Northumbria Research Link

Citation: Shokri, Alireza, Antony, Jiju, Garza-Reyes, Jose and Upton, Michelle (2021) Scoping review of the readiness for sustainable implementation of lean six sigma projects in the manufacturing sector. International Journal of Quality & Reliability Management, 38 (8). pp. 1747-1770. ISSN 0265-671X

Published by: Emerald

URL: https://doi.org/10.1108/ijqrm-08-2020-0261 <https://doi.org/10.1108/ijqrm-08-2020-0261>

This version was downloaded from Northumbria Research Link: http://nrl.northumbria.ac.uk/id/eprint/45084/

Northumbria University has developed Northumbria Research Link (NRL) to enable users to access the University's research output. Copyright © and moral rights for items on NRL are retained by the individual author(s) and/or other copyright owners. Single copies of full items can be reproduced, displayed or performed, and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided the authors, title and full bibliographic details are given, as well as a hyperlink and/or URL to the original metadata page. The content must not be changed in any way. Full items must not be sold commercially in any format or medium without formal permission of the copyright holder. The full policy is available online: http://nrl.northumbria.ac.uk/policies.html

This document may differ from the final, published version of the research and has been made available online in accordance with publisher policies. To read and/or cite from the published version of the research, please visit the publisher's website (a subscription may be required.)

Northumbria University NEWCASTLE

UniversityLibrary

emerald PUBLISHING

International Journal of Quality & Reliability Manag

Scoping review of the readiness for sustainable implementation of lean six sigma projects in the manufacturing sector

Journal:	*International Journal of Quality & Reliability Management*
Manuscript ID	IJQRM-08-2020-0261.R2
Manuscript Type:	Quality Paper
Keywords:	Lean Six Sigma, Green Manufacturing, Organisational Culture, Scoping Review, Systematic Literature Review
Abstract:	

SCHOLARONE™
Manuscripts

Scoping review of the readiness for sustainable implementation of lean six sigma projects in the manufacturing sector

ABSTRACT

Purpose - This work presents a synthesis of current literature published from 2010 to provide an overall understanding of the sustainable implementation of Lean Six Sigma (LSS) projects in terms of project approaches rather than outcomes.

Design/methodology/approach - A comprehensive and validated ten-step model was applied to conduct a scoping review (SR) with the following three broad phases: "review planning", "review execution", and "review reporting".

Findings - The analysis shows that while a few geographically and methodologically broad research studies have been conducted on LSS and green manufacturing integration, no studies have examined organisational culture or conducted readiness assessments on the sustainable implementation of LSS projects in the manufacturing sector.

Research limitations/implications - The present study contributes to existing knowledge by describing the current state of research on green LSS integration. The study also identifies a lack of research on the deployment of sustainable LSS projects for manufacturers. Further empirical analyses that include case studies must be conducted to assess the negative environmental impacts of LSS projects.

Originality - This study serves as an initial call for practitioners and research scholars to favour the sustainable deployment of LSS projects in manufacturing alongside the use of traditional approaches with a focus on costs, quality and delivery.

Key words - Lean Six Sigma, green manufacturing, organisational culture, scoping review, systematic literature review

1. Introduction

Evaluating sustainability non-financial key performance indicators and subsequently mitigating the detrimental impacts of the failure of management systems on the environmental sustainability are crucial and deserve further exploration (Karevan et al., 2020; and Dissanayake, 2020). Due to changing public perceptions and market dynamics and increased public and regulatory pressures, a stakeholder-oriented integration of environmental sustainability and energy efficiency into continuous improvement (CI) methodologies such as Lean Six Sigma (LSS) is becoming a necessity in manufacturing (Jayaraman et al., 2012; Erdil

International Journal of Quality & Reliability Management

et al., 2018; Mishra, 2019; de Freitas et al., 2017; and Kaswan, 2019). Furthermore, according to Lucato et al. (2015) and Ghazilla et al. (2015), a growing number of manufacturing firms running LSS projects are more susceptible to adverse environmental impacts of LSS project deployment and resources while gaining economic competitiveness. The manufacturing industry is also facing more pressures to adhere to stringent environmental regulations and more resource-efficient operations.

Very few studies have been conducted on the importance of the synergic integration of the contemporary LSS framework with environmental sustainability frameworks for the manufacturing sector (De Freitas et al., 2017; and Mishra, 2019). Examples of such studies include Ruben et al. (2018), Cherrafi et al. (2016) and Cherrafi et al. (2017), but they are overwhelmingly conceptual and bibliographically incipient. Moreover, an absence of a sustainability framework for LSS project deployment leaves energy efficiency plans among manufacturing firms that implement LSS more likely to fail (Antony et al., 2017). Despite proven outcome benefits such as lower waste and operation costs and market opportunities, the integration of environmental sustainability with LSS in the manufacturing sector remains highly complex due to a profound focus on economic and quality–centred objectives of LSS (De Freitas et al., 2017; and Erdil et al., 2018). This strong prioritisation conflicts with other manufacturing principles such as green credentials.

Additionally, the importance of sustainable LSS projects was highlighted by scholars (Brkic and Tomic, 2016). Therefore, this study aims to take the first step and scope and synthesise the current literature to check whether there is a gap in the literature about assessing readiness of sustainable utilisation and deployment of LSS projects. The literature synthesis focuses on green LSS project deployment and critical success factors (CSFs), drivers and barriers. Therefore, we describe the current literature associated with the definition of LSS, green LSS and organisational culture, critical factors affecting LSS, green LSS failure and success, and drivers and barriers of LSS and green LSS as search keywords of this scoping review.

2. LSS definition

LSS is a newer form of the linear combination of lean and Six Sigma. LSS is a strategic, rigid and structured improvement procedure with operational capabilities and approaches for reducing variation in organisational processes (Zu et al., 2010; Manville et al., 2012; and Antony et al., 2017). LSS is today's leading technique for maximising production efficiency

International Journal of Quality & Reliability Management

and maintaining control over each step of the managerial process (George et al., 2005). Alexander et al. (2019), Laureani and Antony (2018) and Albliwi et al. (2015) recently defined LSS as a powerful method when combined with process improvement and shareholder value maximisation approaches with ultimate objectives of increased efficiency, customer satisfaction, reliability and process performance optimisation. Highly structured breakthrough projects have rendered LSS a stable management process and guided form of resource allocation that focuses on the organisational bottom line. LSS has in turn become a popular quality and business improvement methodology pivotal to business excellence and competitive advantage (Ismyrlis and Moschidis, 2013; Sreedharan et al., 2019; Sharma and Sharma, 2014; and Antony, 2006).

3. Green LSS and organisational culture

Green objectives such as reducing energy and resource use, greenhouse gas emissions and waste are now part of the corporate agenda of numerous manufacturing organisations (Mishra, 2019; and Garza-Reyes et al., 2018). Despite numerous studies having been conducted on LSS integration with green and sustainable manufacturing since 2010, green output has been the sole focus without addressing the green deployment of LSS projects (De Freitas and Costa, 2017; and Albliwi et al., 2015). This gap in the literature has highlighted a need for an organisational readiness to shift from the currently used narrow, outcome–oriented approach to the use of a hybrid model of energy efficient and outcome-oriented LSS project deployment. Zu et al. (2010) highlighted the influence of organisational culture on LSS practices in the USA. Habidin and Yusof (2012) clearly outlined the contradiction between LSS outcomes such as increased capacity due to increased yields and green manufacturing credentials that address a need for cultural transformation. Pamfilie et al. (2012) emphasised the role of leadership in embracing, championing and correctly applying LSS of different forms including green LSS, which requires more cultural change. Ng and Hempel (2020) stressed the role of organisational culture and its features such as support for LSS success in southern China. With some sectoral variation, visible, communicative, inspirational, consistent and flexible styles of leadership are more conducive to the success of LSS deployment as part of a transformational journey (Laureani and Antony, 2017). This element has also emerged as an integral facet of cultural change towards readiness to adopt green LSS. Shokri et al. (2016) has also highlighted the role of core personal competence, strategic vision and organisational culture in readiness to adopt LSS among German manufacturing SMEs. More recently, Sreedharan et al. (2019) developed an evaluation model measuring readiness to adopt LSS by identifying barriers facing Indian

International Journal of Quality & Reliability Management

manufacturing organisations. Brkic and Tomic (2016) adopted a different approach and identified the role of employees' behaviour and attitude in LSS success. A study by Orji (2019) also focused on examining barriers to organisational change for sustainability and drivers that support sustainable performance in the Chinese manufacturing sector. The following section presents a review of literature on factors shaping the success and failure of LSS and green LSS. Therefore, green manufacturing reflects a need for readiness to enable manufacturers adopting LSS to consider green credentials (e.g., energy consumption) alongside traditional objectives of LSS (e.g., quality, waste reduction and productivity).

4. Factors shaping the success and failure of LSS and green LSS

The integration of LSS with sustainability frameworks to reduce environmental impact seems to be an essential factor that shapes future success or failure. Through a high-level overview, Snee (2010) highlighted the role of top leaders in creating a sense of urgency to support more productive LSS project selection and sustainability, aligning with the start of LSS integration with green manufacturing in 2010 (De Freitas and Costa, 2017). Ruben et al. (2018) highlighted that any contemporary LSS framework must consider elements of eco-efficiency, according to which environmental impacts of LSS must be considered similar to quality and cost reduction impacts on project outcomes. The green LSS model has emerged as a way for organisations to achieve better environmental efficiency while pursuing their economic goals (Mishra, 2019). However, considerable focus has been placed on LSS outcomes rather than on environmental impacts of LSS projects themselves. Drohomeretski et al. (2014) conducted a preliminary comparative analysis of decision-making criteria and performance objectives of LSS as a means to achieve a strategic competitive advantage in the Brazilian manufacturing sector. Kuvvetli et al. (2016) identified CSFs of Six Sigma for Turkish manufacturers through a factor analysis. Both of these studies recommended skills and capacity of the workforce, managerial technical competence, competence to meet clients' expectations, workforce participation, investment in strategic development, effective application of methodology and appropriate project selection as criteria to achieve a strategic competitive advantage.

