Tanzania Journal of Engineering and Technology 2023, **42**(**1**):26-45
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Websites: https://www.ajol.info/index.php/tjet; https://tjet.udsm.ac.tz

ISSN 1821-536X (**print**); ISSN 2619-8789 (**electronic**)
DOI: 10.52339/tjet.v42i1.886

Special Issue – Seventh International Conference on Mechanical and Industrial Engineering (MIE) 2022 Conference, 20 – 21, October 2022, University of Dar es Salaam New Library, Dar es Salaam, TANZANIA

Towards Lean Manufacturing in Developing Countries: Research Gaps and Directions in Tanzania

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ABSTRACT

In the current knowledge-driven economy, many industries across the globe are forced to adopt manufacturing technologies such as lean manufacturing to remain competitive in the globalized world. Despite the increase in lean manufacturing implementations, the adoption rate in Tanzania is very low and estimated to be 8 percent. Likewise, the sustainability of lean manufacturing tools and practices is still questionable, which shows the need to develop lean maturity models. To date, several lean maturity models have been developed but there is a lack of maturity models that consider different levels of manufacturing industries. The study presented in this paper focused on the pre-implementation, implementation, and post-implementation phases of lean manufacturing. To achieve this aim, a systematic literature review and social network analysis using VOS viewer 1.6.18 were conducted. The literature was obtained from four academic databases: Emerald, Elsevier, Springer, and Taylor and Francis. The search covered the period from 2010 to 2022. Of the 100 publications analyzed on lean manufacturing, only 1 percent is from low-income developing countries and 5 percent of publications from Africa. The study has identified that there are few numbers of research publications on lean manufacturing in Africa and low and lower-middle-income developing countries in general, as a result there is a low rate of implementation of lean manufacturing in low and lower-middle-income developing countries. It is recommended that more studies on the drivers and barriers, critical success factors, and lean assessment be conducted in developing countries.

ARTICLE INFO

Submitted: **July 5, 2022**

Revised: **Sept. 28, 2022**

Presented: **Oct. 20, 2022**

Accepted: **Jan. 5, 2023**

Published: **Feb. 25, 2023**

Keywords: *Lean Manufacturing, Lean Implementation, Developing Countries, Manufacturing Industries, Lean Assessment*.

INTRODUCTION

With increasing competition, demanding customers, advance in technology, and the rise of globalization around the world (Brito et al. 2020), companies are facing stiff competition in the markets. To curb that situation, companies are now forced to change the way they operate their business and adopt new manufacturing technologies such as lean manufacturing (Psomas and Antony, 2019). With the introduction of new technologies, companies are expected to achieve benefits in terms of cost reduction, increase in quality, productivity, and operational performance (Psomas and Antony, 2019). The great benefits achieved by Toyota Motor Corporation, the organization which is regarded as the first industry to adopt lean manufacturing, attract manufacturers to adopt lean manufacturing to gain a competitive advantage in the market and improve their business operations (Psomas and Antony, 2019).

Research and practice reveal that lean practices are correlated with a firm's performance improvement in terms of productivity, inventory, cost, and quality (Pakdil et al. 2018). Due to the benefits and advantages derived from the adoption of lean manufacturing, the adoption of lean manufacturing is now spread around the world to both developed and developing countries (Chaplin et al. 2016; Psomas and Antony, 2019).

Despite the lean manufacturing increasingly and adopted in developed and developing countries, the adoption rate in low-income developing countries is very low compared to developed countries. In Tanzania, for instance, the adoption rate is estimated to be 8 percent for all categories of manufacturing industries (Mapunda, 2019). Similarly, as stated from other literature, developing countries such as Tanzania (Kafuku, 2019), Kenya (Maina, 2015), and Ghana (Negrão et al. 2017) provide adoption status based on the most frequently lean practices rather than general statistical figures on lean implementation (Negrão et al. 2017). Furthermore, there has been tremendous growth in the need to identify the maturity levels of lean implementation in organizations (Brito et al. 2020). As stated by Sangwa & Sangwan (2018b), lean assessment has been increasing from year 1996 to 2015. For instance; in 1996 to 2000, 2001 to 2005, 2006 to 2010, 2011 to 2015 were 2, 6, 14, and 44, respectively. This shows that the need to develop lean maturity models for assessing lean implementations and providing recommendable actions for improvement is increasing. Moreover, despite the fact that there are several lean maturity models developed to date, there is a lack of lean maturity models which consider various levels of manufacturing industries in both developing and developed countries (Vivares et al. 2018).

To support the evolution of lean concepts and methods of lean and evaluation of implemented lean practices, researchers are argued to come up with research opportunities (Psomas, 2021). Based on that, this study examined the pre-implementation, implementation, and post-implementation phases of lean manufacturing to identify research gaps and future directions.

LITERATURE REVIEW

Lean Manufacturing

Lean manufacturing originated from Toyota Motor Corporation, and the term 'lean' is used to elucidate the Toyota Production System (Pakdil et al. 2018). Lean manufacturing has been defined as lean because it uses less of everything compared with mass production: half the human effort in a factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product' (Psomas and Antony, 2019). With half the consumption of every resource in the business operations and utilizing the resources effectively, the customers' needs are fulfilled at a low cost (Papadopoulou and Özbayrak, 2005). The ultimate goal of lean manufacturing is to remove all types of waste (Nawanir et al. 2013) and non-value-added activities in each stage of the production process (Psomas and Antony, 2019) to achieve those goals of lean manufacturing; there should be proper utilization of lean concepts (Rafique et al. 2019)

Based on the literature, lean manufacturing has five guiding principles, which are; specifying the value of the customer based on the end product, creating a value stream of activities to identify value-added and non-value-added activities, creating a flow of activities from the first activity to the last activity in the process of manufacturing products, producing and delivering products which are only required by the customers and the last principle is the perfection, that is to produce products perfectly (Psomas and Antony, 2019; Womack and Jones, 1997)

Lean Tools

Lean manufacturing uses various tools in eliminating non-value-added activities in the business operation, some of the tools which are used are Value Stream Mapping, 5 why's, Kaizen, Just in Time(JIT), Total Productive Maintenance (TPM), Total Quality Management (TQM), 5s, Single Minute Exchange of Die (SMED), Kanban, cellular manufacturing, continuous improvement, multifunctional teams, production smoothing, visual control, set-up time reduction, workforce involvement in solving problems, cross-training, lot size reduction, root cause analysis for problem-solving, concurrent engineering, etc (Bhamu and Sangwan, 2014; Psomas and Antony, 2019), all of the tools have the same ultimate goal that is to reduce non-value-added activities.

