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Use of Lean Manufacturing Tools to Support Sustainability Initiatives

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Abstract

During recent years, sustainability has been a relevant topic of common interest for organizations due to several factors. Likewise, continuous improvement is essential for the competitiveness of any company and the Lean Manufacturing philosophy is a fundamental pillar to fulfill this purpose. The objective of this research was to identify the contribution that Lean Manufacturing tools can make to sustainability. To do this, it began with a description of the background, history, and pillars of sustainability. Then, the foundation of the main Lean Manufacturing tools was explained, to finally relate the contribution of these tools to the seven sustainability principles included in the ISO 26000 standard. The results obtained showed that several tools contribute to all the sustainability principles, while others only do so indirectly, the contributions identified were economic, social and/or environmental in nature. Thus, companies could initiate sustainability initiatives from the basic and early stages of production without having to resort to complex or specialized management systems.

Keywords
Sustainability, Lean Manufacturing, CSR, and sustainable development.

1. Introduction

Lean Manufacturing is an oriental philosophy created by the Toyota company whose objective is to optimize processes and tasks within an organization, the philosophy that was built around this philosophy was the reduction of waste and elimination of tasks that do not add value to the final product. This improvement is achieved through tools, each one of them is different and has an individual purpose. However, they lead and contribute to the principles of Lean Manufacturing. Each tool contributes in different ways, for example, there are tools that help to better organize the activities of a process, if these tasks are organized, resources are optimized, unnecessary movements are eliminated and thus there is a better result. Similarly, there are other tools that are visual and allow finding unnecessary tasks and movements that are using resources unnecessarily, knowing these activities can be eliminated or improved and thus add value to the tasks, there are also tools that allow avoiding flaws or failures and even tools that apply to management level (philosophy).

On the other hand, we have sustainability, which for many people is also applied as a philosophy, which mainly seeks the social, economic, and environmental benefit of an environment. According to Miranda Pegueros et al., (2022) sustainability focuses on the balance between the economic, social, and environmental spheres in society so as not to compromise the quality of life of future generations. This topic is currently of common interest in society and is being considered in many aspects of daily life, mainly in organizations, which play a key role in the social and economic

development of the population. It is known that, in companies, it is necessary to be interested in sustainable principles due to reasons such as market requirements, the legal part, stakeholders or for the own interest of the organizations.

Now, as mentioned above, the main objective of Lean Manufacturing tools is to eliminate all those processes or tasks that do not add value, something that is directly consistent with the principles of sustainability. In this sense, if those processes are eliminated, waste, downtime, unnecessary use of resources, among others, are reduced. Thus, this article will present the relationship and impact of Lean Manufacturing tools with sustainability. For this purpose, several tools presented in the so-called Lean house will be taken and related to the seven principles of sustainability described in the ISO 26000 standard.

1.1 Objectives

The purpose of this article is to identify the use of Lean Manufacturing tools as a sustainability proposal. To this end, an instrument will be designed to evaluate the contribution of Lean Manufacturing tools in the pillars of sustainability and their possible application in companies.

2. Literature Review

2.1 History of Sustainability

The progress and evolution of sustainability became relevant as milestones arose that put some factor in society at risk (Zarta 2018). In fact, although the exact moment in which sustainability emerged is not known, there are records dating back to the 12th century where there is a concern for the care of nature. Later, in the 20th century, universal human rights were created after the Second World War, evidencing the importance of the social component. Likewise, in 1944, with the collapse of the Wall Street stock market, the International Monetary Fund was formed to provide for the financial stability of citizens. Later, in the 1960s, global concern for the environment began and the emergence of environmental movements that aimed to make major state, collective, cultural, and economic changes (Zarta 2018).

Thus, over time, milestones have appeared in the economic, social, and environmental fields that make up the field of study of sustainability. Among the most relevant are the Stockholm conference in 1972; the publication of the Brundtland report of the 1980s (Panigua and Moyano 1998; Zarta 2018) ; the publication of the Green Book of the European Union in 2001 (Garzón and Ibarra 2014); the Paris Agreement in 2015; and, finally, the 2030 Agenda of the United Nations Organization that proposes the Sustainable Development Goals, which are not mandatory, but it is expected that economic agents show willingness and support so that they are met (Allen et al. 2016; Cubilla-Montilla et al. 2019). Certainly, the progress of sustainability has been a long road that has had ups and downs.

