

# A Lean Agile Resilient Green Implementation and Technology Utilization: A New Vision in Technology Adoption

Muhammad Zeeshan Raffique<sup>1a</sup>, Hamid Iftikhar Qureshi<sup>1b</sup>, Muhammad Umar Malkana<sup>1c</sup>,  
Syed Mustafa Haider<sup>1d</sup>, Muhammad Atif<sup>1e</sup>

RECEIVED ON 04.02.2019, ACCEPTED ON 03.05.2019

## ABSTRACT

Lean Manufacturing is always important for process improvement in manufacturing industries especially in deem of adoption but the implementation of simple lean is not enough to attain required results. A recent trend has been observed regarding the implementation of strategies like Lean, Agile, Resilient and Green (LARG) in combination to attain fruitful results. However, this combination carries a complication regarding its understanding and implementation and a gap observed regarding the availability of literature study that can cope all these strategies on one platform for understanding and can suggest a proper implementation method. It has been observed that there are some new models that are utilizing electronic configurations to provide powerful platform for process improvements. Utilization of LARG as tool or technique in combination of technologies can be very effective for process improvements. Therefore, this current work emphasis on the combining of LARG along with wireless technologies for obtaining a sustainable improvement in manufacturing sector, which seems unavailable. Based on this ideology, the aim of this research is to conduct a systematic literature study that reviews the previously available LARG research with the objectives to first study the LARG combination for understanding and to develop the interrelation between LARG and previous available technologies for its successful implementation. The literature study results that the LARG combination has many benefits like helpful to attain elimination of non-value activities (lean), responsive to the changing demands of customers as per increasing volatile market (agile), responsive to the unexpected disruptions (resilient) and to adopt environmental protection (green) but typically lacks its utilization with modern technologies (Like RFID) that will be helpful to attain successful implementation. The contribution of this study is the next generation in LARG implementation to emphasis more on the combining of LARG implementation with utilization of modern technologies.

**Keywords:** Technology Adoption, Lean Manufacturing; Agile Manufacturing, Resilient Manufacturing Green Manufacturing, Lean, Agile, Resilient and Green Combination.

## 1. INTRODUCTION

With the continuously increasing competition, Industries are transitioning toward the modern manufacturing

techniques to compete in the market. Technology innovation has brought variety in products [1], thus transition toward the modern manufacturing techniques has now become vital for the survival of company in the global competition [2]. Each industry

<sup>1</sup>Department of Mechanical Engineering, The University of Lahore, Lahore, Pakistan.

Email: <sup>a</sup>[muhammadzeeshanrafique@gmail.com](mailto:muhammadzeeshanrafique@gmail.com) (Corresponding Author), <sup>b</sup>[hamid.iftikhar@me.uol.edu.pk](mailto:hamid.iftikhar@me.uol.edu.pk),  
<sup>c</sup>[umalkana41@gmail.com](mailto:umalkana41@gmail.com), <sup>d</sup>[mustafahaider786@gmail.com](mailto:mustafahaider786@gmail.com), <sup>e</sup>[muhammad.atif1@me.uol.edu.pk](mailto:muhammad.atif1@me.uol.edu.pk)

tries to implement the technique depending upon its requirement out of which Lean manufacturing technique is the most common one. Lean manufacturing technique is the basic need of every industry as it proceeds toward the reduction of wastes (transport, inventory, waiting *etc.*) and a consistent assessment is required for its sustainability. With the changing environment, mass production is becoming obsolete as the customer look for modern and innovating products. This demands flexibility in the manufacturing systems [3] and agility from the past few decades has been adopted to harbor flexible adaptation to the demands. Agile manufacturing demands operations to run in collaboration of different departments. Agility focuses on time management while flexibility aims at capabilities measurement [4]. A call of daily meeting is decided to discuss what is done, what is being done and what to do next. Resilience management has had been a need to cut down these effects for a long time while maintaining the flow of work [5]. Across all of these fields the concept the context of the term resilience may change, is closely related with the capability and ability of an element to return to a stable state after a disruption [6].

