Journal of Cleaner Production 240 (2019) 118205

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Review

Integrated green lean approach and sustainability for SMEs: From literature review to a conceptual framework

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ARTICLE INFO

Article history:
Received 22 March 2019
Received in revised form
7 August 2019
Accepted 27 August 2019
Available online 28 August 2019

Handling editor: Mattias Lindahl

Keywords:
Green-lean
Sustainability
Small and medium-sized enterprises
SMEs
Systematic literature review
Conceptual framework

ABSTRACT

Over the last decades, there has been growing pressure on organizations to manage their operations in a responsible manner to improve their environmental and social performance. This has motivated organizations and researchers alike to identify ways to implement sustainable operations. In this context, Green-Lean has emerged as a major part of the sustainability answer. The discussion on Green-Lean in the context of manufacturing SMEs is in a less developed stage and deserves attention. Thus, the main objective of this research was to identify and analyze, through a systematic review, data on the challenges, success factors, tools and techniques, sustainability aspects, frameworks and benefits of Green-Lean in manufacturing SMEs. A systemic model representing the relationship among the determinants to implement a Green-Lean initiative for manufacturing SMES is also presented and discussed. The findings indicate that the most common challenge to Green-Lean implementation is a lack of metrics and measurement. 5S is the most used tool. In addition, the majority of frameworks have been developed for specific industrial sectors instead of generic frameworks to reduce/eliminate different wastes. However, these frameworks have missed the social dimension. The main contribution of this paper is the provision of an exhaustive summary of the state of knowledge and systematic classification of the relevant literature on the Green-Lean initiative in the context of SMEs. The findings are useful for both academics and SME owners and managers to undertake measures for improving sustainability.

Contents

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https://doi.org/10.1016/j.jclepro.2019.118205
0959-6526/

1. Introduction

To remain competitive, increase production efficiency and lower operational costs, companies must adopt innovative strategies (Cherrafi et al., 2017a). A popular approach to improve operational performance is Lean Manufacturing, a method that identifies and eliminates waste and optimizes resource utilization through continuous improvement (Garza-Reyes, 2015).

Recent concerns about environmental impacts have resulted in companies altering their operational approaches to comply with environmental regulations and to respond to growing customer demands for sustainable products and services (Kaswan and Rathi, 2019). Thus, the green paradigm emerged. “Green” is seen as a philosophy and operational approach that enhances the ecological efficiency of an operation, reduces the negative environmental impact of a service or product and maintains or improves financial performance (Garza-Reyes, 2015).

Many authors see a natural alignment of Lean and Green through their similar operations management approach (Huo et al., 2019; Dieste et al., 2019). Therefore, researchers have proposed a congruency of Lean and Green, and suggested that the two can effectively work together and have a positive impact on environmental and operational performance (Souza Farias et al., 2019). According to De et al. (2018), Lean and Green can both potentially enhance the competitiveness of SMEs in a sustainable manner. Available research data indicates that SMEs are responsible for the majority of the industrial pollution and contribute significantly to environmental degradation (Whitehead, 2013). In addition, SMEs have limited resources and face various barriers. In this context, to achieve sustainability, SMEs need to consider economic, environmental and social issues by adopting Green and Lean initiatives. However, SMEs struggle to effectively integrate lean management with green management (Souza Farias et al., 2019). SMEs need some guidelines, including the identification of challenges, benefits, frameworks and critical success factors in order to encourage them to implement Green and Lean projects to improve their sustainability performance. In addition, according to various scholars, a clear research definition of Green-Lean in the context of SMEs has yet to be determined, and literature on this subject is fragmented and in need of structuring. To understand what limits SMEs to implement Green-Lean, the hindering and favorable conditions of such integrations in companies must be studied.

Hence, starting from this lack of knowledge, we conducted a literature review to systematically collect and critically analyze relevant research in the field of Green-Lean to propose an integration strategy for this approach and Sustainability, particularly within the context of SMEs, through a theoretical framework.

Considering this, the following objectives were formulated:

(1) To identify and critically explore the characteristics and linkage of Lean, Green and Sustainability in the existing literature;
(2) To identify gaps and opportunities in operational practices to integrate Green and Lean with a particular focus on SMEs;
(3) To propose an integration strategy for Green and Lean in the context of SMEs through a theoretical framework.

The paper is divided as follows: Section 2 addresses the research methodology followed by the present study. Section 3 presents and describes the theoretical elements of our integrated framework, and Section 4 discusses key points for an integrated Green-Lean approach. Section 5 provides the conclusions and directions for potential further research.

2. Material and methods

2.1. Location and selection of studies

In this study, a systematic literature review (SLR) on Green-Lean and Sustainability was carried out through a structured process. It involved examining selected articles from different databases and sources (Chugani et al., 2017). The SLR provided a comprehensive, transparent and explicit approach that ensured that the process was conducted with the utmost rigor (Garza-Reyes, 2015). SLR is a method for “identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners” (Okoli and Schabram, 2010).

The search engines, Elsevier (www.sciencedirect.com), Emerald (http://www.emeraldinsight.com), Springer (http://www.springerlink.com), Taylor&Francis (http://www.taylorandfrancis.com), and the Google Scholar database, or library services, e.g., Wiley online library (www.wiley.com), Ebsco (www.ebsco.com), Scopus (www.scopus.com), Metapress (www.metapress.com) and Subito (www.subitoedoc.de), were used to locate relevant journal articles for this study. Search strings included (Lean), (Green), (Green and Lean), (Lean Green), (SME), (small and medium-sized enterprise), (manufacturing) and (sustainability). The resulting search terms were combined using the Boolean operators (AND and OR) in searches of keywords, titles, abstracts and full article text. While using the same search strings in every database led, to some extent, to the appearance of the same articles, this systematic approach was essential to ensure a complete and thorough exploration of the literature. The search was considered to be complete when the same articles continued to appear.

The abstracts of all articles that were included in the search strings were manually reviewed to ensure a maximum coherence. A final sample of 45 articles were identified. Due to the early stage of research in this field, there is a relatively restricted number of studies to refer to, particularly when compared to the vast amount of research in the lean and environmental subject fields. Consequently, there is arguably a lack of a clear and structured research definition of Green-Lean in the literature. Due to the strict search terms that were used to identify relevant articles, papers with unclear abstracts were left out as keywords were missed out. The

Table 1
Systematic literature review process.

Process	Definition	No. of articles
1. Research purpose and objective	Identify purpose and intended goals of the review	
2. Develop research protocol	Proposal for preliminary research question, includes scope, criteria, quality assessment and data extraction	
3. Define relevance criteria	Establish research criteria to include only most relevant papers	
4. Search and collect literature	Search for relevant articles in top academic and specialist journals	Total search result: 253 articles
5. Selection of studies	Based on previously defined criteria. Reasons for non-consideration of excluded studies must be given.	Total publications selected: 104 articles
6. Quality evaluation for relevant studies	Depending on the employed research methodology, assess each article for quality. Articles of insufficient quality should be excluded.	
7. Data extraction	Systematically extract the applicable data from each study included in the review. This can be split up in several steps, from looking at the title and abstract to going over the full paper, to deeper content analysis of the topic.	
8. Synthesis (analysis) of data	Using quantitative or qualitative techniques (or both), combine the obtained facts and illustrate main conclusion of analysis	Total publications analyzed: 45 articles
9. Writing of review	Report process of the systematic literature review as well as the results in sufficient detail	
10. Dissemination	Contribute to knowledge in the field by publishing the systematic review in an academic journal	

Source: Morioka and de Carvalho (2016).

rigid conceptual boundaries of the SLR also did not allow room for exceptions of the inclusion or exclusion of articles. Table 1 exemplifies the literature revision and selection process according to Morioka and de Carvalho (2016). The adopted approach included three phases and ten processes, as shown in Fig. 1.

