

The Essence of Lean Eliminate Waste. Improve Productivity.

Author: - Shweta Sharma

Co-Author- Vimal Kishor Kumawat

ABSTRACT

Despite of its type, location or principal market base, today the manufacturing enterprises are bound to adopt sustainable practices like lean principles, integration of processes and inter-organizational collaborations to meet their corporate goals. The majority of studies usually discuss either a system or a subcomponent of the production systems and manufacturing strategies in literature w.r.t. lean production; but the rational (what, why, how) behind each production activity seems to be missing. This paper addresses a comprehensive assessment of the literature on lean production in relation to the green concept, for its significance, feasibility and need for organizations to sustain in the global market. Findings of the review reveal that lean principles along with green model can improve the process flow & employee morale and lower the environmental regulatory non-compliance risk. Further, the environmental and human health risks are often not explicitly considered in lean initiatives that can affect customers & stakeholders throughout the product life cycle, and the manufacturing enterprises working with lean strategies have the possibility of costs sub-optimization and waste reduction from a lifecycle viewpoint. Eg the outcome of a ball industry has been increased by using the principles of lean manufacturing. As the lean manufacturing implies the reduction of waste with in the manufacturing process by categorizing all the activities and processes into three fields namely value adding, non value adding & non value adding but necessary. The methodology used for the project is to first prepare the current state map by collecting data from the shop floor and then analyzing it for the possible areas of improvements. After that the analysis and comparison of the suggested solutions with the old one has been done and finally proposed the future state map.

Keywords: *Value stream mapping, Supermarket pull system, capacity utilization, environment, lean production, sustainability.*

1. INTRODUCTION

While considering the rest of world in their competitive strategy analysis, the enterprises cannot isolate the external factors such as economic trends, competitive positions or technology advancement; and the major factor to remain competitive in the industrial environment of varying needs is the effective & efficient operation of customized manufacturing system, as well as its ability to quickly re-organize the system for new product introduction. One such set of tools 'lean manufacturing' causes work in a process to be executed with least non-value adding activities and hidden wastes, focusing on quickly meeting the customer demands at minimum time & cost. Waste can be defined as "to use, consume, spend, or expend thoughtlessly or carelessly. In every organization there is a need to eliminate waste from their activities and processes. As we identify this waste and the associated cost of these activities, it is evident that there is scope of improvement in profit. It need to be identified, and also presented to the employees in such a way that everyone understands what is the waste, where it exists in the process, what are the sources, and at what it will cost for the preparation and implementation for the improvement .Toyota production system commenced the lean principles in 1950 in Japan as a set of practices & methodologies that leads to cost reduction. Lean manufacturing was originally

applied to the automotive sector, but it illuminated that lean principles could also be transferred readily to other production functions and sectors. Lean Manufacturing principles involve defining customer value, making customer pull the product, value stream and making it flow, and striving for excellence. For lean, the continuous improvement feature becomes the compelling power for researchers to discover it further for products and machine tools, concentrating at not only dipping but eliminating all forms of non-value adding work in production system and improving overall productivity by adding customer value. Lean production involves respect for people, a level of patience, continual improvement and a focus on process & ability to realize the individual development. The two pillars of TPS are continual improvement (i.e. Kaizen) and respect for people, and these tools are designed to make it simple to see problems, easy to resolve them and easy to learn from mistakes.

Being the system thinkers, an industrial engineer's approach to ecologically-responsible designs & manufacturing practices must incorporate the employee, environment and their interaction for optimal ergonomic efficiency with least disturbance to the environment.

