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Lean Environmental Management Integration System for Sustainability of ISO 14001:2004 standard implementation

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Abstract:

Purpose: The purpose of this study is to present a model for integrating Lean Principles with ISO 14001 Environmental Management System.

Design/methodology: To achieve the objective of the study, the methodology used in this study is based on preliminary literature review of ISO 14001 standards and Lean Principles as well as certain case reports from various proponents and authors of ISO 14001 and Lean as noted in various articles and journals and some books.

Findings: The findings of this study are a new model called Lean Environmental Management Integration System (LEMIS) has been developed and leads to the creation of these measurement standards for evaluating the organization, making its environmental efforts more realistic, focused and attainable.

Research limitations/implications: Future research should be conducted case studies in this direction are required to be conducted for examining the feasibility of amalgamation and implementing ISO 14001:2004 standards with the philosophy of Lean Principles to enable the achievement of world class standards.

Practical implications: This model helps to eliminate any wasteful processes in the organization's implementation of the ISO 14001 standard thus leading to higher environmental performance. Integrating the standard with Lean principles through LEMIS model helps to

specify these performance measures making the standard achieve sustainability and continual improvement.

Originality/value: This study presents a unique approach of integrating the two main models, namely Lean Principles and ISO 14001 Environmental Management System, as a single framework benefiting contemporary organizations.

Keywords: Lean Principles, EMS, ISO 14001, Integration, Continual improvement, Sustainability

1. Introduction

ISO 14001 spells out the criteria for developing an environmental management system (EMS). It is crucial as it states how the EMS should be managed and how an organization should be structured to become more environmentally sensitive. ISO 14001 is a voluntary standard; therefore, organizations are not required by law to implement the standard. The standard has no specific measures of performance, but it deals mainly with the managerial process instead of specifying environmental outcomes and consequences. This is one of the main criticisms towards the standard. Various research studies have cast doubt on the benefits and sustainability of ISO 14001 certification. Some of the studies accuse the standard of not focusing on the environmental performance of an organization or company (Krut & Gleckman, 2002). Rondinelli and Vastag (2000) claim that the standard assumes that firms which have been certified have a management system in place for measuring their environmental results and effects. The main factor making the standard unsustainable is the fact that it does not specify environmental performance measures for organizations.

Environmental measurement systems are developing more rapidly than ever, but most current measurement systems still fail to provide important information . For example, most of the existing environmental data sources were originally designed to monitor regulatory compliance, not measure environmental performance. Measuring environmental performance allows management to identify program successes and failures, and assess the level of environmental goals being met.

Efficiency is a crucial dimension in manufacturing. Lean manufacturing focuses on eliminating waste from organizational processes with a view to deliver more value to a customer. Thus, integrating Lean with the ISO 14001 standard will make the standard more sustainable because it will be customer-oriented, which is consistent with the objectives of many organizations (Simpson & Power, 2005; Shah & Ward, 2007). The research done by Puvanasvaran, Kerk, Suresh and Muhamad (2012) lean principles have positive and highly significant relationship with ISO 14001 requirements. The integration of lean principles in ISO

14001 will serve practical methods for ISO14001 EMS to achieve the continual improvement (Puvanasvaran et al., 2012).

Implementing Lean principles requires an organization to identify all the processes that are involved in the conversion of raw materials into a finished product for the customers. This process is known as mapping the value stream. Integrating Lean with ISO 14001 standard ensures that the environmental impact of all processes leading to the delivery of products to customers are identified and dealt with effectively (Sroufe, 2003; Montabon, Sroufe & Narasimhan, 2007). This will lead to higher environmental performance of organizations. Puvanasvaran, Kerk and Muhamad (2011) effectiveness of integrating Lean and EMS can be realized by adopting processes and procedures designed to eliminate waste and create an economically sustainable work environment.

2. Literature review

This section will focus on an introduction to ISO 14001 and Lean system and subsequently provides an in-depth literature review of ISO 14001 and Lean system related papers published in journals, book and reports.

The hallmark of the ISO 14001 standard that differentiates it from other environmental standards is the integration of managerial decision-making with environmental protection efforts (Raines, 2002). This is a more effective approach that divorces environmental protection efforts from other management activities. Despite its merits, several criticisms have been leveled against the ISO 14001 standard. To start with, it has been argued that the standard does not focus on environmental outcomes but instead it describes managerial processes that lead to such outcomes (Sharma, 2003). This nature of the standard makes it difficult to evaluate organizations' environmental performance based on a standard benchmark (Corbett & Kirsch, 2001). Secondly, compliance with the standard is voluntary which means some organizations may not comply with it. This aspect reduces the effectiveness of the standard in reducing emissions to the environment (Smith, 2001). Some studies have also questioned the cost-benefit value of the standard claiming that the costs of implementing it exceed the benefits for some firms.