According to Kafuku (2019), the following are some of the lean practices commonly adopted in the manufacturing industries of Tanzania: pull production, set-up time reduction, production leveling (heijunka), product design simplicity, Just in time (JIT), cross-functional teams, employee involvement, training, daily schedule adherence, customer and supplier involvement in the design, a group involving in design, continuous flow, preventive maintenance, error-proof equipment (poka-yoke), kaizen, 5s, and customer and supplier involvement in quality control. Tools such as 5S, JIT, TPM, Pull production, kaizen, and VSM were also supported by Maware et al. (2022) as the most common lean practice in developing countries.

Categories of Lean Tools

Lean manufacturing tools have been categorized differently by many scholars. Some scholars have categorized them based on their use and others have categorized them based on the relationship of the tools. De Oliveira et al. (2019) categorized tools into five groups based on their use; the categories are as follows, tools for maximum availability of resources which comprises Total Productive Maintenance (TPM), Overall Equipment Effectiveness (OEE), tools for maximum quality (zero defects) which comprises of Total Quality Management (TQM), tools for maximum speed such as Cellular Manufacturing, SMED, Poka-yoke, tools for minimum inventory which are JIT and kanban systems and the last category involves, tools for supporting decision making and management which comprises of Value Stream Mapping, Kaizen, 5S, Visual Management, etc. (de Oliveira et al. 2019).

Moreover, according to Salonitis and Tsinopoulos (2016) lean manufacturing tools are categorized into five groups as indicated in Figure 1. Table 1 shows the relationship between lean tools and lean category.

Figure 1: Lean manufacturing tools, source: modified from de Oliveira et al. (2019).

Table 1: Lean tools and categories (Salonitis & Tsinopoulos (2016))

Lean Category	Lean Tools
Customer relationships	Customer Involvement
Supplier relationships	Supplier Quality
	Lean supply chain
	Just in Time (JIT)
Human Resources	Workforce commitment
	Employee involvement
	Quality circles/cross-functional teams
Manufacturing Planning and Control	Level scheduling (heijunka)
	Visual Control (Andon)
	Kanban
	Workforce engagement
Process and Equipment	Cellular manufacturing
	Six sigma/Lean sigma
	Continuous flow
	Poke-yoke (error-proof design)
	VSM
	Preventive Maintenance (TPM)
	Kaizen
	5s
	SMED

Phases of Lean

Lean manufacturing has passed several phases since its inception in the early 1970s. As shown in Figure 2 these phases are categorized in terms of decades from when lean originated at Toyota Motor Corporation in Japan (Stone, 2012). The enterprise phase is where lean manufacturing moves beyond manufacturing to other sectors, such as service sectors. Currently, in the performance phase, the lean implementers are struggling to evaluate their lean status through various lean assessment tools.

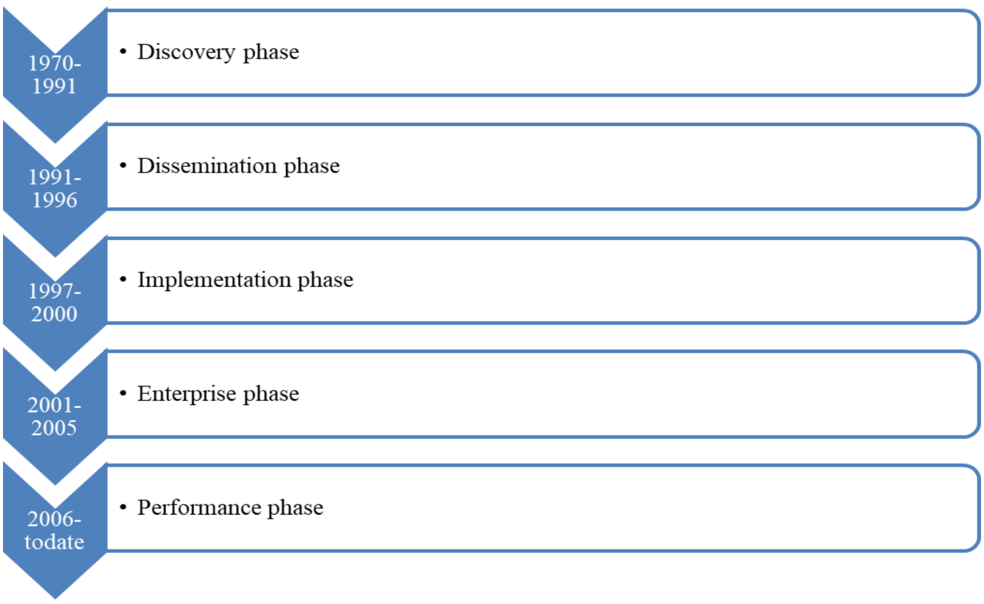

Figure 2: Phases of lean manufacturing, source: modified from Stone (2012).

Lean Implementation

Implementing lean manufacturing is not an easy journey, and there is no standard roadmap or framework for the implementation. The roadmap that might be suitable for one organization does not guarantee that it will work the same in another organization (Almanei et al. 2017). Various approaches can be used by industries in implementing lean manufacturing in their organizations, and the approaches are as follows: conceptual model, implementation framework/roadmap, descriptive planning, and an assessment checklist. Of all approaches, the implementation framework/roadmap is widely used (Rafique et al. 2019). Descriptive planning and conceptual models are usually used in responding to the questions such as "what is". On the other hand, the remaining approaches such as roadmap, implementation framework, and assessment checklist, are used to respond to questions such as "how to". According to Anvari et al. (2011), there are three stages of lean implementation: preparation, designing, and implementation with 21 steps as shown in Table 2.

Table 2. Lean implementation stages (Anvari et al., 2011)

Lean Stage	Step
Preparation	Gap assessment strategic planning
	Understanding waste
	Establishing the objective
	Getting the organizational structure right
	Finding a change agent
	Creating an implementation team
	Training the staff in team building and lean principles
	Suppliers and customers involved
	Recognizing the need for change
Design	Mapping the value streams
	Analyzing the business for improvement opportunities
	Planning the changes
	Identify indicators to measure performance
	Creating a feedback mechanism
Implementation	Starting with a pilot project
	Starting the next implementation projects
	Evaluating and sustaining changes
	Selling the benefits of lean thinking
	Pursuing perfection
	Expanding the scope

Drivers and Barriers to Lean Implementation

Though there is a tendency to perceive lean manufacturing as a set of tools, implementing lean manufacturing in the organization is not as simple as it is perceived. Lean is simply a new management philosophy that affects almost all departments of the organization and makes the implementation process to be complex. Several factors have to be taken into account before implementing lean in the organization with stakeholders who have different interests (Almanei et al. 2017).

