LEAN THINKING: A USEFUL TOOL TO INTEGRATE SUSTAINABILITY INTO PROJECT MANAGEMENT

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Sustainable development is one of the challenges of our time. In order to survive, companies need to make changes and find ways to incorporate sustainability into all their activities, including Project Management (PM). Lean Thinking (LT) methods, which are tools that adopt the principle of focusing on customer value and waste reduction, are closely aligned with the principal features of sustainability. This close relationship therefore makes LT a useful tool that can be used by project managers to achieve sustainability.
This study explores the relevance of LT concepts, their relationship with sustainability, with PM and consequently, the possibility to integrate sustainability into PM. The objective of this paper is to evaluate the state-of-the-art of research into the links between LT, PM and sustainability with a view to: 1) identifying and classifying the literature, 2) analysing the literature and uncovering gaps, and 3) finding new paths for future research. For this aim, a systematic literature review (SLR) has been carried out that extends from the PM, LT methods and sustainability.

Keywords: Project management; Sustainability; Lean thinking

LEAN THINKING: UNA HERRAMIENTA ÚTIL PARA INTEGRAR LA SOSTENIBILIDAD EN LA GESTIÓN DE PROYECTOS

El desarrollo sostenible es uno de los retos de nuestro tiempo. Con el fin de sobrevivir, las empresas necesitan hacer cambios y encontrar maneras de incorporar la sostenibilidad en todas sus actividades, incluyendo la Gestión de Proyectos (PM). Los métodos de Lean Thinking (LT), los cuales son herramientas que adoptan el principio del valor del cliente y la reducción de residuos, están estrechamente alineados con las características de sostenibilidad. Esta estrecha relación hace que LT sea una herramienta útil para los gestores de proyectos y así lograr la sostenibilidad.

Este estudio analiza la relevancia de LT, su relación con la sostenibilidad así como con el PM y la posibilidad de integrar la sostenibilidad en la Gestión de Proyectos. El objetivo de este trabajo es evaluar el estado del arte sobre los vínculos entre LT, PM y la sostenibilidad con el fin de: 1) identificar y clasificar la literatura, 2) el análisis de la literatura y la detección de lagunas, y 3) la búsqueda de nuevos caminos para la investigación futura. Para este fin, se ha llevado a cabo una revisión sistemática de la literatura (SLR) la cual se extiende desde los métodos de PM, LT y la sostenibilidad.

Palabras clave: Project management; Sustainability; Lean thinking

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1. Introduction

Lean Thinking (LT) was first introduced in the Toyota Production System in 1970 (Hines, P. et al 2004), and it became popular in 1990 following the publication of Womack's book *"The Machine that Changed the World"* (Anholon, R., & Sano, A. T. 2015). The approach has been shown to be a significant success, resulting in its worldwide implementation across a range of sectors, including products and services (Folinas, D. et al 2013). This philosophy, according to Womack, J. P., & Jones, D. T. (1996), is based on improvement of continuous flow manufacturing, customer-driven production, waste elimination, zero defects, visual management, safe and orderly working environment, the elimination of non-value adding but cost incurring activities, and customer value (Anholon, R., & Sano, A. T. 2015).

In the literature, LT is viewed from two standpoints that are closely related. These perspectives can be either strategic/philosophical or operational/technical (Bortolotti, T et al 2014). In their study, Bortolotti, T et al (2014) link the authors Womack, J. P., & Jones, D. T. (1996); Upton, D. (1998) to the former perspectives, whilst the work of Shah, R., Ward, P.T. (2003), (2007) can be linked to the latter. Hines, P., Holweg, M., & Rich, N. (2004) explain that the strategic level refers to value creation and understanding of customer value, whilst the operational level is concerned with improved efficiency and cost reductions.

LT has undergone substantial development in recent decades, which, as a result, has led to great changes in its targets, scope, and techniques for implementation (Hines, P. et al 2004). The success of LT in manufacturing has prompted other sectors to adopt this philosophy (Hines, P. et al 2004). Additionally, LT methods and mind-sets are being applied in areas outside shop-floor operations (Hines, P. et al 2004). Aziz, B. (2012) asserts that this philosophy can be extended to PM, yet this is still rarely mentioned in the literature. Reusch, P. J., & Reusch, P. (2013) states that "lean management is a management of values" and it can be applied to improve project management.