A sustainable manufacturing system also calls for environmental friendly processes [7] and green manufacturing implementation is necessarily becoming company's priority in selection of supplier input. Green manufacturing has captured the minds of research scientists in this world of increasing global warming and hazardous gases [8]. Efforts to reduce the consumption of energy and resources in manufacturing processes are considered. Many modern organizations are striving to sustain their market share, this requires their awareness on the adaptation of different holistic strategies in order to survive in this era of market competition [9]. Now organizations are realizing that simply implementation of lean manufacturing or agile does not full fill the requirements of their future challenges and it would require the combination of many useful techniques such as LARG along with the wireless technology so this framework may result in many advantages in implementation. Organizations are recognizing LARG technique as a tool for achieving sustainable competitive advantages [10]. The concept of LARG is to synchronized combination of lean, agile, resilient

and green in a most suitable way for organizational benefits. However, the synchronized management of many different techniques is not an easy task as these techniques have dissimilarities in their workings [11], in contrast to this point of view few researchers have opinions that these four techniques do have overlapping in few aspects [12-13].

To utilize the meaningful combination of these techniques many efforts have been made by researchers and these prevail knowledge and understanding of LARG concept [10, 14-15], furthermore it also helped to fill the knowledge gap required to find those potential area where the organizations can earn more profit [16-18] and also makes convenient for them to decide which strategy they should implement in the continually changing environment. It has been observed that there are some new models which are utilizing electronic configurations to provide powerful platform for process improvements [19-23]. Therefore, utilizing LARG applications as tools or techniques in combination of technologies can be very effective for process improvements. Therefore, this current work emphasis on the combining of LARG along with wireless technologies for obtaining a sustainable improvement in manufacturing sector that seems unavailable. Keeping these aspects in view, a need of literature review study seems required that can elaborate about the LARG implementation and affected performances with a confirmation of requirement of technology combined LARG to meet the needs of today's changing globe. In order to confirm this task, the authors of this research study have planned to conduct a literature review study with the objectives as follows:

- (i) To identify the previously available research about LARG combinational implementations and any compromises in that.
- (ii) To identify the interrelation of LARG with wireless technologies.

In order to attain these objectives, the remainder of paper is structured as follows. Section 2 explains about the research methodology that has been adopted to perform this systematic literature review. Section 3 elaborates the results and discussion inclusion of detailed study of LARG Implementation and

technology utilization in LARG. In last, Section 4 concludes the article with the explanation of managerial implications, limitations and future recommendation.

## 2. RESEARCH METHODS

This study aims to review about lean, agile, resilient and green paradigms based on exploring the previous literature available as previously done [19,21]. Therefore, some research questions need to discuss in order to implement rigorous and extensive research methodology in terms of research objectives as previously discussed in introduction section. A research study has investigated based on the literature available in order to implement a combined LARG paradigm. In start, to study the background the first question is: What are the available lean, green, agile and resilient paradigms? After a detailed search and selection of the literature, the implementation of all paradigms reviewed and contribution of each paradigm considered in the present methodology. The implementation of LARG ideology needs to be studied in view of their contributions, gaps and methodologies, which helped to raise the question considering first objective as mentioned in introduction that is: What are the contributions and originality of LARG implementations available? By providing the available details about the previously available LARG implementation, there is still a need to investigate whether the LARG implementation is utilizing modern technologies and to generate its interrelation will modern technologies which is objective 3 of introduction section and leads to question that is: Is there is any researches about the interrelation between LARG implementation with the help of technology advancements? In view of the research questions that arise in the implementation and review of literature, as mentioned in Fig. 1, the authors were able to approach to the objectives and requirements of this current study. Rafique *et al.* [19] clearly mentioned the methodology regime into two criteria: search criteria and selection criteria. In order to perform this search and selection of required papers that will be helpful for the authors in their systematic literature review, the authors have designed a protocol as mentioned in Fig. 2 which has already been utilized

by the previous researchers like, Rafique *et al.* [19], Jadhav *et al.* [24] and Kitchenham and Brereton [25] in their research study.