Several driving forces drive organizations to implement lean philosophy. The following are some of the drivers which have been highlighted by researchers in the field of lean manufacturing: to increase market share, increase flexibility, development of key performance indicators, desire to employ world best practices, part of the organization's continuous process, to focus on customer's needs, the requirement of the customers, increase the sustainability of the organization, and to employ best practices (Almanei et al. 2017; Salonitis and Tsinopoulos, 2016).

Although industries have high expectations for lean manufacturing implementations, there are some critical issues and barriers which appear during the journey and impede the implementation process (Pakdil et al. 2018). Salonitis and Tsinopoulos (2016) categorized the barriers to lean implementation into four main groups which are financial barriers, such as high initial investment for lean implementation; workforce-related barriers, such as fear of losing a job, poor communication with employees regarding the change, low or poor knowledge regarding lean implementation; top management related barriers such as poor knowledge regarding lean manufacturing, poor belief on the lean approach and its advantages, and top management commitment do not last long. The last category of barriers is termed as other factors such as slowdowns due to conflicts on priorities of the projects, multiple production sites, and difficulties in measuring the benefits ahead (Salonitis and Tsinopoulos, 2016) as it is shown in Figure 4.

Critical Success Factors for Lean Implementation

It is difficult to implement a lean manufacturing in manufacturing industries as compared to other sectors (Achanga et al. 2006). It is therefore believed that the implementation of lean faces many challenges such as lack of adequate funding and leadership deficiencies. Statistics have shown that only 30 percent of change programme gave successfully implementation results (Almanei et al. 2017).

Other scholars indicate that 58 percent of change, including lean management, fails, while other scholars claim 75 percent of lean changes fails to bring expected results. The reasons for the failure of lean implementations is misunderstanding of the appropriate use of lean tools, misconceptions of lean manufacturing as a manufacturing strategy rather than a long-term philosophy, underestimation of the lean concept by the top leaders, resistance to change by employees, organizational culture, application of one tool to solve all problems in the industry, poor decision-making system, improper implementation of lean and lack of understanding on the lean tools and techniques (Sangwa and Sangwan, 2018b).

The above statistics show the need to plan, examine and execute critical success factors before an organisation embarks on lean implementation (Achanga et al. 2006). There are several critical success factors for lean implementation such as; organisational culture and ownership, management commitment and involvement, management capability, provision of adequate resources to support implementation, development of organisational readiness, acquiring external support from consultants at the initial stages; effective communication among members of the organisation, strategic approach to improvements, teamwork, setting realistic timescales for lean change (Salonitis and Tsinopoulos, 2016), customer focus, government intervention (Almanei et al. 2017). There should be a clear vision and strategy for forecasting duration and budget for the implementation (Achanga et al. 2006). The elements of critical success factors for lean implementation are shown in Figure 3.

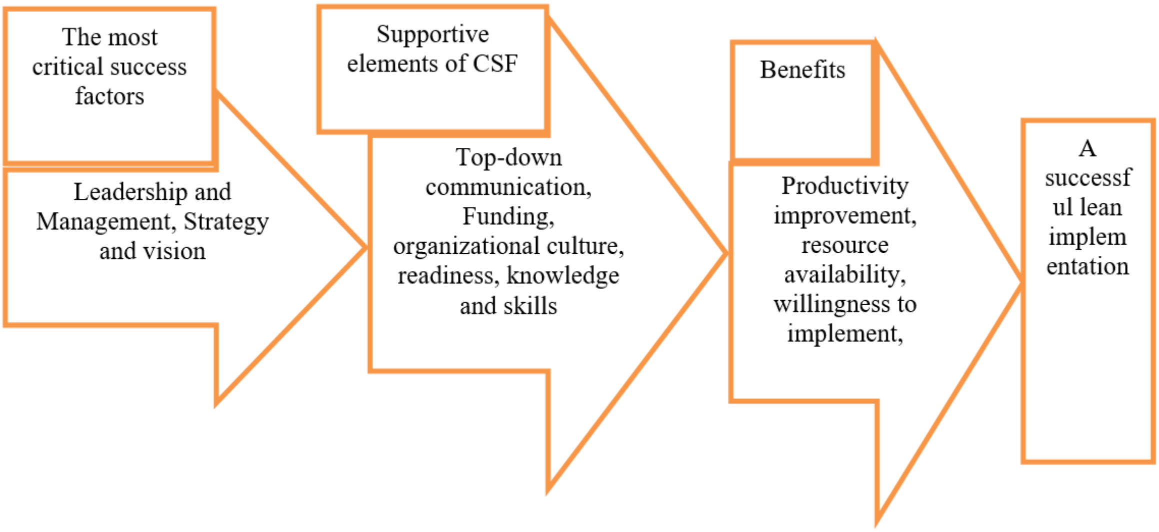

Figure 3: Elements of critical factors for a successful lean implementation: Source: Modified from Achanga et al. (2006).

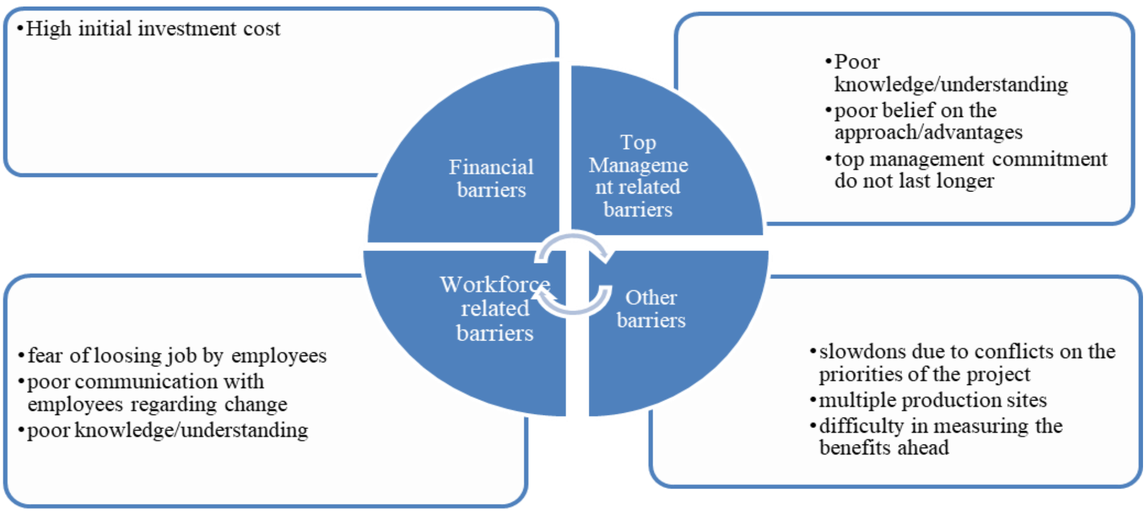

Figure 4: Lean barriers, Source (Salonitis and Tsinopoulos, 2016).

