as well as listening the ideas of all organization's levels, it is also important to reorganize processes to be able to attend the strategy's goals.

An understanding of the new definition of value for the customer point of view is also needed, that is, since the organization will apply a new strategy that aims to cover sustainability

principles and practices in all its phases of the SC, the organization must communicate to the customer what is going to change and demonstrate the benefits to the customer in order to understand what the customer will expect from the products and the organization itself.

A close and collaborative alliance with organization's suppliers is also a component needed in the proposed strategy because suppliers are a crucial factor for the strategy to be successful. This is, for organizations to be able to make their supply chain more sustainable, it is necessary to make changes in terms of purchased raw materials as well as in order distribution and, for this to happen, suppliers must also be committed to the objectives of the organization and the proposed strategy so that in these phases it is possible to make improvements.

Processes improvements or adjustments were also considered a mandatory component as, the goal of the strategy is to adopt Green paradigm practices along the Lean Supply Chain so it will be mandatory to make improvements or adjustments to the current Lean Supply Chain processes. These improvements can be customized so that they are optimized for each company that wants to use the strategy proposed.

Considering the improvements and adjustments of LSC processes, the organization's employees need to know how to deal with the new adjustments and on what the new improvements are based to be capable of performing each activity with the same efficiency. Also, the suppliers must be educated too with the new way of doing things to achieve higher efficiency of the SC and to promote a collaborative relationship.

A philosophy of continuous search for perfection is already implemented inside a Lean organization and has a huge success on contributing to the organization's efficiency. As the principal output of this framework is to obtain an environmentally sustainable supply chain, a philosophy of continuous search for perfection and sustainability must be inherent to the organization day-to-day. This means always looking for better results and that these results are also more sustainable.

4.2.2 Solutions/Recommendations proposed to each Lean supply chain phase

The solutions proposed in this chapter refer to the solutions that, derived from the literature review and considering the assumptions, had to be created and proposed so that each phase of the Lean supply chain would become more environmentally sustainable through the adoption of Green practices.

Therefore, these solutions consist of some improvements and adjustments that are based on proposals for new methods considered by the Green paradigm but that are compatible with the Lean paradigm. Also, proposals for adjustments to the tools currently used by the Lean paradigm so that they start to incorporate environmental metrics. All the proposed improvements also present the new objectives that organizations must consider during each phase of the supply chain in order to allow it to become more sustainable. To achieve it, solutions were proposed.

In the course of explaining the proposed improvements, potential support documents are also identified, shown in the annex, which help to carry out some proposed steps. The improvements proposed will be presented according to the sequence of the supply chain phases studied in the literature review: a) product design, b) procurement, c) production, d) distribution and e) reverse logistics.

1º) Product Design phase

Supply Chain phase	Objectives	Solutions proposed	Environmental benefits	Lean benefits
Product Design	• Design products that can be easily disassembled or recycled • Design products that require less materials • Design products that require less production steps	Use of two new methods: • Eco-Design • Design for Remanufacturing	➢ Products will be made of more eco-friendly materials and recycled materials ➢ Efficient resource management ➢ Due to disassemble, materials will be recovered ➢ Remanufactured products	➢ Efficient resource management ➢ Fewer steps to produce the product ➢ Fewer production of by-products ➢ Less acquisition of raw materials ➢ Recover and generate more value

Table 4- Solutions/ Recommendations proposed to Product Design

The first solution proposed is to use **Eco-Design** and this method is about:

- Designing products that can be easily recycled for, in the future, proper disposal or reuse.
- Avoiding the use of harmful materials.
- Improving resource usage efficiency by considering the product size, service life and characteristics of use.

The second solution proposed is to use **Design for remanufacturing**, and this method is about:

- Designing products that in the future can be easily disassembled for properly reuse or properly disposal.

This combination of requirements is beneficial for both methodologies because the attempt to create a product that does not generate waste and that is made of materials that are not evasive to the environment makes the products designed less complex to produce and composed by fewer components, resulting in a lower product cost and a consequent increase in performance.

Benefits: The proposed improvements to the product design phase mean that the fact that the company designs products that contain recycled materials and does a better management of the resources to be used will allow the company, during the production phase, to need fewer steps to produce the product, that is, production will be simpler and will also allow for a lower percentage of production of by-products. All of this will mean cost savings and efficient resource management.

The fact that the company designs products that are easy to disassemble will allow the company, in the future, to recover materials and components that can be reintroduced in the production of a new product, thus generating more value and less acquisition of resources.

2º) Procurement phase

Supply Chain phase	Objectives	Solutions proposed	Environmental benefits	Lean benefits
Procurement	• Acquire eco-friendly raw materials • Acquire recycled materials • Partnership with sustainable suppliers	• Choose suppliers that addresses environmental concerns • Choose suppliers that have a certification, i.e., ISO 14001. • Purchase raw materials and components that have green attributes	➢ Avoid extreme dependence on raw materials suppliers ➢ Avoid the use of materials and components that are harmful to the environment	➢ Materials can be reused to generate more value to the customer

Table 5- - Solutions/ Recommendations proposed to Procurement

The solutions proposed are based on defining new requirements for selecting raw materials and components as well as the suppliers. The organization to achieve a sustainable procurement phase must make alliance with raw materials suppliers that have already implemented in their organizations environmental concerns and, for example, make alliance with suppliers that have a certification compliant with one of the recognized international standards, i.e., ISO 14001.

The raw materials, components and products purchased must now have desirable Green attributes such as recycled or reusable items, must have disclosure of the environmental or safety attributes, for example, using Green seals and indicators of environmental impacts such as scientific certification system offered by various commercial organizations, and their footprint on the environment must be reduced.

Benefits: The solution proposed for this phase turns the purchase of raw materials more expensive, this is, for the organization to acquire eco-friendly raw materials it is necessary to dispense more money which can be a negative point to the Lean paradigm. However, the purchase of substantially more expensive raw materials, in the future, can be regained by reusing the materials to create a new product and generate more value and less dependence on raw materials

At first glance, the organization will spend more money, but the investment will be returned in form of new products, more value to the customer, less raw materials acquisition, and recycling.

3º) Production phase

Supply Chain phase	Objectives	Solutions proposed	Environmental benefits	Lean benefits
Production	• Eliminate all the waste generated • Eliminate all the scrap produced • Eliminate non-value added activities • Minimize the cycle times • Minime the materials used • Minimize the resources used	• Define metrics and KPI's to obtain information on production performance to each objective • A new VSM that concerns environmental indicators • Reformulate and adapt Lean tools	➢ Environmental wastes will be concerned during the production ➢ Environmental indicators can be measured and controlled	➢ Eliminate even more waste ➢ Lean production methods are not changed

Table 6-- Solutions/ Recommendations proposed to Production

The proposed solutions assent on defining metrics and KPIS's to better control the production performance, create a new value stream map to concern environmental metrics and reformulate and adapt the Lean tools used in production.

The metrics and KPI's allow us to obtain information on production performance for each defined objective. **The metrics and KPI's proposed** are:

- KPI 1: Percentage of waste generated
- KPI 2: Percentage of scrap produced
- KPI 3: Percentage of time consumed by non-value added activities (Total lead time- Total value added time)
- KPI 4: Cycle times average
- KPI 5: Percentage of materials consumed (Total materials used- Total materials needed)
- KPI 6: Percentage of resources consumed (example based on a future proposal: Total water used- Total water needed)

The new value stream map proposed will now concern environmental aspects in order to achieve the objectives setted. The traditional VSM used by a Lean organization is showed in figure 7, the main goal is to identify the time taken by each activity to be possible to calculate the total process lead time and the total value added time of the product life cycle, these indicators help identifiyng which are the non-value activities and in which activities are being generated waste.

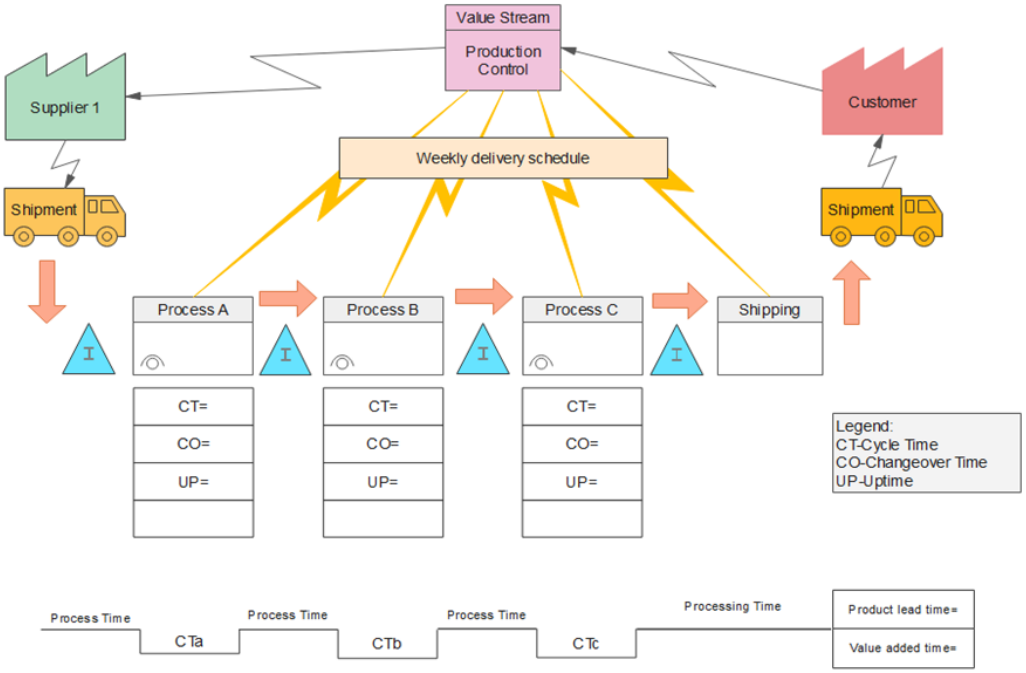

Figure 6-Traditional Value Stream Map

The proposal made to the VSM is based on adding an environmentally sustainable component to the map. With this proposal it will be possible to identify information related to environmental impacts adding to the traditional results of the VSM. The new information that can be identified with the new VSM proposal are:

- The percentage of scrap generated by each activity;
- The percentage of wasted materials (Total materials used- Total materials needed);
- The percentage of wasted resources, i.e. water (Total resources used- Total resources needed).