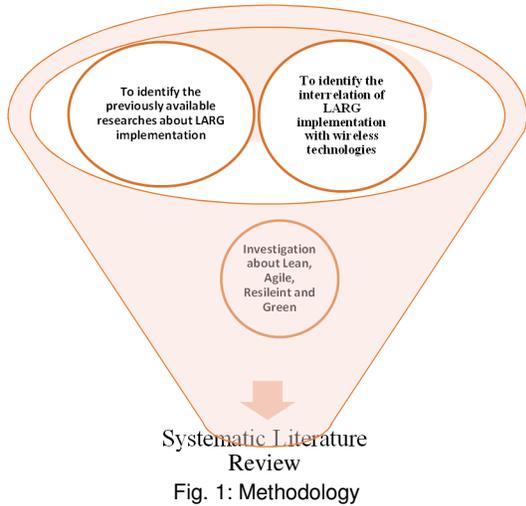
### 2.1 Search Criteria:

Since, this research leads to the study of lean, agile, resilient and green combinational effect. So, all of these paradigms when implement separately or combined move the lean implementation towards sustainability. Therefore, a systematic literature review has to be conducted by using these electronic databases recommended by top researchers of this area [19-20,22-23,26-27]. Large numbers of papers of credible high impact factor journals (Science direct, Springer, Emerald Insight, Elsevier, Taylor & Francis online and many others) searched which contain one of the above-mentioned paradigms or a combination of these paradigms implemented. Basic source of data used for this paper is the information collected from the previous papers in the context of lean, green, agile, resilient, LARG implementation and wireless technology induction either separately or in combined form.

### 2.2 Selection Criteria:

After composing a search criterion for the LARG paradigm, a selection-based design is important to organize the reviewed articles according to the requirements of the research area and the objectives of this study. Selection criteria is the stage in sorting of articles followed by search criteria. Selection criteria takes into account the selection of required articles for the implementation of LARG paradigms in the manufacturing industry. In these selection criteria, papers scrutinized according to the contribution of paradigms, methodology and LARG implementation area. Further, the focus of this research article is to explain the LARG implementation and contribution of each paradigm in the development of the conceptual framework. The articles selected with an objective of LARG implementation studying manufacturing industrial area. Therefore, different articles have been very helpful in achieving the main aim of this study. Scrutiny of articles has done in way of fulfilling the gap in the literature provided in this paper and explicating the previous literature focusing on this aim. According to Morash [28], SCM strategies and

paradigms should be applied suitably to the supply chain management practices. Hence, for selection of articles based on their contribution, a literature review is very important.



### 3. RESULTS and DISCUSSION

#### 3.1 A State of Art Literature Review on LARG Implementation

The competition in the market has forced the companies towards a more competitive supply chain management and the survival for a company has become necessary to be exposed to new technologies and quality management [29]. The organizations are aware of the strategic ingredients to sustain and remain competitive in the growing market [9]. LARG paradigms are found to be the leading paradigms to survive in the current global marketplace. LARG management is about how lean, green, agile and resilient can work together simultaneously to achieve sustainability.



But, it is a very difficult task to manage each paradigm to work in a synchronized manner because of their different way of action [11]. The challenges to respond to the unexpected disruptions (resilient), be responsive to the changing demands of customers in increasing volatile market (agile), environmental protection techniques and restrictions (green) and eliminating the non-value activities and cost and quality management (lean), have attracted company's attention towards the global competition [30]. In short, LARG practices aim to enhance supply chain management efficiency, streamlines and sustainability [10]. A large number of articles shown not only the LARG implementation drivers [14-15], but also provide successful operational performance and three aspects of sustainability (social, economic and environmental) performance [16-18].