Lean Assessment Tools

Narayanamurthy and Gurumurthy (2016), classify lean adaptation into three stages, that is, lean implementation readiness, lean implementation, and lean assessment. Lean assessment is required to measure the implementation process's progress to identify the current status and provide recommendable actions for future improvement (Sangwa and Sangwan, 2018b). Moreover, it is needed to determine the effectiveness of lean applications and if the anticipated competitive advantage required by the organisation has been achieved (Pakdil et al. 2018). Lean assessment is a continuous process divided into four steps: problem identification, lean implementation, leanness assessment, and report preparation (Sangwa and Sangwan, 2018b) as shown in Figure 5.

Lean assessment studies are still in the infant stage as the first publication was made in 1998 (Sangwa and Sangwan, 2018b). Despite its infant stage, to date, several lean assessment tools in different approaches have been formulated from quantitative and qualitative aspects. Some of the tools which have been developed are such as Lean Enterprise Self-Assessment Tool developed by Lean Aerospace Initiative, a lean performance measurement framework with 26 performance indicators developed by Sangwa and Sangwan (2018a), Lean Assessment Tool developed by Pakdil and Leonard (2014).

The lean assessment tools developed assess the whole organisation, such as human resources, customers, new product development, suppliers, and management. Moreover, the scope of lean assessment tools is now changing from looking at the manufacturing plant alone to the whole supply chain (Pakdil et al. 2018).

Lean Maturity models

Lean maturity models explain the stage-by-stage growth of lean implementation from initial to higher stages. Lean maturity models are an emerging issue that has been highlighted in several studies. Several scholars have developed lean maturity models with many models having 5 levels of maturity. Some of the models have 3, 4, 6, 7, or 9 levels (Vivares et al. 2018). Each level of maturity has different features.

Lean maturity models give directions, implementation status, and improvement opportunities for implementing lean in organizations (Maasouman and Demirli, 2016). There are several maturity models which have been developed, various authors have developed lean maturity models with a focus on lean manufacturing (Colín-lozano et al. 2019; Maasouman and Demirli, 2016). Table 3 shows several lean maturity models which have been developed with different maturity levels as well as strengths, weaknesses, and country of origin for each model.

Based on the analysis of the available lean maturity models, it has been noticed that; most of the models do not consider different levels of manufacturing industries. The models developed assume all industries are at the same level and have the same requirements for leanness.

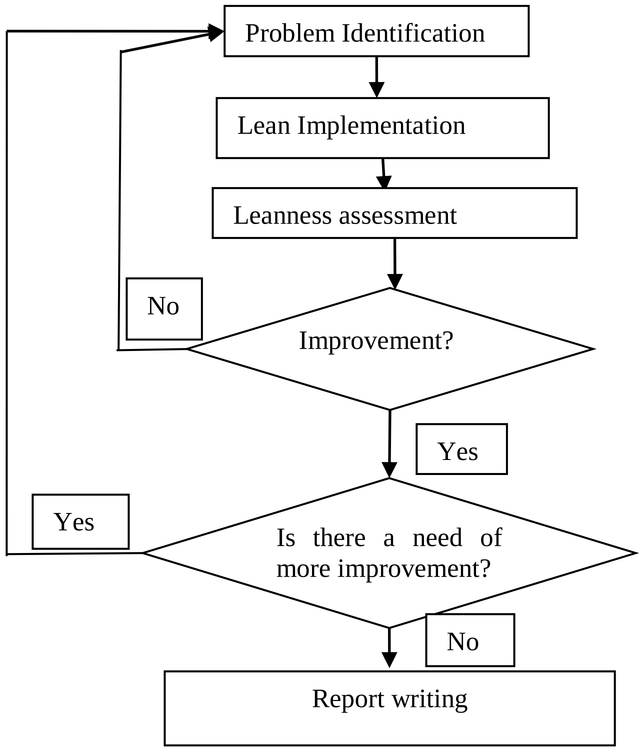

Figure 5: Lean Implementation cycle and its assessment (Sangwa and Sangwan, 2018b).

Table 3: Maturity models

S/No	Author and year of publication	Purpose	Maturity Levels	Strength	Weakness	Country
1	(Zanon et al. 2020)	To develop a framework to assess lean and Performance Management systems in an organisation	4	Combines Lean Maturity and Performance Management System	The model does not consider various levels of manufacturing industries and it was validated in only one sector of manufacturing industries	Developed country
2	(Bento and Tontini, 2018)	To evaluate lean maturity for manufacturing organisations	5	Used eight dimensions of lean manufacturing to evaluate lean maturity and their relationship with operational performance	All lean practices were used in all levels of manufacturing industries without considering the different requirements of each level.	Developed country
3	(Bento and Tontini, 2019)	To examine lean maturity in Brazilian manufacturing industries	5	It was validating the model developed by Bento & Tontini (2018)	All lean practices were used in all levels of manufacturing industries without considering the different requirements of each level	Developed country
4.	(Rajagopalan and Solaimani, 2020)	To study the status of lean manufacturing in Lean Manufacturing companies leaders in India	5	The model evaluated lean implementation to lean management leaders in India and it was a longitudinal survey	It evaluated only large manufacturing organisations	Developed country
5.	(Hallam and Keating, 2014)	To investigate the use of Lean Enterprise Self Assessment	5	Identified maturity levels by using LESAT for selected	The model evaluated only one kind of manufacturing organisation	Developed country

		Tool (LESAT) in aerospace industries in the UK and USA		industries	which is the aerospace sector	
6.	(Maasouman and Demirli, 2016)	To assess the lean maturity level of an operational level for manufacturing industries	4	Developed a visual, data-driven lean maturity model	Evaluated only the operational level of manufacturing industries, other departments were not evaluated.	Developed country
7.	(Gadalla, 2020)	To develop a framework for measuring and tracking lean manufacturing transformation	5	A framework for measuring the lean maturity model is presented	No consideration for various levels of manufacturing industries.	Developed country

METHODOLOGY

Literature Collection

To achieve the study's purpose, 100 articles were collected from Emerald, Taylor and Francis, Springer, and Elsevier. To get several articles that would give wide coverage on the issues of lean manufacturing from pre to post-implementation phase, searching terms included "lean manufacturing implementation" or "lean assessment" or "lean maturity models"; after the search terms were entered, a total of 1505 articles appeared, after applying year limitations from 2010 to 2022 the papers reduced to 1204. The screening proceeded by limiting to academic journals only and the papers reduced to 743. To remain with more relevant papers, more refinement was made by limiting the scope to the following subjects: lean management, lean manufacturing, lean implementation, lean production, Toyota production system, lean tools, lean assessment, critical success factors, barriers, and value stream mapping. According to the database ranking, 100 relevant articles were selected for further analysis. Moreover, exclusion criteria were used to remain with articles that were relevant to the search terms. All papers with terms such as six sigma, industry 4, and lean green were removed from the database, as it is shown in Figure 6, which shows the article screening process. Excel was used to provide trends of research publications, journals used in lean publications, and the academic database used in lean publications.