In the 1990s, the first investigations emerged with regard to the link between LT and the three aspects of sustainability, but these were mainly conducted through observational case studies (Chianiri, A. 2014). Lean, environmental (green), social practices and their effects on different aspects of company performance have been studied separately (Galeazzo, A. 2013; Wu, L. et al 2015). Wu, L. et al 2015, establish that from a sustainability perspective, there is a need to collectively take into account these practices in order to have a more comprehensive framework.

2. Methodology

A literature review was conducted to identify the main ideas underlying the links between Lean Thinking (LT), Project Management (PM) and sustainability. Papers published in peer-reviewed journals and proceedings from the year 2000 up to 2016 were selected (except for Womack's and Jones' book "*The machine that changed the world"* (1990) and "*Lean Thinking*" (1996). Relevant books, reports, and theses were included. The survey was made using the following major research databases: Emerald, Science-direct, IEEE, Springer and ProQuest, Scopus, Web of Science and Google Scholar. A search of the literature was conducted by combining the following keywords: "Lean Thinking", "Lean Thinking Project Management", "Lean Project Management", "Lean Sustainability", "Green Lean", "Lean environmental" and "Lean Project Management Sustainability". Articles containing "Sustainable" where the word refers to "capable of being sustained" were excluded.

Articles were chosen for revision if published in English and Spanish (languages spoken by the authors) and contained the mentioned keywords in the title. After carrying out an

initial filtering process by reading the abstracts, 20 articles were selected for research contribution (Table: 1). Each of the papers was then completely read to ensure that they were relevant to the aims of the current research.

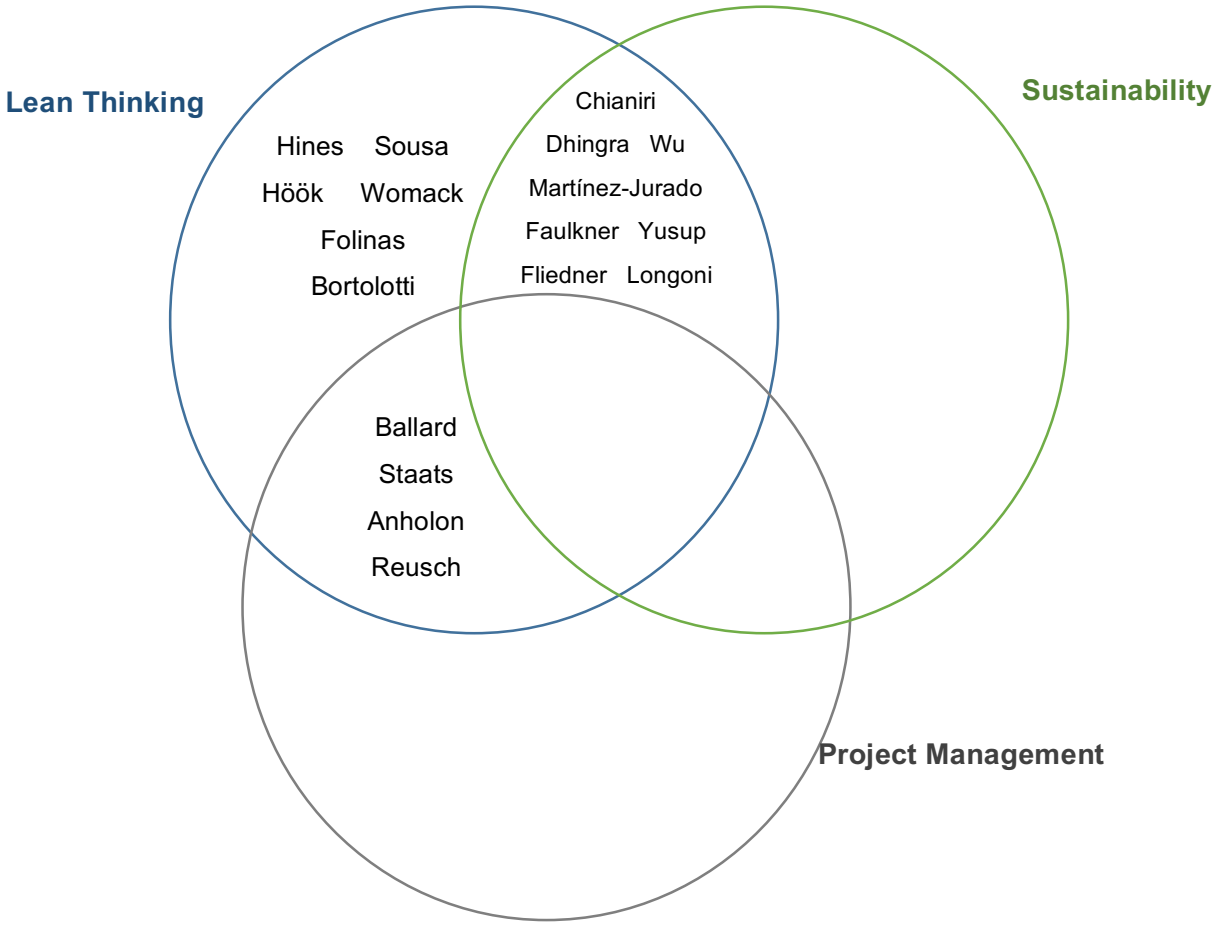
Table 1: Articles selected for research contribution

