Interpretive Structural Modeling for Implementation of Integrated Green-Lean System

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ABSTRACT
Lean system consists of best common sense practices for optimum resource utilization. Green manufacturing focuses on practices which reduce negative impacts on the environment. Global market conditions forced organizations to adopt Green-Lean (GL) concepts in the last few years. This paper focuses on the significant lean practices impacting the environment. The lean practices act as driver for sustainable implementation of GL system. For adoption of GL systems, significant practice bundles essentially need to be recognized, analyzed and discussed. In this research, study factors are the GL practice bundles for sustainable implementation. Authors have identified six significant GL practice bundles from literature review and opinion of the experts. The main objectives of this paper are to identify and rank the GL practice bundles for implementation, to develop and to analyzed the interaction between identified GL practice bundles using ISM and to prepare a framework for integrated Green-Lean system implementation.

General Terms
System Modelling

Keywords
Green; Lean; Green-Lean (GL); Practices; Practice bundles; Interpretive Structural Modelling (ISM)

1. INTRODUCTION
Lean systems take a total system approach to creating an efficient operation and pull together best practices concepts *(Oduoza, 2008).* Severe competition, demand for cost effective on time-in full delivery of quality green products or services at right location as well as issues related to - marketing, packaging, ecology, stringent national and international standards and regulation, economics etc. forced organizations to follow Green-Lean (GL) concepts in the last few years. Integrated GL system leads to enhance operational excellence.

Many green and lean practices coexist. This paper focuses on the significant lean practices impacting the environment. The set of lean practices act as driver for sustainable implementation of GL system. The GL practices clustered in a particular group are termed as practice bundles. To encourage the organizations for adoption of green lean systems, significant GL practice bundles essentially need to be recognized, analyzed and discussed.

The GE practice bundles also influence one another. The understanding of the mutual relationship between GL practice bundles is very important. Some practice bundles prepare a launching pad for other GL practice bundles. Some practices are dependent, some are independent and some have interrelationship. The GL practice bundles which have high driving power and dependency need more consideration. For effective implementation of GL system, integrated practices in a particular bundle or group needs to be used in sequential order. The sequential approach of implementation of these practice bundles is essential. The understanding of the ladder of GL practice bundles would be helpful for the senior management implementing the green lean concepts.

Lot of research has been carried out in the field of analyzing and modeling green as well as lean systems. Some researchers did empirical studies and presented conceptual or theoretical models. Various modeling tools and techniques based on the mathematics, statistics, Operation Research (OR), computer simulation, structural equation modeling, AHP etc. were used. As far as authors' literature review on green manufacturing and lean is concern nobody used Interpretive Structural Modelling (ISM) for Green-Lean system. The authors attempt to expand the body of knowledge by considering at the following two criteria.

1. Developing the relationship between each of critical GL practice bundles and
2. Developing a framework for sustainable integrated Green-Lean implementation

This work may provide a framework for taking suitable actions for successful implementation of GL system. The effective and sustainable implementation of green-lean manufacturing assumes great significance in this context.

This paper is further organized as follows. Research methodology is described in second section. GL Practice bundles are introduced briefly in Section three. Overview of Interpretive Structural Modeling (ISM) and GL modeling using ISM is discussed in section four. Section five discussed the ISM model - A Framework for GL Implementation. Finally, section six includes general conclusions with research findings, implications, limitations and suggestions for future research

2. RESEARCH METHODOLOGY

The main objectives of this paper are:

a) To identify and rank the GL practice bundles for implementation.
b) To develop and analyzed the interaction between identified GL practice bundles using ISM.
c) To prepare a framework for integrated Green-Lean system implementation.

In this research, study factors are the GL practice bundles for sustainable implementation. Authors have identified six significant GL practice bundles from literature review and opinion of the experts.

This work can be characterized as first theoretical concept, specifically for review of literature on practices in green and lean systems implementation and second developing a model for deployment of integrated Green-Lean system strategy. The approach of the research is exploratory in nature, which constitutes a secondary source. First the relevant literature is reviewed. The authors focused on literature from 2005 to 2013. Literature Review includes Green and Lean systems implementation in various global companies. The literature survey was augmented by use of online computerized data base like Taylor and Francis Science Direct, Google Scholar, Bing etc. using primary keywords such as Lean, green and lean supply chain, Just-in-Time (JIT) purchasing, green manufacturing, ISM etc. and secondary key words like practices, benchmarking, modelling, framework etc.