Through a case study analysis of the UK, Manville et al. (2012) highlighted the role of middle management in creating a cultural platform via dynamic capabilities and culture of organisational learning for LSS project success. More recently, Laureani and Antony (2018) emphasised the role of transformational leadership in creating certain culture and objectives and in adopting cultural changes through CSFs of LSS. Jayaraman et al. (2012) also identified

International Journal of Quality & Reliability Management

the CSFs of LSS from a practitioner's point of view and the importance of organisational culture to LSS success. Furthermore, Naslund (2013) revisited CSFs of LSS by focusing on strategic alignment, top management commitment, project management and training as four crucial factors.

Top management commitment, organisational culture, relating LSS to business strategies and leadership have been deemed the most important CSFs for LSS (Snee, 2010; Laureani and Antony, 2012). Through their quantitative analysis of the Malaysian automotive sector, Habidin and Yusof (2013) identified effective leadership and top management commitment as drivers of other CSFs of LSS such as customer focus. Meanwhile, Ismyrlis and Moschidis (2013) classified CSFs of LSS in terms of hard and soft elements where soft elements are mainly associated with leaders and people as two common enablers of any quality improvement initiative. More recently, Sreedharan et al. (2018) assessed critical factors resulting in the failure of LSS methods in manufacturing through a case study analysis in India. Their finding highlighted lack of top management commitment, high implementation cost and internal resistance as top LSS critical failure factors to be considered in the real-world scenario. De Freitas and Costa (2017) found that 70% of companies fail to implement LSS as a strategy due to several factors such as a lack of top management commitment and support, limited training, poor project prioritisation, lacking resources, and the limited integration of LSS projects and business or corporate strategies. Abu Bakar et al. (2015) reviewed and gathered the latest success factors of LSS deployment and implementation into a comprehensive list of factors through a literature review. Their study recommended management commitment, LSS competency, training, organisational infrastructure and project management as the top five critical success factors of LSS.

More recently and through empirical research, Mishra (2019) evaluated existing frameworks of green and LSS integration in the literature and recommended top management commitment, dedication to appropriate strategy selection, long-term planning and participation, and a strong understanding of current products and process designs as top factors facilitating the achievement of desired level of success. However, their study focused on the role of LSS in waste reduction as a green outcome and not on the actual deployment of LSS projects with attention to resource and energy efficiency. Albliwi et al. (2014) explored a comprehensive list of common factors causing LSS project failure and indicated that a significant percentage of these factors are related to a lack of appropriate attention given to CSFs of LSS. Hilton and

International Journal of Quality & Reliability Management

Sohal (2012) stressed the importance of developing a unique combination of personal and corporate competencies such as knowledge, skills, charisma and organisational change management for LSS success and sustainability. Sunder (2016) highlighted the importance of projects and "Inform-Involve-Influence" models of stakeholder management for LSS project success. Tenera and Pinto (2014) adopted an alternative view of LSS success by proposing an LSS project management improvement model integrated with the LSS methodology to avoid excessive LSS project durations and resource overuse as key operational and environmental factors resulting in failure. Antony et al. (2017) shared the experience of LSS practitioners and academics in concluding that focusing on more holistic organisational improvements through sustainable initiatives is essential to future LSS implementation. Later, Hudnurkar et al. (2019) conducted a preliminary quantitative study on deficiencies in Six Sigma project capabilities and recommended organisational capability utilising resources as key element to minimise deficiencies to perform a coordinated set of activities.

5. Drivers of and barriers to LSS and green LSS

A shift in customer interest from a focus on product quality to a focus on high-quality products that generate less waste and environmental impact has motivated many manufacturers to adopt an integrated approach to CI practices such as LSS and sustainability. Despite numerous works examining different themes of LSS in the manufacturing sector, integration has not been explored at length (Albliwi et al., 2015). Erdil et al. (2018) examined ways of embedding sustainability into LSS projects and ways of integrating sustainable practices into LSS methodologies among manufacturing firms. The authors particularly recommend using the "Define" stage of the LSS methodology as a crucial stage in which projects are selected and prioritised. Kumar et al. (2016) identified and categorised barriers to LSS implementation for green product development. Their study recommended competition, uncertainty and lack of top management commitment as top barriers to implement green LSS product development. Hill et al. (2018) identified strategic CSFs and barriers affecting large, complex LSS projects through a case study analysis. They highlighted the importance of training and minimising over-use of tools with high efficiency in LSS projects as CSFs and lack of commitment from operational staff and misunderstanding of the desired outcomes as major encountered barriers. A cross-sectoral survey questionnaire conducted in Egypt also validated the effectiveness of lack of knowledge and dedicated professionals, insufficient financial resources and lack of top management support as the most influential barriers to Six Sigma implementation and their

International Journal of Quality & Reliability Management

varying effects in relation to dimensions of organisational factors such as size and type (Aboelmaged, 2011).

A case study analysis by Yadav et al. (2018) identified ways for Indian manufacturers to overcome barriers to LSS adoption. They recommended top management involvement towards LSS adoption, effective LSS team structure, linking LSS to business strategy and effective utilisation of financial resources for removing barriers of LSS adoption. Through their preliminary study about the integration of LSS with environmental sustainability and its impacts on greener production De Freitas et al. (2017) acknowledged the complexity of integration as a key barrier due to number of synergies and conflicts associated with such integration. They also recommended importance of studies investigate potentially negative impacts of LSS projects on the environment in the future. Sagnak and Kazancoglu (2016) investigated the integration of lean, six sigma and green manufacturing in Turkey through action-based research and highlighted the importance of LSS integration with environmental management practices to remove or minimise unfavourable impacts of products defect or variation on environment. For the same period and through a systematic literature review, Cherrafi et al. (2016) identified limited LSS integration with green manufacturing with a focus on shortcomings and negative impacts of LSS projects on the environment. The authors suggested that meeting LSS goals comes at the cost of using toxic chemicals and excessive water and energy resources for the majority of LSS projects.

Furthermore, significant benefits of LSS for manufacturing such as increased production capacities, quality improvements, increased sales and throughputs may have negative environmental impacts (Albliwi et al., 2015). A framework has been developed to guide companies through five stages and sixteen steps in effectively integrating and implementing green LSS approaches to improve their sustainability (Cherrafi et al. 2017). Earlier, Lucato et al. (2015) proposed a way to incorporate environmental variables into DMAIC (Define, Measure, Analysis, Improve, Control) processes to enhance the eco-efficiency of products. Ruben et al. (2017) also conducted a case study on an Indian manufacturer's implementation of an LSS project to improve overall operational and environmental performance. Through a case study analysis of the US construction industry, Banawi and Bilec (2014) developed a systematic and integrated LSS and green framework for mitigating environmental impacts of the construction industry. The authors also identified a lack of research on collective ways to reduce waste and environmental impacts while increasing the productivity of LSS projects.

International Journal of Quality & Reliability Management

Mkhaimer et al. (2017) later proposed the LSS Energy Management model (LSS_EnMS) based on ISO50001 for energy management. The authors demonstrated how the legal requirements and roles of the LSS methodology and similar tools can limit negative environmental impacts of manufacturing (e.g., waste) through a case study of Jordanian manufacturing firms.

Sreedharan (2018) proposed an integrated green LSS Supply Chain Management (SCM) model designed to reduce the gap between Green SCM and LSS. The authors identified increased pressures from different players in the supply chain and competition as two major drivers behind the integration of LSS with green SCM. Garza-Reyes (2015) and Powell et al. (2017) recommended the environmental and economic benefits of LSS through waste reduction and process efficiency as major driver for the integration. Aldairi et al. (2017) developed a knowledge-based system for LSS maintenance for environmentally sustainable buildings and concluded that having environmental policy is a key driver to remove barriers of green and LSS integration. De Freitas and Costa (2017) carried out a systematic review of literature on how LSS adopted by organisations with sustainability agenda has helped mitigate factors resulting in LSS failure. Through a systematic literature review, Chugani et al. (2017) highlighted the importance of assessing environmental impacts of LSS projects in reducing environmental effects. However, the authors did not focus on cultural drivers of and barriers to this requirement. The integration of LSS with green manufacturing is needed to develop an improved approach that involves organisational readiness analysis (Kaswan, 2019). Despite a comprehensive approach having been developed to examine drivers of and barriers to LSS in different sectors (Costa et al. 2018) and highlighting the role of the LSS framework in greener outcomes, cultural barriers to and drivers of the sustainable implementation of LSS for manufacturers remains unexplored.

6. Methodology

Despite there being an accurate account of the positive impact of LSS on green manufacturing, there is a need for holistic evidence on the sustainable implementation of LSS projects in manufacturing and on cultural approaches to such a change. We conducted scoping review (SR), which is a relatively new and increasingly popular approach for synthesising research evidence (Pham et al, 2014; and Munn et al, 2018). The SR is almost similar to the systematic literature review to provide a rigorous and transparent method for mapping areas of research and existing literature (Pham et al, 2014; and Munn et al, 2018). The systematic literature review approach involves conducting a structured review of the current literature to advance

International Journal of Quality & Reliability Management

our understanding of emerging research and to identify the conceptual content of the field as part of a theoretical contribution (Alinaghian et al., 2020**;** and Chugani et al., 2017). However, a SR of a body of literature can be of particular use when the topic has not yet been extensively reviewed to examine the extent, range, and nature of research activity in a topic area, to summarise and disseminate research findings, and to identify gaps in the existing literature (Pham et al, 2014). Therefore, this method was the most suitable literature review approach for the purpose of our study.