2.2. Criteria

There are several criteria that allow a reasonable exclusion of articles from a literature review. These criteria can draw upon their content, their publication language, the type of source they are published in, their authors, the setting, e.g. including only studies that address the manufacturing industry, dates, etc. (Okoli and Schabram, 2010). For the case of the present study, the criteria of dates, i.e. publications within a certain period of time, and sources were taken as a basis for the inclusion and exclusion of articles. In this sense, only articles published between 2000 and 2018 were included, with the exception of a piece by Ghobadian and Gallear from 1996, which is considered a pioneering contribution to the research of total quality management in SMEs. Finally, any books, websites, conference papers and grey literature such as reports or working papers were excluded, and merely articles published in high-quality, academic journals were taken into consideration.

3. Conceptual framework for integrating Green and Lean in the context of SMEs

The Lean and Green concepts have achieved high popularity in recent years (Cherrafi et al., 2019). It is observed that Lean and Green are two approaches that have been developed in different contexts; they are synergetic and compatible strategies because of their joint focus on waste reduction and efficient use of resources (Garza-Reyes et al., 2015). Consequently, principles and tools from the two approaches have been integrated under the umbrella of a unified improvement approach known as “Green-Lean” to achieve both operational and sustainability excellence (Dües et al., 2013).

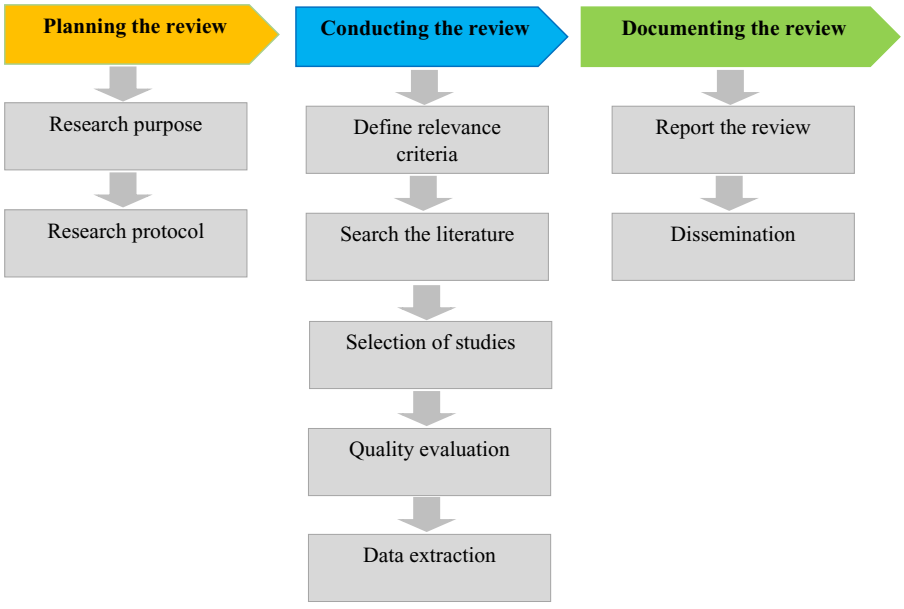

Fig. 1. Research process.

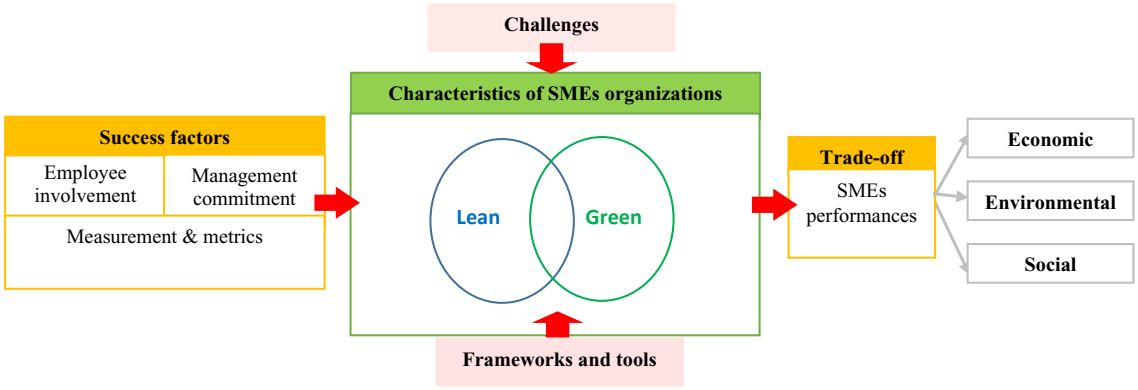

Fig. 2. Framework for Green-Lean approach for SMEs.

Green-Lean is defined as an integrated approach that aims to achieve improvements that are not only financial or operational but also environment-oriented (Leong et al., 2019). The integration of Green and Lean can be seen as a new opportunity for organizations to improve their sustainability performance. According to Cherrafi et al. (2017a), organizations that have simultaneously implemented lean and green practices have achieved better results than those organizations that have only focused on either of the initiatives.

Having found a precise limitation in terms of the a lack of a structured and complete framework for Green and Lean in the context of SMEs, we propose a specific integrating framework for implementing the two approaches based on a combination of theoretical elements, which emerged from the literature review. The conceptual framework is inspired by the structure of a typical IDEF0 diagram. The framework and the theoretical elements are illustrated in Fig. 2. It is important to note that this proposed framework is a conceptual design rather than a final design. It has the aim of describing the key elements required for SMEs to ensure sustainable profitability through cost savings, while being environmentally and socially conscious at the same time. In the center and the core of the framework, the main phenomena investigated, Green-Lean integration is located. Success factors for the Green-Lean integration act as an input to the main phenomena whilst performances in the trade-off are considered as the output. The challenges for Green-Lean integration in the context of SMEs are the controls, which direct and constrain organizational efforts to improve their sustainability performance. Last but not least, frameworks and tools are the enhancing mechanisms.

A discussion of the theoretical elements that emerged from the literature review follows.

4. Results and discussion

4.1. Lean and green challenges

Looking at the various challenges across different continents, see Table 2, it is evident that most companies still struggle with the

Table 2
Green-lean challenges.