Previously, there has been major focus on individual paradigms or combined paradigms. Mittal *et al.* [31] has presented 10 enablers on LGAM (Lean-Green-Agile Manufacturing) for strategic fortification in view of sustainable performance. Similarly, Verrier *et al.* [32] provides lean indicators, green indicators and green intensions indicators in a framework to provide strategic solutions for firms to cope their lean and green performance. In achieving the sustainability by the combined action of these paradigms, environmental performance measures have to be kept in mind to ensure global expedition towards environmental protection. Yang *et al.* [33] details environmental management implementation with the environmental performance measures. Environmental protection is a key aspect of sustainability besides economic and social performance. Involvement of employees at all levels in an organization have been seen an improvement in environmental performance [34]. Economic performance of the latest technologies in various sectors in different countries highlight manufacturing firms contribution to their country is GDP. Goyal and Agrawal [35] has presented a framework showing different managerial and technical practices for practitioners who are inclined to the economic performance of their firms or their nation. A detailed emphasis on socio-economic and environmental issues is presented in [36] focusing on health, pollution and life issues exposed to industrial

emissions. A literature on LARG practices and implementation of paradigms is explained in the Table 1.

### 3.2 Utilization of Technology in LARG Implementation

In view of the modern technologies and pressures from customer demands and various restrictions, all paradigms integrated implementation has become vital to manage supply chain management and supplier management. Unfortunately, there has been a limited research to provide strategies and implementation of combined technologies covering the major drawbacks and solutions to risks and problems. Therefore, a literature review related to LARG implementation with utilization of modern wireless technologies is certainly required. In order to perform this task, in Table 2 the previous researches related to this context has been done. As the potential benefits of the wireless networks are very much. The researchers are thinking about combining these paradigms with wireless technologies. But the literature review from the previous section and as mentioned in Table 2 clearly shows that the most of the wireless research has been conducted in accordance to the modes of green wireless networks because of its feasibility of reducing the harmful effects. That's why, the maximum availability of articles in regime of technology induction are related to green.

Moreover, Fig. 3 clearly elaborates that the availability of literature regarding LARG implementation is inclusive of 22 papers. However, the availability of literature for the combination of technology induction with lean is inclusive of only four related papers [19,21-22,63]. In fact, there is no availability of an integration of resilient and agile manufacturing with wireless technology. From a thorough study of the available literature on LARG and wireless technology implementation as visible through Table 2 and Fig. 3, it is quite evident that there is a lot of literature available on the LARG implementation but no work has been done or reported on the integration of LARG and wireless technology.

There is no doubt that an integration is certainly required to combine LARG with wireless technology

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which will results in a totally new strategy for the future of modern manufacturing by keeping in view

some of the previous researches [19,21-22,63] which certainly worked on combining paradigms with lean.