A number of systematic literature review papers have been published on the impact of LSS on green outcomes (Chugani et al., 2017), on green lean approaches and the need for Six Sigma methods (Garza-Reyes, 2015), on LSS for manufacturing (Albliwi et al., 2015), on LSS for manufacturing SMEs (Alexander et al., 2019) and on LSS in the food industry (Costa et al., 2018). Nevertheless, we found no SR about the integration of LSS and green manufacturing. Therefore, in light of the aims of this study, we conducted a SR of relevant literature by using a comprehensive pre-planned strategy to identify a gap in the literature about readiness assessment of sustainable implementation of LSS projects in manufacturing. The SR approach elucidates the effects of previous research through a broad synthesis of contributions and gaps of current research (Alexander et al., 2019; and Albliwi et al. (2015). The SR method, thus, serves as a rigorous, transparent and explicit means to ensure a comprehensive literature review (Garza-Reyes, 2015).

We adopted the comprehensive approach recommended by Tranfiled (2003), Albliwi et al. (2015) and Alexander et al. (2019) in using a ten-step SR approach to examining LSS in the manufacturing industry. The three broad phases of this ten-step approach (review planning, review execution, and review reporting) are presented in Figure 1.

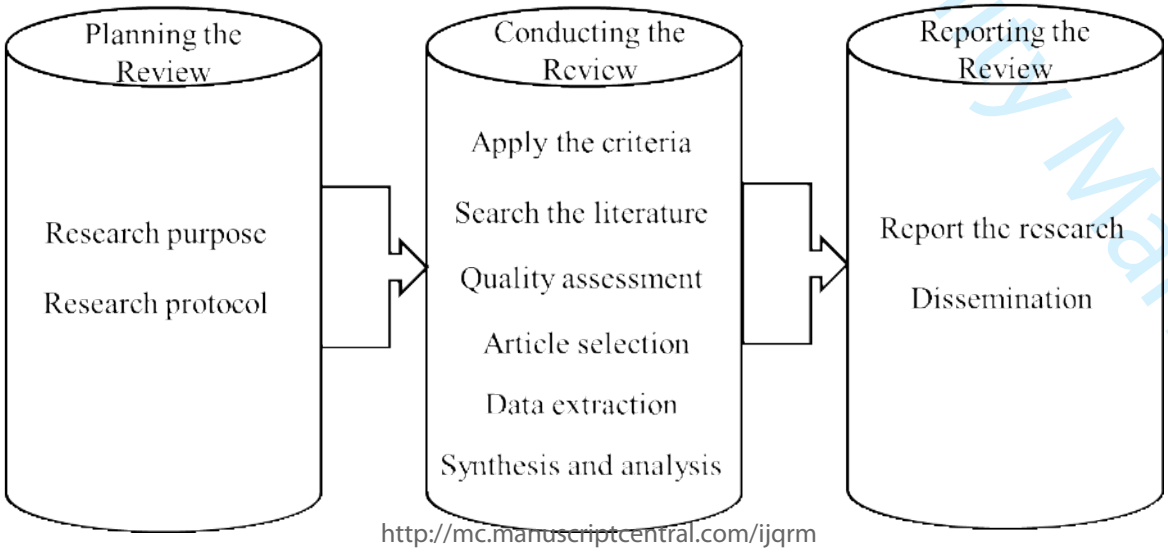

Figure 1 – Summary of scoping review approach and phases

Source: adapted from Tranfield et al. (2003), Albliwi et al. (2015) and Alexander et al. (2019)

6.1. Review planning

The purpose of this study is to perform a SR of articles published in peer reviewed academic journals from 2010 when LSS integration with green manufacturing first emerged in research and practice (De Freitas and Costa, 2017). We evaluated whether a research gap exists on factors related to readiness to adopt sustainable LSS projects in manufacturing.

Our research protocol outlines the search scope, materials and outcomes of our search. Defining the scope of any SR is crucial to ensuring a concise and relevant review (Alexander et al., 2019; and Booth et al., 2012). Inclusion and exclusion criteria (refer to Table 1) are specified to clarify and limit the scope of the research. As part of a quality assessment, we only examined relevant peer reviewed journal articles and journal articles relevant to particular conferences published in English. It is evident from the literature (De Freitas and Costa, 2017) that the integration of sustainable practices with LSS has been a focus of both practitioners and scholars since 2010. Therefore, articles published before 2010 were excluded.

Table 1 appears near here

6.2. Review execution

To conduct a reliable and high quality review, we adopted a multi-layered quality assessment approach to article review and selection. We identified the following broad search terms for the first stage of literature review based on our research aims and objectives: “LSS/Six Sigma culture”, “LSS/Six Sigma and manufacturing”, “LSS/Six Sigma and sustainability” and “LSS/Six Sigma and green manufacturing”. The search was carried out using major electronic social science, business and management databases and publishing websites, including Emerald, Elsevier, Green file, the Sage Premier journal collection, the Science Direct freedom collection, Scopus, Springer link contemporary, the Taylor and Francis library and Wiley online. The search initially identified 51,600 articles from our screening and scoping process. After applying exclusion and inclusion criteria as part of the scoping stage, 1133 articles were identified as potential materials for the SR.

International Journal of Quality & Reliability Management

After cross-checking through title and keyword screening and removing duplicate and irrelevant results, 144 articles were identified as the most suitable and relevant according to their topics and keywords and based on our third layer search keys and themes. The cross-checking happened among three experienced researchers and academics, of which one of them as a Professor and LSS expert (with Master Black Belt qualification), the other one an Associate Professor and LSS expert (with Green Belt qualification) publishing many papers about LSS in combination. The third one is a Professor and an expert in sustainability publishing papers about green manufacturing. Each stage of screening and scoping was verified and cross-checked by all three members of the team through sharing synthesis documents such as excel spreadsheet of data and brainstorming.

These themes included the following: "green manufacturing and its drivers and barriers", "green LSS and organisational culture", "factors shaping the critical success or failure of green LSS" and "green LSS integration and its drivers and barriers". These four search keys were classified as four themes for final scanning and scoping due to their contributions to our main search keywords (culture and readiness to adopt green LSS projects in manufacturing). Finally, 73 articles were selected after a final screening of abstracts. Figure 2 summarises the scoping and screening process used.

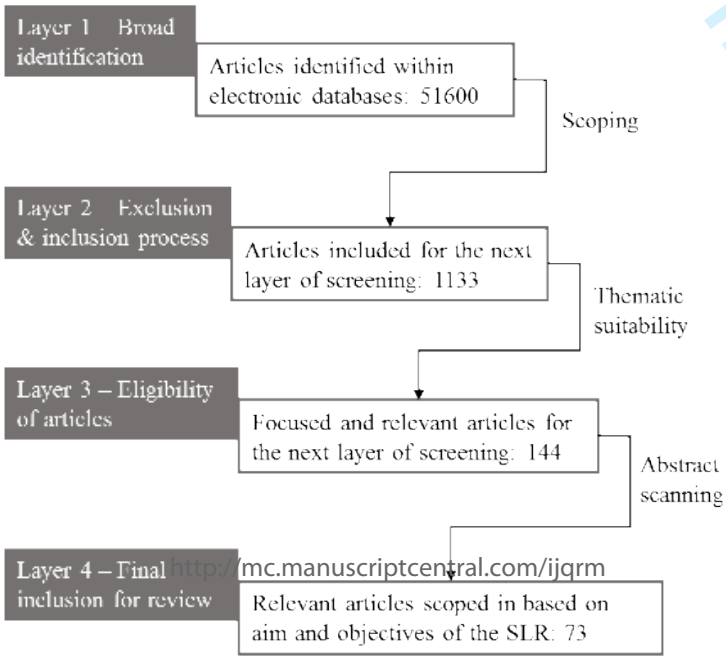

Figure 2 – Article selection and screening process

The 73 journal articles selected as relevant to the four identified themes and research objectives are published in a variety of journals of different publishers. We have identified that some articles shared search keys as part of our second round of cross-checking. Most are published in mainstream LSS journals such as the "International Journal of LSS" and "International Journal of Quality and Reliability Management". Many of the articles focused on green and LSS integration are published in the "Journal of Cleaner Production". Figure 3 shows the number of papers published in each journal.

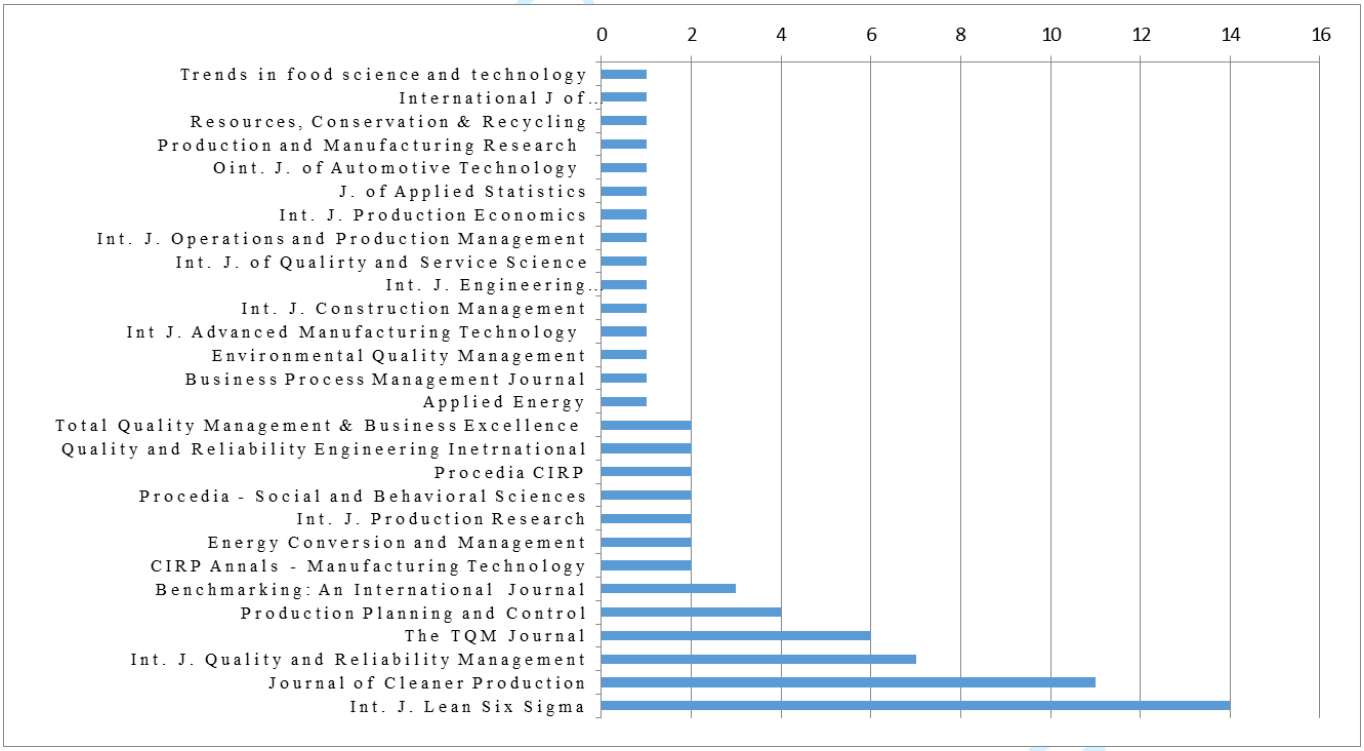

Figure 3 – Number of papers published in each journal

Figure 4 shows a distinct positive trend of interest in research and publication on green and LSS integration and its cultural aspects in general, clearly showing that the integration of environmental sustainability with LSS and cultural receptiveness to the idea has recently become a prominent area of research. Statistics for 2019 are incomplete, as data were extracted in mid-2019.