Today application of lean principles is not confined to manufacturing operations only but has extended to all forms of businesses including insurance, health institutions, government departments, airlines, etc. In every firm that has adopted these principles the main goal is to improve the organization's performance by eliminating unnecessary activities (Eng, 2011). The key challenge in adopting a Lean philosophy for non-manufacturing organizations is determined which principles apply and how to apply them. This is where the principles of continuous learning and improvement gain even more significance.

Lean principles are essentially about reducing wastage in organizational processes. Thus, establishing an organizational culture with a waste elimination mind-set is the first step towards implementing the Lean philosophy (Visser, 2010). It is also necessary to change the organizational structure to make it more flexible. Flexibility allows the redeployment of organizational resources according to customer's needs. To avoid employees' resistance to change it is crucial to involve all employees in the adoption of the principles from the start (Cowley, 2007). In addition, there should be a comprehensive and efficient information system linking downstream and upstream partners of the organization to enhance demand and supply visibility.

Lean thinking exists in conceptual form which means that it is not a particular methodology to be applied to organizational processes (Pun, Fung & Wong, 2006). However, the philosophy provides a unified focus for organizational operations, which is eliminating wasteful activities which do not deliver value to customers (Sarkar, 2008).

Picchi (2001) the term "techniques" (or tools) is generally used for routines, standardized for training and communication, such as Kanban, Total Productive Maintenance (TPM), 5S, Poka-yoke. We can say that techniques are more related to operational aspects, system integration aspects, and philosophy to conceptual aspects (Table 1). In truth, the separation of technique/system/philosophy is not simple. Every technique (Kanban, for example), when taught, is integrating to the system (e.g. The JIT production system) and several conceptual aspects, or philosophy, are emphasized (pulled production, total quality, etc.) (Picchi, 2001). The most important element in lean thinking is a philosophy rather than the system and techniques. Besides a conceptual basis provided by philosophy, a company needs practical application templates, in the operational level, to design its systems and select techniques. The direct application of techniques developed in an industry to a different sector is limited, due to specific characteristics of each industry (as stated by Koskela and Vrijhoef (2000)). In this case, more adaptation is demanded in the operational extreme (techniques) and lies in the conceptual extreme (philosophy).

Level	Aspects	Focus	Aspects	Adaptation demanded
Philosophy	Conceptual	Permanent goals	**⇓ Operational Conceptual ⇑**	**⇓ More Less ⇑**
System	Coordination aspects	How techniques are integrated, coherently with philosophy		
Techniques	Operational	How to put the philosophy in practice		

Table 1. Lean Thinking: Philosophy, system, and techniques (Picchi, 2001)

To understand the concept of lean systems, it is essential to understand its principles. Womack and Jones (1996) organize the fundaments of Lean Thinking in five principles:

- Value Definition
- Identifying the Value Stream
- Making Value-Creating Steps Flow
- The Pull Principle
- Perfection

The 5 lean principles give us a better understanding of the lean philosophy and its core concepts. To apply these concepts in different environments (as other industries) it is interesting to deploy these ideas or principles in detailed concepts, but not reaching the operational field. Table 2 presents a proposal of this deployment in core elements. The conceptual part of this Table is presented as a tree, expanding from objectives and Womack and Jone's five values to more detailed concepts, named "core elements", presented in two levels of detailing (columns three and four).

Objectives	Principles	Core elements	
Permanently improve company's competitiveness by: • eliminating waste • consistently attending client's requirements in variety, quality, quantity, time, price	VALUE	Enhanced product / service package value	Solution that enhances value for the client
			Product variety
		Time based competition	Production lead time (order to delivery)
			Product development lead time
	VALUE STREAM	High value adding in the extended enterprise	Value stream redesign eliminating waste
			Suppliers involvement in production and product development systems
	FLOW	Dense, regular, accurate and reliable flow	Dense flow , with hight adding value time, clear pathways and communication
			Regular flow - paced by client / next process demand
			Accurate and reliable flow
		Standard work	Work standardization
			Transparency
			Low level decision
	PULL	JIT production and delivery	Pull versus push system
			No overproduction, WIP (Work In Process) reduction
			Demand smoothing : harmonizing market variations and production flexibility
			Reflecting product variation in short periods of production
		Flexible resources	Information flexibility
			Equipment flexibility
			Workers flexibility
	PERFECTION	Learning	Fast problem detection
			Fast problem solving in lower level and solution retention
			Evolutionary learning
		Common focus	Leadership and strategy
			Structure
			Client and production focus diffusion
			Human respect
			Total employee involvement
			Total system diffusion

Table 2. Lean Principles core elements (Picchi, 2001)

3. Research methodology

The research design is one of the key factors in determining the effectiveness of the research study. If the method applied does not meet the needs of the objectives, the findings and analysis of data collected are wasted. Therefore, this study was intended to develop Lean–EMS integration model to help organization to sustain the Environmental management system though effective continuous improvement method. Integration of Lean and ISO 14001 standard requires the application of Lean principles into the implementation of the standard. Figure 1 shows the framework development steps. The framework was broken into 6 phases and the details as per below:

- Phase 1: In phase 1, data collections in Environmental management system were identified by review of papers, journals, books, magazines, report and dissertations. This step was part of the Literature Review effort.