No.	Authors	Paper name	Year	Journal	Times cited (G.Scholar/ Scopus)
1	Anholon R. Sano A. T.	Analysis of critical processes in the implementation of lean manufacturing projects using project management guidelines.	2015	International Journal of Advanced Manufacturing Technology	0/0
2	Aziz, B.	Improving Project Management with Lean Thinking?	2012	Master thesis. Institute of Technology, Linköping University, Sweden	1/No info
3	Ballard, G. Howell, G.	Lean project management	2003	Building Research & Information	159/69
4	Bortolotti, T. Boscari, S. Danese, P.	Successful lean implementation: Organizational culture and soft lean practices.	2015	International Journal of Production Economics	18/5
5	Chiarini, A.	Sustainable manufacturing-greening processes using specific Lean Production tools: an empirical observation from European motorcycle component manufacturers.	2014	Journal of Cleaner Production	26/13
6	Dhingra, R. Kress, R. Upreti, G.	Does lean mean green?	2014	Journal of Cleaner Production,	14/3
7	Faulkner, W. Badurdeen, F.	Sustainable Value Stream Mapping (Sus-VSM): methodology to visualize and assess manufacturing sustainability performance.	2014	Journal of Cleaner Production	29/10
8	Fliedner, G.	Sustainability: a new lean principle.	2008	In Proceedings of the 39th annual meeting of the decision sciences institute	16/No info
9	Folinas, D. Aidonis, D. Triantafillou, D. Malindretos, G.	Exploring the greening of the food supply chain with lean thinking techniques.	2013	Procedia Technology	3/0

10	Galeazzo, A. Furlan, A. Vinelli, A.	Lean and green in action: interdependencies and performance of pollution prevention projects.	2014	Journal of Cleaner Production	19/11
11	Hines, P. Holweg, M. Rich, N	Learning to evolve: a review of contemporary lean thinking.	2004	International Journal of Operations & Production Management	1027/420
12	Höök, M. Stehn, L.	Lean principles in industrialized housing production: the need for a cultural change.	2008	Lean Construction Journal	53/No info
13	Longoni, A. Cagliano, R.	Cross-functional executive involvement and worker involvement in lean manufacturing and sustainability alignment.	2015	International Journal of Operations & Production Management	0/0
14	Martínez-Jurado, P. J. Moyano-Fuentes, J.	Lean management, supply chain management and sustainability: a literature review.	2014	Journal of Cleaner Production	47/15
15	Reusch, P. J. Reusch, P.	How to develop lean project management?	2013	(IDAACS), 2013 IEEE 7th International Conference	3/1
16	Sousa, R. Voss, C. A.	Quality management: universal or context dependent?	2001	Production and Operations Management	179/No info
17	Staats, B. R. Brunner, D. J. Upton, D. M.	Lean principles, learning, and knowledge work: Evidence from a software services provider.	2011	Journal of Operations Management	157/63
18	Womack, J. P. Jones, D. T.	Lean thinking	1996	Book	7084/No info
19	Womack, J. P. Jones, D. T. Roos, D.	Machine that changed the world.	1990	Book	13575/No info
20	Yusup, M. Z. Mahmood, W. H. W. Salleh, M. R. Yusof, A. S. M.	Review the influence of lean tools and its performance against the index of manufacturing sustainability.	2015	International Journal of Agile Systems and Management	1/0