In fact, the path that has been outlined to apply and raise awareness about sustainability has not always been voluntary, but rather because there have been no more alternatives to the damage caused or, due to some law that has been imposed and must be complied with (Shah & Siddiqui, 2019). Nonetheless not even the legal part guarantees that these laws are complied with because there are several cases of corruption, lack of ethics, adult, and child labor exploitation in different environments despite the existing protection and care laws, as well as of organizations that claim to protect human rights (De Romero et al. 2020).

2.2 Pillars of Sustainability

Currently, three pillars are used to address sustainability which are in the economic, social, and environmental spheres. Zarta (2018) states that sustainability in the economic field is achieved when business success is possible and, in turn, treating clients and workers with integrity, recognizing them with good payments. On the other hand, social sustainability can be achieved through links with society with the contribution of projects that improve people's quality of life. Finally, environmental sustainability is achieved when the limits of use of natural resources are not exceeded through planning their use and consequences.

2.3 Business Sustainability

Diez-Martinez and Peiro-Signes (2022) affirm that sustainability is becoming a key and long-term strategic factor in organizations. This term has progressively become relevant and is an unstoppable trend throughout the socioeconomic context. As the authors mention, in recent years customers are concerned about purchasing ecological products and services. This action has directed and accelerated the integration of habits that generate environmental awareness.

On the other hand, the result of the application of sustainable practices can be evidenced both in the effect they produce on the environment and in the social and economic results that organizations perceive during their business life. For a company to execute sustainable practices, it requires constant research and innovation (García-Torres and Rey-García 2020).

In the same context, another tool that generates competitiveness is the value chain, which is very beneficial for companies because it adds value not only to the final product but to the entire process that integrates the creation of a product or service. For its part, the sustainable value chain seeks to implement sustainable practices within the processes required to create a good or service. In this regard, Bernal et al. (2022) affirm that the sustainable value chain carried out as a team brings benefits to interested parties and minimizes risks. Furthermore, this practice encourages the application of sustainable activities which triggers greater competitiveness for the company. Of this way, the importance of the rise of sustainability is demonstrated in society and interest of organizations to adopt practices sustainable in its operations (Zarta 2018).

2.4 Corporate social responsibility

Social Responsibility begins with approaches of philanthropic acts in the years of the first Industrial Revolution. Thus, the emergence of the United Nations Organization served as a basis to raise awareness of social issues (Jiménez and Pérez 2016). In the business field, social importance is born to contribute to the community in progress, development and provide a dignified life to a certain group of people and in this way demonstrate positive changes in their development (Duque et al. 2013).

Furthermore, this importance lies in the need for a company to respond to the changes produced, internally and externally, in organizations such as pollution, lack of raw materials, among others (Jiménez and Pérez 2016). Therefore, it is established that a company generates value in four ways: through the minimization of materials and contaminants, business ethics, technological development and through the creation of goods and services that satisfy consumers (Duque et al. 2013).

2.5 Lean Manufacturing

Lean Manufacturing is an eastern philosophy known for improving the productive systems of a company that is linked to productive efficiency in industries because it is aimed at eliminating all activities or waste that do not add value and affect the quality of a product or service (Shah and Patel 2018; De la Cruz-Felipe et al. 2021).

On the other hand, this philosophy is made up of the so-called "3M", which constitute a fundamental part of said philosophy. These three key concepts focus on identifying and eliminating problems that negatively affect productivity and product quality. Radin et al. (2023) suggest that the 3M are classified as:

- Muda: It refers to waste and therefore does not create value for the consumer.
- Mura: This concept refers to the variability in operations.
- Muri: Refers to the overload of machinery or workers with tasks that exceed their capacity.