Europe	
Aguado et al. (2013), Spain	Combining competitiveness of a business with economic development in addition to environmental and social sustainability; Development of environmental innovation capable of improving current situation; Measurement of efficiency and sustainable improvements
Cherrafi et al. (2017c), Morocco	Minimisation of trade-offs between Lean and Green; Deploying lean and green as a systematic way and recognizing the "ideal formula" for each business
Duarte and Cruz-Machado (2013), Portugal	Poor quality of human resources; Lack of environmental awareness; Lack of expertise training and education; Fund constraints; Lack of statistical Lean and Green thinking; Lack of visual and statistical control during Green-Lean implementation; Lack of communication and cooperation between departments; High cost; Lack of top management involvement in adopting Green-Lean initiative; Resistance to change; Poor corporate culture separating environmental and continuous improvement decisions
Kurdve et al. (2014), Sweden	Lack of integration strategy; Lack of sustainability metrics; Responsibility and ownership of environmental management in relation to operations
Edeltraud, G., Scheibe (2006), Germany	Efforts for sustainability are not seen as useful; Employees are not sufficiently informed about aims; Employees are not informed about environmental relevance of products and services
North America	
Kleindorfer et al. (2005), USA	Integrating environmental, health, and safety concerns with Lean and green operations; Integrating environmental, health, and safety concerns with closed-loop supply chains
Africa	
Cherrafi et al. (2016). Morocco	Lack of awareness among managers; Lack of involvement of human resources into lean projects; Lack of metrics; Perception of higher cost; Organizational structures separating environmental and continuous improvement decisions
South-America	
Alves and Alves (2015), Brazil	View of production improvements as means to obtain cost reduction in the short term; Focus mostly on physical changes and application of tools; Limited attention to different leadership styles and employees' behaviour; Need for cultivating a culture and employee mind-set is overlooked

Table 3
Tools and techniques for Green-Lean.

Europe	
Duarte and Cruz-Machado (2013)	*Lean Tools and Techniques* Corporate culture; Long-term philosophy; Leadership empowerment; Employee involvement and engagement; Continuous improvement; Waste elimination; Resource productivity; Information sharing; Stakeholder relationship; 6S (5S and safety); Value stream mapping; 5 Why's; Product life cycle; 3R's
Chiarini (2014)	*Lean Tools and Techniques* Value Stream Map; TPM implementation; 5S; SMED (Single-Minute Exchange of Dies) implementation *Green Tools and Techniques* Environmental Value Stream Mapping
Garza-Reyes et al. (2018)	*Lean Tools and Techniques* Just-in-Time; TPM; Overall Equipment Effectiveness; 5S; Value Stream Mapping; SMED implementation; 5 Why's
Piercy and Rich (2015)	*Lean Tools and Techniques* Total quality management; TPM; Workplace improvement; 5S; Community engagement; Worker engagement; Standardisation; Re-layout/redesign; Waste reduction; Supply chain improvement; Local Sourcing; Policy deployment; Strategy changes *Green Tools and Techniques* Positive working environment; Training/up-skilling; Ergonomic workplace; Local sourcing; Cost sharing; Sustainability audits; Sponsorship of charities; Engagement with schools
Garza-Reyes (2015a)	*Green Tools and Techniques* Environmental operations management (EOM); Green manufacturing; Green supply chains (GSC); Reverse logistics; Eco-design; Design for environment (DFE)/Green building; Sustainable Value Stream Mapping; Life Cycle Assessment
Dües et al. (2013)	*Lean Tools and Techniques* Value Stream Mapping; Inventory minimisation; Higher resources utilization rate; Just-in-Time; Shorter lead times *Green Tools and Techniques* Sustainable Value Stream Mapping; ISO 14000; Eco-design; Life-Cycle Assessment; Green purchasing; Environmental risk sharing
Asia	
Ruben et al. (2018)	*Lean Tools and Techniques* Value stream mapping; Just-in-Time; TPM; 5S; Overall Equipment Effectiveness; Training; Communication; Employee involvement
Vinodh et al. (2011)	*Lean Tools and Techniques* Value Stream Mapping; 5S; TPM; Pre- Production planning; Kaizen; Lean supplier networks; Poka-Yoke *Green Tools and Techniques* Green value stream mapping
North America	
Torielli et al. (2011)	*Lean Tools and Techniques* 5S and safety; Statistical process improvement; 7R
Sawhney et al. (2007)	*Lean Tools and Techniques* Employee involvement and empowerment; Mistake proofing; Quick changeover; Pull systems; Product mix/variability; TPM; Supplier development
South America	
Sobral et al. (2013)	*Lean Tools and Techniques* Employee involvement; Kaizen/Quality Circles; TPM; 5S; Continuous improvement; Inventory reduction; Supplier collaboration
Alves and Alves (2015)	*Lean Tools and Techniques* SMED, TPM, 5S

implementation of Green-Lean practices. A common challenge is the lack of measurement and metrics that is uniform across most considered countries and authors (Duarte and Cruz-Machado, 2013). Specifically, this regards the measurement of the efficiency and improvements of sustainable initiatives. Additionally, most countries and authors see unexploited potential in the management of the executives, as they seem to either lack awareness of the need for sustainable improvement methods such as Green-Lean (Cherrafi et al., 2016), are apprehensive of involvement (Duarte and Cruz-Machado, 2013) and avoid responsibility and ownership (Kurdve et al., 2014). While research has shown that businesses have found the integration and implementation of both paradigms challenging (Cherrafi et al., 2017c), only one paper addresses the lack of an integration strategy (Kurdve et al., 2014). The focus of these challenges may differ due to the importance that the values and norms of each country place upon them, such as for example a strong emphasis on health and safety in the USA (Kleindorfer et al., 2005).

Key findings:

- The most common challenge is the lack of metrics and measurement
- Absence of management support is addressed by most authors
- Collectivist countries place greater focus on employee engagement and organizational culture

4.2. Tools and techniques for Green-Lean

The authors consider Green-Lean tools and techniques to be principles or concepts that have the goal of identifying and removing waste and to optimize resource utilization, see Table 3. While Ecodesign is not strictly a tool or technique, but a design approach that "*aims to design products where the minimizing of their environmental impact throughout their life cycle is considered*" (Pinheiro et al., 2018), we considered this strategy to be aligned with other concepts from our list of tools and techniques presented in Table 3.

After analyzing 13 papers, it becomes apparent that each author and organization uses a variety of different tools, aligned to their specific needs and/or company size. However, particular tools and techniques appear more often than others and are evidently applied by most organizations that have integrated Lean and Green. For ease of analysis, the tools and techniques have been divided into Lean tools and Green tools and have been examined through a radar chart, see Fig. 3.