Table 1: LARG Implementation in Manufacturing Industry

Author	Title	Methodology	Research Area	Findings (Authors point of views)
Carvalho <i>et al.</i> [10]	Lean, agile, resilient and green: divergences and synergies	Case study	manufacturing industry	Authors explain various factors in the manufacturing system focusing on the divergences between LARG paradigms and their KPIs and effects on the supply chain management system
Cabral <i>et al.</i> [29]	A decision-making model for Lean, Agile, Resilient and Green supply chain management	Case study	Automotive industry	A conceptual model based on Analytical Network Process (ANP) is proposed to observe the LARG tools and their KPIs on different criteria like quality, cost, service, time etc. and synergic behavior of the tools on SCM.
Cabral [30]	An Information Model for Lean, Agile, Resilient and Green Supply Chain Management	Literature Review	Manufacturing industry	This paper points out various parameters to be integrated into the supply chain practices. Lean, agile, resilient and green paradigms along with information and decision making framework to predict the flow of product maintaining quality, lead time reduction, customer response and supplier relations are integrated the form a model based implementation.
Mittal <i>et al.</i> [31]	Adoption of Integrated Lean-Green-Agile Strategies for Modern Manufacturing Systems	Literature review	manufacturing industry	In this article, different analytical techniques are implemented to the organizations using various enablers for the adoption of combined Lean-agile-green paradigms. The analytical approaches decide the organizational strength, supplier selection, material selection etc. to validate the best possible criteria.
Pham and Thomas [37]	Fighting fit factories: Making Industry Lean, Agile and Sustainable	Theoretical	Automotive industry	Authors explain the fit manufacturing on business as well as supply chain perspective. Fit manufacturing is an integration of various technology based principles and measures the sustainability with respect to the market trends.
Mollenkopf <i>et al.</i> [38]	Green, lean, and global supply chains	Literature review	Manufacturing industries	Authors described various frameworks to combine lean, green and global supply chain strategies and highlighted the strategic approaches based on the review. They suggested these frameworks for future perspectives.
Pham and Thomas [39]	Fit manufacturing: a framework for sustainability	Case study	Manufacturing industry	This paper proposes a flexible manufacturing system which can help different manufacturing enterprises in achieving their economic and social goals. The proposed manufacturing system is flexible enough to be adopted by different enterprises to achieve sustainability and help in reducing the risks which are caused by the implementation of conventional techniques.
Carvalho and Cruz-Machado [40]	Integrating Lean, Agile, Resilience and Green Paradigms in Supply Chain Management (LARG_SCM)	Literature review	Manufacturing industry	The paper first shows the pros and cons of lean, agile, resilient and green strategies on supply chain and then develops a model. Indicating the effect of all of these strategies when implemented altogether. The effect of these practices on supply chain is observed through performance indicators.
Azevedo and Cruz-Machado [41]	Influence of Lean, Resilient and Green Practices on Supply Chain Sustainability	Literature review	Manufacturing industry	Author extracts the social, economic and environmental impacts of lean, green and resilient practices from literature and present in the form of model. This paper highlights the importance of supply chain for competition and also the gap of social impacts of lean, green and resilient practices present in literature.
Carvalho <i>et al.</i> [42]	Agile and resilient approaches to supply chain management: influence on performance and competitiveness	Literature review	Manufacturing industry	This paper shows the agile and resilient supply chain management practices (applied in upstream, daily internal operations and downstream manner) and highlights the indicators to check effect of agile and resilient practices on supply chain management. Author presents a comprehensive conceptual model for a better supply chain management system after thoroughly understanding the effects of agile and resilient practices separately and in combined effect.
Chiarini [43]	Sustainable manufacturing-greening processes using specific Lean Production tools:	Case study	Motorcycle industry	The paper highlights the implementation of five lean tools: VSM, cellular manufacturing, 5S, TPM and

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	An empirical observation from European motorcycle component manufacturers			SMED to predict the impacts on environmental performance and compares the tools efficiencies.
Govindan <i>et al.</i> [44]	Impact of supply chain management practices on sustainability	conceptual model	Automotive industry	Authors explain the integration of lean, green and resilient practices using hypothesis to construct a model which highlights combined impacts on all sustainability dimensions. Model based study is done based on 5 case studies on automotive supply chain.
Azfar <i>et al.</i> [45]	Performance measurement, a conceptual framework for supply chain practices	Literature review	Manufacturing industry	Author highlights the parameters for measuring the efficiency and performance of the implemented techniques. This paper presents the conceptual framework for the implementation of LARG practices and for the measurement of its impact on the supply chain
Mari <i>et al.</i> [46]	Sustainable and Resilient Supply Chain Network Design under Disruption Risks	Literature review/Case study	Garment industry	Author presents a model for making a resilient sustainable system that can withstand different types of disruptions and then perform weighted analysis to reduce the deviation of variables from the goals of casts, emission and resilient sustainability
Govindan <i>et al.</i> [47]	Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach	Conceptual model	Automotive industry	This paper suggests the interrelations on lean, resilient and green practices based on interpretive structural model and classifies the practices on structural self-interaction matrix by detailing the dependencies of practices on each other
Soltan and Mostafa [48]	Lean and agile performance framework for manufacturing enterprises	Literature review	Manufacturing organization	Combination of lean and agile by decoupling points improves benefits and explains a broad method for analyzing performance on enterprise level as healthy organization but its success depends on consideration of the challenges that enterprise may face.
Sohi <i>et al.</i> [49]	Does lean & agile project management help coping with project complexity?	Survey	Construction projects	Combination of lean and agile in construction project management is promising to handle the complexity and its improvements.
do Rosário Cabrita <i>et al.</i> [50]	Integration of lean, agile, resilient and green paradigm in a business model Perspective: Theoretical Foundations	Literature review	Manufacturing industry	Author developed a business model having nine components and then comprehensively detailed the comparison/effect of each component with the LARG practice this paper highlight the gap present for the intersection of business model and LARG practice.
Ruiz-Benitez <i>et al.</i> [51]	Environmental benefits of lean, green and resilient supply chain management: the case of the aerospace sector	Case study	Aerospace sector	Authors explain the synergic implementation of lean, green and resilient and their effects on environment based on two approaches: Importance-performance analysis (IPA) and Interpretive Structural Modeling (ISM) to solve complex matrix of implementation of practices.
Ciccullo <i>et al.</i> [52]	Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions	Literature review	Manufacturing industry	A review has been conducted in this paper in which the selected paradigms are investigated and categorized based on dependencies on each other and it provides the cumulative study for future researches.
Salvador <i>et al.</i> [53]	Approach of the Two-way Influence Between Lean and Green Manufacturing and its Connection to Related Organizational Areas	Literature review	Manufacturing industry	A review presents synergic and complementary relation between lean and green manufacturing and shows after-effects of these paradigms in various organizational perspectives.
Cherrafi <i>et al.</i> [54]	A framework for the integration of green and lean six sigma for superior sustainability performance	Literature review/case study	Manufacturing industry	This paper contains 4 phases for the implementation of lean six-sigma technique and in each phase the necessary required drivers, parameters and indicators are highlighted. Author shows the result after implementation of this technique in defined 4 phases on four different companies.
Azfar <i>et al.</i> [55]	Application of Lean Agile Resilient Green Paradigm Framework on China Pakistan Economic Corridor: A Case Study	Case Study	Manufacturing industry	Scenario planning for four routes is proposed fulfilling the supply chain attributes with CPEC study as benchmark