The main goal of the VSM is to identify and eliminate all the waste generated in all activities so, with these new indicators proposed, a ninth waste is added to the eight Lean waste, being called "Environmental waste". This waste will be identified through these new results. The VSM proposed is showed in figure 8:

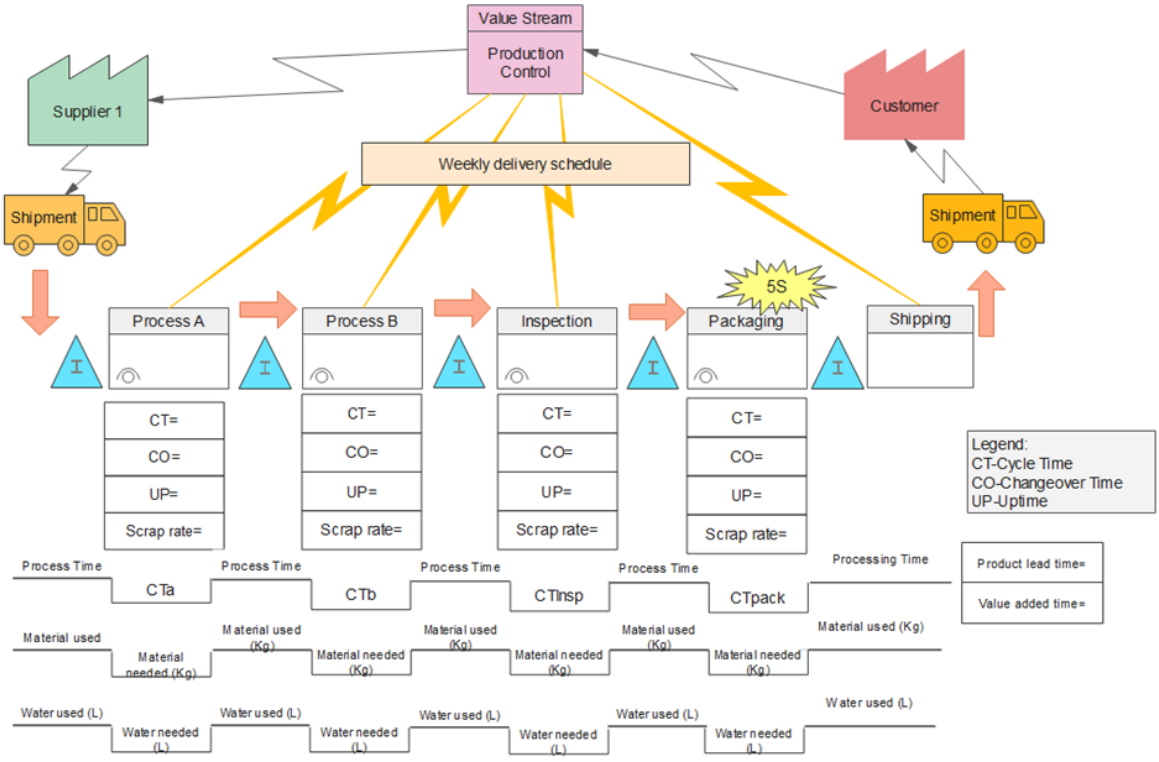

Figure 7-Proposed Value Stream Map

It is possible to calculate the percentage of scrap generated because information of how many units the activities will produce is usually available. Consequently, during that time there is some type of scrap produced due to problems with the materials used (materials with defects), being thus easy to calculate the percentage of scrap produced in each activity.

Adding improvements regarding the amount of resources and materials spent as well as the amount of scrap produced is a great Green initiative as the Green paradigm aims to eliminate all environmental waste caused during the life of the product as well as to efficiently optimize the use of resources (water, energy, etc.).

At least, it is also important to **adapt and make some modifications to the Lean tools** in order to them consider the Green principles. The proposed adaptions are:

1) **Kaizen-** Kaizen is a philosophy that changes the company's culture for continuous change in search of perfection. Since the search for perfection and the reduction of failures are already well established in this practice, our proposal is based on introducing an environmental perspective in continuous improvement in order to change the mindset of the organization to get not only better Lean results but also new environmental results. It is a continuous search for the best environmental performance, until reaching perfection. This is, Kaizen activities aim to identify problems and solutions for them as well as allow employees to share their ideas to help improving some activities based on the daily/weekly results fixed, our proposal is to promote that each employee understands that their actions have a huge impact, not only on the organization, but on the environment too, this will help that employees remain motivated in the search for sustainability.

2) **5S-** This tool aims to improve the company's performance by making the organization workspace safety, efficient for people do not waste time and, also, by eliminate all the wastes generated in each workstation. Our proposal is to add a new "S" to this practice, being it sustainability (5s+ sustainability). This new "S" will join the sustain component of this tool, as it will be based on promoting the improvement of environmental performance (sustain + sustainability). That is, instead of sustain forming a routine only for continuous improvement practices, it will also promote those same practices for environmental improvements in order to promote environmental performance. To facilitate this adaptation, our proposal also aims to add regular evaluations to the 5S performance in each workstation. These assessments can be made through checklists or score sheets, showed on Annex 6, and the results must be public to all members of the company because the fact that everyone has access to the provision of each workstation makes workers more motivated to continue the good work and helps to maintain the good results obtained.

3) **Just-in-time-** This practice relates to not producing anything without the customer's order, minimizing the inventory and increasing efficiency. Although the JIT strategy eliminates some waste, the fact that it only receives raw materials when customers place an order increases the travel between suppliers and the company's facilities, which contributes to environmental impacts associated with the increase in carbon emissions and additional used fuel.

This problem can be overcome by upgrading the ERP system, that is called Materials Requirement Planning, that calculates and manages raw material orders, that is, the best and largest possible grouping of raw material orders must be made so that the number of trips between suppliers and the company to be optimized without ever comprehending the final

delivery time. Of course, this improvement could mean an increase of 1/2 days in the usual delivery time, but it is necessary to demonstrate to the customer that the fact of receiving the order a day or two later is due to the fact of trying to optimize the trips and reduce the carbon emissions.

Another solution found to generate the least number of trips possible and reduce distances as much as possible, concerns partnering with suppliers closer to the focal company and its customers, as well as partnering or allowing distributors to share the cargo space of the truck with other companies so that travel is optimized to the maximum.

Benefits: The definition of a new waste, environmental waste, is considered a benefit under the Lean paradigm because the main goal of the paradigm is to eliminate all the waste produced and this waste will improve the elimination of the eight wastes, it is like an "extension". Although, it is also a huge benefit under the Green paradigm because with the new map, the production phase is concerned with the environmental impacts that all the activities have on the environment and, it is possible to measure and control the environmental metrics.

The adaptations made to the Lean tools are not a problem because the fundamental tools were not changed. This is also a benefit to the Lean paradigm because the methods are the same but with little modifications trying to consider Green principles.

4ª) Distribution phase

Supply Chain phase	Objectives	Solutions proposed	Environmental benefits	Lean benefits
Distribution	• Reduce carbon emissions from transport • Reduce number of transportations • Reduce the package dimensions • Reduce the materials used to produce the package	• Alliance with distribution suppliers that use more environmentally friendly transport • Group the largest number of deliveries possible • Allow truck's load sharing • Invest on a software for optimizing the package	➢ Alliance with sustainable distribution suppliers ➢ Use of transport with less ecological footprint ➢ Optimization of transportations	➢ Less distribution costs ➢ Optimization of trucks

Table 7- - Solutions/ Recommendations proposed to Distribution

The proposed solutions are based on establishing new requirements and methods for carry out the distribution activity. The distribution phase concerns the distribution of deliveries from organization facilities to the customers and the packaging activity.

This is the phase where the bigger conflict between Lean and Green paradigms exists due to the fact that Lean paradigm bases its distribution strategy on deliveries of small quantities of finished products. This is caused by JIT production system, which increases the number of

transport deliveries. In addition, the Green paradigm focuses its strategy on the main goal of reducing carbon emissions which requires the reduction of the replenishment frequency instead of what happens in Lean paradigm,

Regarding the packaging, the Green paradigm defends that packaging performance directly affects the environment because better package will minimize the use of materials, increase the use of space in the warehouse and in the transportation and decrease the amount of handling needed. For example, if the packaging becomes smaller or flexible it is possible to increase the volume of goods being transported and then reduce carbon emissions and cost optimization. In the Lean paradigm there is no relevant literature about packaging specifications.