The research is based on secondary data, which includes compilation of research articles and survey reports etc. after scanning the reference sections of the initially selected papers. The ultimate list of articles reviewed for this paper covers articles published in reputed referred scholarly journals on green and lean systems.

Based on this search, articles that met the criteria of practices in Green-Lean implementation and presented a model or framework were selected. A survey of literature was carried out on the basis of editorial scope and contents of the journals and a list of journals was compiled. Journals stating in their editorial scope issues such as green, environment, sustainable, lean, JIT, TPS, ISM etc. were selected. A comprehensive review of the table of content of the journals, abstracts, and where ever necessary review of the complete paper was carried out. Literature Review primarily focus on Green-Lean implementation in manufacturing sector like automotive, machine tools, heavy industries, aerospace etc. and secondarily on other sectors like supply chain management, transportation**,** relationship management, service etc.

Structural self-interaction matrix for GL practice bundles was developed by the team members comprising of lean practitioners and experts. Structural self-interaction matrix later on used to develop an ISM model showing relationship between the studied variables. The interaction among the GL practice bundles was analyzed using ISM. It requires examination of direct and indirect relationships between the GL practice bundles rather than considering these GL practice bundles in separation. This analysis will help the managers to devise the strategy for rolling out the integrated Green-Lean system in their organization.

3. GREEN-LEAN PRACTICE BUNDLES

Lean and its associated practices are generally considered best practices in the operations management field *(Longoni, 2013).* The integrated GL practices are interrelated to each other. There is a great risk of integrated Green-Lean system failure if practices are applied in isolation or in improper sequence. These practices are clustered in different groups. The term ‘‘bundle’’ is used to club together inter-related and internally consistent GL practices. Following GL practice bundles are used in this paper based on the literature reviewed and opinion of experts:

3.1 Waste elimination practice bundle
3.2 Green quality practice bundle
3.3 Low cost practice bundle
3.4 Green human resource management practice bundle
3.5 Health and safety practice bundle and
3.6 Green creativity and innovation practice bundle

The core content of integrated Green-Lean strategy includes practices for green HRM, cost minimization, green quality enhancement, waste elimination, health and safety, green creativity and innovation etc.

3.1 Wastage Elimination Practices

Waste may be in the form of material, energy, utilities like water, gas etc. during manufacturing. Seven types of waste can be uncovered using value stream mapping.

3.2 Green quality practice bundle

Green-Lean approach emphasizes on fusion of environmental criteria directly into cost reduction and quality control methodologies. Environmentally conscious customer demands high green quality ecofriendly products or services adhering to environmental standards. Green quality practices improve the quality in all activities and functions of the business and total supply chain. The green quality practice bundle comprises TQM, TQC, SQC and green Supplier Management/ green vendor Development.

3.3 Low cost practice bundle

The price of product is determined by the market conditions. Market share of the company is greatly boosted with selling economical and quality green products. An organization with green quality culture, minimal waste, innovative green products / green processes and rapid response to customers demand or flexibility will be able to reduce the product costs. Application of GL practices (explicitly waste elimination) in production results in cost reduction. The best practices for cost reduction are inventory reduction, and green purchasing.

3.4 Green Human Resource Management (GHRM) Practices Bundle

GHRM practices seamlessly connect various GL practices as a synchronous unit. GL HRM practices offer incredible benefits to the organization and workers. The practices in GHRM bundle includes green quality circle, communication of Green-Lean goals, effective employee development programs, building green-lean culture, rewards and appreciation and effective employee-management partnership.

3.5 Health and Safety Practices Bundle

All necessary resources like man, machine, facilities, environment etc. interact together during production. Top management has to make sure that the adequate resources and facilities are in place to satisfy occupational health and safety

needs. GL approach emphasis of reduction of Muda (wastage), Muri (strain) and Mura (Errors) during manufacturing. Obviously the risk of health and safety hazards is reduced greatly. The practices in health and safety bundle consist of five S, Six S, Poka Yoke (error proofing), Visual Management, Standardised work, Ergonomic Work station or Cell Design and Total Productive Maintenance (TPM).

3.6 Green Creativity and innovation Practices Bundle

The Green-Lean practitioners need to be creative and innovative in developing newer techniques to make - green, qualitative and affordable products. Green creativity and innovation practices bundle includes Kaizen (Continuous Improvement), TRIZ, applications of advance technologies etc.