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Table 2: Technology in LARG Implementation

No.	Author	Technology Induction	Lean	Agile	Resilient	Green	Methodology	Research Focused Area	Implementation approach type	Findings: Authors points of view	Technology Induction limitations
1.	Jasti and Kodali [21]	Yes	●				Literature review	Implementation framework	A pillar based framework for lean implementation	Used pillars to design framework and IT system	Conceptual stage framework without validation
2.	Jasti and Kodali [22]	Yes	●				Literature review	Implementation framework	A pillar based framework to attain improvement in production	Used pillars to design framework and IT system was one of the pillars	No validation done and framework was in conceptual phase
3.	Chowdhury <i>et al.</i> [56]	Yes				●	Theoretical framework	Green hybrid wireless-optical broadband access network (WOBAN)	Reduction of energy usage in the wireless networks without effecting the performance quality considerably, using different energy- aware WOBAN by considering a mixed integer linear program (MILP) model as benchmark.	Using proper designing constraints reduction in energy usage can be obtained by energy-aware mode without compromising the network performance quality considerably. These energy-aware techniques also can be generalized for their use in other networks.	Analyzing the working of green WOBAN with through practical implementation.
4.	Wang <i>et al.</i> [57]	Yes				●	Theoretical analysis Simulation And experimentation	Green wireless communications	Transmission systems which are based on TR can be a perfect solution for green communication as they can harvest energy from environment and causing less interference to other receivers.	The results reveal that TR systems have ability for reduction in power usage and alleviation in interference as well as highly gain in multi-path diversity. It was shown by both simulation and experimental values.	The efficiency of TR based systems need to be investigated in many different environment and along with integration with other techniques e.g. lean, agile and resilient.
5.	Bu <i>et al.</i> [58]	Yes				●	Simulation	Green wireless cellular networks	Minimizing the operational expenditure and reducing the environmental pollution problems by the reduction of CO <sub>2</sub> emission by utilizing the proposed scheme.	The results obtained from simulations shown that green wireless networks are significantly affected by smart grids and the proposed scheme can help in reduction of operational cost and CO <sub>2</sub> emissions for green wireless networks.	The proposed framework with the heterogeneous wireless networks with femtocells needs to be considered. The practical application of proposed solution needs to be verified.
6.	Suarez <i>et al.</i> [59]	Yes				●	Literature review	Green wireless networks	Summarizing the metrics used in relevant literature for it evaluation and focused on current proposal (power amplification, cell layout adaptation and additionally management of radio resources	None single trend presented in the literature is enough and it requires a joined approach as it was presented in the proposal. A good hard work is required to obtain the goals of energy reduction and it is expected that	Combining many of the proposals and considerations of many others aspects e.g. cost effectiveness should also be considered. The practical implementation of many research in case of green networks is essential.