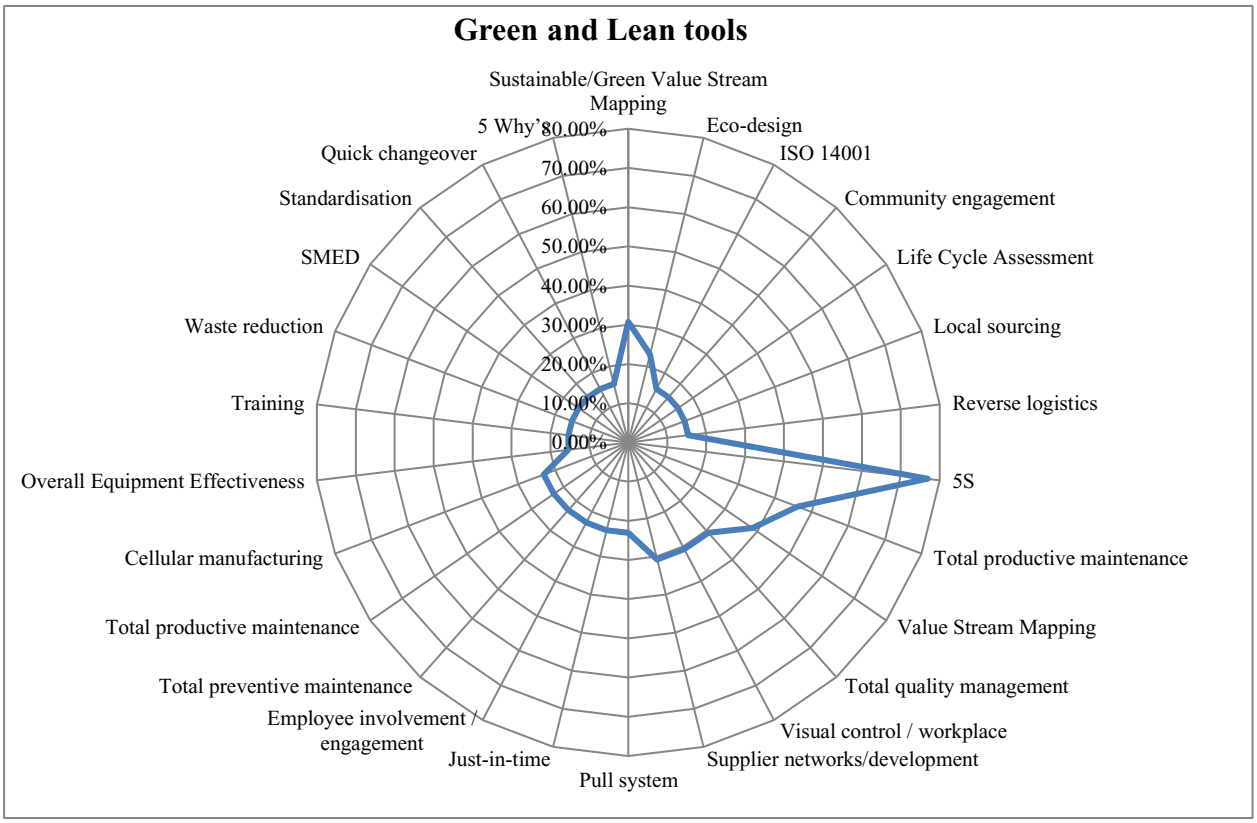

Fig. 3. Radar chart of Green and Lean tools.

The most common appearing Lean tool with 77% (10/13) is the 5S tool (Sort, Set, Shine, Standardize, and Sustain), occasionally with a sixth addition of Safety. Almost half of the papers (6/13) applied Total Productive Maintenance, followed by a declining application of Value Stream Mapping, Total Quality Management, Visual Control/Visual Workplace and the development of the supplier network. Other tools were found in less than 25% of the papers, with many only occurring once.

The most frequently applied Green tool in four out of six articles that listed Green tools and techniques was Green Value Stream Mapping (Chiarini, 2014; Piercy and Rich, 2015; Dües et al., 2013; Vinodh et al., 2011). Eco-design was used by half of the studies, while tools such as the ISO 14000 Environmental Management norms, Life Cycle Assessment, Reverse logistics or local souring were applied by only a third of the authors and companies.

Of the thirteen articles that were screened, only six listed Green tools in addition to Lean tools and techniques. This could indicate that most companies still rely entirely on Lean tools to achieve both Lean and environmental objectives. The majority of Green tools that were applied dealt primarily with the environmental aspect of sustainability, and less than a quarter of authors referred to methods such as local sourcing or community engagement that address the social dimension. Portugal is the only country to address the necessary techniques to sustain Lean and Green efforts which, in general deal with the cultural transformation of an organization and the importance of individuals and groups.

Key findings:

- Most commonly appearing tool is 5S (Sort, Set, Shine, Standardize, and Sustain)
- Only 46% of the papers listed Green tools in addition to Lean tools and methods
- A lack of focus on cultural transformation of the company may serve as a reason for organizations having trouble to sustain their Green-Lean efforts

4.3. Success factors for Green-Lean

The success factors illustrate, see Table 4, several areas that require increased attention in order for organizations to effectively employ and sustain Green-Lean efforts. Every paper without exception listed employee involvement as a crucial factor to success. Similarly important is the commitment and support of (top) management (Duarte and Cruz-Machado, 2013; Cherrafi et al., 2016; Wong and Wong, 2014), and several papers agree that measurements and metrics are necessary for accomplishing continuous improvement goals (Duarte and Cruz-Machado, 2013; Daily and Huang, 2001; Cherrafi et al., 2017b). Other recurring factors are a corporate company culture, strategic planning and goals and the training and education for employees.

Only papers from the United States focus on specific environment-focused training, in addition to general training and skill development (Rothenberg et al., 2001; Daily and Huang, 2001). Authors from the United Kingdom advice to keep hierarchies flat and use cross-functional processes instead (Piercy and Rich, 2015). A noticeable difference across the various continents is that only North American and Asian countries employ reward systems (Wong and Wong, 2014; Daily and Huang, 2001) or compensation linked to performance (Rothenberg et al., 2001).

The success factors from the analyzed articles coincide in many areas with the challenges that are associated with Green-Lean, as described in Section 4.1. This implies that employing these factors in an organization is not only the safest way to succeed with and

Table 4
Success factors for green-lean.

Europe	
Duarte and Cruz-Machado (2013)	Strategic Planning through management: Management commitment and involvement; Lean and Green measures and metrics; Value-adding processes; waste reduction; Lean and Green; Employee engagement, training and education; creating stakeholder value
Piercy and Rich (2015)	Policy deployment to meet strategic goals; Cross-functional processes; Perception of workers as value-adding resources; Integration of TPM
Dües et al. (2013)	Adaptation of corporate company culture; integrating Lean and Green practices into support functions; high level of employee involvement; few hierarchical levels; employee responsibility to encourage involvement
Africa	
Cherrafi et al. (2016)	HR management; Management support and leadership; Supplier partnership; Data and metrics; Culture and communication; People involvement; Training and education; Teamwork; Governance
Cherrafi et al. (2017b)	Organizational Readiness; Project selection and prioritization; Commitment of management and employees; Communication; Resources and skills to facilitate implementation; Focus on measurement and results
Asia	
Wong and Wong (2014)	Management commitment and engagement; Linking Lean with business strategy and customer; Information and knowledge sharing; Staff involvement and rewards; Lean infrastructure; Selection of projects; Financial capability; Use of top talent
South America	
Alves and Alves (2015)	Layout change to improve flow; Implementation of tools; Inventory reduction; Standardized methods; Cultural transformation of organization; Focus on employees' behaviour; Cultivation of culture and employee mindset; Employee engagement, commitment and motivation; Change in attitudes, values and behaviors
North America	
Rothenberg et al. (2001)	Highly restrictive worker selection; Encouragement to continuously innovate and implement process change; Greater levels of worker participation in environmental activities; Overall philosophy of waste reduction; Environment-focused Training; Reduction of status barriers between managers and workers; High levels of training and skill development; Teamwork compensation linked to performance
Daily and Huang (2001)	Employee training and empowerment; Promote internal and external communication on environmentally significant issues; Monitoring and measurement; Periodic review by senior management; Top management support; Environmental training and education; Culture transformation; Reward system; Teamwork

sustain Green-Lean, but simultaneously poses the greatest challenges as well.