4. Interpretive Structural Modeling (ISM)

4.1 Introduction to ISM

Original theoretical development of ISM is credited to J.W. Warfield. *Farris and Sage (1975), Sage (1977), Sage and Smith (1977)* have contributed to the development and application of the ISM methodology for a variety of purposes - especially those concerned with decision analysis and worth assessment in large scale systems. The ISM process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes *(Mishra et al., 2012; Ahuja et al., 2009).* ISM has been used by researchers for understanding direct and indirect relationships among various variables in different industries. *Faisal et al. (2007)* used ISM to analyse the enablers for Supply chain agility.

4.2 Applications of ISM

ISM is a well-known technique, which can be applied in various fields. *Wang et al. (2008)* used ISM to investigate the interactions among the major barriers which prevent the practice of energy saving in China. *Sharma et al. (1995)* utilized ISM methodology to develop a hierarchy of actions required to achieve the future objective of waste management in India. Interpretive Structural Modelling (ISM) approach have been used by *Mudgal et al. (2010)* to model and analyze key barriers of green supply chain practices. *Diabat and Kannan (2011)* developed a model of the drivers affecting the implementation of green supply chain management using an Interpretive Structural Modeling (ISM) framework. The study carried out by *Kannan et al. (2008)* analyzed the interaction of criteria that is used to select the green suppliers who address the environmental performance using Interpretive Structural Modelling (ISM) and Analytic Hierarchy Process (AHP).

4.3 Procedure for Model Development using ISM

A stepwise procedure is to be adopted to develop a model or frame work using ISM. *Ravi and Shankar (2005)* described the various steps involved in the ISM methodology as follows:

Step 1: Variables affecting the system under consideration are listed, which can be objectives, actions, and individuals etc.

Step 2: From the variables identified in step 1, a contextual relationship is established among variables with respect to which pairs of variables would be examined.

Step 3: A Structural Self-Interaction Matrix (SSIM) is developed for variables, which indicates pair wise relationships among variables of the system under consideration.

Step 4: Reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a variable A is related to B and B is related to C, then A is necessarily related to C.

Step 5: The reachability matrix obtained in Step 4 is partitioned into different levels.

Step 6: Based on the relationships given above in the reachability matrix, a directed graph is drawn and the transitive links are removed.

Step 7: The resultant digraph is converted into an ISM, by replacing variable nodes with statements.

Step 8: The ISM model developed in Step 7 is reviewed to check for conceptual inconsistency and necessary modifications are made.

4.4 Interpretive Structural Model (ISM) Development

The interrelationships among different GL practice bundles for successful implementation have been achieved through these steps mentioned above.

4.4.1 Structural Self-Interaction Matrix (SSIM)

Six GL practice bundles were identified through literature review and experts opinion. The next step is to analyze the interrelationship between these GL practice bundles using ISM. ISM methodology proposes the use of the expert opinions based on various management techniques such as brainstorming and nominal group discussion technique in developing the contextual relationship between GL practice bundles. These experts from the industry and academia were well conversant with GL practices.

'Leads to' or 'influen ces' type of contextual relationship is chosen for analyzing the GL practice bundles. This means that a particular GP practice bundle influences another practice bundle. On the basis of this, contextual relationship between the identified GL practice bundles is developed.

Following four symbols were used to denote the direction of relationship between the GL practice bundles (*i* and *j*):

V: practice bundle *i* influences practice bundle *j*

A: practice bundle *i* influenced by practice bundle *j*

X: practice bundles *i* and *j* influence each other

O: practice *i* and *j* do not influence each other since they are unrelated

Consultation and discussions with the five lean practitioners and experts, helped in identifying the relationships between the identified GL practice bundles. On the basis of contextual relationship between GL practice bundles, the SSIM has been developed. Final SSIM is presented in Table 1.

Table 1: Structural Self Interaction Matrix for GL Practice Bundles

SN	GL Practice Bundle	6	5	4	3	2	1
1	Waste elimination	A	A	A	V	V	
2	Green quality	A	O	A	V		
3	Low cost	A	A	A			
4	Green HRM	V	V				
5	Health and safety	A					
6	Green creativity & innovation						

4.4.2 Development of the initial and final reachability matrix:

The next step is to develop the initial and final reachability matrix from the SSIM.