The first solution proposed is to make alliance with distribution suppliers that uses more environmentally friendly transport (more fuel or energy efficient) because it is important to choose suppliers with a small ecological footprint. The second solution is to group the largest number of deliveries, this is, try to group the biggest number of finished products, without affecting in many days the delivery date, in order to optimize the transportation.

The third solution proposed is to allow sharing the truck's load capacity, this is, when the focal organization has small quantities to deliver, we must allow the supplier to share their truck's load capacity with other deliveries from other organizations that may have a destination close or equal to ours in order to optimize the truck's capacity.

The last solution proposed is about investing on a software that via algorithms which consider the package weight, volume, product dimensions, constraints, etc. can be an enabler for the organization to optimize the packaging activity, this software will allow the reduction of the package size so that the trucks could carry more load at once.

Benefits: The proposed solutions to this phase means that the organization will have an alliance with sustainable and ecological suppliers, that have more environmentally friendly transports, which is a huge benefit to the Green paradigm and, the fact that the organizations deliveries can be grouped with other companies deliveries, we are reducing distribution costs because instead of paying for the whole truck we will only pay for the space that our deliveries occupy, which is a benefit under the Lean paradigm. The solution of grouping the biggest number of deliveries possible is also a benefit to both paradigms because we are delivering more orders at once with a smaller number of transportations, which is a benefit to Green paradigm because we are reducing carbon emissions and is a benefit to Lean paradigm because we are optimizing resources and costs without compromising the value delivered to the customer.

5º) Reverse Logistics

Supply Chain phase	Objectives	Solutions proposed	Environmental benefits	Lean benefits
RL	• Increase the sustainability and efficiency of supply chain • Recover value through assets to increase revenue • Proper disposal • Reduce waste dumped in landfills • Promoting recycling reuse, resource reduction and substitution of materials	• Promote incentives for the customers return their products • Alliance with the distribution suppliers to optimize the empty trips	➢ Reduction of raw materials dependence ➢ Avoid waste of materials by reusing ➢ Adequate recycling ➢ Optimization of the empty trips by not increasing the carbon emission	➢ Optimization of empty trips ➢ Recover value ➢ Resource's optimization ➢ Avoid waste of materials by reusing

Table 8- - Solutions/ Recommendations proposed to Reverse Logistics

At this phase it is all new to the Lean paradigm because, once the product is delivered to the final customer the paradigm stops caring. Here, we are proposing that the products, after their useful life, return to the focal organization in order to them be recycled and reused, properly disposal or repaired.

To carry out this phase, the organization needs to define some procedures, very specific to their reality, like defining which products should be included in the RL process because it is important to make an analysis about all the company's products with the objective to understand which are worth to being included in the reverse logistics. That is, consider by product type, product price, disassembly cost, as the objective remains not to increase costs and there may be products that do not compensate being remanufactured or that the cost of bringing them back is very high. So, only the products that have a huge environmental impact or the products that have a low disassembly cost must be returned.

The first solution proposed is based on promoting incentives for customers who return their products, the organization can add a return fee to the product that will be paid to the customer after he returned the product. This type of incentive helps guarantee the product's return and is seen in an easier way to do for the customers. Of course, that this rate may only be applied to products that represent a high environmental impact or to products of high value in order to recover them to reuse the components.

The second solution proposed is based on making an alliance with the distribution suppliers to carry out the RL process. The distribution suppliers are responsible for picking up the deliveries at the focal organization facilities and deliver them to the final customers (stores). Thus, our proposal is that when the supplier is delivering orders to stores, stores will be in charge of delivering to the distributor of the products that are to be returned and the distributor should deliver to the focal company only when they are again picking up orders. With this proposal we

are optimizing the trips made by the distributor and taking advantage of empty trips to bring the returned products. The returned products should be identified with type of return, that can be to repair, to repair, to recycle and reuse and to dispose of.

Benefits: The solutions proposed are all new things to the Lean paradigm but this RL phase have some benefits to this paradigm like, the recuperation of product's value in form of reuse, the optimization of resources by recycling and reutilizing components and, also, the avoidance of a new source of waste by ensure that the majority of the products is not dumped in landfills but properly disposed. To the Green paradigm the benefits arise from the optimization of the empty trips and, consequently, not increasing the carbon emissions because the trip was still going to be made. Also, considering that now it is possible to reutilize, recycle and generate a new product and value, the reduction of raw materials dependence is another advantage. The resources reutilization results in an avoidance of resources waste which is another advantage for Green as well as for Lean paradigm because, the avoidance of a new source of waste by ensure that the majority of the products is not dumped in landfills but properly disposed.

4.2.3 Guidelines for an implementation of the strategy proposed

In the next figure the strategy implementation flow to achieve the goal of making a Lean supply chain environmentally sustainable through the adoption of Green practices will be presented.

This strategy was designed considering and following the fundamentals of a supply chain, according to what was studied in the literature review and, in addition, the strategy has the help of documents and tools that aim to support the proposals made in each phase.

It was considered important to divide the strategy implementation flow by steps and phases, the flow is divided in five phases: identification and definition, analysis and assessment, planning and designing, implementation and execution and documentation and monitoring.

Figure 8-Strategy implementation flow

The participants during the strategy implementation flow are the focal organization, this is, the organization responsible for the product design and production SC phases, the organization's suppliers (raw materials suppliers and distributor suppliers) and the customers.

It was considered important to set as steps the implementation so, the steps it will be explained by phases.

1) Identification and Definition phase

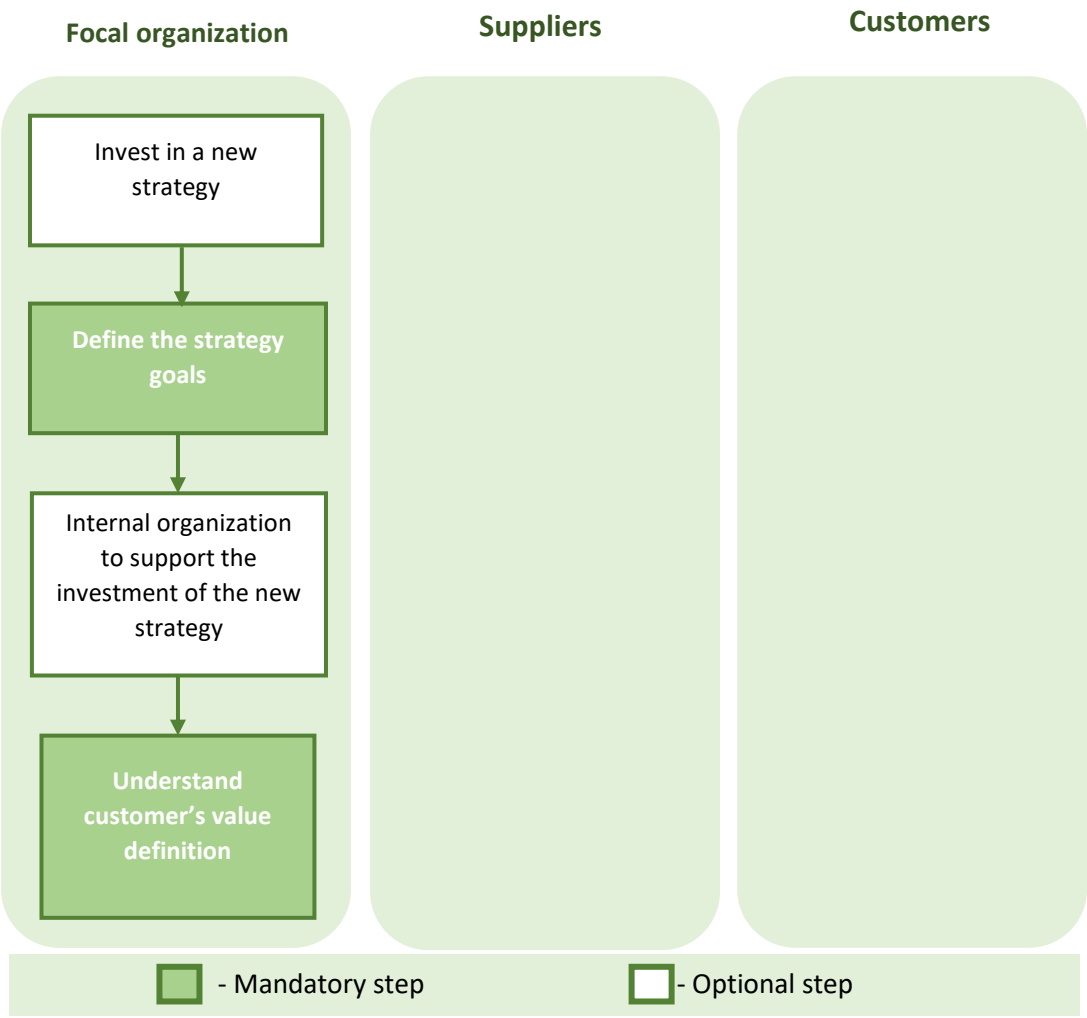

Figure 9-Phase 1) Identification and Definition

Generally speaking, the organization that will implement the strategy proposed will start by considering investing in a new Supply chain strategy. For the organization to understand why it is important to invest in a new strategy, the environmental needs that can be addressed inside the organization in each SCM phase must be identified. The identification of environmental needs can be carried out through the template showed on Annex 1.