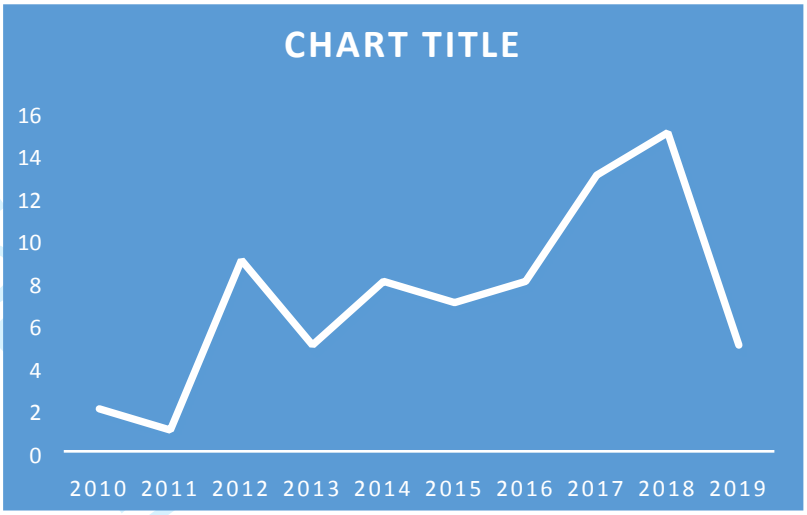

Figure 4 – Number of papers published each year across the period studied

6.3. Reporting review findings and discussion

From our careful analysis and synthesis of the results, we identified a number of key findings that meet the criteria specified above. In the rest of this article, we present the results of our review in terms of article keywords, research methodologies used, countries studied and focuses of each article in relation to the four major research themes examined.

6.3.1.Article keywords

It was important for us to identify keywords representing the 73 articles to identify extend of research focuses and research gap based on keywords as a common search practice. As clearly shown in Figure 5, keywords most frequently identified in these articles are widely used in many LSS articles with environmental sustainability being the only sustainability–focused keyword of the most frequently used keywords. Words such as “drivers”, “barriers” and “energy efficiency” are used less frequently. “Green LSS” also appears among the least widely used of more common keywords. In addition, “sustainable implementation of LSS”, “green LSS project” and “energy efficient LSS project” are not identified as major keywords.

International Journal of Quality & Reliability Management

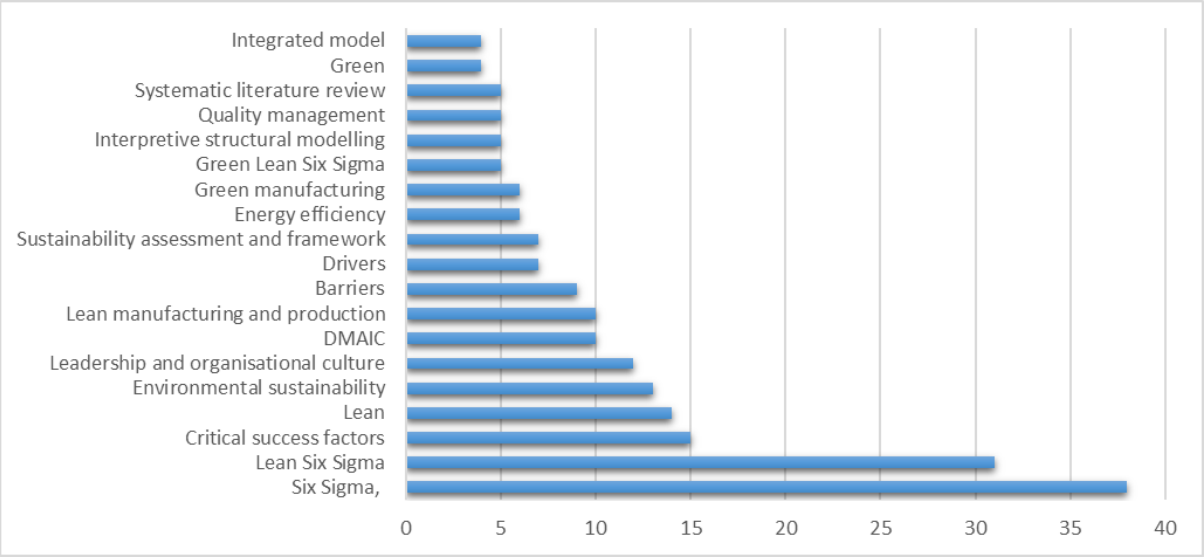

Figure 5 – Most frequently used keywords

6.3.2. Research method applied

Our analysis of research methods used in the sampled studies reveals the most and least frequently used methods for examining the integration of LSS and green manufacturing and its cultural aspects. The analysis reflects approaches widely used in studies of this field, revealing more popular research methods. Survey questionnaires and case studies are the most common followed by systematic literature reviews (Figure 6). The large share of systematic literature reviews found demonstrates the popularity of this method among scholars of this area and opportunities to identify current gaps in the literature and avenues for further research. However, no SR was found among methodologies in this field.

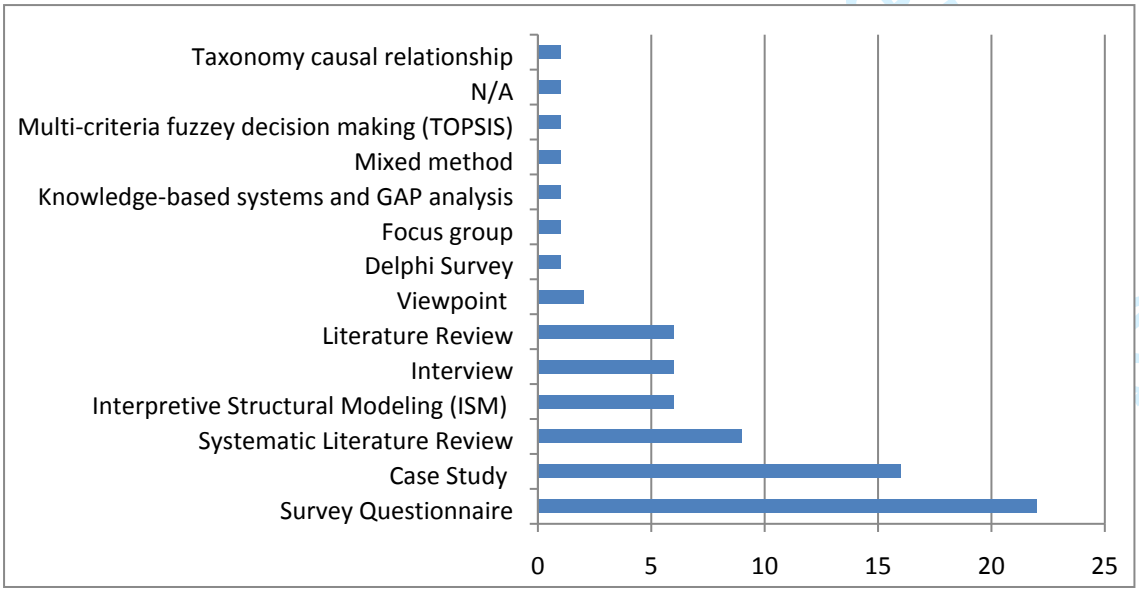

Figure 6 – Overview of research methodologies employed

6.3.3. Distribution of research publications across different countries

Our geographic analysis of research studies and their publication specifications reflects research interest in cultural assessments of the integration of sustainable practices with LSS among manufacturing firms. As shown in Figure 7, the geographic distribution across countries is quite broad. The distribution is not normal and leans towards certain countries, including India, the UK, Brazil, Malaysia, the US and China, with the latter being a dominant manufacturing economy relative to the UK and India. Interestingly, these few countries produce the most environmental pollutants globally (Orji, 2019; Subramanian and Abdulrahman, 2017; Digalwar et al., 2017; and De Freitas et al., 2017). This production serves as a promising indicator of a positive trend towards more research being conducted in these countries to address environmental issues. Researchers in India and the UK seem to be pioneering this area of study due to environmental enforcement and cultural change among manufacturers and governmental research and development support, respectively (Kaswan, 2019; Ruben et al., 2018; Ruben et al., 2017; Aldairy et al., 2017; Chugani et al., 2017; and Kumar et al., 2016). The distribution is not limited to research on green integration with LSS and its cultural assessment and includes cultural analyses of LSS implementation.