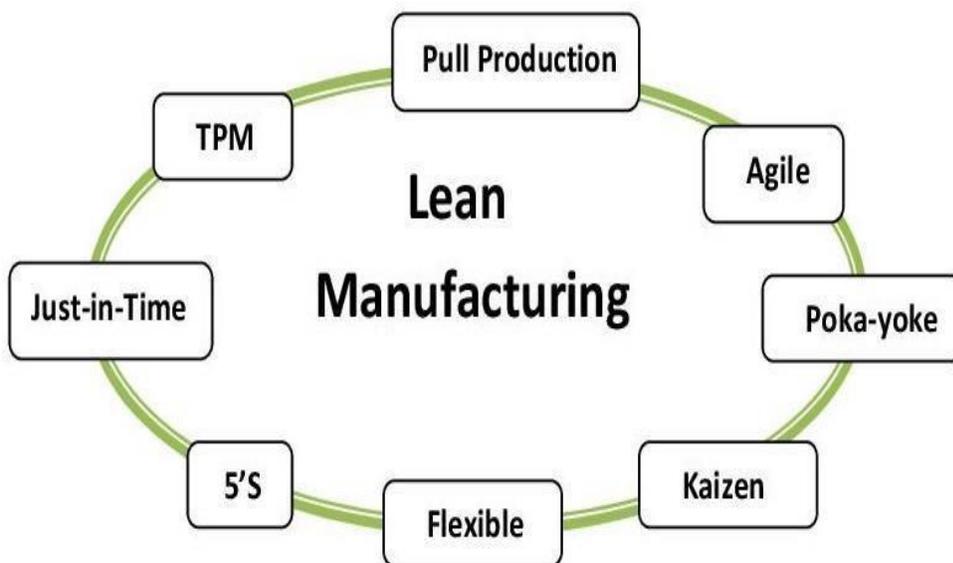


Figure 1 Lean Manufacturing

In 2010, it was described the evolution of four production systems according to their environmental practices as:

- Traditional production systems- based on disposal of wastes as a principle;
- Lean production systems- waste reduction for better resource utilization;
- Green production systems- apply the 3 R's principle (Reduce, Reutilize or Recycle wastes);
- Sustainable production systems- apply the 6 R's principle (Reduce, Reutilize, Recycle, Recover, Redesign and Re-manufacture).

Though, one weakness of lean is that, regardless of the process approach that aims at reducing the risk of sub-optimization, it primarily focuses on the production part of the lifecycle, and an organization working with this approach risks sub-optimization of costs from a life-cycle perspective. When companies have limited time and resources, efforts should be placed where they contribute the most, which is not always in the production phase. Another potential weakness of lean is that Just-in-Time (JIT) can lead to increased shipment, as pointed

out, this is however not perceived as a problem by the interviewed companies as transport is strongly linked to costs that can be very low through proper planning and managing the transports. In 2014, it was revealed that lean can lead to a lack of consideration of ecological risk, that the companies' activities may cause risk remaining hidden.

1.1 Need for Lean and Environment Integration

Clearly considering the environmental goals and opportunities in implementation, lean improves process flow, lowers the regulatory non-compliance risk and improves employee morale which is only possible with full regulatory obligations. Currently, there is an emphasis on lean thinking surrounded by the environment, health & safety as well and adopting green practices are not only good for sustainability reasons but are also good business. The Studies show that the 'envi-lean' integration is not only possible but also advantageous from business and environmental considerations.

It is found that combining lean & environmental methods is not only possible, but it also offers the potential to gain competitive advantages and environmental sustainability. Furthermore, combining the two methods would support lean on the aspects where it has been considered weak i.e. the life-cycle view and awareness of environmental risks (**Table 1**). The polluter pays principle (PPP), also known as **extended producer responsibility (EPR)**, emphasizes that the summation of all environmental costs throughout the life cycle of any product should be reflected in the market price of that product. This would mean that manufacturers would absorb greater responsibility in cleaning, storing, recycling, and reuse of produced waste that leads to national policy formulation, and hence to include the environmental waste into lean thinking.

Table 1 Lean Efforts & Their Affects

Sr. No.	'Envi-lean' efforts	After affects
1.	Less scrap, fewer defects and less spoilage	Reduced environmental waste
2.	Fewer defects, no over-production and simpler & right-sized products	Reduced use of raw materials
3.	Less storage and no inventory space needed	Reduced material, land & energy use
4.	No over-production, no lighting/heating/cooling, no extra space and no over-sized equipment	Less energy use

5.	No over-processing and more efficient transport & movement	Lower emissions
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Authors have presented lean manufacturing strategy in a structured sense, and an attempt has been made in this paper to categorize the literature along-with leading conceptual and research methodological dimensions to trim down the wastes & loss of economy to enterprises, by integrating the environmentally-lean (envi-lean) model.

RESEARCH METHODOLOGY

Literature review is a research methodology and the content analysis of historical papers/literature has been applied in this paper so as to create the replicable and valid implications from contents for their use. Content analysis is a scientific method for briefing, quantitative analysis of messages, many words of text into fewer content groupings based on explicit coding rules, where it defines content analysis as 'a technique for building inferences by objectively and scientifically identifying specific characteristics of messages'. Thus, content analysis is a research tool that determines the presence of certain words or theories within texts or a set of texts. In this paper, the target population is the published articles on various databases, followed by the sampling procedure.