Social Network Analysis

In this study, the citation-based network analysis was conducted by using VOSviewer 1.6.18. Two typical networks were formed and analyzed. The networks established are the co-author network and keyword co-occurrence network. A co-author network was established to analyze the scientific research collaboration. A keyword co-occurrence network was established to identify keywords and themes that appear in papers and to establish a correlation between a particular research topic or research direction.

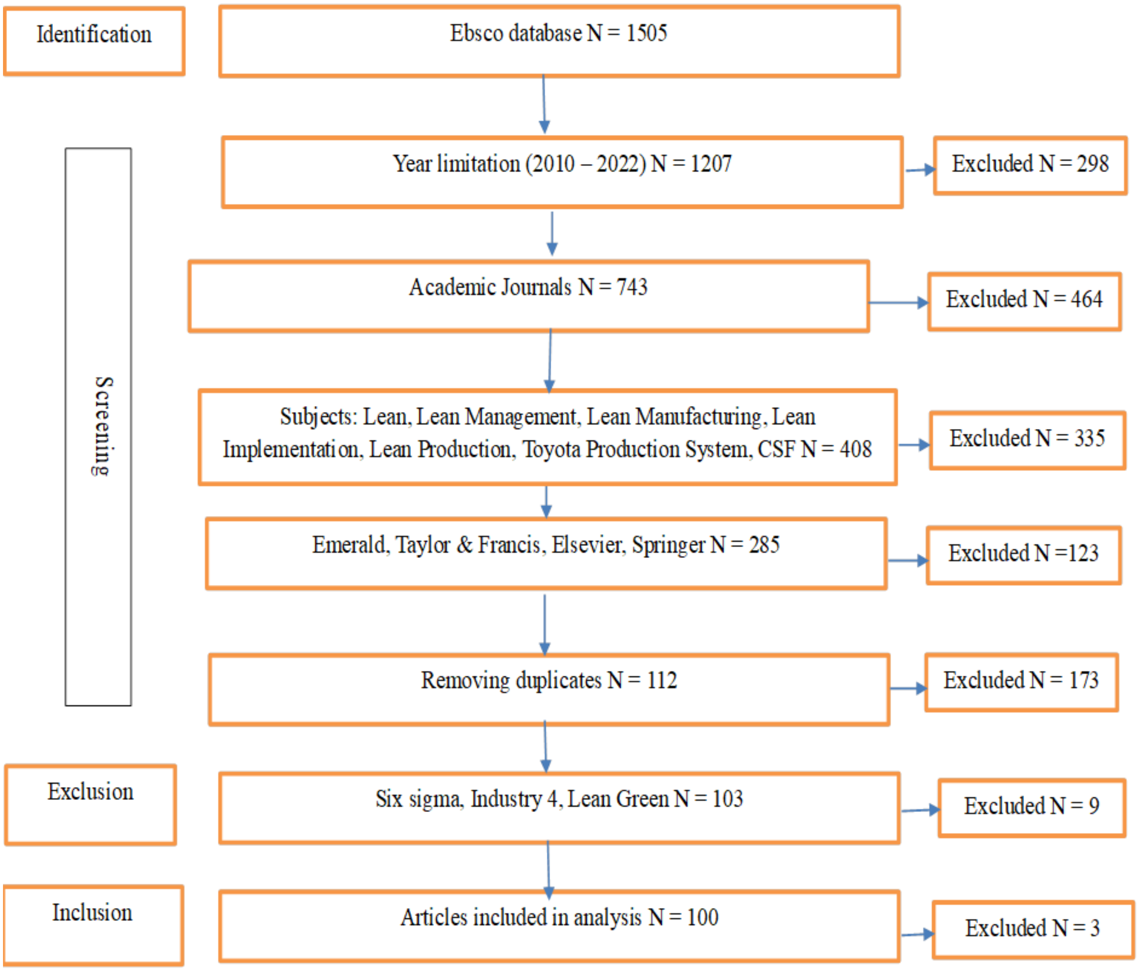

Figure 6: Articles screening process.

RESULTS AND DISCUSSION

Trend of Research Publications

The trend of research in the areas of lean is growing, as can be seen in Figure 7. The number of publications in the year 2010 was 1, 2011 and in 2012, there were no publications, but as time went on, the number of publications has been increasing though the increase is not constant. The low number of studies on lean in the years 2010, 2011, 2012, and 2015 might be caused by the fact that lean assessment studies werestill in the infant stages (Sangwa & Sangwan, 2018b).

Journals used in lean publications

Several journals have been publishing studies in lean manufacturing. Of all 26 journals reviewed in the study, the journal of manufacturing technology management is leading with a high number of publications in the areas of lean production. The journal has published a total of 17 articles as it is indicated in Figure 8, followed by the international journal of lean six sigma with 11 papers and the international journal of productivity and performance management with 10 papers. The rest of the journals have published papers with less than 10 papers and the last one was journals with one publication which includes a Basic Journal of Economics, Business Process Management Journal, Engineering Construction and Architectural Management, International Journal of Computer Integrated Manufacturing, International Journal of Fashion Design, Technology and Education, International Journal of Quality and Service Sciences, Irish Journal of Medical Sciences, Journal of Engineering Design, Journal of the Operational Research, Neural Computing and Applications, Procedia Computer Science, Procedia Economics and Finance, and Procedia Engineering.