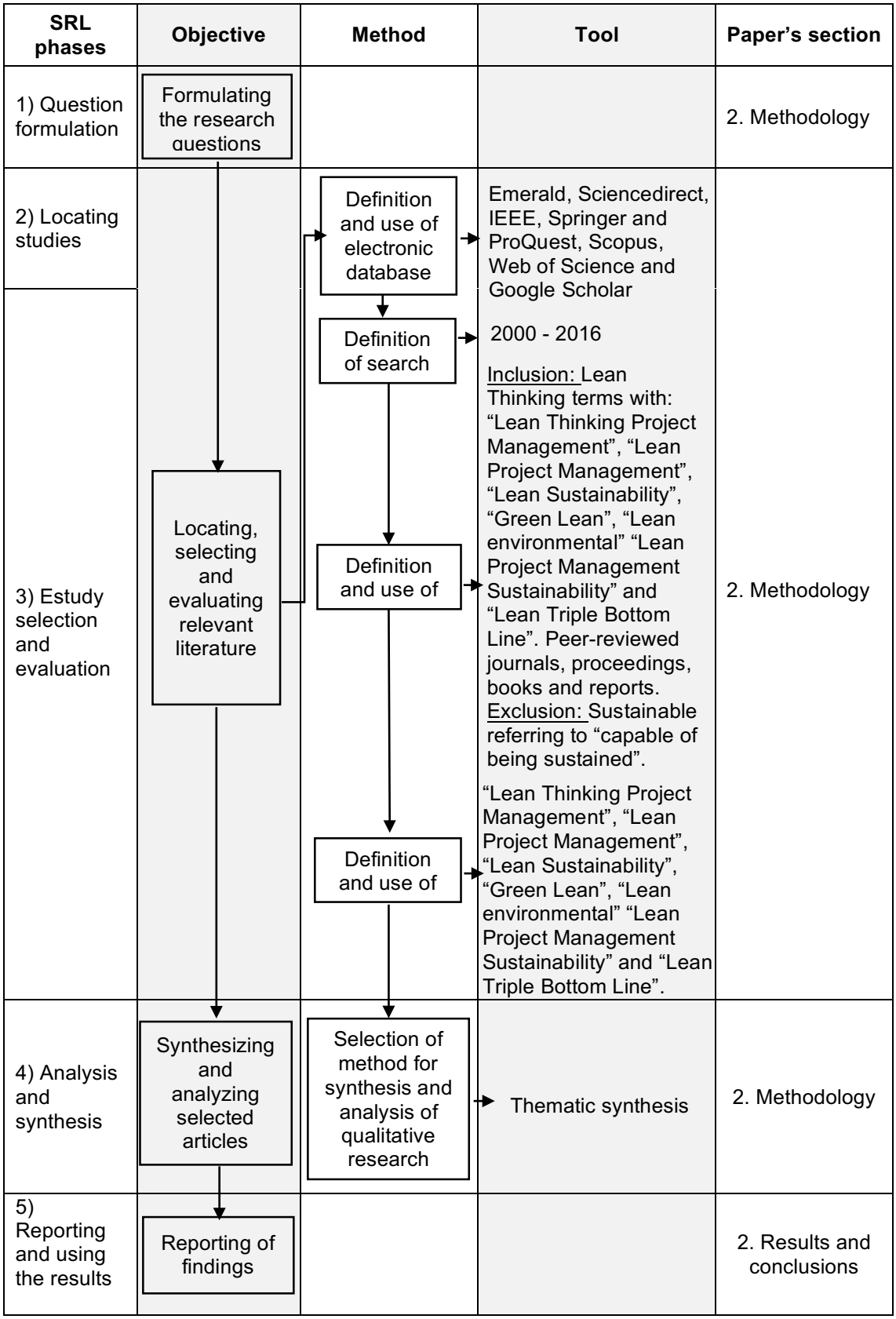
In the majority of the articles, the content was concerned with LT, PM, and sustainability in isolation, whilst only a few explicitly combined two of the concepts. The only document found that alluded to the relationship between the three topics is the paper by Galeazzo, A., Furlan, A., & Vinelli, A. (2014) (Figure 1).