Then, the organization should define the goals for each SCM phase, this is, they must define the goals that must be achieved through the environmental improvements that will be made through all the SCM. It is already known that the main goal is to make a Lean Supply Chain environmentally sustainable through the adoption of Green practices, but it is also possible for the organization to define other important objectives, for example:

- Continuously improve the SC to create value.
- Seek to have more satisfied customers and more motivated employees.
- To create a more competitive and resilient SC.
- Reduce the number of resources used.
- Produce products with more quality at a lower cost and with new environment standards.

- Decrease production environmental impacts.
- Protect future generations.
- Reduce the carbon emissions.

To better define the objectives, the organizations can use the template showed on Annex 2.

It is also important that in this phase the organization gives voice to all organization levels listening to their ideas and thoughts as well as to let them participate in strategy implementation to encourage them to become enablers of improvements. If all level of the organization were informed, it will be more easily to improve the SC through environmental practices because the integration of new practices and the adjustment of existing practices require that all employees be motived, and this is only possible if they were aware of the new strategy.

The last thing to do is to understand, with the new SCM strategy, what will be the customer's value definition of organization's products. To achieve this step, it is important that the organization communicate to all their customers that they will implement a new strategy that concerns environmental principles in their operations and try to explain what will change in order to the customer's loyalty remain the same.

After identifying why it is important to change and defining what objectives the organization want to achieve, it was considered that the second phase of implementation of the proposed framework should include an analysis and assessment of how things are done in the organization's present in order to identify environmental issues along the entire SC.

2) Analysis and Assessment phase

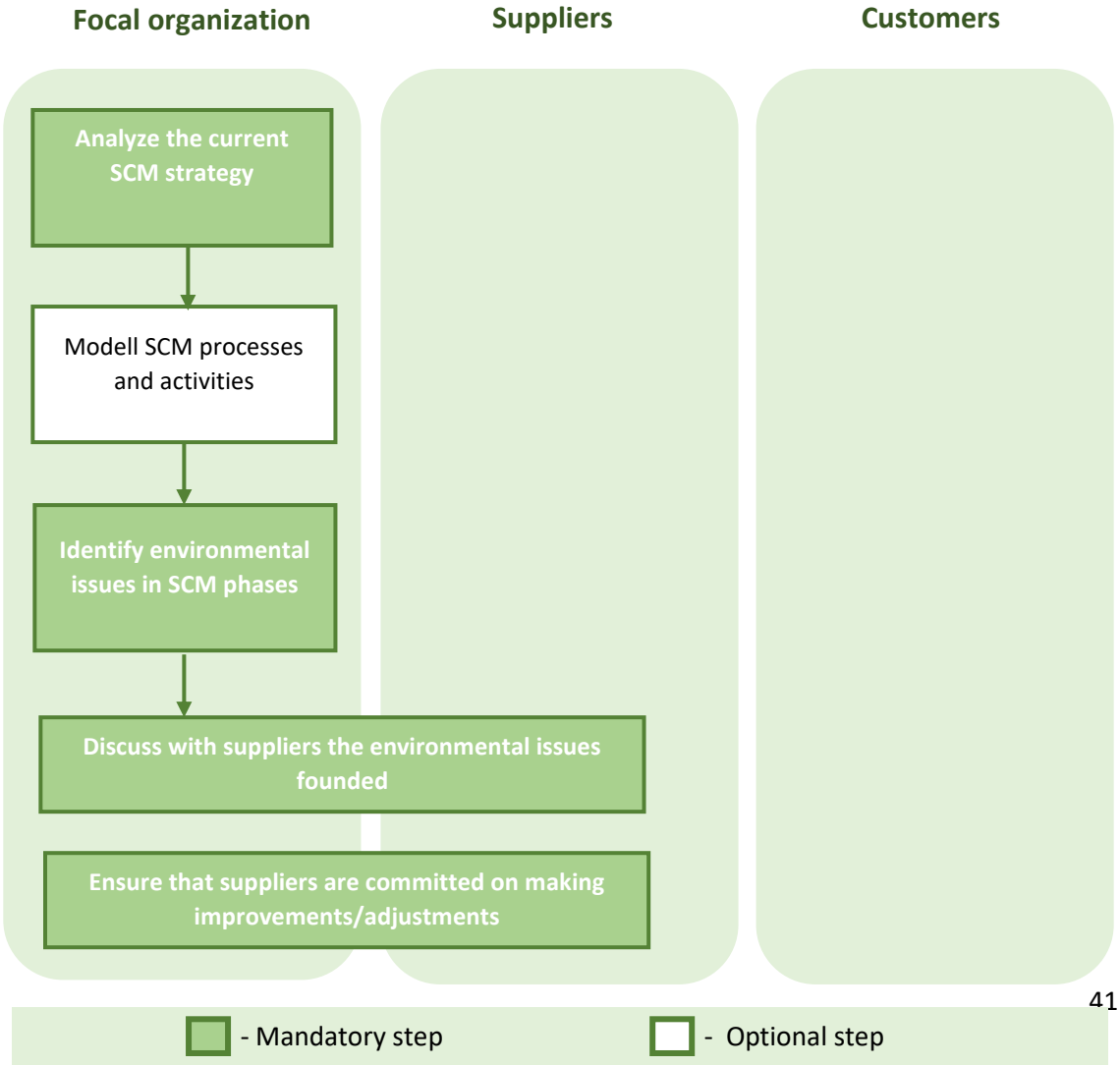

Figure 10-Phase 2) Analysis and Assessment

This phase is like an "*as-is*" analysis and it is focused on analyzing the current supply chain strategy and the processes and practices used along and within the supply chain.

This assessment of SCM strategy is mandatory because it is important to have a clear vision of each SC phase processes and practices in order to improve them. Each phase of the supply chain must be analyzed separately and, it is an organization's choice the modelling of the SCM processes and activities by phases. Note that the modelling may be a useful procedure because it is easier to identify flaws and issues.

This *as-is* analysis will help understanding how the relationship between the organization and its raw materials suppliers is, how the product design is realized, how production is working, how is the relationship between the distribution supplier and the organization, as well as the relationship between the organization and the retail store. The analysis and assessment of the existent processes and practices aims to improve transparency and to reveal opportunities to implement the improvements proposed.

Considering this analysis and the goals settled in phase 1, the organization must identify in which points Lean paradigm conflict with Green paradigm throughout all SCM phases. This will allow the identification of the environmental issues in the organization's reality. The organization can also recur to a simple comparison between "where we are now" *versus* "where we want to be" in order to be more clearly identified the environmental issues, to make this comparison they may use the proposed template, showed on Annex 3, to assess this comparison.

At a third phase of implementation, it was considered that it was the stage where the organization should start re-think their internal processes and customize the improvements proposed.

3) Planning and Designing phase

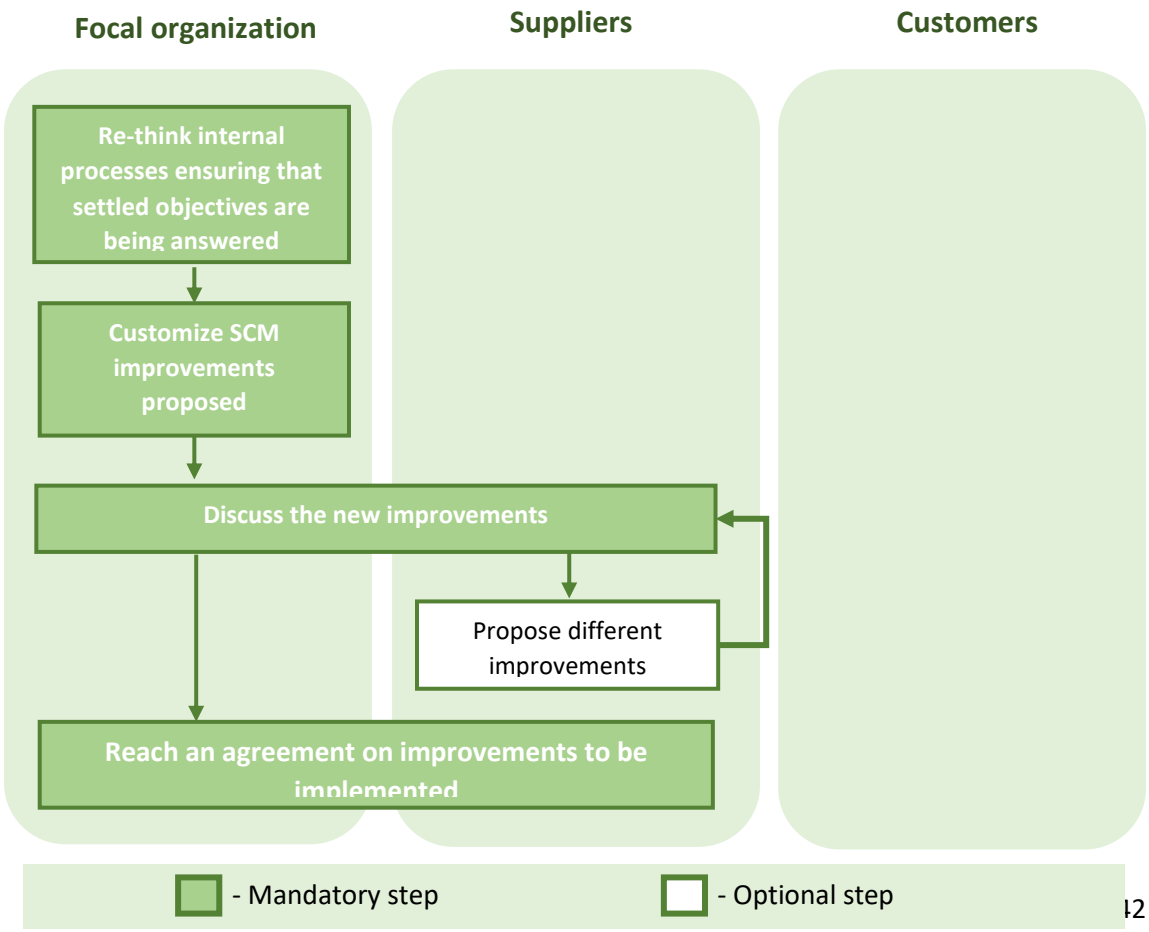

Figure 11-Phase 3) Planning and Designing

After it were identified the main point of conflicts between the two paradigms in all SCM phases and what are the environmental issues that must be taken into consideration, the organization must start re-thinking SCM processes ensuring that customer's needs and settled objectives to achieve an environmentally sustainable supply chain are being answered.