In order to facilitate a clear 'line-of-sight' from information basis and comprehensive overview of the previous research findings, methodologies/reviews of lean production along with environmental concerns, a sample size of about 110 articles has been taken followed by the deductive approach in selecting and evaluating the body of literature on 'envi-lean'.

{a} Coding and Categorization

Categorization of the content is very important in content analysis, which is defined by set of criteria or standard that is incorporated about a theme or value. Categories used in the content analysis are supposed to be very clear and should enable other researchers to have identical outcomes while re-examining the same data with defined categories. The categories in this paper are determined by probing the literature, reviews and researches regarding the 'lean production and green' concept. A codebook has been developed to employ as a coding instrument, where codebook is an instrument that includes all of the operational definitions of variables. All the selected articles were further integrated into the defined framework of four categories of variables i.e. descriptive features, definitional issues, theoretical concerns and research approaches for the conceptualization and methodological analysis. (Table 2).

No.	Grouping	Content covered	Basis
1.	Descriptive features	Title, country, industry, year, sector, journal	Express the features of sample articles.
2.	Definitional issues	Approaches, conceptual framing, constructs, discipline, process	Discover stability or variation in 'envi-lean' definitions to various dimensions.

			Classify the area that researchers argue falls in lean production.
3.	Theoretical concerns	Purpose, strategy, range, application, function	Establish the range of theories used to enlighten lean and their applications.
4.	Research approaches	Modeling, research methods, hypothesis, case study	Determine the assumptions and research methods used to define lean'.

Particularly, the grouping 1 provides an examination of the sample articles/theories expressing its features & trends in the literature like title, year of publication, industry/sector to which the study is applied; grouping 2 discovers the area of supply chains covered by researchers from a range of perspective using either new or existing organizing designs, processes employed; while grouping 3 also illuminates the literature dealing with the issues more or less related to the theoretical bases such as strategies applied or the purpose of study, application of research & its scope; finally, grouping 4 examines the issues associated with research methodology and assumptions used, hypothesis, modeling.

{b} *Validity and Reliability*

Validity may be stated as the degree to which a measuring method represents the intentional, or it is the quality of research results that directs us to suppose them as realistic, and the external validity is associated to whether the sample of study corresponds to the population or not. In this paper, all the population i.e. articles integrating lean with the environmental concept and in the context of diverse continents is included and hence, the external validity is assured. Then face validity is confirmed that whether the instrument measures exactly what it is planned to assess or not, and agrees with the results if reasonable.

2. ANALYSIS

The selected articles were integrated into a framework based on various dimensions and classified into four discrete, yet rationally ordered, groupings initiating with least complex perceptions and advanced research issues, and categorized in the following way:

Descriptive Features

The review shows that over hundred journals covering diverse disciplines were captured, and the International journal of production economics consist accounted for 47% of the total articles, and among which about 78% studies having special emphasis on envi-lean; whereas the remaining literature appears to be focused in another part of lean like productivity & quality improvement, setup time reduction, sustainability issues etc. and based on these explanatory feature the reviewed studies are categorized as below:

Figure 2 categorizes the percentage of the reviewed studies with respect to their year of publishing, and the graph shows that 70% studies are published in last five years (2010 - 2014).