Figure 1: Authors related by research topic



The systematic literature review (SLR) for this paper was based on the model developed by Garza-Reyes (2005). It consists of the following five consecutive phases: (1) question formulation, (2) locating studies, (3) study selection and evaluations, (4) analysis and synthesis, and (5) reporting and using the results. Each of these phases explains its objective, method, and tool along with the section of the paper where the information is located (Figure 2).

Figure 2: SLR phases, methods, tools and location within the article (Garza Reyes, 2015)



The following research questions have been addressed, based on a SLR of the existing literature on the three topics. The aim of this paper is to answer these using the analysis of the research.

Question 1: What concepts of LT are relevant for PM and sustainability?

Question 2: What are the connections between LT and sustainability?

Question 3: What are the connections between LT and PM?

Question 4: How can sustainability be integrated in PM practices with LT?

3. Results

3.1 Lean Thinking principles, wastes, tools and techniques

3.1.1 Lean Thinking principles

LT has five principles defined in Womack's and Jones' Book "Lean Thinking", which focus on value and elimination of waste. These principles could be applied across a wide range of industrial settings (Sousa, R., & Voss, C. A. 2001; Höök, M., & Stehn, L (2008). The LT principles are:

1) Value specification: to define value from the customer's perspective.

2) Value stream identification: to identify all the steps in the processes that delivers the customer's values and remove everything that do not add value to the customer.

3) Flow: to take actions that ensure continuous flow in the value stream.

4) Pull: to produce only what the customer wants just in time

5) Perfection: to strive for perfection by delivering what the customer wants and expects through a continuous removal of waste.

3.1.2 Lean Thinking wastes

Every operation involves a mixture of processes that could be regarded as value adding and non-value adding. Non-value adding processes are characterized by wastes of different forms (Folinas, D. et al 2013). LT classifies these into seven types of waste (Toyota's seven wastes) in a business process, including the following (Womack, J. P., & Jones, D. T. 1996) (Table: 2).

Table 2: PM processes

1. Transport	2. Inventory	3. Motion	4. Waiting
5. Over-processing	6. Overproduction	7. Defects	

3.1.3 Lean Thinking tools and techniques

The majority of the tools and techniques used in LT aim to bring about changes in a company that enable it to adapt to the needs of the customer (Folinas, D. et al 2013). The US Environmental Protection Agency (EPA) mentioned eight core methods and tools that organizations use to implement LT systems (EPA, 2003). Yusup, M. Z. (2015) investigates how the implementation performance of LT selected tools contributes to establishing sustainable practices (mainly in manufacturing). Table 3 shows the most common tools that are referred to in the reviewed literature.