The organization must, according to their SCM reality and environmental issues identify design and customize the SCM improvements/ adjustments proposed to each SC phase on 4.3.2 topic.

These improvements previously presented can and should be customized by every organization that wants to implement the proposed strategy. Through this customization, the organization is able to make the right adjustments considering the reality of the organization SC and the environmental issues that were identified before. This is, for example, some organizations may not need to implement improvements in some processes because they are already optimized.

After the organization designs and customizes the proposed improvements, they must discuss with the suppliers the improvements that they want to make. This is a mandatory step because some improvements are directly related to the suppliers and without their commitment it will not be possible to achieve successful and implement some improvements.

The suppliers are able to purpose different improvements or small adjustments to what is proposed by the organization and they must discuss together until they reach an agreement on improvements to be implemented.

The fourth phase is about implementing and executing the improvements designed and customized.

4) Implementation and Execution phase

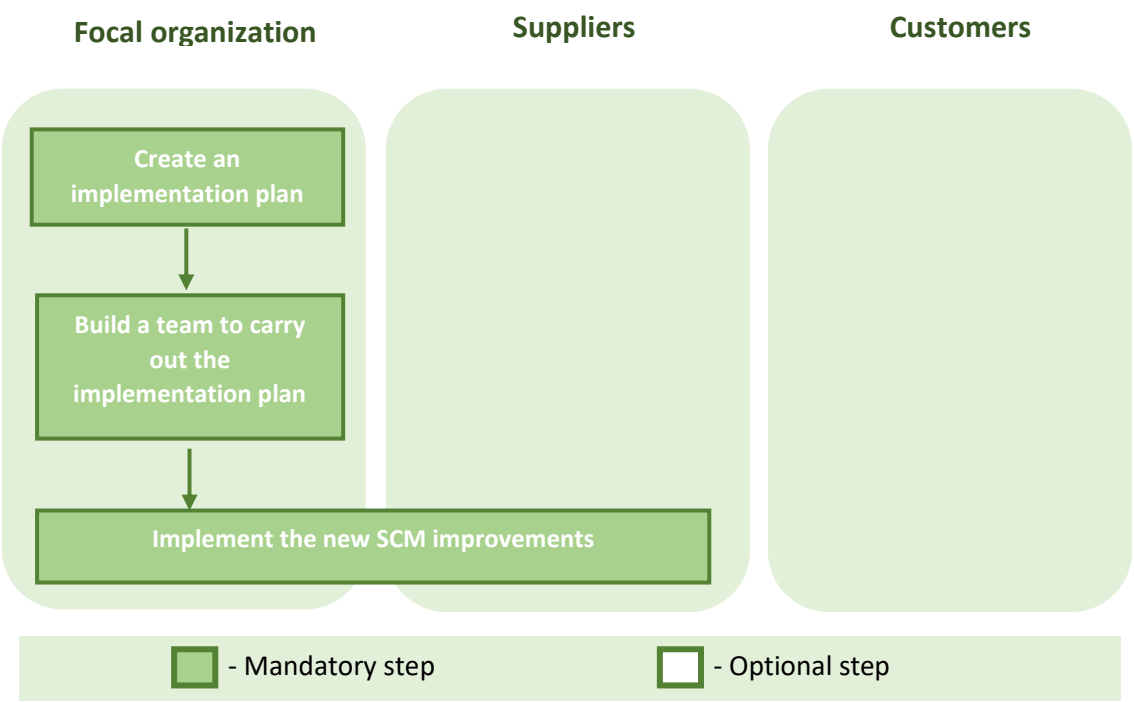

Figure 12-Phase 4) Implementation and Execution

Here is where the organization must create an implementation plan to carry out the improvement's implementation. Also, they must build a team to carry out the implementation plan, to create this team the organization can use the template showed on Annex 4.

Then, it is possible to implement the new SCM improvements.

The fifth and last phase, aims to ensure the philosophy of continuous search for perfection and sustainability.

5) Documentation and Monitoring

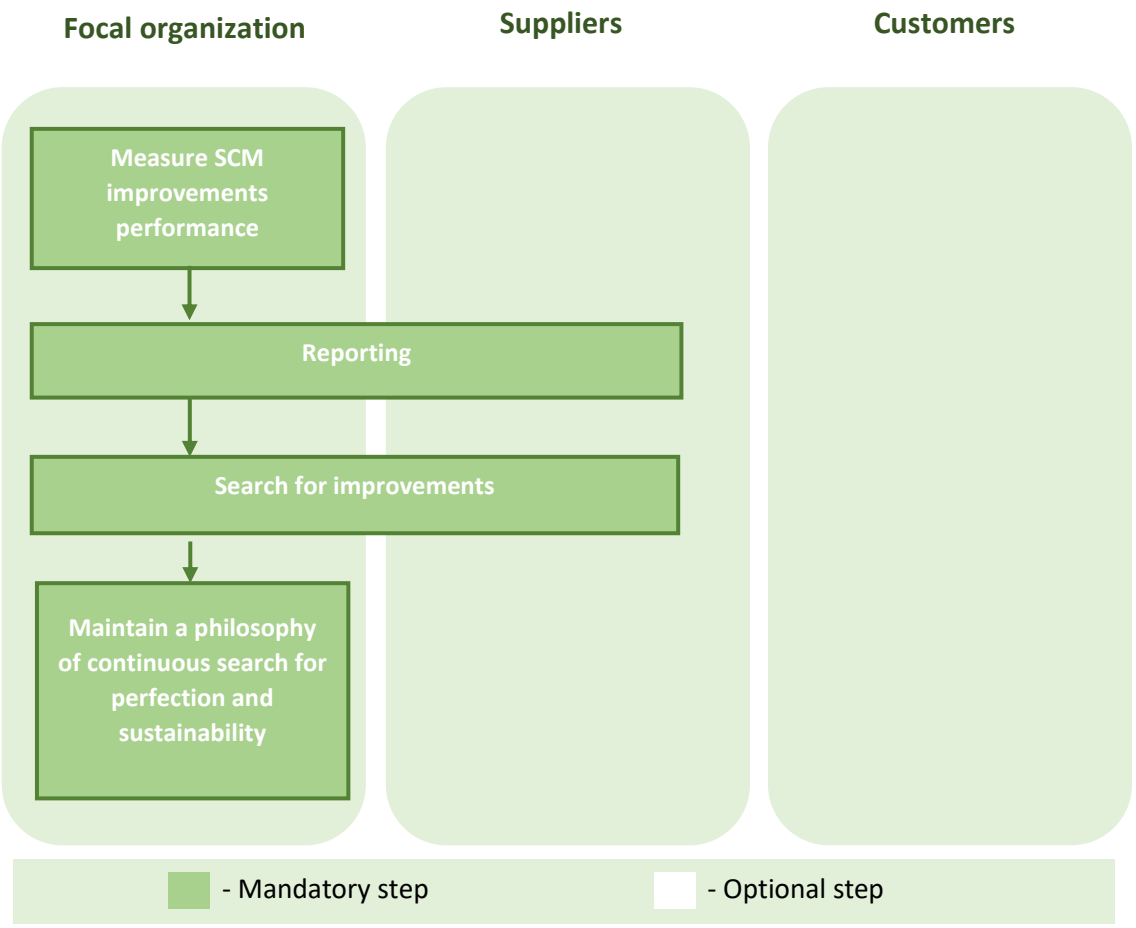

Figure 13-Phase 5) Documentation and Monitoring

The last phase of the proposed strategy implementation is about measuring and control the SCM improvements implemented. It is mandatory to measure the SCM improvements performance, this is, to each SCM improvements were settled objectives and, in some cases, KPI's so, it must be measured if the improvements are being successful or not. The organization must identify and measure the progress by measuring the actual results *versus* the plan

To help measuring, it is important that there is a continuous routine of reporting how things are going, that is, realizing what the organization's performance is at the different stages of the supply chain to be possible for the organization to identify points of improvement and inefficiencies during the various processes.