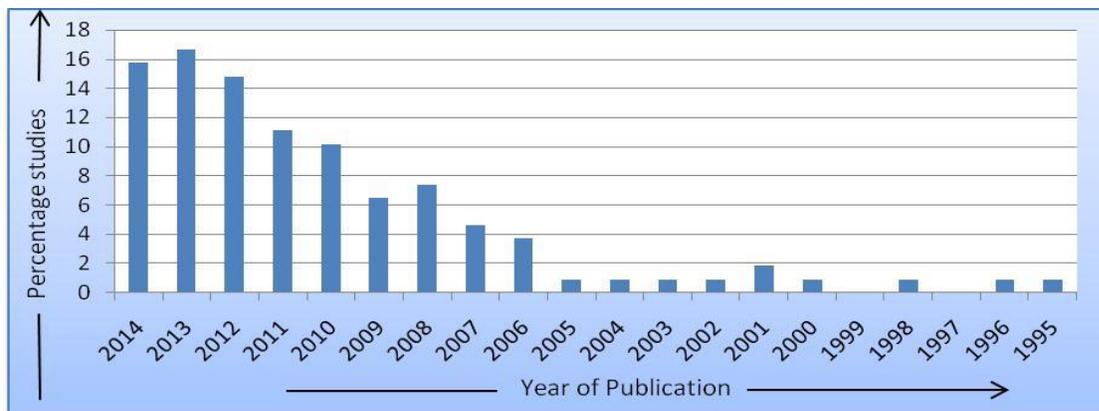


Figure 2 Classification for Year-wise Studies

Improving the environmental performance also leads to reducing costs, increase competitiveness and to be more innovative across the value chain. It mainly discussed lean production in textile industry that fosters a sustainable work environment focused on integration of environmental and operations management in two companies presented the role of lean for achieving better environmental performance and an emergent business model for supporting eco-efficiency by literature review.

Figure 3 categorizes the percentage of the reviewed studies with respect to the country/continent, and the graph shows that more than 70% studies are carried out by European & Asian author.

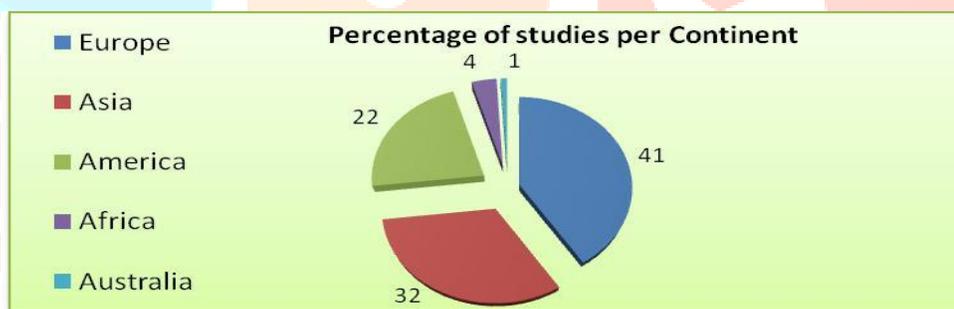


Figure 3 Classifications for Continent-wise Studies

Below Figure showed that hybridizing the lean & agile systems together is technically valid to be implemented in an industrial setting, It presented a multi-objective line-cell conversion model of traditional conveyor assembly line for reducing worker & increasing productivity.

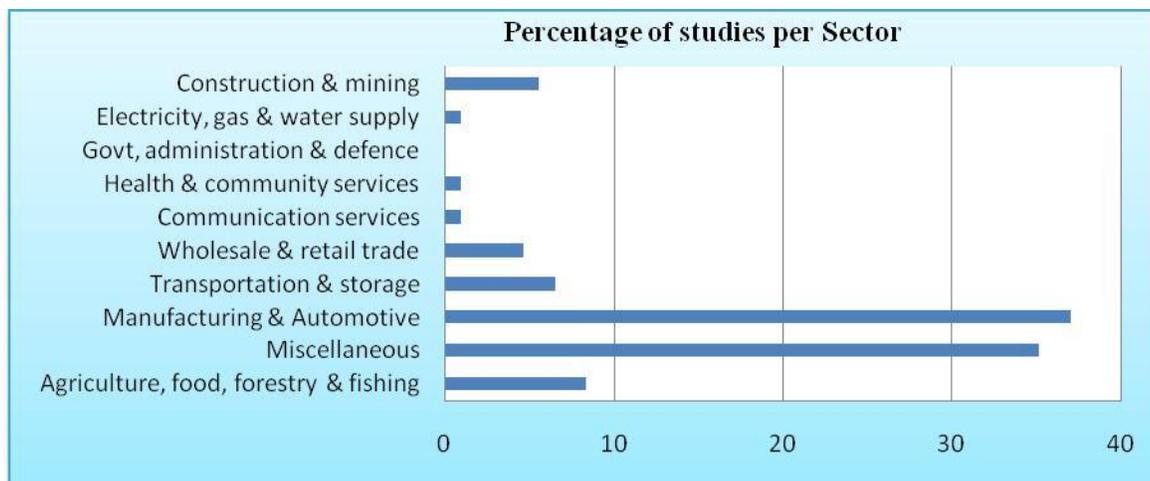


Figure 4 Classification for Sector-wise Studies

Figure 4 categorizes the percentage of reviewed studies with respect to the sector/area, and the graph shows that most of the studies have been conducted in manufacturing, automotive, agri-food, transportation & storage sector.