Table 3: LT tools found in the literature reviewed

Author	LT tool
EPA, 2003	Kaizen, 5S, Total Productive Maintenance (TPM), Cellular Manufacturing / One-piece Flow Production Systems, Just-in-time (JIT) / Kanban, Six Sigma, Pre-Production Planning (3P) and Lean Enterprise Supplier Networks
Folinas, D. et al (2013)	Takt Time, Kaizen, Statistical Process Control, Poka-Yoke, 5S, Value Stream Mapping (VSM), Total Quality Management, Kanban, Jidoka.
Hines, P. et al (2004)	TQM, Agile, Drum-buffer-rope, Level scheduling, 6 Sigma, TPM, MRP, TQC, Postponement, TOC, KANBAN, SPC, ERP, Takt Time, APS.
PMBok	Cause and effect-diagram, control chart, run charts, scatter diagram and FMEA
Yusup, M. Z. (2015)	5'S, JIT, Root cause analysis, SMED, Takt time, Bottleneck analysis, Standardised work, Jidoka, Poka-yoke, Heijunka, CFA, Kanban and Andon, Visual factory.

From the other hand, Hines, P. et al (2004) go farther and suggest a classification of the LT methods and tools shown in Table 4.

Table 4: LT methods and tools classification (Hines, P. et al 2004)

Quality	Responsiveness	Capacity	Production	Variability	Availability	Control
TQM	Agile	Drum-Buffer-Rope	Level scheduling	6 Sigma	TPM	MRP
TQC	Postponement	TOC	KANBAN	SPC		ERP
			Takt Time			APS

3.2 Relationship between Lean Thinking (LT) and Project Management (PM)

Currently, PM exists as a universal methodological framework to define the application of knowledge, skills, and tools to manage the projects to meet their requirements. There are several published PM guidelines, and whilst they differ in terms of structure, they all cover the same broad principles of PM. Anholon, R., & Sano, A. T. (2015) mention some relevant publications such as the International Organization for Standardization (ISO), the Project Management Institute (PMI, through the 5th edition of the Project Management Body of Knowledge - PMBoK), and the Office of Government Commerce (OGC) in the UK (Prince2 guidelines).

For the aims of the research in this paper, we used the 5th edition of the PMBok Guide. This guideline describes 47 project management processes within five project management process groups, dividing these processes into ten knowledge areas (PMI, 2016) (Table 5 and 6).

Table 5: PM processes

1. Initiating	2. Planning	3. Executing	4. Monitoring & Controling	5. Closing

Table 6: PM areas

1. Integration	2. Scope	3. Time	4. Cost	5. Quality
6. Procurement	7. Human Resources	8. Communications	9. Risk Management	10. Stakeholder Management

PMBok refer to the use of several LT tools, including the cause and effect diagram (also known as the fishbone or Ishikawa diagram), control chart, run charts, scatter diagram and FMEA. LT activities are recommended in the Project Quality Management knowledge area. This guide states that “quality improvement initiatives such as Total Quality Management (TQM), Six Sigma, and Lean Six Sigma could improve the quality of the projects” (PMBok, 2013).

Reusch, P. J., & Reusch, P. (2013) stated that “lean management is a management of values” and it can be applied in order to improve project management. In their paper, they cite Stephan Wood, who claims “Quality Management means Lean Management”. Quality Management principles (ISO 9000) such as costumer focus, continual improvement, and process approaches, are, among others the bases of lean management (Reusch, P. J., & Reusch, P. 2013). This is important for linking LT to PM since, as mentioned in the paragraph above, Quality Project Management is one of the ten knowledge areas of PM.

On the other hand, Aziz, B. (2012) relates aspects of LT to PM activities through the following concepts:

- LT is to specify the value of project activities.
- Value is defined by the costumer and focuses on long-term strategy benefits.
- Project scope consists of value adding (activities essential for the costumer) or non-value adding (waste) activities.
- The elimination of non-value adding activities reduces the project scope.
- Value-adding activities save resources whilst improving the efficiency and effectiveness of projects.

According to this author, each concept is applicable to all project’s activities including product related activities and administrative activities (project office).

3.3 Lean Project Management

Lean Project Management (LPM), as a concept, was found in some of the documents analysed for this paper. Aziz, B. (2012) proposes the following definition: “LPM is the application of LT in PM, it tends to focus PM toward creating value and preventing waste, LPM improves project productivity”. Reusch, P. J., & Reusch, P. (2013) based on the definitions of LPM from Leach, L. P. (2005). Karim, A., & Nekoufar, S. (2011), establish the following LPM principles:

- Specify what creates value from the customer´s perspective.
- Identify all the steps along the process chain.
- Make those processes flow.
- Identify waste – based upon needs and expectations of customers.
- Eliminate waste – based upon needs and expectations of customers.