Key findings:

- Employee involvement, management commitment and measurement & metrics are considered to be the essential factors for the success Green-Lean
- Different focus points of the various countries are environmental training in the USA or flat hierarchies in the UK
- The main success factors are, at the same time, also the greatest challenges for the implementation of Green-Lean, as seen in Section 4.1

4.4. Green-Lean frameworks

Considering an excerpt of models or frameworks that have been developed by scholars and practitioners for the integration of Green-Lean or Lean and Sustainability, see Table 5, the number of models developed for a specific sector or industry was high (Alves and Alves, 2015), compared to only one generic framework that was designed to be implemented in all sectors (Cherrafi et al., 2017a). The industry-specific models would therefore need to be rethought and edited to fit a general approach for organizations from all kinds of industries. Other frameworks leave room for improvement in the design and comprehensibility of their different steps or stages (Duarte and Cruz-Machado, 2013).

Some frameworks immediately begin with the implementation of Green-Lean without prior ensuring the suitability or readiness of the company (Piercy and Rich, 2015). Few frameworks discuss which tools may work best for the individual company, but rather predetermine the type of Green-Lean tools and techniques an organization should deploy, therefore potentially restricting the scope of its application (Piercy and Rich, 2015). However, some tools require greater financial investment than others and may thereby prove unsuitable for SMEs.

A number of models lack a form of feedback mechanism (Alves and Alves, 2015; Bateman and David, 2002) that allows the user to return to or go through a certain phase or stage again and rectify any mistakes.

The previously discussed research gap concerning the social dimension of sustainability when implementing Green-Lean can also be found in most papers. Many frameworks only address the environmental and economic dimension, but fail to include the social pillar (Sawhney et al., 2007; Bateman and David, 2002). Contrary to this, Wong and Wong's (2014) framework stands out as the only framework geared towards the integration of the human factor to sustain lean operations, while entirely omitting the environmental and economic pillars of sustainability. Sustaining Green-Lean efforts is another challenge that many authors fail to address in their models (Cherrafi et al., 2017a; Aguado et al., 2013; Piercy and Rich, 2015) and that has long been considered by many scholars as a reason as to why many companies struggle to maintain their Lean efforts over the years. The current existing frameworks are additionally more useful for larger organizations, as they rarely contemplate the characteristics of SMEs, such as a lack of financial and human resources, see Section 4.7.

It is clear from the literature review that significant shortcomings exist, which can be overcome by the development of a single comprehensive, simplified and generic framework that integrates Lean and environmental, economic and social sustainability, while at the same time addressing the factors that sustain Lean and Sustainability practices, and that is aligned to the attributes of SMEs.

Key findings:

- The majority of frameworks have been developed for specific industrial sectors instead of generic frameworks
- Many frameworks predetermine the tools and techniques that should be deployed when implementing Green-Lean

Table 5
Green-lean frameworks.

Framework	Key objective	Complexity	Practicality	Effectiveness	Usability	Limitation
Cherrafi et al. (2017a)	Framework explains how organizations can integrate Lean Six Sigma and Green in a systematic manner to improve economic, environmental and social performance. Consists of self-assessment models and five phases broken down into sixteen steps.	Designed in comprehensible steps that fit many industries and company sizes.	Generic framework that is designed to be implemented in all sectors.	Framework was tested for its validity before rolling it out to other companies.	Stages are broken up into individual steps which guides user through implementation process.	Little detail on the sustaining of achieved results. Feedback mechanism is missing.
Alves and Alves (2015)	Model integrates principles of lean manufacturing and sustainability, supported by cultural transformation of organization.	Very well-structured and comprehensive.	No loop for feedback mechanism, designed for production sector only.	Model yet needs to be tested. Includes cultural transformation for sustaining change.	Stages are clearly defined, tools are predetermined.	The proposed model is designed only for production sector. Predetermined tools are tailored to production sector.
Piercy and Rich (2015)	Theoretical model for lean and sustainable change in a single framework. Shows linkages between lean and sustainable operations and identifies full sustainability benefits of lean operations beyond green improvements at workplace level, including community, supply chain and company strategy.	Easy to comprehend. Stages include necessary techniques and tools.	Includes loop for feedback mechanism. Lean and Sustainability stages have separate starting points.	Integrative, stage-based model that captures holistic change process.	Clear, consecutive approach.	The proposed model misses to evaluate the readiness of organizations to integrate Lean and Green. The proposed model misses to indicate how to address sustaining Lean and Green.
Verrier et al. (2014)	Tool to target and promote best practices for lean-oriented sustainable development. Proposes Lean indicators, Green performance indicators and Green intentions indicators. Benchmarking to target best practices.	Works with plotting graphs and matrices. Difficult to comprehend the overall structure.	Not one joint framework, but three separate indicators.	Repository that allows measurement of Green and Lean ability and benchmarking. Maps companies according to their organizational and Green performance.	Indicators relatively easy to calculate.	Framework needs a group of companies available to benchmark them.
Wong and Wong (2014)	Framework addresses human integration in lean for sustaining operations.	Quite complex through several hierarchical structures, matrices and indexes.	Lacks feedback mechanism.	Benefits have been proven through case study, results signify that people can be integrated through scientific methodology in lean.	Detailed introduction into methods of model required.	Framework focuses only on the social dimension.
Aguado et al. (2013)	Model identifies and quantifies efficient, sustainable improvements in lean through processes of environmental innovation by waste elimination.	Framework design lacks clarity and expressiveness. Description of model is very comprehensive.	Steps are achievable through tools. Identification and quantification of improvements of environmental impact and productivity.	Model was tested by small business. Results demonstrate a competitive advantage through reduced costs and reductions in emissions and waste.	Approach can be easily adapted to most businesses oriented towards production.	The proposed model is not validated in real environment. The proposed model misses to indicate how to address sustaining Lean and Green.
Duarte and Cruz-Machado (2013)	Model indicates how and when Lean and Green strategies can be synergetic and compatible, using principles and tools from both philosophies.	Criteria for business model are expansive and comprehensible.	Feedback mechanism is incorporated. Some criteria are not explained in enough detail.	Model needs to be fully developed, tested and validated.	Good guidelines for different success factors, however model itself needs to be expanded further.	The model is not validated in real environment to justify that lean and green strategies are synergetic.
Sawhney et al. (2007)	Model assists in developing relationship between environmental concerns and Lean principles.	Complex, but thorough.	Loop for feedback mechanism. Model designed only for one particular manufacturing process (metal cutting).	Effective to use in the metal-cutting industry.	Specific software needed.	Limited validation and generalizability of the proposed framework. Model misses to take into consideration the social aspects.
Bateman and David (2002)	Model identifies level of sustainability of shop floor based process improvement programmes	Specific area of focus and therefore complex to non-specialists.	Single framework, no loop for feedback mechanism.	Model successfully used to classify levels of sustainability achieved in 40 activities in 21 firms.	Detailed introduction into implementation of model needed.	Framework misses to take into consideration the social aspects. Framework designed only for cell level and factory level.