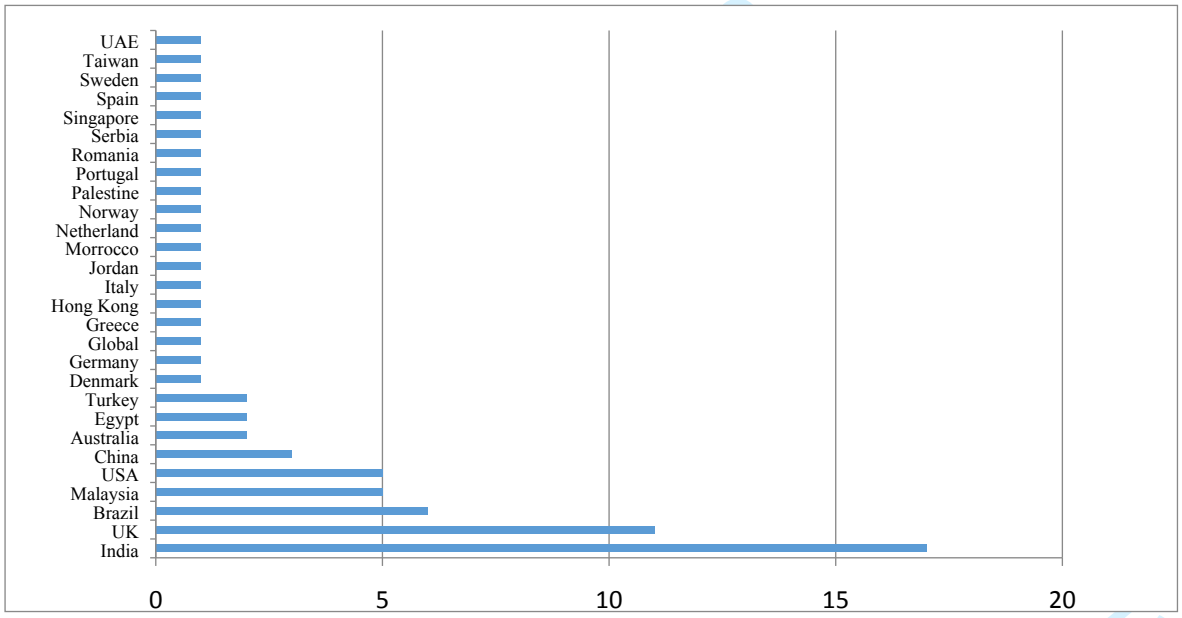

Figure 7 – Distribution of research and publication across countries

6.3.4. Focus of the reviewed articles

The focus area of current relevant literature is imperative to identifying gaps in research on the cultural assessment of the integration of green paradigms with LSS project deployment. We,

thus, analysed the literature on critical factors affecting LSS and green LSS success and failure and using drivers and barriers as keywords of cultural assessment, which were used as a main criterion in our final stage of paper selection.

Our analysis revealed that sixteen articles had a pure focus on cultural and readiness assessments of green manufacturing practices and strategies such as energy efficiency and environmental management systems. However, all those articles focus on green paradigms of manufacturing with no reference to LSS apart from one article (Farias et al., 2019), which discusses lean and green integration in manufacturing. Therefore, we decided to exclude these articles from further analysis of current literature about readiness for LSS and its integration with green manufacturing.

Green LSS and organisational culture

From our final review of article abstracts, we identified only nine articles published on organisational culture for LSS from 2010 onward. The articles mainly focus on measuring human behaviours, leadership patterns, core values and organisational cultural change. Despite broad recognition of the importance of organisational culture and its features for LSS among the studied articles and across different countries, analyses of organisational cultures for green LSS integration appear to be less common across the research publications. Table 2 presents a summary of this analysis.

Table 2 appears near here

Factors affecting the success or failure of LSS and green LSS

Our careful analysis of twenty articles covering a broad geographic distribution among developing and developed countries reveals a focus of research on the success of LSS projects in the manufacturing sector. Approaches used in this research are both broad in examining many different factors and narrow in assessing a few selected factors such as leadership, top and middle level management commitment, project management, stakeholder analysis and training. Most of the articles only focus on LSS projects and only three evaluate factors affecting the success or failure of green LSS integration. As shown in Table 3, a systematic literature review by Ruben (2018) proposes an integrated framework of green LSS implementation. Through a detailed case study analysis, Mishra (2019) identified CSFs of green LSS integration. Both of these studies conducted in India examine green LSS integration

International Journal of Quality & Reliability Management

outcomes (i.e., waste reduction) rather than LSS project deployment (i.e., energy and resource efficiency across the project life cycle).

Table 3 appears near here

Drivers of and barriers to LSS and green LSS

The final step of our focused analysis on the twenty-eight selected articles reveals the importance of analysing drivers of and barriers to LSS and its integration with other management concepts such as environmental sustainability. Studies on this element of cultural assessment are also geographically broad, as scholars from both developed and developing countries are interested in exploring drivers and barriers as important indicators of cultural evaluation. However, some of the studies focus on drivers of and barriers to LSS or on more general cultural aspects such as LSS project deficiencies. In contrast, some articles focus on drivers of and barriers to green LSS integration. Erdil (2018), Cherrafi (2016), De Freitas (2017) and De Freitas (2017) adopt more general approaches to green LSS integration by using a three-dimensional definition of sustainability that covers environmental sustainability. Sagnak (2016), Garza Reyes (2015), Lucato (2015) and Mkhaimer (2017) mainly focus on incorporating environmental variables and energy management into LSS processes.

Studies by Kumar (2016), Garza Reyes (2018) and Kaswan (2019) focus on barriers to and drivers of LSS integration with green production. Cherrafi (2017) and Powell (2017) adopt an alternative approach by evaluating how LSS can reduce environmental impacts of final products. Banawi (2014) and Aldairy (2017) propose environmental integration with LSS in the construction industry. None of these studies however evaluate or analyse drivers of and barriers to the green deployment of LSS projects in the manufacturing sector. A summary of these articles is presented in Table 4.

Table 4 appears near here

7. Discussion of research and practical implications

This work presents a SR of current literature published from 2010 to provide an overall understanding of the sustainable implementation of LSS projects in terms of project approaches rather than outcomes. This study contributes into existing conversation in research associated with green LSS. This SR reveals a significant gap in research and knowledge among both

International Journal of Quality & Reliability Management

researchers and practitioners. This preliminary review of research articles shows that LSS research scholars and practitioners have only focused on green LSS integration in reference to positive outcomes such as waste reduction. According to our descriptive analysis of existing relevant literature, it was evident to us that scholars are interested in investigating how and under what cultural environment LSS can positively contribute in green manufacturing through reducing the waste. We also found that research associated with green manufacturing and LSS is emerging in different countries across the globe. However, our finding reflects there has been no empirical research conducted about readiness of organisations to review negative implications of LSS projects on the environment. Therefore, our SR is considered as a preliminary research in the area of green implementation of LSS project in manufacturing.

In focusing on the sustainable implementation and reduced negative environmental impacts of LSS at the project level, the study complements previous studies by Ruben et al (2017), Chugani et al (2017), Sagnak et al (2016) and De Freitas et al (2017) who demonstrate the positive impacts of LSS for manufacturing at the outcome level. The present SR illustrates the essence of studies of readiness assessment and integrated green LSS project frameworks (Kaswan, 2019; Kumar et al, 2016, Garza-Reyes, 2015). We identified a lack of research on the readiness analysis of resource and energy efficient LSS project deployment. We also identified a gap in practice with reference to 44 screened articles (figure 6) that used empirical research (survey, case study, interview) involving practitioners. This reflected that all of these research studies in collaboration with LSS and manufacturing practitioners were conducted to review the readiness of implementing LSS for green outcomes and not green LSS project. Our finding of this SR is in line with studies conducted by Ruben (2018) and Mishra (2019). Nevertheless, we looked at CSFs of the green and LSS integration with different perspective from theirs. Respectively, our finding of this SR is also in line with Studies by Kumar (2016), Garza Reyes (2018) and Kaswan (2019). However, unlike their studies, we assessed the literature for the drivers and barriers of green and LSS integration in relation to actual LSS project rather than outcomes. We also anticipate a significant gap in practice in relation to evaluating environmental impacts of LSS projects where traditional outcomes will remain a priority. It is thus important for managers to optimise benefits of the sustainable implementation of LSS projects by saving costs and time while limiting negative environmental impacts of projects.

8. Concluding remarks and future studies

International Journal of Quality & Reliability Management

From our rigorous and multi-layered analysis of existing literature, we identified a lack of attention among scholars to approaches to green LSS integration and to its readiness assessment. Our analysis demonstrates that scholars have focused on positive impacts of LSS on green manufacturing in terms of reducing waste in assessing cultural readiness based on drivers and barriers. We, thus, call for preliminary environmental impact analyses of LSS methodologies to prevent the design of large, unsustainable LSS projects that take considerable time and complex tools to implement with high risks of failure.

However, due to gaps in research and practice regarding approaches to green implementation of LSS projects, we also anticipate difficulties with cultural change. Therefore, assessing readiness for consideration of green implementation of LSS projects needs to be the first stage gate for both scholars and practitioners. We, thus, conducted a SR of literature on the cultural and readiness assessment of the sustainable implementation of LSS. It is crucial for managers and scholars to assess organisational readiness for, drivers of and barriers to green LSS implementation, which may lead to drastic cultural shifts or minimal organisational cultural change depending on modes of LSS adoption within manufacturing firms.

Despite providing a valuable account of current research in this field, this study presents limitations. It first focuses exclusively on academic sources from selected databases based on a rigorous selection procedure, which may have resulted in us leaving out resources from other sources. We also view this work as the start of a more critical investigation of the negative impacts of failure in LSS projects. We, thus, recommend that further empirical studies such as survey questionnaires, interview- and action-based research and case studies to provide a clearer understanding of cultural readiness for and managerial implications of the sustainable implementation of LSS projects. Finally, future studies can also explore the development of a self-assessment model for evaluating the readiness of organisations to adopt Green LSS for both manufacturing and service sector.

References

Aboelmaged, M. G., (2011) "Reconstructing Six Sigma barriers in manufacturing and service organisations", *International Journal of Quality and Reliability Management,* Vol. 28 No. 5, pp. 519-541.