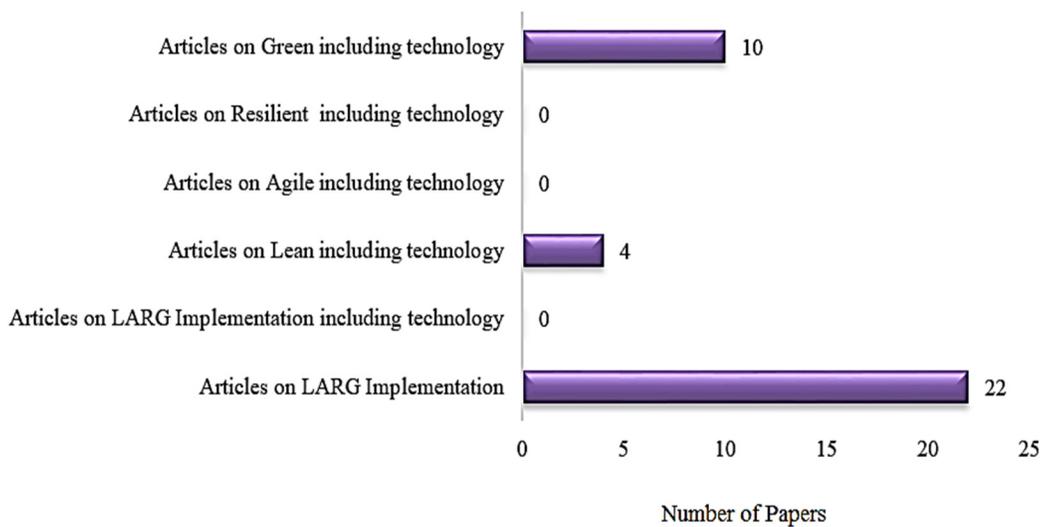
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								and cognitive radio) along with the support of references. A framework by the integration and classification is presented.	it would take years.		
7.	Mahapatra <i>et al.</i> [60]	Yes				•	Theoretical Framework	Green communications wireless Heterogeneous Networks	Minimizing whole system energy requirements, Application of Energy cognitive cycle	The energy cognitive cycle extends classic cognitive cyclic method and helps to minimize the energy consumption of network while sustaining quality of service	The user mobility should be considered in future work. The benefits and disadvantages of the proposed framework should be investigated
8.	Abou-Zeid and Hassanein [61]	Yes				•	Simulation	Predictive green wireless access (PreGWA)	Minimizing energy requirements of the network by Prediction of user location and application information	Development of a distributed heuristic and its results under varying traffic load showed that significant energy can be saved by small predictions requirements.	Prediction errors should be resolved by a practical environment test. Requirements of such models that capture the variability and accuracy of the predicted information. Robust method and algorithms are required to address the inaccuracy. There should be any resources that do work on applications other than video streaming. The practical use of these work should be made.
9.	De Domenico, <i>et al.</i> [62]	Yes				•	Survey	Wireless networks	Reducing the energy requirements of wireless networks. Low cost & power Access Points (APs) usage. Implementation of resource management of Dynamic radio and use of Flexible type hardware platforms. Use of enablers for energy efficiency.	Mostly researchers do focus on limiting energy consumption and don't keep its effect on RF radiated power moreover the effect of EMF on human health should be considered.	The relationships of basics of green enablers and EMFs needs to be understood and analyzed to have some novel approach for reduction of electromagnetic radiations effects and energy consumptions. Green solutions (such as cell zooming) may constraint few Aps to operate at maximum radiated power
10.	Olesen <i>et al.</i> [63]	Yes	•				Case Study	Implementation framework	Used RFID as ICTs for lean termlization	RFID Technology has been utilised to .attain location detection and operational visibility to attain lean implementaiton	No information about technology adoption has been provided
11.	Rafique [64]	Yes	•				Theoretical Framework	Lean Implementation	Implementation Framework for technology combined lean implementation	The framework has helped to implement lean with the help of technology-Organization-Environment framework to implement RFID technology combined lean implementation	The framework is in literature review process and requires validation through case study