The changes or waste, which are a key concept in Lean Manufacturing, Shah and Patel (2018), are classified as:

- Overproduction: It refers to producing what is necessary and when it is necessary so as not to have excess inventory. This reduces the risk of having obsolete or incorrect products.
- Defects: There are several errors that can increase the costs of products, which can be physical or management.
- Inventory: Excess inventory implies large financing, as well as high costs to store the merchandise and, therefore, a higher defect rate. This waste delays production time does not allow problems to be identified quickly and requires a lot of space.
- Transportation: Refers to unnecessary movements that do not add value such as repeated or prolonged movements.
- Waiting time: This refers to times when there is no activity in the plant due to some machinery failure or inefficiency on the part of the workforce.
- Motion: Refers to downtime for both people and machinery due to bottlenecks or poorly designed production flows. This results in delays in the production of products.
- Overprocessing: It consists of the excess details that are given to a product and that this is not necessary because it will not be perceived by the customer. That is, they are unnecessary tasks carried out involuntarily. Now, due to the evolution of the industry, some authors consider an eighth waste, which is unused talent.
- Non-utilized Talent: Refers to not recognizing or enhancing the intelligence of workers.

On the other hand, the essence of the Lean Manufacturing philosophy is embodied in the Lean House or also known as Toyota Production System (TPS), which is made up of foundations, two pillars, and a roof. This house has evolved over time due to the implementation of new tools and philosophies that complement this system.

The foundation of the house represents stability, which proposes a corporate culture that directs its efforts in the long term (Toledano et al. 2009). With respect to standardization, this refers to the safest and most effective method to take advantage of productive resources and carry out work in the shortest possible time. These foundations are supported by two principles: Hiejunka and Kaizen. The first one, helps the production of what is necessary and when it is necessary, leveling the production of orders according to a repetitive factor that makes the average daily production similar to that of other production days. The second one represents continuous improvement in all processes and by the company's personnel. Likewise, Alefari et al. (2020) defines continuous improvement as a permanent work of improvement.

Next, there are the pillars of the house that are represented by two principles, Just-in-Time (JIT) and Jidoka, which are broken down into tools and principles that support these pillars. Thus, JIT seeks to supply parts in the necessary quantity, at the exact place and time; this is achieved by minimizing waste (Dange et al. 2016). Jidoka, for its part, includes technological and human processes. In this line, Puche and Costs (2011) state that this principle is based on the fact that, when there is a problem, the machine stops and the root causes are investigated, solutions are proposed, and the most effective and cheapest solution is executed. In turn, these pillars are reinforced with tools such as continuous flow, Takt Time, Pull System, Andon, Poka Yoke, 5's, among others. Finally, we have the roof of the Lean house, which represents the objective of the philosophy that focuses on providing high quality products, with low costs and with the shortest waiting time (Toledano et al., 2009).

2.6 Lean Manufacturing Tools

Manufacturing tools are those instruments that eliminate waste and streamline tasks to increase the value perceived by the customer (Ukey et al. 2021). There are several tools that support the fulfillment of the objectives of the philosophy and that also support the pillars of the house. Among the main and best-known tools of Lean Manufacturing are:

- 5S: It is used for order and cleanliness in the workplace, through standardization and order habits (Manzano & Gisbert, 2016). Its name is derived from the Japanese terms Seiri, Seiton, Seiso, Seiketsu and Shitsuke, which mean Selection, Systematization, Cleansing, Normalization and Self-discipline, respectively (Piñero et al. 2018).