Abu Bakar, F. A., Subari, K., and Mohd Daril, M., (2015), "Critical success factors of Lean Six Sigma development: a current review", *International Journal of Lean Six Sigma*, Vol. 6 No. 4, pp.339-348.

International Journal of Quality & Reliability Management

Albliwi, S., Antony, J., Lim, S., and Wiele, T., (2014), "Critical failure factors of Lean Six Sigma: a systematic literature review" *International Journal of Quality and Reliability Management,* Vol. 31 No. 9, pp.1012-1030.

Albliwi, S., Antony, J., and Lim, S., (2015), "A systematic review of Lean Six Sigma for the manufacturing industry", *Business Process Management Journal,* Vo. 21 No. 3, pp.665-691.

Aldairi, J., Khan, M., and Munive-Hernandez, M., (2017), "Knowledge-based Lean Six Sigma maintenance system for sustainable buildings", *International Journal of Lean Six Sigma*, Vol. 8 No. 1, pp.109-130.

Alexander, P., Antony, J., and Rodgers, B., (2019), "Lean Six Sigma for small-and-medium – sized manufacturing enterprises: a systematic review", *International Journal of Quality and Reliability Management*, Vol. 36 No. 3, pp.378-397.

Alinaghian, L., Qiu, J., and Razmdoost, K. (2020), "The role of network structural properties in supply chain sustainability: a systematic literature review and agenda for future research", Journal of Supply chain Management.

Antony, J., Snee, R., and Hoerl, R., (2017), "Lean Six Sigma: yesterday, today and tomorrow", *International Journal of Quality and reliability Management*, Vol 34 No. 7, pp.1073-1093.

Antony, J., (2006), "Six Sigma for service processes", *Business Process Management Journal*, Vol. 12 No. 2, pp.234-248.

Banawi, A., and Bilec, M., (2014), "A framework to improve construction processes: Integrating Lean, Green and Six Sigma", *International Journal of Construction Management*, Vol. 14 No. 1, pp.45-55.

Booth, A., Sutton, A., and Papaioannon, D., (2012), "Systematic approaches to a successful literature review" *Sage*, Los Angles, USA.

Brkic, V. S., and Tonic, B., (2016), "Employees' factors importance in Lean Six Sigma concept", *The TQM Journal*, Vol. 28 No. 5, pp.774-785.

Cherrafi, A., Elfezazi, S., Chiarini, A., and Mokhlis, A., (2016), "The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model", *Journal of Cleaner Production*, Vol. 139, pp.828-846.

Cherrafi, A., Elfezazi, S., Govindan, K., Garza-Reyes, J., Benhida, K., and Mokhlis, A., (2017), "A framework for the integration of Green and Lean Six Sigma for superior sustainability performance", *International Journal of Production Research*, Vol. 55 No. 15, pp.4481-4515.

Chugani, N., Kumar, V., Garza-Reyes, J., Rocha-Lona, L., and Upadhyay, A., (2017), "Investigating the green impact of Lean, Six Sigma and Lean Six Sigma, a systematic literature review", *International Journal of Lean Six Sigma*, Vol. 8 No. 1, pp.7-32.

International Journal of Quality & Reliability Management

Chuang, S., and Yang, C., (2014), "Key success factors when implementing a green-manufacturing system", *Production Planning and Control*, Vol. 25 No. 11, pp.923-937.

Costa, L. B. M., Filho, M., Fredendall, L., and Paredes, F., (2018), "Lean, Six Sigma and Lean Six Sigma in the food industry: A systematic literature review", *Trends in Food Science and Technology,* Vol. 82, pp.122-133.

De Freitas, J. G., Costa, H., and Ferraz, F., (2017), "Impact of Lean Six Sigma over organisational sustainability: A survey Study", *Journal of Cleaner Production*, Vol. 156, pp.262-275.

De Freitas, J., and Costa, H., (2017), "Impacts of Lean Six Sigma over organisational sustainability", *International Journal of Lean Six Sigma*, Vol. 8 No. 1, pp.89-108.

Digalwar, A., Mundra, N., Tagalpallewar, A. R., and Sunnapwar, V. K., (2017), "Road map for the implementation of green manufacturing practices in Indian manufacturing industries: An ISM approach", *Benchmarking: An International Journal,* Vol. 24 No. 5, pp. 1386-1399.

Dissanayake, D. (2020), "Sustainability key performance indicators and the global reporting initiative: usage and challenges in a developing country context", *Meditari Accountancy Research.*

Drehomeretski, E., Gouvea da Costa, S., de Lima, E., and da Rosa Garbuio, P., (2014), "Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy", *International Journal of Production Research*, Vol. 52 No. 3, pp.804-824.

Erdil, N. O., Aktas, C., and Arani, O., 2018), "Embedding sustainability in Lean Six Sigma efforts", *Journal of Cleaner Production*, Vol. 198, pp.520-529.

Farrias, L., Santos, L., Gohr, C., de Oliveira, L., and de Silva Amorim, M., (2019), "Criteria and practices for lean and Green performance assessment: systematic review and conceptual framework", *Journal of Cleaner Production*, Vol. 218, pp. 746-762.

Ghazilla, R., Sakundarini, N., Abdul-Rashid, S., Ayub, N., Olugu, E., and Musa, S., (2015), "Drivers and barriers analysis for green manufacturing practices in Malaysian SMEs: A preliminary findings", *Procedia CIRP*, Vol. 26, pp.658-663.

Garza-Reyes, J., Yu, M., Kumar, V., and Upadhyay, A., (2018), "Total quality environmental Management: adoption status in the Chinese manufacturing sector", *The TQM Journal*, Vol. 30 No. 1, pp.2-19.

Garza-Reyes, J. A., (2015), "Green Lean and the need for Six Sigma", *International Journal of Lean Six Sigma*, Vol. 6 No. 3, pp.236-248.

Goh, T. N., (2014), "Future-proofing Six Sigma", *Quality and reliability Engineering International*. Vol. 30, pp. 1389-1392.

International Journal of Quality & Reliability Management

Habidin, N. F., and Yusof, S., (2013), "Critical success factors of Lean Six Sigma for the Malaysian automotive industry", International Journal of Lean Six Sigma, Vol. 4 No. 1, pp.60-82.

Habidin, N. F., and Yusof, S., (2012), "Relationship between Lean Six Sigma, environmental management systems, and organisational performance in the Malaysian automotive industry", *International Journal of Automotive Technology*, Vol. 13 No. 7, pp.1119-1125.

Hill, J., Thomas, A., Mason-Jones, R., and El-Kateb, S., (2018), "The implementation of a Lean Six Sigma framework to enhance operational performance in an MRO facility", *Production and Manufacturing Research*, Vol. 6 No. 1, pp.26-48.

Hilton, R. J., and Sohal, A., (2012), "A conceptual model for the successful deployment of Lean Six Sigma", *International Journal of Quality and reliability Management*, Vol. 29 No. 1, pp.54-70.

Hudnurkar, M, Ambekar, S., and Bhattacharya, S., (2019), "Empirical analysis of Six Sigma project capability deficiency and its impact on project success", *The TQM Journal*, Vol. 31 No. 30, pp.340-358.

Ismyrlis, V., and Moschidis, O., (2013), "Six Sigma critical success factors and toolbox", *International Journal of Lean Six Sigma,* Vol. 4 No. 2, pp.108-117.

Jayaraman, K., and Kee, T., (2012), "The perceptions and perspectives of Lean Six Sigma (LSS) practitioners", *The TQM Journal*, Vol. 24 No. 5, pp.433-446.

Karevan, A., T. K. F., and Vasili, M. (2020), "A reliability-based and sustainability-informed maintenance optimization considering risk attitudes for telecommunications equipment", *International Journal of Quality and Reliability Management.*

Kaswan, M. (2019), A"nalysis and modelling the enablers of green LSS implementation using Interpretive Structural Modelling", *Journal of Cleaner Production*, Vol. 231, pp.1182-1191.

Kumar, S., Luthra, S., Govindan, K., Kumar, N., and Haleem, A., (2016), "Barriers in green lean Six Sigma product development process: an ISM approach", *Production Planning and Control*, Vol. 27 No.7-8, pp.604-620.

Kuvvetli, U., Firuzan, A., Alpaykut, S., and Gerger, A., (2016), "Determining Six Sigma success factors in Turkey by using structural equation modelling", *Journal of Applied Statistics*, Vol. 43 No. 4, pp.738-753.

Laureani, A., and Antony, J., (2018), "Leadership – a critical success factor for the effective implementation of Lean Six Sigma", *Total Quality Management & Business Excellence*, Vol. 29 No. 5, pp.502-523.

International Journal of Quality & Reliability Management

Laureani, A., and Antony, J., (2012), "Critical success factors for the effective implementation of Lean Six Sigma", *International Journal of Lean Six Sigma*, Vol. 3 No. 4, pp.274-283.

Li, W., (2012), "Eco-efficiency of manufacturing processes: A guideline case", *CIRP Annals – Manufacturing Technology*, Vol. 61, pp.59-62.

Lucato, W. C., Viera Junior, M., and Santos, J., (2015), "Eco-Six Sigma: integration of environmental variables into the Six Sigma technique", *Production Planning and Control*, Vol. 26 No. 8, pp.605-616.

Manville, G., Greatbanks, R., Krishnasamy, R., Parker, D. W., (2012), "Critical success factors for Lean Six Sigma programmes: a view from middle management", *International Journal of Quality and Reliability Management*, Vol. 29 No. 1, pp.7-20.

Michael, G., Rowlands, D., Price, M., and Maxey, J., (2005), "Lean Six Sigma Pocket Tool Book", *McGrow-Hill*, USA.

Mishra, M. N., (2019), "Identify critical success factors to implement integrated green and Lean Six Sigma, *International Journal of Lean Six Sigma.*

Mkhaimer, L. G., Arafeh, M., and Sakhrieh, A., (2017), "Effective implementation of ISO 50001 energy management system: Applying Lean Six Sigma approach", *International Journal of Engineering Business Management,* Vol. 9, pp.1-12.