Monitoring enables the organization to optimize the points of inefficiency found and carry out the improvements identified. The objective is for the organization to always be responsive to

the performance of its supply chain and, at the same time, always try to find ways to optimize processes always in search of better results.

To support the optimization process, it is important to implement a philosophy of continuous search for improvements and, mainly, for sustainability, which is the new key component of this strategy. To develop this type of philosophy, the organization can apply the kaizen methodology, which has already been seen in other stages. An example of this methodology can be seen on Annex 5.

This phase can be considered as a closed loop because it is always repeating the steps by measuring SCM performance, identifying problems, proposing improvements and then it goes back again to measuring performance to see if the proposing improvements are being successful.

4.3- Evaluation

The framework validation process consisted in individual interviews with four relevant specialists, that allowed their name to be mentioned in this investigation, they were:

- Isabel Abreu dos Santos, professor of environmental engineering at Lusófona University and researcher at MARE-NOVA.
- Pedro Malta, professor of information systems at NOVA IMS University.
- João Matos, Lean project manager at an e-commerce company.
- Henrique Marçal, CEO & Partner at The Lean Six Sigma Company Portugal and Brasil.

Initially, the motivation and objective of the research work was explained. Then, an introduction to the two main studied areas was made and, lastly, four questions were asked to the participants, for them to answer according to their expertise and backgrounds on Lean or Green paradigm as well as their personal thoughts about what was presented.

The four questions asked were:

Q1	Do you think the proposed framework can be useful in Lean supply chains? Why?
Q2	Do you have any criticism towards the proposed strategy?
Q3	Would you consider implementing the proposed strategy?
Q4	Do you have any recommendation or suggestions for further improvements of the proposed strategy?

Table 9- Individual meetings questions

As these individual interviews were very rich, it was only included a synthesis of the answers of each participant to the three questions in the content of this section.

4.3.1. Q1: Do you think the proposed framework can be useful in Lean supply chains? Why?

Isabel Abreu dos Santos

I consider the proposed model very useful as long as there is an integration between the proposed improvements, that is, the improvements must be part of the organization's culture and my life.

I'll give you a practical example, I have my own way of managing my home in my day-to-day life, and I don't need someone to start saying "look now you're going to join your management in choosing products of this type, you should start to separate the residues and you must turn off the light when you move from one division to another "because all of this is already incorporated into my culture, I have incorporated these principles as many of us have already incorporated, we can stamp with the" brand "Lean or Green but these principles are already within us. And then all of this is fluid, flexible. And I think so, that the proposal is useful if it is this way and to be this way there has to be a change in behavior and in order for this change to exist, it is necessary to motivate people to change their behavior and convince them that it is the thing more certain to do because deep down everyone wants to have a better life and everyone has values and values are part of our backbone, and it is our structure that makes us different from other beings.

Pedro Malta

Yes, I find it useful. Of course, it is possible to look at the two paradigms and propose here a strategy that is useful for framing these two concepts.

João Matos

I definitely think so, for the fundamental reason that for me the main focus of Lean, despite looking at many things, is undoubtedly the elimination of waste. And then you end up also having the Green strategy in which the elimination of waste also ends up being one of the main pillars, therefore, we have our resources that are limited, and we have to try to make the least use of them, but the ones that we are going to use try to make the best use possible.

I see the Green strategy as a fuel for the Lean strategy in the sense that, for example, some things that you propose here in the model, such as the acquisition of recycled materials, this is something that you would not think personally for a Lean strategy but that you end up thinking about a green strategy that can then be a fuel for Lean in the sense that if the Green strategy tells you to buy sustainable materials and you in Lean can think "ok, if I buy sustainable materials I will end up reducing the waste at the end of the supply chain "and therefore turns out to be Lean and Green at the same time.

The question of the design of products that can be easily disassembled and recycled and that can even take these components to, in the future, reuse again in the production chain, turns out to be something that the Green tells you directly to do and that you end up for also eliminating waste from the point of view of Lean.

For example, the creation of waste indicators, at this point you end up again knowing that in the green strategy you must reduce the consumption of water, energy, etc., and you also end up eliminating Lean waste, therefore, they end up being two complementary paradigms. This new waste that you have incorporated, environmental waste, is a concept so talked about by the green paradigm that it ends up also being incorporated into Lean, with the sense of being a waste.

Lean's focus is on eliminating waste, but companies sometimes lack ideas on how to eliminate waste and here the Green strategy clearly tells us what waste we should eliminate and therefore this ends up helping to answer the many questions that companies put themselves on "how to eliminate waste". Lean asks itself "how are we going to eliminate waste" and the Green clearly tells you what you have to eliminate, and you end up drawing ideas.

Henrique Marçal

First of all, I would like to say in advance that the topic is quite interesting. I think the work is well structured, it is clear that it is difficult not to have a very concrete and practical example, that is, it is all very generic and conceptual, but it also has its value, any company can take the proposed model and adjust to what is its reality and so I think it is very good in that aspect. I'll give you an example, it may not be very relevant, but maybe it ends up being, we in our company give training in Lean and we changed from 100% physical books to e-books which led to a reduction in the number of printed sheets, of course we have a small stock because there are people who still prefer physical books but, basically, the paradigm has changed, before people paid for the course and we offered the physical books and now they pay for the course and we offer the e-books but, whoever wants leaving this more sustainable model and opting for physical books has to pay an extra price for them. As the option for physical books is outside the company's "sustainability strategy" in relation to the books supplied, people already have to pay an extra price.

I think the Green paradigm is a paradigm that sooner or later will have to be a reality, it will have to involve everyone, customers, suppliers, companies, and that is why I think it is very current.

Do I find the proposed strategy useful? Of course, yes! Especially because it turns out to be more of a "requirement" and Lean focuses on the requirements that our customers want so it focuses on the internal requirements of the organization itself, that is, each company has its strategy and if we now have to integrate principles of sustainability in the organization it is clear that it will be one of the requirements to be considered. Lean is designed to be flexible and agile to respond and adapt processes to meet our requirements.

4.3.2. Q2: Do you have any criticism towards the proposed strategy?

Isabel Abreu dos Santos

I think that the model itself does not fully explain what Beatriz means, everything you have written is very clear and precise, but the model itself does not show it as well as the text that supports it.

I think it is a very interesting topic because many times, entrepreneurs do not want to hear about the environment, as they immediately associate it with costs while adopting sustainable practices is good for the company's management and for themselves.

Another thing I wanted to tell you is that in the aspects in which Beatriz identified as the main differences between the Lean and Green paradigm, there is regulation and legislation that is not applicable to the Lean paradigm because it is voluntary, but that can be applied to the Green paradigm. For example, there is legislation that requires me to reduce waste and separate it so I have legislation for one paradigm, and I don't have legislation for the other. I don't know if you want to add it or not, but it is more of a difference between the two paradigms, while in the Lean paradigm I'm voluntarily applying it and on the Green, I can also be voluntarily applying it, but I have obligations, I can be punished and get a ticket and close the company. It can be a negative effect when comparing the two paradigms.

Beatriz mentioned very well that many of these obligations are already part of the regulations of each country, they are regulations of the country that come from the European Union and that in turn come from the United Nations and come in the form of protocols or policies derived from scientific work that they point to a possible collapse in the system where we live and, then,

based on that there are protocols and commitments that countries sign and commit to comply with, which result in a lot of legislation, for example the reduction of carbon emissions.

That is why I think that the model does not explain 100% what Beatriz wants to propose, because everything Beatriz said is part of a collaborative structure, for her the environment and sustainable behaviors are and must be present in all phases supply chain, which in turn are part of a circuit, and these must be inherent to the organization's culture.

I think the work is really great, but in my opinion the model could be more dynamic in order to demonstrate the difference between before and after.

Pedro Malta

I think you could present a better correlation of concepts through a table, for example, a three-dimensional table in which there were three columns to demonstrate the various stages of the supply chain, with Lean and Green, to be easier to visualize then where and how the two concepts can be integrated.

João Matos

I pointed out two points, the first concerns the proposed improvement for the “product design”, in this improvement you mention that the use of materials that are not invasive to the environment makes the product design less complex, derived from the use fewer components and, in turn, resulting in a lower cost. Regarding this point, I do not agree so much because there are currently cheaper products that the supply chain still manages to include, but which end up being more invasive to the environment, but which are still used because they are cheaper. I think that at this point it is not so straightforward that it will result in including Green practices in a cheaper product, however, I also think that this difficulty can be overcome through balancing and showing the customer the value of buying a more expensive product, but that it is done in a sustainable way, that is, you must demonstrate to the customer that you are paying more for a product that deserves to be paid for that amount.

The second point concerns Just-in-time, regarding the production of small quantities. Just-in-time ends up holding a bit with the issue of reducing to the minimum possible what remains as stock and inventory. As you say, well, this production system requires more transport, and which can then be filled with the suggestion that you have to share the transport of the truck. So, there was this point here, to understand how just-in-time is used and that it is not so compatible with the Green issue.

This turns out to be a criticism, but later on in your work you end up giving a valid solution and that is why I think the difference will be overcome.

Henrique Marçal

I have no criticism to make regarding what you have presented. We are bringing together two paradigms, the Lean paradigm with the Green paradigm and the environment, so there is nothing to add. One paradigm encompasses a worldwide concern and the other is a way and one of the best practices to achieve our goal. So, these are two highly synergistic paradigms and so they make perfect sense together and, as you said, well, we already do many of the Green practices unconsciously in the Lean world. In Lean the objective is to use the minimum resources and optimize them and, if we think about it, the fact that we try to use less water or less light,

we are not only implementing a sustainable principle but also minimizing the use of a resource and the optimize it.