- Value Stream Mapping (VSM): Also known as value chain, it is a management tool that is responsible for adding value to production processes (Paredes-Rodríguez 2017).
- Total Productive Maintenance (TPM): It is a tool that seeks to improve the reliability and availability of equipment, as well as reducing variability in operations (Dinas et al., 2009). Furthermore, it is composed of several sequential activities, which facilitate competitiveness (Castillo-Flores et al. 2018).
- Poka Yoke: It is a tool that seeks to eliminate errors from the root to prevent them from arising in the future (Middleton 2001). In turn, it facilitates permanent supervision and feedback tasks within an organization (Hernández et al. 2018).
- Andon: It is a visual and auditory communication tool that allows operators to interact with different manufacturing areas to solve problems that arise throughout the workday, preventing workers from having to travel in search of assistance (Purmala and Sudarto 2023). According to Martínez-Hernández et al. (2020), this tool increases quality and productivity levels at the lowest cost and prevents failures from passing to the next level of production.
- Single Minute Exchange of Die (SMED): The tool allows increasing flexibility, keeping an organization prepared to face the changes required by demand, as well as minimizing inventories (González 2007).
- Takt Time: In Lean Manufacturing, Takt Time is the pace at which products must be completed or finalized to meet demand needs (Tapia et al. 2017). In addition, it represents the average sales during a specific period of time, as well as the time available to produce a piece (Shingo, 1989).
- SIPOC diagram: It is a tool that allows us to recognize the suppliers of a process, as well as their inputs and outputs (Cañedo et al. 2012). Parkash and Kaushik (2011) claim that this diagram also contributes to achieving the mission and purpose of the work team, as well as recognizing opportunities to minimize or eliminate tasks that do not add value to the process.
- Kara-Kuri: This tool aims to seek the automation of processes. Currently, it is used to carry out objective activities or tasks to increase productivity. The objective of this tool is to minimize or eliminate human movement that is not necessary with the manufacture of a machine.(Madisa et al. 2019).
- 3P: The 3Ps, which stand for Production Preparation Process, focus on reducing waste through process and product design. In addition, it seeks to satisfy customer needs starting with product development from scratch to create and design processes that require less raw materials and economic resources (Yusuf et al. 2016).
- Spaghetti Diagram: This diagram is represented visually and uses a continuous flow line to show the cycle of an activity. This helps the team recognize repeated processes and identify opportunities to streamline tasks (Daneshjo et al. 2021).
- Quality Control Circles (QCC): They constitute a tool used to solve production problems. Monroy (1985), states that Quality Control Circles are an administrative tool that promotes participation, in which managers are committed to supporting and directing efforts and resources to workers so that they develop their creative problem-solving skills. Likewise, this tool is widely used because it encourages employees to work as a team and share ideas with management to define, solve and coordinate solutions.
- Six Sigma: Six Sigma is used in business management to improve processes by minimizing product failures or defects. According to Sharma et al. (2019), this tool allows improving quality in manufacturing processes and reducing manufacturing costs by reducing process variation and reducing defects. Furthermore, it consists of five stages that are definition, measurement, analysis, improvement, and control (Montoya et al. 2008).
- Ishikawa diagram: The Ishikawa diagram, also known as the Cause-and-Effect diagram, is used to identify the potential causes and effects of a specific problem. Its graphic representation allows teams to organize a large amount of information regarding a problem and, in this way, define its root (Rodríguez et al. 2012). Likewise, this diagram allows us to better understand the elements that participate in the quality of a good or service, allowing us to bring to light the causes of dispersion and organize the relationship between the causes in a matter that may be focused on various fields (Delgado et al. 2021).
- Pareto diagram: It is a visual tool which is represented by a histogram where data and values about a problem are presented. In this regard, Sales (2013) states that using this tool, the most important problems can be identified by applying the Pareto principle. The latter states that 80% of the results produce 20% of the elements.

- Chaku Chaku: This tool seeks to make quick and efficient movements. According to Krugh et al. (2017), Chaku-Chaku significantly eliminates work in progress, practices defect-free manufacturing, and has very high space and labor utilization.
- Total Quality Management (TQM): TQM, also known as Total Productive Maintenance, is a quality management method whose main objective is for employees in a company to ensure and become aware of quality in each of the sectors of the organization. TQM seeks excellence and, to do so, creates timely attitudes and controls to prevent defects and possible failures. In this way, it seeks to improve customer satisfaction through effective and efficient processes (Orellana-Intriago et al. 2019).
- PDCA cycle: The PDCA cycle is a tool used in quality management to improve production processes and solve problems. According to García et al. (2003), this method is related to the planning, implementation, control, and continuous improvement that involve the products and processes of the quality control system. Likewise, the authors mention that the acronym of this tool represents Plan, Do, Check and Act.
- Hoshin Kanri: The word comes from Japanese and means management of policies or objectives. It represents the concept of guiding the company in a consensual and clear direction. Its objective is to provide significant improvements in company performance by organizing and aligning workers' activities with its strategic objectives (Marsden 1998).

The tools mentioned are just some of the main ones that were created by the authors of the philosophy and, in general, they provide competitiveness to the company because they eliminate unnecessary tasks and time, allowing the finished product to be perceived with greater value (De la Cruz-Felipe et al. 2021).