It explored a framework of new business model for the tanning sector to minimize the environmental impact of manufacturing processes and products. Mainly it investigated how lean and environmental aspects affect one another and how they could be integrated into a single model; though, it presented a comprehensive discussion of hazards associated with disposal of used or waste electronics & electrical equipment that can be recycled or reused.

It is stated that environmental concerns are a part of the lean concept and air/water emission, generation of solid waste, etc. represents the waste of production and it elaborated the concept of lean design, its application fields and indicated that it is the only way to establish lean enterprise that make comprehensive lean design.

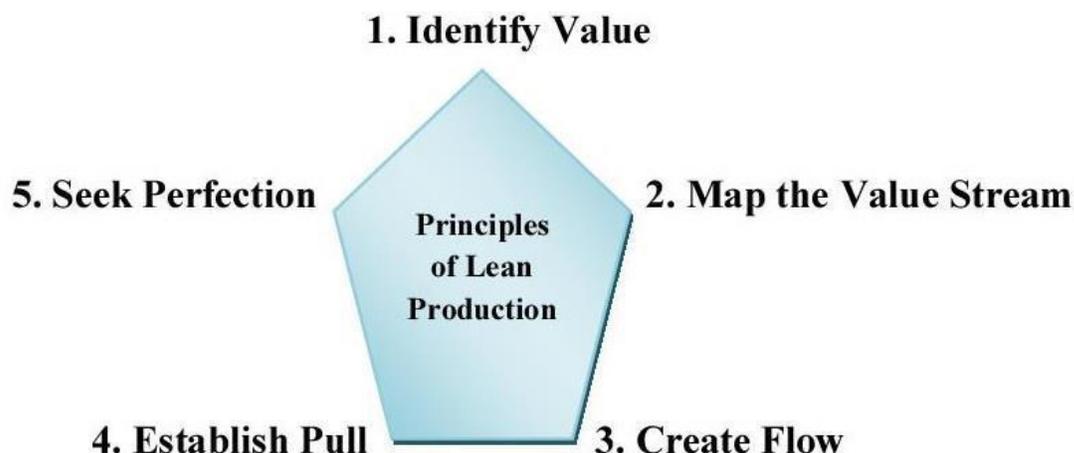


Figure 5 Principles of Lean Production

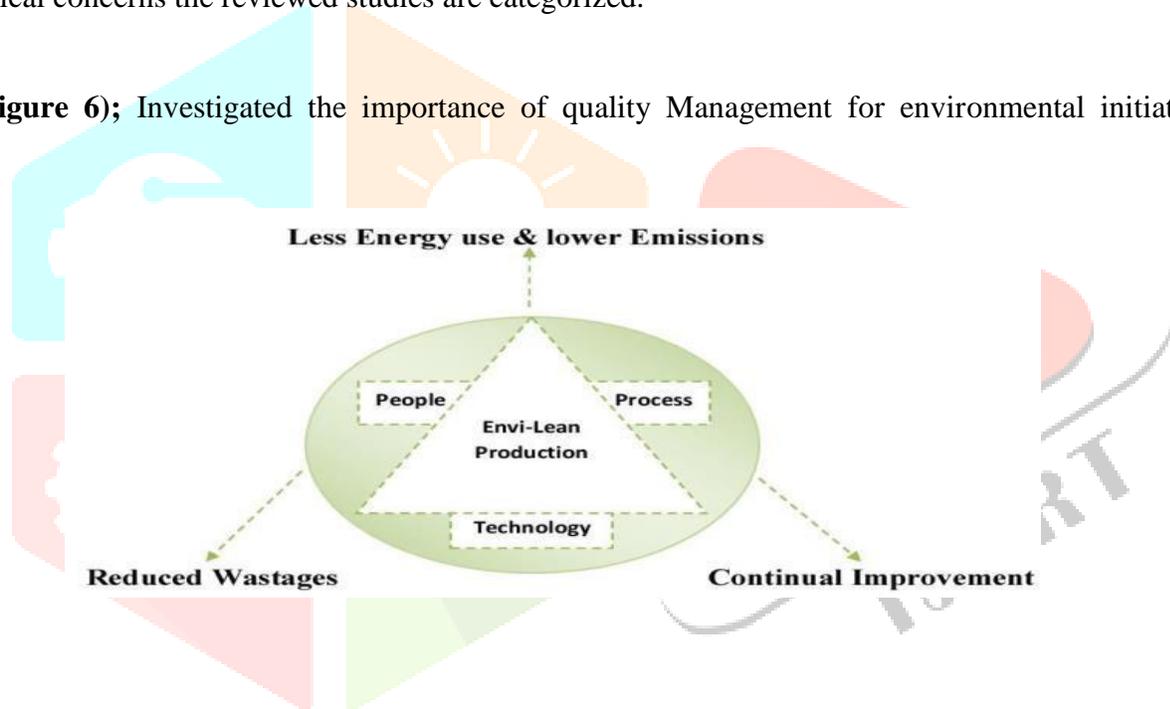
It was explored the possibility to merge lean, agile, resilient and green ideas in supply chain management, where lean-supply-chains seeks waste reduction, agile supply chain (SC) directs rapid-react to market changes, resilient SC responds efficiently to disturbances and the green SC cuts environmental impacts. It mainly concentrated on how various contingency factors influence the inventory turnover of lean manufacturers through cluster & correlation analysis and proposed an introductory course for students so as to familiarize with prominent operations Management strategies.