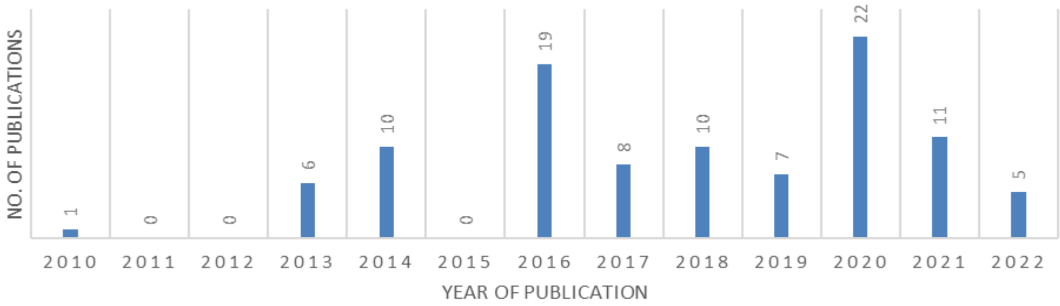

Figure 7: Trends of research publications

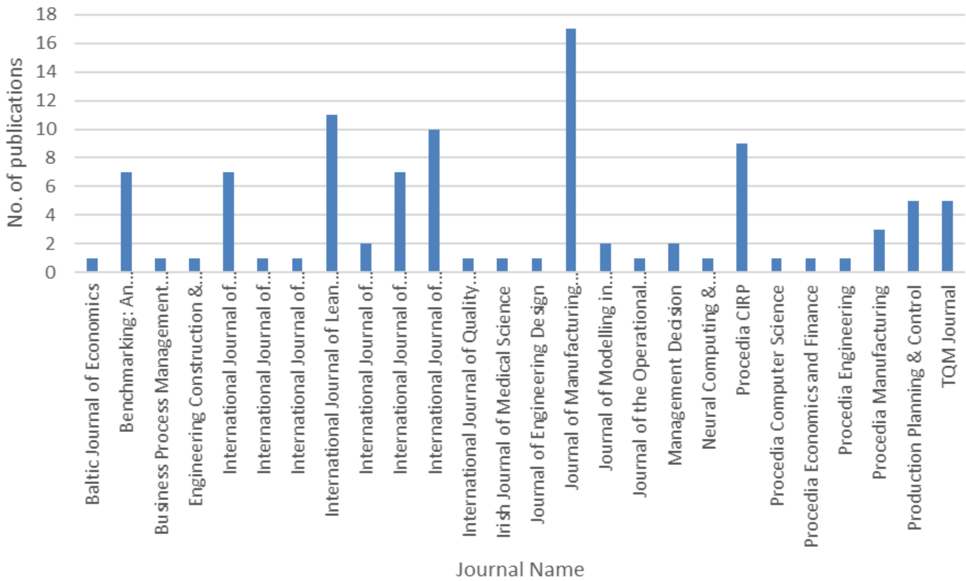

Figure 8: Journals used in lean publications.

Academic Database Used in Lean Publications

The academic databases which were used to collect papers for the study are Emerald Group Publishing Limited, Elsevier, Springer, and Taylor and Francis. Of all the databases which were used, Emerald Group publishing limited is leading with a high number of publications. The database has published 59 articles followed by Taylor and Francis with 17 articles, Elsevier with 15 articles, and the last one is Springer with 9 articles as it is shown in Figure 9. This shows that, Emerald Group Publishing Limited has published several articles in the areas of lean manufacturing.

Publications of paper countrywide

Of the 100 papers analyzed, India and Brazil lead in lean publications with 26 and 25 publications respectively. The number of publications in Africa is very low, only 6 percent of publications are from Africa that is Egypt, South Africa, Tunisia, Zimbabwe, and Morocco. 39 percent of published papers are from developed countries that are Australia, Canada, France, Greek, Ireland, Italy, Sweden, the UK, the USA, Spain, Portugal, Poland, Malaysia, and China. The remaining 61 percent of publications are from developing countries. Of all developing countries the publications of papers from low-income countries is 1 percent which is from Zimbabwe while the rest are from upper middle-income as it is shown in Figure 10. This shows that there is lack of publications on lean manufacturing in Africa and developing countries, especially in low-income and lower-middle-income countries. The results are supported by Belhadi et al. (2018) on a study which was conducted in North Africa.

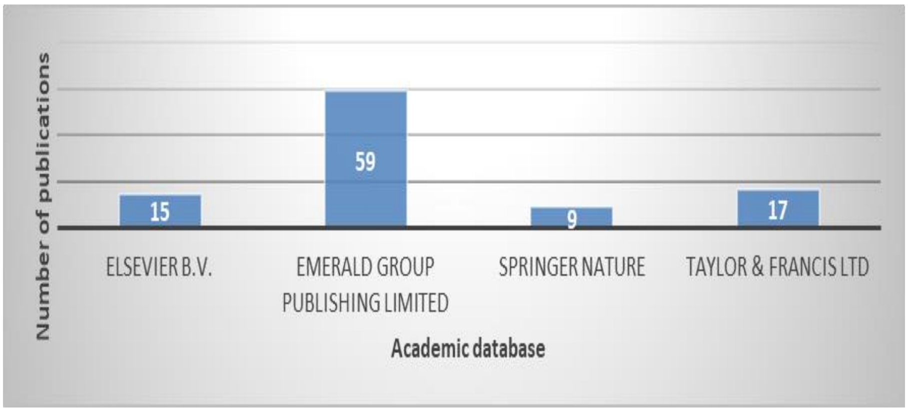

Figure 9: Academic database used in lean publications.

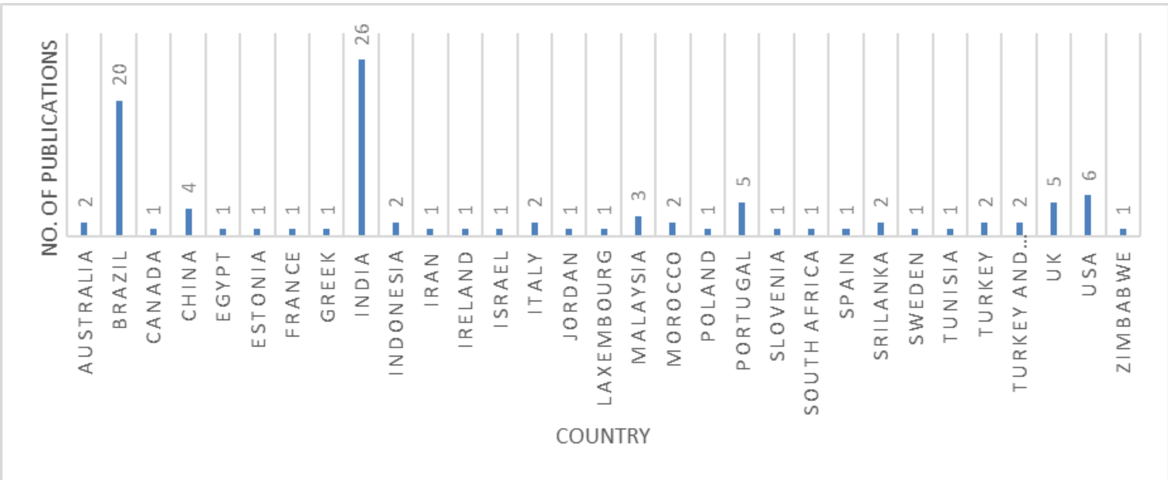

Figure 10: Publications of paper countrywide.