3. Methods

The present research is qualitative, non-experimental, with a descriptive approach, as it is based on observation and analysis of the information. For the development of this work, a standard was first identified that allows defining the sustainability or social responsibility criteria that it is recommended that companies should follow in order to align themselves with the principles of sustainability; Subsequently, the field of application of each lean tool and its advantages were analyzed, seeking coincidences with the principles of sustainability or CSR in order to finally be able to relate the use of these tools with their contribution to the principles of sustainability. Among the standards analyzed, ISO 26000, AA1000, SA8000, SGE21, GRI 2022 were considered, finally selecting the ISO 26000 standard since it is applicable to any organization and has a comprehensive holistic approach that is developed through seven core subjects and seven sustainability principles.

4. Results and Discussion

ISO 26000 is an international standard based on principles of Social Responsibility. This standard can be used by any organization, both public and private in any country. The standard is an instrument so that companies can carry out their activities in a socially responsible manner and so that they can adapt to market needs (ISO, 2010). ISO 26000 consists of seven fundamental social responsibility core subjects that are:

1. Organizational governance: This principle is an organized way of providing direction and control through policies and processes to meet short- and long-term goals (Carvajal & Ramos, 2020).
2. Human rights: This principle guarantees universal human rights that are applied to all human beings by virtue of their existence.
3. Labor Practices: This principle covers all activities and policies related to workers, whether internal or subcontracted. These policies include recruitment, training, training, comprehensive health, disciplinary conduct, promotions, work hours, payments, among others (ISO, 2010).
4. Environment: Due to the daily activities of companies, it is impossible for them not to generate impacts on their environmental environment. This principle covers the use of resources, geographic location, waste production and pollutants which affect ecosystems (ISO, 2010).
5. Fair operating practices: This principle refers to relationships with interested parties. In this way, it is expected that there will be ethical relationships.

6. Consumer issues: This principle covers everything related to the consumer with a responsible approach. That is, product guarantees, sustainable consumption, fair promotion practices, among others.
7. Community involvement and development: This principle expects the participation of the community and to this end proposes developing policies and processes that contribute to the political, economic, and social development of the communities. (ISO, 2010)

Once the sustainability issues are identified, the application of each lean tool is analyzed under these principles. For practical issues, the analysis carried out for two of the aforementioned tools (5s and value stream mapping) is presented. The results can be seen in Table 1 and Table 2.

Table 1. 5s tool and its relationship with sustainability principles

Lean tool: 5S
Organizational governance: 5s is a tool used for order and cleanliness in the workplace, this promotes and implements an organizational culture where resources are used in a better way. In this way, you stay informed about any important situation so that the company can implement policies and make decisions.
Human Rights: Each of the 5 stages of this tool aims to provide improvements, not only in the processes but also in the quality of life at work so that people can function in an optimal and safer way in their jobs, in this way. way the right to a decent workplace is guaranteed.
Labor practices: One of the principles of this section is health and safety at work, and this tool contributes to this principle with (Seiton) which is order, because in this step safety signs are used so that workers can have precautionary measures to warn of any existing danger or risk.
Environment: 5s promotes order and cleanliness in workspaces, and therefore the efficient use of the resources of each department. This contributes to sustainability because fewer resources are used in an orderly space, which will result in a decrease in waste, waste, energy, among others.
Fair Operating Practices: No significant relationship was found with this principle.
Consumer issues: The 5s, by proposing a sequence of steps of order and cleanliness, eliminate unnecessary activities and movements and therefore waste within the production processes, which contributes to a reduction in costs in the final product, and this can also improve the quality of products, which is beneficial for consumers.
Community involvement and development: No significant relationship was found with this principle.