- Make only what is pulled by the customer.
- Strive for perfection by continually removing wastes.
- Amplify learning.
- Make decisions at the right time.
- Empower the team, build integrity.
- See the whole.

On the other hand, Ballard, G., & Howell, G. (2003) developed a model called the Lean Project Delivery System (LPDS) for construction projects. They state that this model has emerged from theoretical insights from other industries (lean production). The LPDS focuses on several aspects of project delivery, such as improving dialogue among stakeholders, deferring decisions, process design, eliminating waste, flow and pull (Ballard, G., & Howell, G. 2003).

Some studies have explored the link between LT and PM in various types of projects. When LT is connected to PM, the construction industry is primarily used as an example (Ballard, G. & Howell, G. 2003). According to Staats, B. R. et al., (2011), it is possible to implement LT in software projects, and in doing so, organizations learn through hypothesis-driven problem solving, streamlined communications, simplified processes, and to a lesser degree, specified tasks (Staats, B. R. et al 2011).

3.4 Relationship between Lean Thinking and the three sustainability aspects

Yusup, M. Z. (2015) links the performance of LT practices with increased levels of sustainability in manufacturing. The author groups them into three aspects of sustainability performance: the competency accomplishment performance (CAP) (related to the social aspect), economic achievement performance (EAP) and environmental responsiveness performance (related to the social aspect) (ERP).

The only document found that mention the three topics of this research was the paper from Galeazzo, A., Furlan, A., & Vinelli, A. (2014). However, the study just focuses on the relation with LT and the environmental aspect of sustainability. Additionally, it uses projects as case studies and not really, a relationship with PM practices.

According to Martínez-Jurado, P.J et al (2013) and Wu, L. et al (2015), LT is directly related to a firm's profitability and indirectly addresses concerns related to environmental and social dimensions. Many organizations have found that a by-product of the LT principles are related to environmental performance, even when lean activities were not initiated for environmental reasons (Fliedner, G. 2008). Womack and Jones (1996) wrote: "Lean thinking must be "green" because it reduces the amount of energy and wasted by-products required to produce a given product".

Fliender, G. (2008) identifies eight methods and tools that are associated with the environmental benefits (Table 7). The author states that while LT improves processes and saves money through waste reduction and elimination, these methods and tools have also been demonstrated to produce environmental benefits.

Table 7: Lean methods and tools associated with environmental benefits (Fliender, G. 2008).

Lean Method/Tool	Environmental Benefits
Kaizen Events	• Uncovering and eliminating hidden wastes and waste generating activities.
Value Stream Mapping	• Magnification of environmental benefits of lean production (e.g., reduced waste through fewer defects, less scrap, less energy usage, etc.) across the network.

5S	• Clean windows reduce lighting requirements. • Spills and leaks noticed more quickly.
Cellular Manufacturing	• Smaller set-up times reduces energy and resource needs. • Fewer product changeovers reduces energy and resource needs.
Pull Approach	• Lower in-process and post-process inventory; avoids potential waste from damaged, spoiled, or deteriorated products.
Total Preventive Maintenance	• Increased longevity of equipment decreases need for replacement equipment and associated environmental impacts.
Six Sigma	• Fewer defects which reduces energy and resource needs; avoids waste. • Focuses attention on reducing the conditions that result in accidents, spills, and malfunctions, thereby reducing solid and hazardous wastes.
Pre-production Planning	• Reduces waste at the product and process design stage, similar to “Design for Environment” methods • Use of right-sized equipment lowers material and energy requirements. • Reducing the complexity of the production process (“design for manufacturability”) can eliminate or streamline process steps; environmentally sensitive processes can be targeted for elimination, since they are often time-, resource-, and capital-intensive.
Lean Supplier Networks	• Magnification of environmental benefits of lean production (e.g., reduced waste through fewer defects, less scrap, less energy usage, etc.) across the network.