- The lack of integrating social sustainability poses a significant research gap
- Few models discuss how to sustain Green-Lean efforts

4.5. Factors of Sustainability for Green-Lean

Table 6 presents the factors of Sustainability for Green-Lean. The varying use of Green-Lean or Lean and Sustainability demonstrates the lack of clarity in this research area. Most authors who address Green-Lean perceive 'Green' as the environmental aspect of sustainability, but rarely attend the economic or social dimensions. Articles that discuss the term 'Sustainability' differ therein that they either address environmental, economic and social sustainability, or focus on sustaining Lean efforts over the long term.

For most reviewed papers, the environmental aspect of sustainability in connection with the concept of Lean is reflected in the reduction of waste, pollution, energy and (raw) material consumption (Verrier et al., 2014; Cherrafi et al., 2016), as well as in reducing the negative ecological impact of their products, services and processes (Alves and Alves, 2015). The social aspect may help a company to gain the status of a socially responsible organization (Verrier et al., 2014) or expresses itself in a safe product for employees and consumers (Cherrafi et al., 2016). It is also seen as the establishment of fair practices for workers and communities (Alves and Alves, 2015). The economic aspect of sustainability is mostly perceived as economic value created through Lean (Verrier et al., 2014) or the achievement of the company's financial objectives (Garza-Reyes, 2015).

Only four out of seven articles address means of sustaining Green-Lean (Wong and Wong, 2014; Glover et al., 2015; Ali et al., 2013). This indicates that many organizations need to focus on this particular matter in order to maintain their results in the long term. The papers put a strong focus on the importance of people: employees must be well-managed (Wong and Wong, 2014) and encouraged to learn and develop their skills (Ali et al., 2013; Glover et al., 2015) through the support from senior management, with an overall cultural transformation of the organization (Alves and Alves, 2015).

Alves and Alves (2015) additionally emphasize that sustainable development should be a balanced combination of operating results, respect for people and environmental preservation. The reviewed articles show that there still exist many difficulties with integrating sustainability into an organization. The greatest challenge is, again, considered to be a company's people and their non-alignment with operation management strategies (Alves and Alves, 2015), without which the goal of sustaining Green-Lean activities is deemed impossible. Some lean tools, such as Just-in-time, may also not be compatible with sustainability principles (Cherrafi et al., 2016). Verrier et al. (2014) furthermore address the cost factor, a lack of maturity of existing tools and a general lack of understanding as the challenges that companies need to overcome before they can successfully implement and sustain Green-Lean and Sustainability.

Key findings:

- While the perception of environmental and economic sustainability is similar throughout most research, the social aspect lacks a clear and commonly accepted definition
- There is a lack of understanding on the importance of sustaining Green-Lean initiatives
- Many researchers assume a holistic view of sustainability to include the supply chain or product design

4.6. Benefits of Green-Lean

The most common benefit of implementing Green-Lean is clearly the reduction of waste that can be observed in almost every single study that was analyzed (8/10), see Table 7. This is usually accompanied by a reduction of resource usage such as material, energy or capital. These factors also lead to reduced costs of operations and an improved profitability. Another advantage that was found across various countries were higher levels of safety for workers (Cherrafi et al., 2017a; Piery and Rich, 2015; Sawhney et al., 2007). This improved safety is achieved through an enhanced awareness of employees, additional training or standardized work (Cherrafi et al., 2016; Piercy and Rich, 2015). Companies also benefit from better employee health (Sawhney et al., 2007; Cherrafi et al., 2016). Other frequent assets of Green-Lean are increased worker engagement and commitment, less defects and scrap work, reduced unnecessary production and a reduction in pollution.

The advantages that Green-Lean methods entail extend over several other areas of an organization such as the supply chain (Sobral et al., 2013), product design (Vinodh et al., 2011) and even a company's reputation/public image (Cherrafi et al., 2016; Rusinko, 2007).

In a study that examined more than 300 manufacturing firms from 22 countries in Europe, North and South America and Asia/Pacific, Yang, Hong and Modi (2011) found that the overall correlations of benefits across the countries were the same: Lean manufacturing enhances environmental management practices, which in turn are positively associated with environmental performance. Both Lean and environmental performance are positively connected to a firm's market and financial performance.

Key findings:

- Overall benefits of Green-Lean are uniform across the various countries and continents
- Most common observed benefit was the reduction of waste
- The advantages of the deployment of Green-Lean extend over many functional areas (e.g. supply chain or product design)

After analyzing Green-Lean with a particular focus on Sustainability in the current literature, it is easier to understand its composition, the impacts it can have, and how organizations perceive both Green-Lean and the concept of Sustainability. The following subsection addresses small and medium-sized companies and examines their characteristics and challenges before linking them back to an implementation of Green-Lean and Sustainability.

4.7. Small and medium-sized enterprises

As pointed out in Section 1, there are significantly few SMEs that have integrated Lean into their operations. In the following subsections, it will be discussed how vital SMEs are for the economy, what distinguishes them from large organizations, and which challenges their size pose.

4.7.1. Economic contribution of SMEs

The European Commission defines SMEs as organizations with fewer than 250 employees and a turnover of less than €50 Million (European Commission, 2018a). Worldwide, SMEs add up to 90% of businesses and provide 50%–60% of jobs (Antony et al., 2016). In the European Union (EU), SMEs represent 99% of all businesses and have created approximately 85% of new employment in the past five years. They provide two-thirds of the private sector employment (European Commission, 2018b). In the UK, 99.6% of businesses employ fewer than 250 people (ONS, 2018) and represent

Table 6
Factors of sustainability for green-lean.