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., and Aromataris, E., (2018), "Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach", *BMC Medical Research Methodology,* Vol. 18 No. 143, pp. 1-7.

Naslund, D., (2013), "Lean and Six Sigma – critical success factors revisited", *International Journal of Quality and Service Science*, Vol. 5 No. 1, pp.86-100.

Ng, I. C., and Hempel, P., (2020), "Organisational culture and the implementation of Six Sigma in Southern China", *Total Quality Management & Business excellence*, Vol. 31 No. 1, pp.82-98.

Orji, I. J., (2019), "Examining barriers to organisational change for sustainability and drivers of sustainable performance in the metal manufacturing industry", *Resource, Conservation and Recycling,* Vol. 140, pp.102-114.

Pamfilie, R., Petcu, A., and Draghici, M., (2012), "The importance of leadership in driving a strategic Lean Six Sigma management", *Procedia – Social and Behavioural Science*, Vol. 58, pp.187-196.

International Journal of Quality & Reliability Management

Pham, M. T., Rajic, A., Greig, J.D., Sargeant, J.M., Papadopoulos, A., and McEwen, S.A., (2014), "A scoping review of scoping reviews: advancing the approach and enhancing the consistency", *Research synthesis Methods*, Vol. 5, pp. 371-385.

Powell, D., Lundeby, S., Chabada, L., and Dreyer, H., (2017), "Lean Six Sigma and environmental sustainability: the case of a Norwegian diary producer", *International Journal of Lean Six Sigma,* Vol. 8 No. 1, pp.33-64.

Ruben, R. B., Vinodh, S., and Asokan, P., (2018), "Lean Six Sigma with environmental focus: review and framework", *International Journal of Advanced Manufacturing Technology*, Vol. 94, pp.4023-4037.

Ruben, R. B., Vinodh, S., and Asokan, P., (2017), "Implementation of Lean Six Sigma framework with environmental considerations in an Indian automotive component manufacturing firm: a case study", *Production Planning and Control*, Vol. 28 No. 15, pp.1193-1211.

Sagnak, M., and Kazancoglu, Y., (2016), "Integration of green lean approach with Six Sigma: an application for flue gas emissions", *Journal of Cleaner Production*, Col. 127, pp.112-118.

Sangwan, K. S., Bhakar, V., and Digalwar, A., (2018), "Sustainability assessment in manufacturing organisations, development of assessment models", *Benchmarking: An International Journal*, Vol. 25 No. 3, pp.994-1027.

Shokri, A., Waring, T., and Nabhani, F., (2016), "Investigating the readiness of people in manufacturing SMEs to embark on Lean Six Sigma projects", *International Journal of Operations and Production Management*, Vol. 36 No. 8, pp.850-878.

Snee, R. D., (2010), "Lean Six Sigma – getting better all the time", *International Journal of Lean Six Sigma,* Vol. 1 No. 1, pp.9-29.

Sreedharan V, R., Raju, R., Sunder, V., and Antony, J., (2019), "Assessment of Lean Six Sigma readiness (LESIRE) for manufacturing industries using fuzzy logic", *International Journal of Quality and Reliability Management*, Vol. 36 No. 2, pp.137-161.

Sreedharan V, R., Gopikumar, V., Nair, S., Chakraborty, A., and Antony, J., (2018), "Assessment of critical failure factors (CFFs) of Lean Six Sigma in real life scenario", *Benchmarking: An International Journal*, Vol. 25 No. 8, pp.3320-3336.

Sreedharan V, R., Sandhya, G., and Raju, R., (2018), "Development of a Green Lean Six Sigma model for public sectors", *International Journal of Lean Six Sigma*, Vol. 9 No. 2, pp.238-255.

Subramanian, N., and Abdulrahman, M. (2017), "An examination of drivers and barriers to reducing carbon emissions in China's manufacturing sector", *International Journal of Logistics Management*, Vol. 28 No. 4, pp. 1168-1195.

International Journal of Quality & Reliability Management

Sunder M, V., (2016), "Lean Six Sigma project management – a stakeholder management perspective, *The TQM Journal*, Vol. 28 No. 1, pp.132-150.

Suresh, S., Antony, J., Kumar, M., and Douglas, A., (2012), "Six Sigma and leadership: some observations and agenda for future research", *The TQM Journal*, Vol. 24 No. 3, pp.231-247.

Tenera, A., and Pinto, L., (2014), "A Lean Six Sigma (LSS) project management improvement model", *Procedia – Social and Behavioural Science*, Vol. 119, pp.912-920.

Tranfield, D., Denyer, D., and Smart, P., (2003), "Towards a methodology for developing evidence-informed management knowledge by means of systematic review", *British Journal of Management*, Vol. 14 No. 3, pp.207-222.

Yadav, G., Seth, D., and Desai, T., (2018.), "Prioritising solutions for Lean Six Sigma adoption barriers through fuzzy AHP-modified TOPSIS framework", *International Journal of Lean Six Sigma,* Vol. 9 No. 3, pp.270-300.

Zu, X., Robbins, T. L., and Fredendall, L. D., (2010), "Mapping the critical links between organisational culture and TQM/Six Sigma practices", *International journal of Production Economics,* Vol. 123, pp.86-106.

International Journal of Quality & Reliability Management

Table 1– Scope and criteria of the SR

Included	Excluded
Articles published in peer reviewed academic journals	Books, book chapters, articles published in non-peer reviewed journals, and business reports/articles
Articles related to LSS and green manufacturing	Articles on other subjects and sectors
Articles published in English	Articles published in languages other than English
Articles published from 2010	Articles published before 2010
Articles focused on cultural aspects of LSS and its integration with green manufacturing	Other LSS articles

Table 2 - Summary of relevant articles focused on "green LSS/LSS and organisational culture"

Theme	**Author**	**Country**	**Focuses**	**Limitations**
Green Lean Six Sigma and organisational culture	Orji (2019)	China	Examines barriers to and drivers of organisational change for sustainability in Chinese manufacturing through interpretive structural modelling	Only focuses on barriers to and drivers of organisational change for sustainability with no reference to LSS
	Shokri et al. (2016)	Germany	Investigates the role of core personal competence, strategic vision and organisational culture in readiness to adopt LSS in German manufacturing SMEs	A survey study focused on organisational behaviour towards LSS in manufacturing with no reference to environmental sustainability
	Ng and Hempel (2020)	Hong Kong	Explores the role of organisational culture and its features in Six Sigma success in southern China based on a survey questionnaire	A survey study focused on organisational culture for Six Sigma with no reference to lean and green paradigms
	Sreedharan et al. (2019)	India	Develops an evaluation model to measure readiness to adopt LSS and identifies barriers facing Indian manufacturing organisations	A single case study focused on readiness to embark on LSS in manufacturing with no reference to green paradigms
	Habidin and Yusof (2012)	Malaysia	Examines the role of ISO14001 in the relationship between LSS and organisational performance	A survey study examining LSS integration with environmental management systems using an outcome approach rather than a project utilisation approach
	Pamfilie et al. (2012)	Romania	Identifies a global means of relating leadership to LSS and CI vision	A survey study focused on the role of organisational cultural change in LSS with no reference to green paradigms
	Brkic and Tomic (2016)	Serbia	Identifies which employees' behavioural dimensions can lead organisations to better concept integration and how LSS actively contributes to employee performance	A survey focused on the role of organisational behaviour in LSS success with no reference to green paradigms
	Zu et al. (2010)	The USA	Examines the influence of organisational culture on LSS practices while investigating	A survey study focused on the role of organisational change in LSS success without reference to

			different cultures of the US context	green manufacturing

Table 3 - Summary of relevant articles focused on "Factors affecting the success or failure of LSS and green LSS"

Theme	Author	Country	Focuses	Limitations
Factors affecting the success or failure of green LSS	Hilton and Sohal (2012)	Australia	Examines the role of facilitators' and project leaders' competence and interpersonal and technical attributes of LSS success	An interview-based study focused only on human resource attributes of LSS success with no reference to green manufacturing
	Drohomeretski et al. (2014)	Brazil	Compares Lean, Six Sigma and LSS approaches in relation to achieving strategic competitive priorities and competitive advantages through a survey questionnaire	A survey study focused on a comparative model on competitive priorities for LSS success without reference to green paradigms
	Sunder M. (2016)	Global	Develops a structured stakeholder management model for successful LSS project management in the financial sector	An interview-based study focused strictly on stakeholder management for LSS success in the financial sector with reference to green manufacturing
	Ismyrlis and Moschidis (2013)	Greece	Identifies and classifies hard and soft CSFs of Six Sigma in connection with five EFQM enablers	Presents a classification model only for Six sigma success with no reference to integration with green paradigms
	Sreedharan et al. (2018)	India	Assesses and ranks factors affecting the failure of LSS in manufacturing and services	A case study only focused on factors affecting the failure or success of LSS in manufacturing with no reference to green paradigms
	Ruben et al. (2018)	India	Develops a generic integrated framework of green LSS implementation from a systematic literature review	Presents a generic green LSS integration model without reference to green approaches to LSS projects
	Mishra (2018)	India	Evaluates existing frameworks of green and LSS integration in the literature and identifies CSFs from which integration can achieve desired stability within organisations	A survey study only focused on CSFs as an attribute of culture and focused on outcomes of integration rather than on LSS project deployment
	Digalwar et al. (2017)	India	Identifies and develops structural relationships among different factors for the successful implementation of LSS through a survey questionnaire	A survey study of CSFs of LSS without reference to green paradigms