It was concluded that the lean & green can be integrated and offered simultaneously in the operation management to reduce waste & pollution; In (2014), it was cleared that lean is a powerful tool and it can create superior financial & operational outcomes.

Theoretical Concerns

To comprehend lean production, the articles were analyzed to ascertain whether the theories existed or new ones. Comprehensive list of reviews with existing theories were offered in diverse aspects such as economics, application, information, strategic management, sustainability, sociology, functions, and based on these theoretical concerns the reviewed studies are categorized.

(Figure 6); Investigated the importance of quality Management for environmental initiatives through survey



Research Approaches

Studies can be tested using the profile and form of the subsequent knowledge generated assuming scientific method, empiricism, views, phenomena, relationships, and modernism. For this particular parameter, the framework consisting functionalism as well as the fundamental humanism and structuralism was employed, and based on these research approaches the reviewed studies are categorized.

Some companies of North east china disseminated the selected lean techniques in companies of North-east England to improve productivity and obtained the savings as eight times greater than total costs from 15 companies; In (2011), it was suggested the motion study to achieve company goals and ARENA software to simulate the inspection lanes at Motor Vehicle Periodic Inspection station and yielded an expected improvement of 174.8% in production capacity. Current trends in lean production research incorporate the development of productivity & quality improvement processes within environmental boundaries; on the other hand, sustainability, integrated manufacturing, deployment of information technology to reduce manufacturing lead time, and human health issues have also been placed on priority by authors.

DISCUSSION

Based on the findings of the review, it is possible to discuss the issues like how to conceptualize and develop the field and evaluate the impact of the various trends in lean production research. The review also indicates that many other sectors like government, health services, construction, communication and industrial markets do not yet appear to have researched comprehensively. Apart from this, some findings of the review are as:

- a) Despite of the process approach, lean production primarily focuses at reducing the risk of sub-optimization and the production part of the lifecycle; thus, the associations working with lean have the possibility of costs sub-optimization from a life-cycle viewpoint.
- b) Lean along with green concept improves the process flow & employee morale, and also lowers the regulatory non-compliance risk. Adopting green practices are not only good for sustainability but are also good for business value.
- c) There is a need to include environmental waste along with other lean wastes where focused waste management requires shop floor people, engineers, and management to know what & where the waste is being generated.
- d) Lean can be leveraged to create even more improvement by addressing the environmental 'blind spots' as they are often suppressed in overhead & facility support costs.
- e) The environmental & human health risks are often not explicitly considered in lean initiatives that can affect customers & stakeholders throughout the product life cycle.
- f) The more difficult problem to overcome waste is the lack of vertical integration between the organizational data on environmental waste and the processes that created the waste.

CONCLUSION

After the comprehensive literature assessment, it is concluded that the human health & environmental issues, improved product quality and the associated economic benefits in sustainable production systems can be achieved through lean principles that eliminate uncertainties in processes, reduce wastes and non-value adding activities; and integrated product development and manufacturing processes along with the interoperability of information systems can enhance the business value in production systems.

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