(i) Initial reachability matrix

Obtain the initial reachability matrix from the SSIM format by transforming the information of each cell of SSIM into binary digits (i.e., 1s or 0s). This transformation has been done by substituting V, A, X, O by 1 and 0 as per the following rules. Rules for transformation are given in Table 2.

Table 2 : Rules for transformation

If the (*i, j*) entry in the SSIM is	Entry in the initial reachability matrix	
	(*i, j*)	(*j, i*)
V	1	0
A	0	1
X	1	1
O	0	0

Following these rules, initial reachability matrix is prepared as shown in Table 3.

Table 3: Initial Reachability Matrix for GL Practice Bundles

SN	GL Practice Bundle	6	5	4	3	2	1
1	Waste elimination	0	0	0	1	1	1
2	Green quality	0	0	0	1	1	0
3	Low cost	0	0	0	1	0	0
4	Green HRM	1	1	1	1	1	1
5	Health and safety	0	1	0	1	0	1
6	Green creativity and innovation	1	1	0	1	1	1

(ii) Final reachability matrix

To get Final reachability matrix, the concept of transitivity is introduced, and some of the cells of the initial reachability matrix are filled in by inference. If a variable *'i'* is related to *'j'* and *'j'* is related to *'k'*, then transitivity implies that variable *'i'* is necessarily related to *'k'*. The final reachability matrix is developed after incorporating the transitivity concept in Table 3 and is presented in Table 4 wherein entries marked † show the transitivity.

Table 4: Final Reachability Matrix for GL Practice Bundles

SN	GL Practice Bundle	6	5	4	3	2	1	Driver Power
1	Waste elimination	0	0	0	1	1	1	3
2	Green quality	0	0	0	1	1	0	2
3	Low cost	0	0	0	1	0	0	1
4	Green HRM	1	1	1	1	1	1	6
5	Health and safety	0	1	0	1	†*1*	1	4
6	Green creativity & innovation	1	1	0	1	1	1	5
	Dependence	2	3	1	6	5	4	

4.4.3 Level partitioning the final reachability matrix:

After creating the final reachability matrix, obtain the structural model. *Warfield (1974)* has presented a series of partitions, which are induced by the reachability matrix on the set and subset of different variables. From these partitions one can identify many properties of the structural model *(Farris and Sage, 1975).*

The reachability set and antecedent set for each GL practice bundles are established from the final reachability matrix. The reachability set for a particular GL practice bundle consists of the practice bundle itself and the other practice bundles, which it influences. Whereas the antecedent set consists of the GL practice bundle itself and the other practice bundles which may influence it. Subsequently, the intersection of the reachability and antecedent sets is derived for all the GL practice bundles and levels of different practice bundles are determined. The GL practice bundles for which the reachability sets and the intersection sets are identical, assigned the top level in the ISM hierarchy. The top-level GL practice bundles are those that will not lead the other GL practice bundles above their own level in the hierarchy. Once the top-level practice bundle is identified, it is discarded from further hierarchical analysis (i.e. that GL practice bundle from all the different sets) and other top-level practice bundles of the remaining sub-group are found. This iteration is repeated till the levels of each practice bundles are found out (Tables 5 to 10). Level identification process of these practice bundles is completed in six iterations.

Table 5 : Level Partition – Iteration 1

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2, 3	1, 4, 5, 6	1	
2	2, 3	1, 2, 4, 5, 6	2	
3	3	1, 2, 3, 4, 5, 6	3	I
4	1, 2, 3, 4, 5, 6	4	4	
5	1, 2,3, 5	4, 5, 6	5	
6	1, 2, 3, 5, 6	4, 6	6	

Table 6 : Level Partition – Iteration 2

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1, 2	1, 4, 5, 6	1	
2	2	1, 2, 4, 5, 6,	2	II
4	1, 2, 4, 5, 6,	4	4	
5	1, 2, 5	4, 5, 6,	5	
6	1, 2, 5, 6	4, 6	6	

Table 7 : Level Partition – Iteration 3

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1	1, 4, 5, 6	1	III
4	1, 4, 5, 6	4	4	
5	1, 5	4, 5, 6	5	
6	1, 5, 6	4, 6	6	

Table 8 : Level Partition – Iteration 4

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
4	4, 5, 6	4	4	
5	5	4, 5, 6	5	IV
6	5, 6	4, 6	6	

Table 9 : Level Partition – Iteration 5

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
4	4, 6	4	4	
6	6	4, 6	6	V

Table 10 : Level Partition – Iteration 6

GL Practice Bundle No.	Reachability Set	Antecedent Set	Intersection Set	Level
4	4	4	4	VI

Final list of Level Partitions is given in Table 11. The identified levels aids in building the final model of ISM. First level GL practice bundles are positioned at the top of model and so on.