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12.	Gandotra and Jha [65]	Yes				•	Survey	Green communication	Different energy-efficient setups for green communication . Proposal of a three-layer architecture that highlights information transmission through relays. Enumeration of secure power optimization of relays	The use of energy efficient systems for green wireless technology are essential for reducing energy consumption and CO <sub>2</sub> addition in environment moreover the use of network security is also an important parameter in green network	In future there will be much more need of wireless networks, as a result there would be more radiations effects more CO <sub>2</sub> production and more energy requirements, so there must be any solution of these problems such as green communication networks to avoid these future problems.
13.	Wang <i>et al.</i> [66]	Yes				•	Mathematical model	Green wireless	Reducing the total cost of energy in heterogeneous green wireless network by the application of hybrid energy. Using a mathematical modeling for problem solving.	The result from simulation described that the proposed solution has much effectiveness in energy cost reduction in comparison with peer algorithms. And it has less operational complexity.	The practical implementation of this mathematical model still need investigation.
14.	Dahal <i>et al.</i> [67]	Yes				•	Experimentation	Green wireless technology	Turning automatically power on and off unnecessary transmitters on low and higher traffic conditions	This technique enables dynamic adjustment of number of transmitters as requirements without effecting service quality and reduction of energy consumption up to 18.8% as compared to traditional system and also reduces environmental effects.	For the future there will be more necessity for developing cell zooming technology in heterogeneous network and for the wireless technology based on green.

**Literature Availability**



**Fig. 3: Literature Portfolio on Technology Induction**

#### 4. CONCLUSION

Lean Manufacturing is one of the process for improvement in manufacturing industries especially in deem of adoption towards Lean. Recently it has been noticed that lean manufacturing holds much significance in reducing the non-value adding processes but this practice does not assure the long term sustainability of the manufacturing industry. The quest of industries to achieve long-term sustainability spectacles that only lean is not enough to compete continuously varying trend of market, in such environment, industries are looking towards new and advance paradigms like, Agile, Resilient and Green either separate or in combined form as LARG to achieve goals. The concept of LARG is synchronized combination of lean, agile, resilient and green in the most suitable way to achieve the benefits of all these tools and reduce their divergence as much as possible. The main problem is to synchronize all tools together in which the utilization of wireless technology can play a vital role. However, the synchronization of LARG and then combination of LARG with technology is not an easy task as these technologies have much dissimilarity in their working. Therefore, based on this ideology, the aim of this study is to collect and study previous data available on LARG and search for the utilization of LARG with wireless technology. The first objective states that many researchers have done a lot of effort to utilize the meaningful combination of these techniques in the form of comprehensive framework/models on LARG which unfortunately covers various domains of manufacturing industries and try to maximize the synergic benefits of these four techniques and reduce their divergence to a minimum possible point. There is no doubt that this ideology has helped organizations in finding potential areas where more profit and long-term sustainability can be achieved in the hostile environment of market. However, in second objective, which is looking towards the advanced techniques of LARG in combination with wireless technology, there is availability of data in case of green and Lean, and shows the dearth of data availability for the utilization of LARG with wireless technology which is need of present era and many organizations have recognized

this advanced combined technique as a useful and beneficial tool. In fact, it ascertains lack of data for the implementation and modernization of LARG that is the requirement of practitioners and academicians working on the LARG to attain modernized manufacturing.

#### ACKNOWLEDGEMENT

The authors of this research study are highly thankful to The University of Lahore, Lahore, Pakistan, for providing us the platform and facilities to conduct this research.

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