Author	Environmental aspects	Social aspects	Economic aspects	Sustaining Green-Lean	Other sustainability factors for Green-Lean	Difficulties of integrating sustainability
Europe						
Verrier et al. (2014)	Reductions in waste generation, energy and raw material consumption. Environmental legislation is becoming more stringent.	Social dimension is still clearly neglected and should be placed at the center of new ways of thinking for production.	Economic earnings received through Lean actions should be considered.	N/A	Relationships between Lean and environmental aspects are influenced by culture or resource usage in the production of quality products. Varies depending on considered Lean principles.	Costs and company priorities. Existing tools have not yet been adapted and/or are not mature enough, often not recognized by industry. Lack of understanding, integration of sustainability too late in product life-cycle phases.
Garza-Reyes (2015a)	Reduction of negative ecological impact of organization's products and services, improved environmental efficiency of operations.	N/A	Achieving organizations' financial objectives	N/A	Elimination of waste in every area of design, production, factory management and supplier network.	Further research needed to investigate aspects regarding constitution, effectiveness, applicability and practical implications and challenges of Lean and Green.
Africa						
Cherrafi et al. (2016)	Products using processes that minimize negative environmental impacts and conserve natural resources and energy.	Safe products for employees, consumers, and communities.	Products that maximize profit.	N/A	Complete view covering entire supply chain and manufacturing system.	Some lean principles may not be compatible with sustainability, e.g. Just-in-time.
South America						
Alves and Alves (2015)	Planet: use of sustainable environmental practices and reduction of environmental impact by decreasing generation of pollutants and waste in production processes.	People: establishment of fair practices for employees, partners and community.	Profit: economic value generated by company through viable enterprises to meet expectations of shareholders or to provide economic benefit to surrounding community and society.	Cultural transformation of organization to maintain improvements on long-term basis. Support from senior management to promote growth and development of potential of people by changing attitudes, values, behaviour and structure of organization.	Sustainable development as balanced combination of operating results, respect for people and environmental preservation. Provide company with healthy manufacturing resulting from rational use of raw materials and natural resources and low waste.	Greatest challenge to achieve sustainable operation is people. If strength of human resources is not aligned with OM strategies, goal of sustaining operations is very difficult to be achieved.
Asia						
Wong and Wong (2014)	Well-being of environment.	Improves well-being of people.	Creates value to stakeholders, ensures ongoing commercial success.	Lean is meant for sustaining operations: employees must be managed well to ensure high performance and achievement of lean objectives, which will eventually lead to sustainable operations.	Must integrate issues and flows that extend beyond core of OM: product design, manufacturing by-products, product life extension, product end-of-life and recovery processes at end-of-life.	If strength of people (or human resources) is not aligned with OM strategies, goal of sustaining operations is very difficult to be achieved.
Ali et al. (2013)	N/A	N/A	N/A	Strategic focus: importance of individuals and groups using organizational goals to focus and prioritize improvement activities. Management: leaders influence employees' innovative behaviour. Learning/knowledge sharing: motivates employees through skills development.	N/A	N/A
North America						
Glover et al. (2015)	N/A	Value and culture	N/A	Accepting changes, including 'open-minded' workforce and reinforcement of change from management, loyalty and commitment via leadership demonstration and recognition of non-economic factors; encourage learning and stewardship among employees.	N/A	N/A

the major source of employment. Small and medium-sized enterprises are considered key drivers for economic growth, job creation and innovation. They ensure social integration and contribute greatly to the competitiveness of markets (Antony et al., 2016; European Commission, 2018b). Since SMEs frequently act as suppliers to large enterprises and considering that modern economies function as complex networks of businesses, the competitiveness of SMEs influences the competitive ability of an economy in its entirety (Wessel and Burcher, 2004).

4.7.2. Characteristics of SMEs

The typical structure of a small and medium-sized business is characterized by a flat hierarchy with few layers of management (Yusof and Aspinwall, 2000). Unlike large companies, they do not have a set of business units, but integrated business functions (Antony et al., 2016). The management of SMEs is therefore highly visible and delegates less (Ghobadian and Gallear, 1996), which results in a much higher adaptability and flexibility to customer needs than large companies have (Antony et al., 2016). Therefore, only a low degree of specialization is possible, which may result in the dependence on external aid through a lack of expertise (Yusof and Aspinwall, 2000).

Informal and simple procedures facilitate an SME's flexibility and quick reaction to customer demands. This informality, however, also often leads to a "gut feeling" approach when making decisions, which can result in errors in judgement. This approach is often applied, as SMEs frequently need to operate in a "fire-fighting mode" in order to survive (Antony et al., 2008).

The culture of SMEs is strongly influenced by the managers and/or owner's attitudes and values (Kumar et al., 2014). Strong leadership therefore has great potential to ensure a successful implementation and the sustaining of new initiatives. Due to a smaller number in staff, the working environment tends to be innovative, and change is more often embraced than resisted (Yusof and Aspinwall, 2000). However, a constraint in size often also entails a lack of financial capabilities, which discourages investment in training or research and development (Antony et al., 2016; Yusof and Aspinwall, 2000).

4.7.3. How do SMEs differ from large organizations?

There exist significant structural differences between SMEs and large businesses. These become apparent in the exploitation of resources, policy-making procedures and the structure of organizations (Ghobadian and Gallear, 1996). Due to the size of large businesses (250 + employees), they are typically bureaucratic, likely to be specialized, highly standardized and formalized (Hudson et al., 2001). SMEs, by contrast, tend to have informal procedures that extend to loose working relationships and an absence of standardisation (Antony et al., 2008). Bureaucratic structures would be less efficient for SMEs because of their turbulent environment that is oriented towards fast results, innovation and the flexibility to adapt to new situations (Yusof and Aspinwall, 2000). Large organizations have several layers of management, which results in top management to be far removed from the point of delivery. In SMEs, hierarchies are flat, and the top management is visible to other employees, effective communication is facilitated, and it is easier for managers to lead by example (Antony et al., 2008; Ghobadian and Gallear, 1996).

The flexible work environment of SMEs that is associated with flat hierarchies allows for upper management to develop strong personal relationships with their employees (Hudson et al., 2001; Antony et al., 2008). Nonetheless, it may also increase potential for interpersonal conflict. Large organizations have a range of management styles, such as direct, participative or paternal. Employees are often judged based on their performance, leaving less room for personal relations (Ghobadian and Gallear, 1996).

The culture of a large organization is usually diversified and inert, due to the number of employees, departments and business functions, while an SME's culture tends to be more unified and fluid (Yusof and Aspinwall, 2000; Hudson et al., 2001). Owing to limited financial resources and a lack of qualified specialist workers, SMEs have limited capabilities for training and staff development. Large organizations, on the other hand, plan their staff training with a specific budget and implement it on a large scale (Ghobadian and Gallear, 1996). Overall, this leads to a defining difference between the two forms of organizations. While large companies are system-oriented, they are also less innovative and responsive to a change in customers' demand, take more time to respond to environmental changes and experience a high degree of resistance towards change (Yusof and Aspinwall, 2000). SMEs, in contrast, are people-oriented, can respond more easily to market needs, adapt to change and use their innovative capabilities to meet customers' demand (Antony et al., 2008).

4.7.4. Challenges of SMEs

According to our literature review, the challenges for SMEs are reflected in the following aspects:

(1) Manpower constraints

In small businesses, every employee has a key role, sometimes several, leading to little spare resources (Wessel and Burcher, 2004). Detaching employees for a project will leave them less time for their actual work, a reason why management often considers training employees as a waste of time, and why a small workforce is considered a critical failure factor for SMEs (Albliwi et al., 2014).

(2) Financial constraints

SMEs' lack of financial resources implies that companies cannot afford large investments in technology, sufficient infrastructure and training of staff, even though these are considered as critical to reduce the implementation time of continuous improvement methods and ultimately result in savings and a reduction of labor cost (Antony et al., 2016).

(3) Poor management and leadership

Projects fail easily if top management is not prepared to be committed, involved and has an appropriate attitude (Antony et al., 2016). Often, management is not willing to compromise on production in order to improve the quality of the final product. Top management is considered to be reluctant to invest in quality and employee training as this would increase production costs (Wessel and Burcher, 2004).