Co-Authorship Network

For this study, a total of 266 authors were involved in 100 papers. A threshold of 1 paper was set for an author and the unit of analysis is the author. Of the 266 authors, all met the threshold that they had published one paper for each collaboration. After conducting co-authorship analysis, some of the co-authorship was found not to connect; only 17 co-authorship was found to have linkage with each other, the 17 items were found to have the highest total strength link and they were categorized in five clusters. The classification details of the clusters are shown in Table 4.

Table 4: Clusters for Co-Authorship Network

Cluster 1 (5 items)	Cluster 2 (3 items)	Cluster 3 (3 items)	Cluster 4 (3 items)	Cluster 5 (3 items)
De castro fettermann, diego	Anzonello, Michel	Bouzon, marina	Ferreira, evelise	Fogliatto, flavio s
Foglialto, flavio sanson	Fettermann, diego	Campos, lucila	Tortorella, guilherme	Jurburg, Daniel
Frank, alejandro	Sawhney, rainder	Santanna, pathrycia	Vergara, lizandra	Kumar, Maneesh
Marodin, giuliano				
Tortorella, guilherme luz				

Figure 11 shows how clusters have connected from cluster 1 to cluster 5. Clusters 1 and 5 are connected, and the connection is caused based on the correlation that exists between researchers. Of the two clusters, Tortorella, Guilherme luz was the core researcher because the node which represents him was the largest among all nodes in the network. It indicated that he cooperated more with others and thus had the strongest correlation. The major research topic for Tortorella, Guilherme luz was lean manufacturing implementation. Furthermore, for cluster 5, all nodes have equal size, which shows that all researchers in that cluster have equal contributions to research. In cluster 2, Fettermann has a big node which demonstrates that he had a big contribution to publications, and the main areas in his recent publications are on the influence of various variables on lean implementation, most of his studies he cooperated with Tortorella. The rest of the authors on the cluster have the same size of the node.

In cluster 4, Tortorella had the big node, which indicates that he had a big contribution to that cluster in comparison with the remaining researchers; tortorella had collaborated with all authors on that cluster. While for cluster 3, all nodes had the same size, which implies all researchers had published an equal number of papers in lean manufacturing.

Keyword Co-occurrence Network

The co-occurrence network of the author's keywords constituted the network linkage of keywords for 33 keywords from 411 keywords which were obtained by setting a minimum number of occurrences of a keyword in greater than 3 appearances. The keywords obtained after applying a threshold were clustered in 5 groups, numbered from 1 to 5 depending on the size of the group as shown in Table 5, and Figure 12 shows networks of keywords.

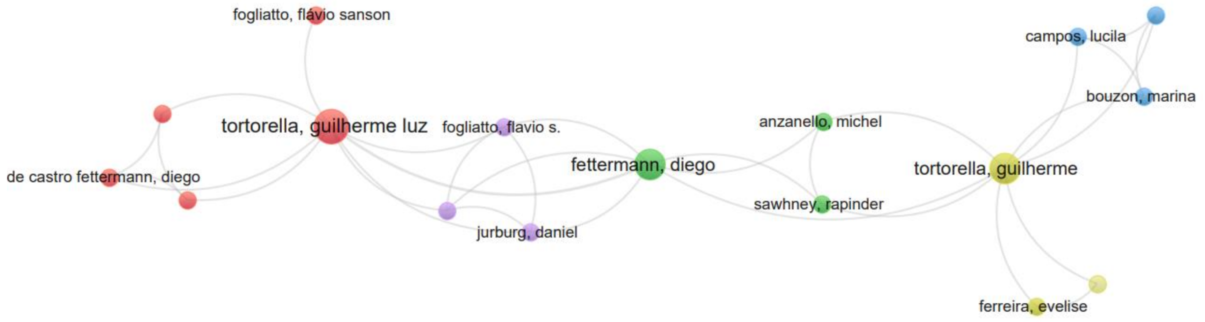

Figure 11: Co-authorship network.

Table 5: Keyword Co-occurrence network

Cluster 1 (11 items)	Cluster 2 (10 items)	Cluster 3 (5 items)	Cluster 4 (4 items)	Cluster 5 (3 items)
Decision making	Employee perception	Barriers	Case study	Lean implementation
Industry 4.0	Leadership	Benchmarking	Case report	Lean manufacturing
Lean assessment	Lean	Lean production	Ergonomics	Value stream mapping
Lean management	Management science and operations	Organizational performance	Quality management/ system	
Lean transformation	Operations/process management	strategy		
Management	Performance			
Manufacturing industries	Survey			
Manufacturing processes	Survey development			
Supply chains	Technology management			
Total productive maintenance	Toyota production system			
Total quality management	`			

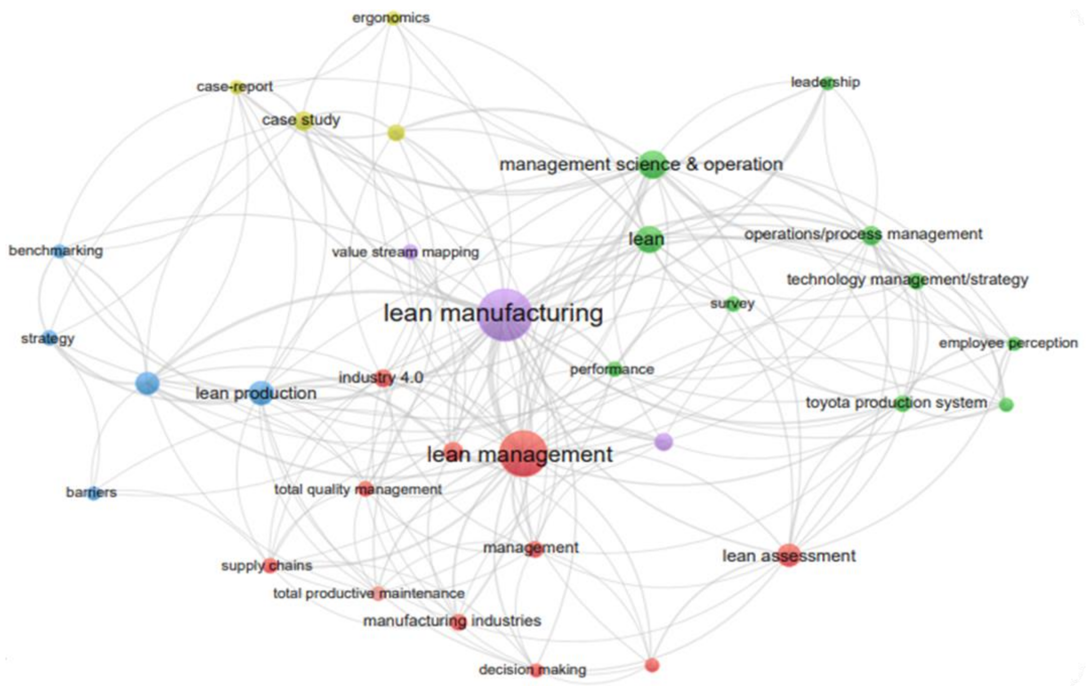

Figure 12: Co-occurrence network for author keywords.