Table 11: Final list of Level Partitions

Level	GL Practice Bundle No.	GL Practice Bundle
I	3	Low cost
II	2	Green quality
III	1	Waste elimination
IV	5	Health and safety
V	6	Green creativity and innovation
VI	4	Green HRM

4.4.4 Building the ISM-based model

The model developed with the identified GL practice bundles is shown in Figure 1. It is clear from the ISM model that the most important GL practice bundles that enables successful implementation of Green-Lean system is green human resource management, which form the base of ISM hierarchy whereas low cost practice bundles which are dependent on other GL practice bundles has been appeared on top of the hierarchy.

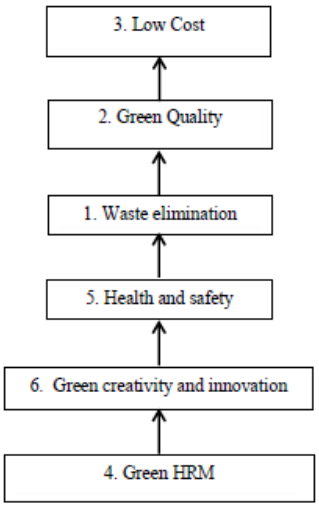

Fig. 1: ISM model: A Framework for GL Implementation

5. DISCUSSION

ISM-based model for GL practice bundles (Fig.1) recommends the priority order of implementation of GL practice bundle as follows:

1.Green Human resource management practice bundle.
2.Green creativity and innovation practice bundle.
3.Health and safety practice bundle.
4.Waste elimination practice bundle
5.Green quality practice bundle
6.Low cost practice bundle

Fig. 1 provides a direction for sustainable GL implementation in the organization in a phasewise manner. It shows the sequential approach for sustainable GL implementation. In this sequence the order of perticular practice bundle is very important. If GL implementation is not directed in the appropriate sequence then there is higk risk of its failure.

Phase1: Green human resource management

Implementation of system lay in the hands of employees. Employees may make or break the system. Integrated GL system is necessarily a human system. Top management should device the green HR policies to create and nurture culture for: Green-Lean, green creativity and innovation. Training should be provided after identified the needs of employees to develop green lean set of mind. GL goals should be communicate to employees. GL achievements of employees must be publically acknowledged, celebrated and rewarded. Employee-management relationship must be based on mutual trust. Green-Lean quality circle concept should be introduced for continual improvement and to tap the talents of workers. Thus journey towards green lean enterprise begin with proper human resource management. Human resource management provides the foundation for green lean enterprises.

Phase 2: Green creativity and innovation

Creativity can be viewed as the ability to invent or develop something new of value *(Childs, 2006; Childs and Tsai, 2010)*. Converting creativity ideas into reality is called as innovation. These ideas are filtered through certain criteria like benefits, techno-economical feasibility etc. Only viable and usable ideas are converted into real products and services.

Top management should provide encouraging environment for green creative idea generation. Values, work environment, leadership qualities, the creative contributions of its employees and the policies or existing systems to explore the creativity of its talented employees are some of the factors responsible for innovativeness of the organization. Methods that can be used to enhance creativity and stimulate imagination include synectics, lateral thinking, morphological analysis, analogy, TRIZ, mind mapping, 6-3-5 chart etc. *(Johari et al., 2011)*.

Creativity and innovation practices bundle includes slightly advance version of quality circle i.e. Kaizen (Continuous Improvement). Kaizen offers incremental improvements whereas other creative methodologies like TRIZ, latest technology for manufacturing, support of information & communication technology etc. offers breakthrough improvements. The green-lean HRM practices play an important role in creativity and innovation. The organization can launch the second phase of lean journey, once the foundation of green-lean human resources practices is established.

Phase 3: Health and safety practice bundle

Health and safety issues in products and during manufacturing are as important as quality. The practices in health and safety bundle consists of five S, Six S, Poka Yoke (error proofing), visual management, standardized work, ergonomic work station or cell design and Total Productive Maintenance (TPM). It ensures streamlined flow of information and material with minimum strain on workers. The healthy and safe working environment as well as proper work place organization is developed by these practices. In turn it helps in reduced - rejections, reworks, wastage and environmental pollution. The organization can start fourth phase of GL journey after successful implementation of health and safety practices.