(4) Lack of strategy

Projects are often not aligned with the company's strategic goals, creating a weak link between the two. According to Antony et al. (2012), it is important to select projects that align with the organization's strategic goals. Targets commonly focus on solving existing problems instead of focusing on strategic opportunities such as new product development. Missing objectives and strategy can frequently be found in SMEs as these often struggle to survive. Poor or no planning and an emphasis on short-term objectives prove as additional challenges (Albliwi et al., 2014).

(5) Resistance

Timans et al. (2012) found that internal resistance is the main factor (54%) in SMEs that challenges the implementation of continuous improvement methods. Resistance from employees is a natural phenomenon to encounter, as they are often afraid of their jobs being endangered by a new problem-solving methodology (Albliwi et al., 2014).

Table 7
Benefits of green-lean.

.	Type of Industry	Size of enterprise	Key benefits	Country
Europe				
Piercy and Rich (2015)	General	N/A	- producing same output with less resources (materials, energy, capital) - reducing cost of operation - improved quality leads to less production defects and scrap/rework - positive correlation between worker engagement/involvement and environmental performance - higher levels of safety through visual management, worker training, and standardized work - information sharing to reduce unnecessary production, transportation, and stock holding	United Kingdom
North America				
Sawhney et al. (2007)	Metal-cutting	N/A	- higher machine efficiency - fewer points of material transfer - better plant layouts - better employee health and safety - less pollution - reduced waste - reduced consumption of energy & resources	USA
Rusinko (2007)	Commercial carpeting	13 commercial carpet manufacturers, various company sizes	- pollution prevention practices associated with decreasing manufacturing costs - improved company image - attraction of new customers - promotion of innovative ideas	USA
Africa				
Cherrafi et al. (2016)	General	N/A	- improved employee morale and commitment - optimized human resources applied to waste reduction - improved employee awareness about environmental, health and safety issues - reduced costs - improved marketability of products - meeting of customer expectations - increased reliability of processes and equipment - reduction of environmental impact and increase of environmental benefits - improved resources efficiency - avoided risks from noncompliance with regulatory requirements - improvement of product durability and reliability - improved efficiency of waste reduction efforts - increased organizational efficiency and cultural improvements - better relationships with suppliers and other stakeholders - better reputation	Morocco
Cherrafi et al. (2017a)	Various	N/A	- decreased use of natural resources - improved energy and materials efficiency - reduced risks of spills and mishandling - improved waste management - minimized risks to health and safety of workers and environment - problem solving culture with scientific and structured thinking - engagement of employees and unleashing of creativity - reduction of material wastes and pollution - avoided excess consumption and environmental waste - improved longevity of equipment - reduced inventory and overproduction - extended environmental responsibility across supply chain	Morocco
Asia				
Vinodh et al. (2011)	Manufacturing	N/A	- elimination of waste - lower energy and resource usage - reduction in defects - reduced consumption of materials and chemicals - increased longevity of equipment - improved product durability and reliability - reduced complexity of production processes and product design	India

Table 7 (*continued*)

.	Type of Industry	Size of enterprise	Key benefits	Country
South America				
Sobral et al. (2013)	Automotive	700 employees	- improved environmental efficiency - reduced input consumption, reused resources, recycled materials - increased equipment life - less scrap and rework - avoidance of excess consumption and waste - extended environmental responsibility; reduced cargo transport	Brazil
Alves and Alves (2015)	Production	N/A	- inventory reduction - improved production costs - product quality improvement - shorter production cycles - faster delivery to end customers - improved worker safety - environmental awareness - reduced waste - limited use of resources - development of culture of continuous improvement	Brazil
Various continents				
Yang et al. (2011)	Manufacturing	309 samples, various company sizes	- enhanced environmental management practices - improved environmental performance - positive association with market and financial performance	Europe, North and South America and Asia/Pacific

(6) Project selection

According to Su and Chou (2008) and Duarte et al. (2012), selecting the wrong project can cause an entire project effort to fail, especially if the first projects omit to showcase the savings potential.

The identification of challenges for SMEs and the implications for Green-Lean and Sustainability demonstrate why such a significant number of SMEs has yet to integrate Lean, much less Green-Lean and Sustainability, and why a stronger focus on this particular type of organization is necessary. A lack of resources prevents many companies from exploring the idea of integrating a continuous improvement method or a sustainable strategy. Top management plays a crucial part in this, as their reluctance to invest in employee training or quality efforts prevent organizations from taking a step towards Green-Lean. Additionally, without the full support and commitment of management, the workforce will show resistance. The fact that many SMEs struggle to survive means that the concept of Green-Lean and Sustainability must be clear, simplified and aligned to the specific needs and characteristics of SMEs in order for them to consider implementing these concepts into their business.

5. Conclusions

Environmental, economic and social sustainability have become a strategic requirement for organizations to align to their more traditional priorities of profitability and efficiency. This study investigates how all three dimensions of sustainability can be merged with the continuous improvement initiative Lean and help organizations sustain and utilize the advantages of both paradigms together. To the best of our knowledge, only a handful of researches that have focused on the integration of Green-Lean and Sustainability as a joint approach and to take a holistic view of the interrelated factors in the context of SMEs. Due to a lack of research in this field, this study additionally focuses on small and medium-sized enterprises as the medium of integration. For these reasons, this study fills a research gap as previously highlighted in Section 1 and concludes from the extensive literature review that:

(1) Due to their restricted size and resources, SMEs struggle to effectively integrate lean management with green management.
(2) The analysis has shown that a lack of management support and missing metrics are the main factors that prevent companies from implementing lean management and green management.
(3) Employee involvement has been proven to be a crucial condition to allow an integration to succeed.
(4) An analysis of existing frameworks demonstrates that current models are generic frameworks that predetermine tools that are not designed for all companies, and additionally lack long-term efforts to sustain an integration.
(5) The benefits of Green-Lean clearly prove to be of environmental, social and economic value.

Practitioners may use the results of this study to gain an overview over the concepts of Green-Lean and Sustainability to develop a deeper knowledge on both methods. This may help to successfully implement and sustain these in their own business. The paper additionally encourages them to think, source and operate sustainably to preserve the environment, achieve long-term results and aptly care for their employees and community. Academic audiences can utilize these insights to broaden their understanding of the concepts and may be motivated to carry on research to provide a clear and definite theory on Green-Lean and Sustainability.

The literature review also demonstrates that significant shortcomings in regards to the understanding and application of Green-Lean and Sustainability still exist. These can be overcome by promoting their integration through a comprehensive, simplified and generic implementation framework. A toolkit for Green-Lean and Sustainability has also yet to be developed, as many tools have either not been adapted, are not mature enough or are frequently not recognized by the industry. The authors additionally recognize a need for a greater focus on the context of SMEs to assist them in effectively integrating both paradigms. The reluctance towards the integration of Green-Lean is fed by a lack of theoretical contribution in this field. Only if these research gaps are attended, the integration of the Green-Lean and Sustainability approach into businesses be achievable.

Disclosure statement

No potential conflict of interest was reported by the authors.

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