Jayaraman et al. (2012)	Malaysia	Identifies the importance of CSFs and organisational culture for LSS success from a practitioner's point of view through a systematic literature review	A survey study focused on CSFs of LSS without reference to green paradigms
Habidin and Yusof (2013)	Malaysia	Identifies and evaluates CSFs affecting LSS implementation in the Malaysian automotive industry through a factor analysis	A survey study only focused on CSFs of LSS in one manufacturing sector without reference to green paradigms
Abu Bakar et al. (2015)	Malaysia	Reviews and gathers the latest comprehensive list of CSFs of LSS deployment and implementation through a literature review	Presents results only on CSFs of LSS without reference to green paradigms
Tenera and Pinto (2014)	Portugal	Proposes an LSS project management improvement model supported by the DMAIC cycle and its tools to identify main project management problems and their causes	A case study only focused on project management attributes of LSS success without reference to integration with green paradigms
Naslund (2013)	Sweden	Revisits CSFs of Lean and Six Sigma by focusing on strategic alignment, top management commitment, project management and training	A study strictly focused on generic and common CSFs of LSS without reference to green paradigms
Shan-Ping Chuang	Taiwan	Proposes a three-layered model to evaluate the performance of a green manufacturing system and identifies CSFs of its implementation	A case study only focused on CSFs of green manufacturing with no reference to LSS
Kuvvetli et al. (2016)	Turkey	Identifies CSFs of Six Sigma through factor analysis and structured equation modelling	A survey study focused on CSFs of Six Sigma with no reference to lean and green paradigms
Laureani and Antony (2018)	The UK	Analyses the role of leadership and other factors affecting LSS success	A survey study focused on limited attributes of LSS success with no reference to green paradigms
Manville et al. (2012)	The UK	Identifies the role of middle management in create a cultural platform from dynamic capabilities and organisational learning cultures for LSS project success	A case study focused on how organisational culture shapes LSS success without reference to green paradigms
Laureani and Antony (2012)	The UK	Identifies and ranks CSFs of LSS presented in the literature and in preliminary research	A survey study focused on CSFs of LSS without reference to green paradigms
Albliwi et al. (2014)	The UK	Explores factors affecting LSS failure in different sectors through a systematic literature review	A study focused on factors affecting LSS failure without reference to green paradigms

International Journal of Quality & Reliability Management

	Snee (2010)	The USA	Provides a high-level overview on Six Sigma, Lean and LSS methods for the past few years	Presents a high-level overview of LSS with reference to generic LSS CSFs and without reference to green paradigms

Table 4- Summary of relevant articles focused on "drivers of and barriers to LSS and green LSS"

Theme	Author	Country	Focuses	Limitations
Green Lean Six Sigma and its drivers and barriers	de Freitas et al. (2017)	Brazil	Integrates LSS and sustainability and impacts of LSS on 3BL sustainability with global approaches through a systematic literature review	A survey study focused on the integration of LSS and sustainability in reference to outcomes rather than LSS project deployment
	Lucato et al. (2015)	Brazil	Proposes a way to incorporate environmental variables into DMAIC processes as a way to enhance the eco-efficiency of firms	A single case study focused on the integration of LSS and green practices in reference to outcomes rather than LSS project deployment
	de Freitas and Costa (2017)	Brazil	Identifies impacts of LSS on organisations from a 3BL sustainability perspective through a systematic literature review	Focuses on the integration of LSS and sustainability in reference to outcomes rather than LSS project deployment with no reference to cultural assessment
	Costa et al. (2018)	Brazil	Shows how Lean and LSS practices are evolving and implemented within the food industry through a systematic literature review	A case study on the food sector investigating drivers of and barriers to LSS evolution without reference to green paradigms
	Garza-Reyes et al. (2018)	China	Provides insight into fundamental issues regarding the implementation of TQEM in the Chinese manufacturing sector	Presents a general green and TQM integration model with no particular focus on LSS
	Hill et al. (2018)	Egypt	Identifies strategic CSFs and barriers facing large and complex LSS projects through a case study analysis	A case study focused on complications of large LSS projects and their CSFs without reference to green paradigms
	Sharma and Sharma (2013)	India	Develops an integrated model based on Six Sigma and TPM frameworks focused on introducing performance indicators and improving manufacturing performance	A case study focused only on the integration of LSS with lean practices to enhance success without reference to green paradigms

Kumar et al. (2016)	India	Identifies and categorises barriers to green LSS implementation for product development and analyses their relationships through interpretive structural modelling	Focuses only on barriers to green and LSS integration based on products and not based on LSS project deployment
Yadav et al. (2018)	India	Identifies ways to prioritise means to overcome barriers and facilitate the adoption of LSS through a systematic literature review	A case study only focused on barriers to LSS success without reference to integration with green paradigms
Hudnurkar et al. (2019)	India	Identifies deficiencies in Six Sigma project capabilities and empirically validates corresponding impacts on project success	A survey study focused only on project management attributes of LSS success without reference to integration paradigms
Ruben et al. (2017)	India	Identifies ways to reduce environmental impacts to improve overall operational and environmental performance via DMAIC methods	A single case study focused only on the role of LSS in green manufacturing based on products and outputs and not based on LSS project deployment
Sreedharan et al. (2018)	India	Proposes a Green LSS Supply Chain model to reduce the gap between Green Supply Chain Management (SCM) and LSS by introducing green practices into the public sector	A focus group study focused only on LSS and green SCM integration in the public sector and not in manufacturing
Kaswan (2019)	India	Identifies, categorises and investigates interactions between green LSS enablers through Interpretive Structural Modelling	Focuses only on green LSS enablers based on outputs rather than LSS project deployment
Mkhaimer et al. (2017)	Jordan	Proposes the LSS Energy Management model (LSS_EnMS) based on ISO50001 for energy management	A single case study developing a general LSS energy management model with no reference to cultural assessment
Cherrafi et al. (2016)	Morocco	Integrates lean manufacturing with Six Sigma and sustainability approaches	Develops a general model of green and LSS integration with no reference to LSS project deployment
Cherrafi et al. (2017)	Morocco	Presents a framework that guides companies through five stages and sixteen steps to effectively integrate and implement green LSS approaches to improve their sustainability performance	A generic model for guiding green LSS based on outputs and not on LSS project deployment
Powell et al. (2017)	Norway	Investigates the application of LSS in the food processing industry and evaluates the impact of LSS on environmental sustainability	A case study focused on the role of LSS in the green food processing industry with no reference to green project deployment

International Journal of Quality & Reliability Management

Goh (2013)	Singapore	Identifies ways to improve Six Sigma approaches in the future	Presents generic guidelines on the future of LSS with no assessment of cultural shifts towards green LSS deployment
Sagnak and Kazanancoglu (2016)	Turkey	Presents action-based research on the integration of lean, Six Sigma and green manufacturing to mitigate limitations of green and lean integration and to assess the role of this integration in reducing environmental impact	An action-based study examining the role of Six Sigma in mitigating limitations of green and lean integration with no reference to the cultural assessment of impacts of LSS projects on the environment
Aboelmaged (2011)	The UAE	Validates how the strongest barriers to Six Sigma implementation may vary with dimensions of organisational factors in a developing country through a cross-sectoral survey questionnaire	A survey study of a developing country evaluating the role of organisational factors in Six Sigma success with no reference to green and lean paradigms
Antony et al. (2017)	The UK	Reports academic and industry practitioners' views on LSS trends	A high-level overview of projected trends of LSS with no particular focus on cultural assessments of LSS and green manufacturing integration
Albliwi et al. (2015)	The UK	Explores the most common themes of LSS in the manufacturing sector and finds gaps in the literature through a systematic literature review	Focuses only on LSS implementation in manufacturing with no reference to green paradigms
Garza-Reyes (2015)	The UK	Examines effects of Six Sigma on green and lean integration and their compatibility through a systematic literature review	A survey study focused on the capacity for Six Sigma methods to mitigate limitations of lean and green integration but with no reference to the cultural assessment of this integration based on project deployment
Aldairy et al. (2017)	The UK	Develops a knowledge-based system for LSS maintenance in environmentally sustainable buildings	Focuses on LSS and green construction integration based on outcomes and not focused on the manufacturing sector
Chugani et al. (2017)	The UK	Identifies environmental impacts of Lean, Six Sigma and LSS projects in terms of energy use, resource optimisation and resource saving through a systematic literature review	Focuses on LSS and green integration in relation to outcomes with no particular assessment of cultural attributes
Alexander et al. (2019)	The UK	Explores the most common themes of LSS in relation to manufacturing SMEs and identifies research gaps through a systematic literature review	Presents a general yet focused approach to LSS implementation in SMEs with no reference to green paradigms

	Erdil et al. (2018)	The USA	Embeds sustainability into LSS projects and practices	Develops a generic sustainability model of integration with LSS based on outcome and without reference to green paradigms based on deployment
	Banawi and Bilec (2014)	The USA	Develops a systematic and integrated LSS and green framework to lessen environmental impacts of the construction industry	A case study examining only on the construction sector based on outcomes of green LSS integration

International Journal of Quality & Reliability Management

Responses to the reviewers' comments

The review has raised some more helpful issues with our paper and provided further insightful comment. We are really grateful for the reviewer's constructive comments. As a consequence, we have made further changes to the paper in association to your comments. The following section refer to each specific review point in turn, explaining where and how we have amended the paper. We think the paper is now a much stronger piece and we hope it deals with the reviewer's comments in a satisfactory manner.

Reviewer 2

Comments	Response/ amendments
You insist the research is a systematic review but it is a scoping review, and this must be corrected across the whole paper.	*Thank you for your comment. We took your comment on board and changed the systematic literature review term into scoping review (SR) accordingly throughout our paper. We have also referred to scoping review with some description and discussion using your suggested references. Please, refer to the first and second paragraph under methodology (section 6).*
My comment in the methodology about cross-checking was not fully addressed. How many researchers were engaged in the research, what were their skills and qualifications and how the selection and screening outcomes were verified between them?	*Thank you for your comment. We took your comment on board and added some further information to clarify this. Please, refer to the second paragraph under section 6.2.*
There are some spelling and grammar errors. I suggest checking the use of language thoroughly.	*Thank you for this comment. We had already completed the editing through professional publisher's editing services. However, we noticed there have been some typo and editing issues due to corrections and track changes as the result of previous review that were all addressed now. We have also gone through another grammatical checking, and with the best of our knowledge this article has been improved.*