Phase 4: Waste elimination practice bundle

Generally seven types of wastes like over-production, over-processing, inventory, motion, defects, waiting and transportation exist in any system. The focus of GL system is on reducing/eliminating the wastages which have negative impact on environment. Streamline processes, appropriate shop floor layout, quick changeover etc. helps in reducing the wastage. Value stream mapping is useful tool to expose wastage and to prepare a plan for its elimination.

Phase 5: Green quality practice bundle
Modern customers are aware of environmental standards, the impact of products and services on the environment etc. They are ready to support the green production. So the corporate has to create the green image through production of green products for its survival in global market. The green quality practice bundle includes TQM, TQC, SQC, Six Sigma and Supplier Management/vendor Development. To enhance the green quality in internal manufacturing facilities may adopt TQM, statistical quality control, six sigma etc. The specific quality raw material is required to manufacture the green products. Waste elimination practices (Phase 4) like VSM; standard work etc. inevitably results in quality improvement and cost reduction. This guarantees uninterrupted flow of material in the system.

Phase 6: Low cost practice bundle
The best practices for cost reduction are inventory reduction, green JIT Purchasing. Green JIT purchase practices are useful in this endeavour. Green JIT purchase advocates few reliable green suppliers. Cost reduction is the significant benefit derived from green-lean systems along with energy and environment conversion. Cost reduction is the ultimate result of persistent implementation of GL system throughout the supply network. The low cost practice bundle has highest dependence and lowest driving power. Hence it appears at the top of ISM model.

6. CONCLUSIONS

6.1 *Research findings and implications*

The major GL implementation issues are associated with human being, culture, facilities and resources etc. Employees of the organization embrace the Green-Lean philosophy from bottom of heart for sustainable GL implementation. Change management and knowledge management have to play big role in transformation into green-lean enterprise. Change in existing – processes, operating system, manufacturing system, culture is inevitable. Organization has to develop mutually beneficial relationship with vendors and customers. The financial performance of green-lean organization must improve if it follows GL system.

This paper makes develops a model to implement six green-lean practice bundles. Although, ample literature is available on green-lean manufacturing and various issues related to it. The relationship between green-lean practices has not been modelled for manufacturing organizations. The present model will help managers and green-lean practitioners to understand the relationship in detail. This research assumes significance contribution in this regards.

In this research, green-lean practices of manufacturing organizations are modelled in terms of their driving power and dependence. Strong driving power (with weak dependence) practices should be dealt with strategic actions as they influence other practices. Cost reduction without compromising on green quality can be achieved by improving the driving practices continually. The purposes of present research include identification and ranking the GL practices and their influence on cost reduction. It includes a number of vital practices, therefore, a model showing interaction would offer a great help to managers and green-lean practitioners. Contextual relationship between the green-lean practices can be developed using brainstorming. An overall implementation structure can be built for the GL system using ISM. The overall effort put in the present research has ensued in identification of significant green-lean practice bundles for sustainable implementation in manufacturing organizations and in development of interrelationships to gain managerial insights into the priority of these practices.

This work can be a guide for taking appropriate action to roll out the successful green-lean deployment. The success of global integrated manufacturing strategies such as green-lean will not be entirely based on application of appropriate tools and techniques alone but also on the interactions between top management and employees. Top management has to play important role in how the green-lean strategy is understood, implemented and deployed effectively throughout the business.

6.2 *Limitations and Suggestions for future research*

The present study is primarily focused on green-lean in manufacturing sector. The GL issues in other sectors may slightly differ from manufacturing sector. The issues may vary based on country, geographic location within the country and work culture of the organization. The ISM model is highly dependent on the experience and judgment of the expert team. The GL system model developed needs to be validated.

Once the green-lean practice bundles are identified, a number of research propositions may be proposed that would be appropriate for further study and research relating to the modelling the green-lean practice bundles using various modelling techniques like AHP, ANP etc. Implementation strategy can be developed for successful and sustainable implementation of green-lean using tools like Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Balance Score Card and Hoshin Kanari policy deployment etc. Research work in this area may act as a roadmap for successful green-lean implementation. It would be a light house to green-lean practitioners and researchers.

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