Table 2. Value stream mapping tool and its relationship with sustainability principles

Lean tool: Value stream mapping (VSM)
Organizational governance: VSM is a tool used to visualize the steps of an activity, and this can contribute to this principle because, if there is a better visualization of the activities or tasks that are generating problems of any kind in the organization, policies, reforms, or decisions can be implemented to improve them**.**
Human Rights: If you have an overview of all the tasks and those responsible for them, you can improve the distribution and assignment of activities according to the capabilities and aptitudes of each person, which provides motivation and job stability.
Labor practices: Having activities well planned and described allows the worker to mitigate operational errors, which results in good working conditions and greater safety; likewise, the worker will be able to perform better.
Environment: Having the main activities of a process captured allows us to recognize the movements, times, and resources necessary to carry out a task. This results in saving energy, time and reducing waste.
Fair Operating Practices: Being able to easily visualize a process allows you to eliminate, change or improve any commercial activity with a supplier that is having a negative impact on the community or that is not in accordance with the ethical and social responsibility values and principles of the company.
Consumer issues: Carrying out a detailed mapping of the activities to be executed allows you to reduce time, activities, and the use of unnecessary resources, among others. In this way, costs are reduced, and the quality of the products is improved because the entire production process is specified and controlled.
Community involvement and development: Detailed the production needs in an organization makes it possible to acquire materials provided by local communities, which encourages their participation and development.

A similar analysis was carried out with the rest of the aforementioned tools to determine their contribution to the principles of sustainability. It should be noted that there are certain tools that, due to their more administrative (management) approach, cover a greater range of sustainability opportunities, while other tools, more operational, present certain limitations and focus on sustainable principles that are more aligned with reducing the use of resources (energy, materials, labor, etc.) and improving the quality of work (occupational health and safety, motivation, etc.). The following Table 3 presents a summary of the tools analyzed and the sustainability principles on which they can have a positive impact, the sustainability principles are numbered from 1 to 7 following the same order as presented in Table 1 and Table 2.

Table 3. Contribution of lean manufacturing tools to sustainability principles

Lean tool	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 6	Principle 7
5s	+	+	+	+	-	+	+
VSM	+	+	+	+	+	+	+
TPM	+	+	+	+	-	+	+
Poka Yoke	-	+	+	+	-	+	-
Andon	+	+	+	+	-	+	-
SMED	+	-	+	+	-	+	-
Takt Time	+	-	+	+	-	+	-
SIPOC diagram	+	-	+	+	+	+	+
Kara-kuri	-	+	+	-	-	+	-
3P	+	+	+	+	+	+	+
Spaghetti diagram	+	+	+	+	-	+	-
QCC	+	+	+	+	-	+	+
Six sigma	+	-	+	+	-	+	-
Ishikawa diagram	+	+	+	+-	-	+	+
Pareto diagram	+	-	+	+	-	+	+
Chaku-chaku	-	-	+	+	-	+	-
TQM	+	+	+	+	+	+	+
PDCA	+	+	+	+	+	+	+
Hoshin Kanri	+	-	+	-	-	+	-

Note: + direct impact in sustainability principles, - no significant relationship was found with this principle

5. Conclusion

Lean Manufacturing has several tools focused on different aspects such as visual knowledge of a procedure, order in workspaces, automation of processes, streamlining of movements, reduction of inventories between others. All these characteristics are intended to improve efficiency and production systems in an organization. However, it is important to recognize that this philosophy also highlights important contributions to sustainability in its different dimensions: economic, social, and environmental. As could be seen, the tools contribute to sustainability because they are related to the principles of waste reduction, elimination of unnecessary tasks, improvement of the work environment, optimization of the use of resources of any type, reduction of inventories, etc.

According to the relationship that was made with the tools and sustainable principles, it was observed that a large part of the tools are related in a positive and significant way to the principles of the ISO 26000 standard. Most of the management tools comply with all the principles. because their relationship is more direct. However, several unrelated tools were also found, mainly with Fair Operating Practices and Active Participation and Community Development. This lack of relationship occurred because no direct impact was found. This does not mean that there is no relationship,

but rather that there is an indirect contribution. That is, the benefits are derived from the initial purpose of the tool and are not directly appreciated.

The analysis carried out in this work demonstrates that many of the lean tools can have an impact that goes beyond the technical improvement of productive and administrative processes. Usually, these tools and their application are designed to have their greatest application in production and operations environments, however it has been shown that their usefulness can go beyond what is usually thought.

Certainly, when these tools were created, contributions to sustainability were not thought of, however, the potential that these tools continue to have is demonstrated and this work can serve as a starting point for future work where more in-depth recommendations can be made on how these tools can be used. tools can be used to promote sustainability and social responsibility.

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