4.3.3. Q3: Would you consider implementing the proposed strategy?

Isabel Abreu dos Santos

Yes, without any doubt.

I was very interested in something that Beatriz mentioned, which had to do with “just-in-time” in which you said it was a point of differentiation between Lean and Green and I don't know if it really is, for example , if I have dangerous materials in my company, and I have many times, I never want to have large storage of this type of materials because of environmental hazards, that is, I will want to apply just-in-time. If I have an accident at the facility, the consequences will be brutal if I have storage and not if I used the just-in-time system.

I know that when Beatriz refers to just-in-time as a point of differentiation between Lean and Green, you are referring to the distribution phase and it makes sense, we now have an open market but it is probably even there could be a collaborative alliance between the transport companies in which they stopped being directed to the customer and became with the region, for example, imagine that I want goods to be delivered to Castelo Branco in several companies and I have 4 carriers that do a different service, that is, they are competitors of each other, and I want to move from a storage system to the just system -in-time so, I instead of having 4 carriers I can only have 1 carrier that will make me less number of trips because every time the carrier goes to supply, it will supply all the companies that are in Castelo Branco instead of being the 4 carriers to supply, thus reducing emissions.

Pedro Malta

Yes, I think that as long as the company is willing, yes. Sometimes these things are conceptual and then when we want to apply, companies think that things are not quite like that. Therefore, it will always depend on each company and how it can be implemented.

João Matos

Regarding whether the implementation of the proposed strategy would be considered, I definitely think so, as I think it is really a question of survival, not only business survival, in the sense that it is clear that you have to maximize the use of your resources, for now we must use the fewest resources possible and the ones we use we must maximize what we do with them, reduce waste and increase the competitive advantage with it, but it is also about the survival of the human species, all ecosystems and everything that surrounds us.

The fact that you as an organization show that you are committed to this survival also ends up adding value to the organization and ok, you will probably end up having to sell more expensive products because they were also more expensive to produce, but in the end, it ends up paying off in both ways. So yes, I am sure that I would implement the strategy.

Henrique Marçal

If I find it useful and highly interesting, obviously I would implement the strategy proposed by you and I even gave the example of my company's books, which is very similar to the improvements you suggest, being already a more sustainable contribution. So yes, it would implement**.**

4.3.4. Q4: Do you have any recommendation or suggestions for further improvements of the proposed strategy?

Isabel Abreu dos Santos

Yes and here it has to do with the fact that Beatriz's strategy is a conceptual strategy and its application may be more difficult, but, without a doubt, the success of any strategy and any change in behavior and paradigms, which is what we are verifying today, there really has to be legislation and punishments for companies because, nowadays people's mental age is still very low but there must be above all and always motivation, knowledge and awareness and, for that, people have to feel things and to feel they have to put their hands in their pockets because the main reason for a company to exist is not values, it is economic profitability.

So, we have to go for the demonstration of economic profitability and to go that way we have to demonstrate that it exists and that it is possible and, above all, that it does not take much work. And for that, we put ourselves in the role of science and scientists, science has to leave its castle and it has to go to the street, to companies and to people. The technical language has to be transformed into a common language and companies must necessarily get there, they really have to, it is our duty. And just like that, and I say this Beatriz because in addition to having an academic and research career, I am a consultant in companies and I assure you that if I don't put my hand in my pocket and put money in there nobody pays attention to me and nobody wants me listening, therefore, the only and best way is to put your hand in the pocket of companies.

The Green paradigm is mandatory, which is why I was telling you that the piece of legislation is a little bit important. the Green paradigm is mandatory, but there are many things that are good practices, but I will also apply good practices only if the work I have to apply them is less than my compensation, because if it gives me more work than compensation that I will have, I as a company hang up immediately.

There was a constitutionalist who said that this dialogue on sustainability was very unfair because we do not have representatives of future generations today to negotiate, because they do not yet exist. That is why it is we, the generation of the present, who are making a projection of the future, which can often be wrong, and the question that falls on the question is “what are we going to do to negotiate today?”, which is very difficult.

So, suggestions or recommendations? Above all, it is to sensitize, train and incorporate these sustainability concepts in people's lives and make it clear that all of our actions have consequences. The Lean principle is “more with less”, as you mentioned, and this principle is a philosophy of efficiency and is transversal to everything.

Finally, I congratulate you, your work is very beautiful.

Pedro Malta

As it is a conceptual proposal, it would be good to have a focus group with employees of companies that can validate the reality of this in a company, it would be very useful. If you do not have a case study, therefore, it is a conceptual proposal, but you have the opinion of a group of people in the market who think that the proposed strategy would be useful to implement and that, in my opinion, is a way of supporting your thesis.

João Matos

Here I only have a very simple suggestion regarding the model proposed by you, where you identified the last phase as “documentation and monitoring” and, here I would add the word communication, that is, it would be “documentation, monitoring and communication”. That is, on a daily or weekly basis, those indicators that you create and monitor, you must communicate them to the employees of the company so that they also realize that the actions they are taking also have an action, not only in the company itself, but also on the environmental issues that are so talked about today, with which almost everyone identifies and that touches everyone.

And also, not only internal communication, but also external, that is, when communicating the results of the company, these indicators should be communicated and emphasized, for example, how much water have we saved, how much energy have we saved, how many end-of-life products we ended up reusing, etc., all of this ends up bringing value and added value to the organization. The objective is to make these indicators as or more important to be shown, such as profit, share value, dividends, etc.

Henrique Marçal

The theme is very interesting, the work is very well structured and is very clear and well written.

One suggestion I can make is regarding the “main concepts of framework” when referring to the customer's value perception and, in my view, it is not clear if when you say that it is necessary to perceive the perception of value for the customer, it is because the company is the one that wants to change its strategy and integrate sustainability principles or whether it is the customer who is demanding these principles because, normally, in the eyes of Lean it is the customer who “commands” and the company bases its strategy on the requests of its customers. But, if it is the other way around, it is also valid, the company can invert the paradigm and tell its customers that from now on it will change its strategy so that it integrates sustainability principles.

It is clear that Lean focuses on the requirements of the external client, but organizations have their strategy and now sustainability plans start to be part of the strategic plans of the organization, therefore, even if it is not an external requirement, it can be an internal requirement of the organization. organization to have a more sustainable supply chain and from there Lean is designed to be agile and flexible in order to respond and adapt processes to our requirements, I can conclude that it is a perfect combination.

Another suggestion I have to make is that you read and investigate a little about the “Lean enterprise” concept, which is basically what you’re talking about, this concept basically refers that if we have a huge supply chain, it doesn’t make sense just to analyze our installations as a company, we have to work together with our suppliers and customers so that the work is more efficient and that we are all interconnected to be able to optimize the supply chain as much as possible.

4.4- Discussion of Results

All of the experts enquired consider that, in a theoretical plan, the framework proposed may be used for Lean Supply Chains. Although they consider the proposed strategy to be quite conceptual, everyone believes that it can be used and adapted by companies as long as they consider other aspects such as, for example, customer education so that they understand the fact that the company wants to be more sustainable and demonstrate the benefits and value that new products and services will have with the changes, since the Lean paradigm works according to what the customer wants, the change of behaviors within the organization so that the implementation of the solutions found is efficient, and a practical example where it is

possible to see the results resulting from the proposed improvements in terms of cost and benefit.

One of the criticisms made is that the proposed model does not show at first glance all the solutions found and proposed, stating that the model does not do justice to the text that accompanies it. Another criticism concerns the doubt that some experts had regarding the effectiveness of some solutions presented, but which at the same time became positive points because their doubt ceased to exist when they read the support text for each solution and began to believe in the effectiveness of the solution.

It is unanimous for all the specialists that the Lean paradigm can and should be combined with the Green paradigm in supply chain, with the elimination of waste being the focus referred to by all of them, stating that the Green paradigm further promotes the elimination of waste and helps to eliminate the already defined by Lean. All of them stated that the proposed solutions were good and possible to implement in a company and that they would undoubtedly implement the proposed strategy.

Among the recommendations and suggestions, almost all of the experts mentioned points of information that I could add to the model, so that it becomes more complete, for example, adding some aspects in which the paradigms differ, changing the name of some phases and adding information, referring to certain concepts that they can also reflect what is being proposed, etc.

5. CONCLUSIONS

This research sought to find value in the combination of Lean paradigm with Green paradigm for Lean organizations to achieve an environmentally sustainable supply chain. Considering the opinions of relevant specialists, it was possible to meet the objectives of the research.

Not being possible to apply the proposed framework in an organization, it is mentioned that the proposals can be customized and designing to be adapted to each organization supply chain reality.

5.1 – Synthesis of the developed work

The present research investigation started with the background of the work to conduct, and what motivated it. Research questions were defined.

Then, resorting to an adequate literature review, Supply chain management was briefly studied; Lean paradigm was analyzed, namely its origins and main tools; the Green paradigm was also studied, in particular its roots and definition. The two paradigms when applied to supply chain management were also studied as well as their similarities and differences.

Subsequently, the investigation methodology was defined, it was chosen the Design Science Research methodology, and it was explained how it would be applied to this research investigation.