Cluster 1 includes mainly lean dimensions and other factors recently published in different journals by different authors. They include lean assessment, lean transformation, lean, total productive maintenance, and total quality management. Other keywords in the cluster such as decision-making, industry 4.0, supply chains, and manufacturing industries were used to show the link with lean constructs. Lean assessment as a new concept in the field of lean manufacturing is now receiving much attention from researchers as it is vital for providing current status and improvement recommendations for lean manufacturing implementation (Tortorella et al. 2017). Moreover, lean assessment assists in deciding the organisations whether to proceed with the current implementation as it is or to make some improvements (Sangwa and Sangwan, 2018b).

Furthermore, with the current growth of research in the areas of lean manufacturing, the focus of lean implementation has been moving from the industry alone to the whole supply chain of the business such as suppliers, producers, and customers (Maware et al. 2022; Vamsi & Jasti, 2017). Technology advancement has made the eruption of a new industrial phase called industry 4.0. With the emergence of industry 4.0, researchers are now linking lean implementation to the facilitation of industry 4.0 (Mckie et al. 2021).

Cluster 2 has 10 keywords, which generally can be termed as critical success factors for lean manufacturing, keywords such as management, and leadership are all important for the successful implementation of lean and thereafter improves the performance of the organization (Achanga et al. 2006). Moreover, the kinds of studies which are used in assessing critical factors for successful implementation are surveys, as it can be seen that the keyword survey also appeared in this cluster.

For the case of cluster 3, the cluster includes mainly obstacles and ways for overcoming those obstacles in lean implementations. There is a growing increase in the research areas for identifying barriers to the implementation of lean manufacturing and ways to overcome those barriers. As an approach to overcoming barriers, benchmarking, and strategy were used as mediation factors in overcoming barriers for the lean implementation (Jadhav, 2013).

The kind of studies which are commonly used in the area of lean manufacturing is demonstrated in cluster 4. Case studies are frequently used in research linked with lean implementation.

The last cluster of keywords has 3 items: lean implementation, lean manufacturing, and value stream mapping. The cluster can generally be termed as lean manufacturing tools. Value stream mapping has been frequently used as a critical tool for the implementation of lean manufacturing in various organizations (Mojib et al. 2021).

Frequency of occurrence of keywords in publications

Based on the analysis using Vosviewer 1.6.18, the following were some of the keywords with the highest appearance in the articles which were collected and reviewed as shown in Table 6. Based on the analysis, it shows that several papers have been published in the areas of lean management, but there lacks much research in lean assessment and research which link lean implementation and industry 4.0.

Table 6: Frequency of occurrence of keywords in publications

Keyword	Frequency of occurrence
Lean manufacturing	59
Lean management	45
Operations/Process management	8
Organizational performance	11
Lean assessment	11
Lean implementation	7
Industry 4.0	7

Research gaps and directions in Tanzania

Despite growing trend of lean manufacturing publications, there are no enough publications from Tanzania, which shows that there is a low implementation of lean manufacturing in the country. Based on that, future research areas can be on the areas of lean assessment for determining the leanness of manufacturing industries, barriers and drivers for lean manufacturing, and critical success factors for lean implementation in Tanzania.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Numerous studies have been reviewed on the application of LM in manufacturing industries. This study has identified that there is no enough publications on lean manufacturing in Tanzania and low & lower-middle-income developing countries. This might be caused by the low adoption of lean manufacturing in low-income developing countries. The low rate of adoption might be caused by various reasons such as the presence of barriers for implementation as well as the lack of critical success factors for lean implementation.

Implications and recommendations of the study

The study has several implications to the practitioners and researchers; it will assist to determine the barriers and drivers for lean implementation, as well as lean assessment tools which are compatible to Tanzania and low-income developing countries in general.

Based on social network analysis using VOSviewer 1.6.18, the following keywords; lean constructs and factors, critical success factors, barriers, case studies, and lean manufacturing tools appeared several times compared to other keywords. The research areas for further studies were generated such as lean assessment, lean implementation, industry 4.0, and organizational performance. Further studies can be obtained by combining keywords and research areas. The following are further studies proposed: several studies are required to link how lean implementation may facilitate the adoption of industry 4.0 technologies in the manufacturing industries in developing countries. Though there are several articles on the critical success factors, there are inadequate studies on the critical success factors for lean implementation in lower-income developing countries. Moreover, studies are recommended to develop lean assessment tools for implementing lean manufacturing in lower-income developing countries which consider different levels of manufacturing industries. Furthermore, there is a need to establish the statistical figure of lean implementation in lower-income developing countries.

Moreover, there is a need for higher learning institutions to direct their research works toward establishing suitable lean manufacturing tools for the implementation of lean manufacturing in lower-income developing countries. A study on the barriers to the implementation of lean manufacturing in lower-income developing countries is required, etc., and assessment of the knowledge of lean manufacturing tools. The study is proposed based on the fact that many of the lean implementations fail. According to Jadhav (2013), only 10 percent or less of organizations succeed in implementing lean manufacturing; the low rate of success necessitates the need for a study on the understanding of lean manufacturing tools (Sangwa and Sangwan, 2018b). Furthermore, a need for a study to establish lean manufacturing tools suitable for different levels of manufacturing industries and lastly, a study on the assessment of the approaches commonly applied in assessing lean implementation in developing countries.

Limitations of the study

In this study, the authors highlighted several limitations that affected the scope of this study and its results. The study used the reviewed literature related to Lean Manufacturing from developing and developed nations. The reviewed contexts help to generalize the status of the LM both in developed and developing nations. However, the studies did not provide information from the company websites. This could also provide valuable input on how manufacturing organizations view the application and impact of the Lean Manufacturing. Moreover, the EBSCO Database was used but did not have access to other academic databases such as a web of science, dimensions, etc, and other publications which are not freely accessed.

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