Faulkner, W., & Badurdeen, F. (2014) suggest the use of LT tool Value Stream Map (VSM) to identify non-value added activities or wastes. According to the authors, this practice can include metrics for evaluating environmental and societal sustainability performance. A new methodology known as ‘sustainable’ Value Stream Mapping or Sus-VSM was developed and was tested in three case studies (Dhingra, R. 2015).

In a document published online, titled “*Lean Manufacturing and Environment*”, the EPA presented findings from a research study conducted in four American companies by means of observations (EPA, 2003). The research underlined how Lean Thinking can be taken into account to improve environmental performance (Chiarini, A. 2014). According to Chiarini, A. (2014) the most relevant outcomes are:

- LT produces an operational and cultural environment that is highly conducive to the minimization of waste and the prevention of pollution.
- LT can be leveraged to produce more environmental improvement, filling key ‘blind spots’ that can arise during Lean implementation.
- LT experiences regulatory ‘friction’ around environmentally sensitive processes.
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The US Environmental Protection Agency (EPA) suggests a table of correlation between the LT wastes and their associated environmental effects (EPA, 2003). An extract from this table is shown in Table 8.

Table 8: Environmental Impacts Linked with Manufacturing Waste (EPA 2003) (Chiarini, A. 2014)

Waste type	Environmental impact
Defects	Raw materials consumed in making defective products. Defective components require recycling or disposal.

	More space required for rework and repair, increasing energy use for heating, cooling, and lighting.
Waiting	Potential material spoilage or component damage causing waste. Wasted energy from heating, cooling, and lighting during production downtime.
Overproduction	More raw materials consumed in making the unneeded products. Extra products may spoil or become obsolete requiring disposal.
Movement and transportation	More energy use for transport. Emissions from transport. More space required for work-in-process (WIP) movement, increasing lighting, heating, and cooling demand and energy consumption. More packaging required to protect components during movement.
Inventory	More packaging to store WIP. Waste from deterioration or damage to stored WIP. More materials needed to replace damaged WIP. More energy used to heat, cool, and light inventory space.
Complexity and Overprocessing	More parts and raw materials consumed per unit of production. Unnecessary processing increases wastes, energy use, and emissions.
Unused creativity	Fewer suggestions of pollution and waste minimization opportunities.

The relationship between LT implementation and social practices has also emerged in academic research in recent years (Wu, L. et al 2015). According to Wu, L. et al 2015, De Treville, S., & Antonakis, J. (2006) establish that LT practices have an impact on social performance, the most important of which is on the internal human resources of the firms. This can be achieved by empowering, educating, motivating, and designing jobs for employees, (Wu, L. et al 2015).

Wu, L. et al (2015) make two interesting statements. First, they affirm that Total Production Maintenance (TPM) activities largely prevent workplace injuries and deaths, contributing to better employee health and safety. Second, they state that LT practices impact customers primarily through Total Quality Management (TQM) programs. In addition, they remark that researchers such as Jasti, N. V. K., & Kodali, R. (2015) recommend covering a wide range of stakeholders along the supply chain such as suppliers, shareholders, employees, customers, as well as the society as a whole.

4. Conclusions

In the Results section of this study, the main concepts of the three topics of the literature review were described. It was possible to find theoretical information regarding some links between LT and PM as well as LT and the three concepts of sustainability.

- PMBok guide include the use of LT tools for PM practices.
- This guide states improvement of the project's quality by using LT methodology.
- The LT core elements such as costumer focus, continual, improvement, process approaches affect positively the PM practices.
- Detection of LT tools and methods associated with the environment benefits.
- Relation with firm's profit and LT through waste elimination and costs reduction.
- Impact on social aspect mostly at internal human resources of the organizations and costumer.

4.1 Gaps found in the research which should lead to future research

The social aspect was not widely developed in the researched articles, just in some cases the employee and customer integration but not all the project's stakeholders.

Likewise, there is a lack of information on how LT concepts can contribute to PM to integrate sustainability. A solution could be developed based on a specific model or framework.

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