Based on the revised literature regarding the two fields of study, the framework to combine Lean with Green paradigm as an enabler for an environmentally sustainable supply chain was developed. The framework proposed was then presented individually to four relevant specialists, for a subsequent discussion of the results.

5.2 – Investigation Limitations

Notwithstanding the fact that the main goal was to present a framework where Lean is combined with Green paradigm for supply chain in order to became environmentally sustainable and not final solutions for immediate application, some limitations to the work conducted were found.

The main limitation to this research work is the failure to check the feasibility of the framework proposals. This limitation is due to the short period of time spent to carry out this master's thesis and because of this fact, it was not possible to incorporate a practical application of this framework in the scope of this master's thesis.

Another limitation of this research is the fact that, due to the first limitation mentioned, the proposals submitted are very generic, but it is referred that they can be customized and adapted to the reality of each organization. Although, it is not possible to verify which proposals have the best results and facilitate the achievement of a more environmentally sustainable supply chain.

A third limitation is the fact that the validation of the proposed framework could have involved more participants but, due to the short time to carry out the thesis, it was not possible to interview more experts.

5.3 – Future Work

Unfortunately, and as it was explained in the previous section, it was not possible to check the practicability of the framework proposals.

Saying this and in line with what was concluded after the individual interviews, the practical application of the framework should be done in the future in order to improve it, based on a practical application in a real-life organization scenario.

It is also proposed an understanding of the role of the consumer in an environmentally sustainable supply chain is also proposed. This understanding involves not only educating the consumer so that he understands why the organization has to change its strategy, but also explains the importance of a sustainable model by demonstrating the advantages for the environment and, especially, for the consumer.

Finally, a strong education should be proposed to organizations that want to implement the proposed framework because it is a strategy that requires the integration of all levels of the organization so that there is a change of behavior and it is possible to implement the proposals.

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ANNEXES

Annex 1- Identify environmental needs.

Environmental needs	
EN1:	
EN2:	

Annex 2- Clarify the goal.

Objective Definition:	
Question	Answer
1.What it means to be successful?	
2.What is the impact expected with the strategy?	
3.What will be the reactions of potential customers?	
4.What will change and how will it change?	

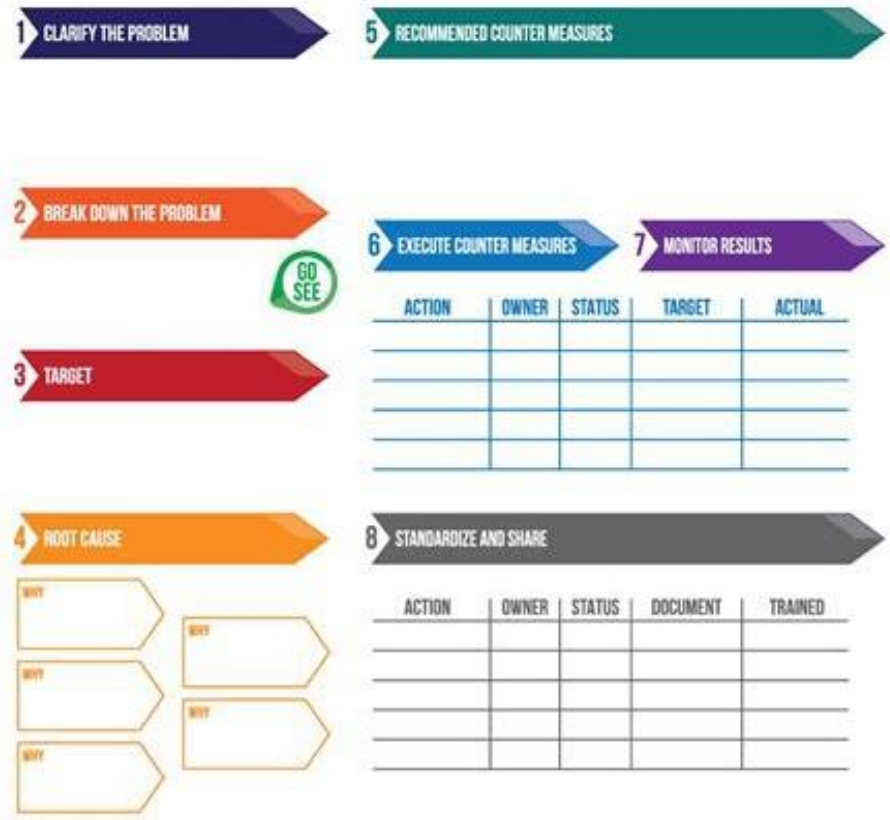
Annex 3- Comparison between "Where we are now" versus "Where we want to be".

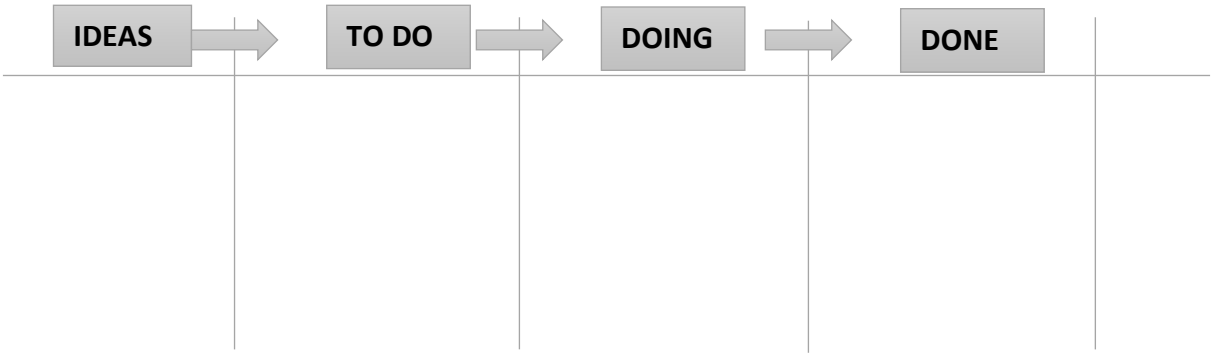
SC phase	Where are we now	Where we want to be

Annex 4- Build a team

Name	Strenghts 	Knowledge 	Background 	Department 

Annex 5- Continuous improvements





Annex 6- 5S checklists

AREA:_____ Previous Score:___/___ (%) Final Score:___/___ (%)

Auditor:_____ Date:_____

1. Checklist

5S	#	Check Item	Description	Score				
				0	1	2	3	4
1S: Sort	1	Materials or parts	Are there any unneeded materials or parts around?					
	2	Machines or other equipment	Are there any unused machines or other equipment around?					
	3	Tools, Supplies, Parts	Nothing on the floor except Legs, Wheels, or Pallets?					
	4	Frequency	Have items been sorted by everyday use vs. those used occasionally?					
	5	Written standards	Has establishing the 5S's left behind any useless standards?					
			Sub Total:					
2S: STORE (Set Locations & Limits)	1	Location indicators	Are shelves and other storage areas marked with location indicators and addresses?					
	2	Item indicators	Does everything HAVE a place? Is everything IN its place?					
	3	Quantity indicators	Are the maximum and minimum allowable quantities indicated (Kanban)?					
	4	Marking of walkways and storage areas	Are lines or markers use to clearly indicate walkways and storage areas?					
	5	Tools	Are tools arranged functionally to facilitate picking them and returning them?					
		Note: A Kanban is a self-sustaining inventory system. (It has a Min, Max, Re-order Point, and Re-order Quantity)	Sub Total:					
3S: Shine & Sweep	1	Floors	Are floors kept shiny and clean and free of waste, water, dust and/or oil?					
	2	Machines	Are the machines wiped clean often; kept free of waste, dust, and/or oil?					
	3	Cleaning and checking	Is there a cleaning checklist being followed that is effective?					
	4	Cleaning responsibilities	Is it clear (understood and communicated) who is responsible for cleaning?					
	5	Habitual cleanliness	Do workers habitually clean their workstation without being told (sweep floors, wipe equipment, desk, etc)?					
			Sub Total:					
4S: Standardize	1	Improvement Audits	Was the 5S audit completed for this area last month? Month before?					
	2	Improvement ideas	Were the improvement ideas from the last audit acted upon?					
	3	Key procedures	Are standards procedures written, clear and actively used?					
	4	OPLs	Are One Point Lessons used to communicate key activities / procedures?					
	5	The First 3 S's	Are the first three S's (Sort, Set Locations and Shine) being maintained?					
			Sub Total:					
5S: Sustain	1	Training	Is everybody adequately trained in standard procedures?					
	2	Tools and parts	Are tools and parts being stored correctly?					
	3	Stock controls	Are stock controls being adhered to (Kanban)?					
	4	Procedures	Are procedures updated (within last year) and regularly reviewed?					
	5	Activity boards	Are activity boards used? Are they updated and regularly reviewed?					
			Sub Total:					

2. Score Criteria

Item	Total "S"	Type	Criteria
0	0	Serious	activities not conducted at all
1	5	Major	activities implemented between 0 – 30%, danger of process going down
2	10	Minor	activities implemented between 31- 60%, if not attention paid could become a Major
3	15	Trivial	Activities conducted in a systematic way but could improve, 61-90%
4	20	Excellent	Activities implemented and used in a systematic way, 91-100%. Focused Improvement