- Phase 2: In Phase 2, information's from phase 1 were used as a base. We elaboration of the ISO 14001:2004 clauses from 18 main clauses to 42 sub clauses which will give a better understanding of the clauses and ensures that all the clauses are well considered for the standards sustainability. Use who, how, when and why as an input, where and what as an output to identify the essential of each sub clauses and help to understand better on the ISO14001:2004 standards. The outcome of WH Question was reviewed and validated by an EMS expert from manufacturing industry.

- Phase 3: In phase 3, data collections on Lean were identified by review of papers, journals, books, magazines, report and dissertations. This step was part of the Literature Review effort.

- Phase 4: In phase 4, five principles of lean were detailed out into nine core elements which give a better view of each principle. The framework for this phase was adapted from Picchi (2001) research paper.

- Phase 5: In this phase the 42 sub requirements of ISO14001 were integrated with the Lean principles Core element. This was done by crossing the each Sub requirement of the ISO 14001 with each lean principles core element. The 42 sub requirements of ISO14001 represented in rows and the Lean core elements were represented in columns. Figure 2 illustrates an example of the integration process.

- Phase 6: This is the final phase of the framework development. The critical success factor for the framework were determined through literature review and based on the preliminary data which was collected through questionnaire survey. Besides that, the developed framework was validated by lean and EMS experts. Eight experts from the

related field were invited to validate the framework. Focus group methodology was adopted in this phase.

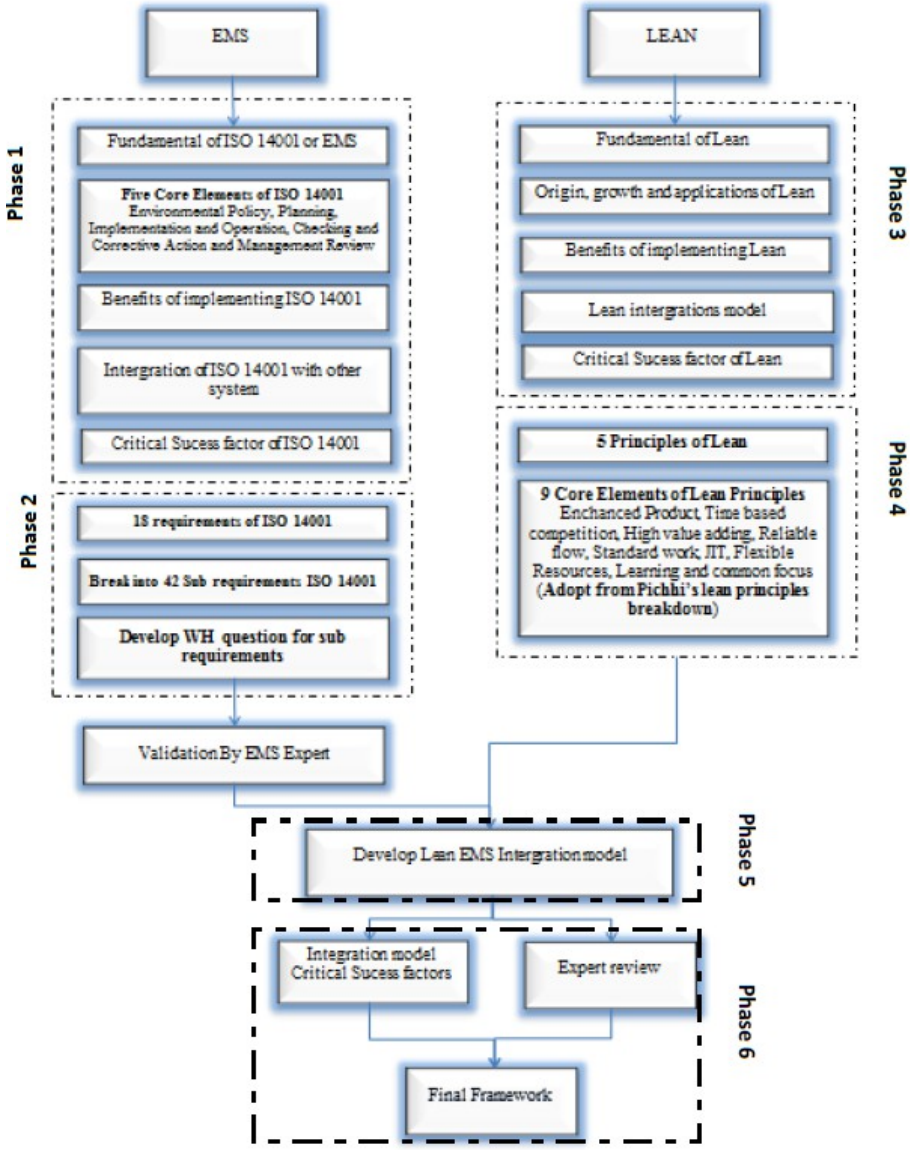

Figure 1. Framework Development Flow

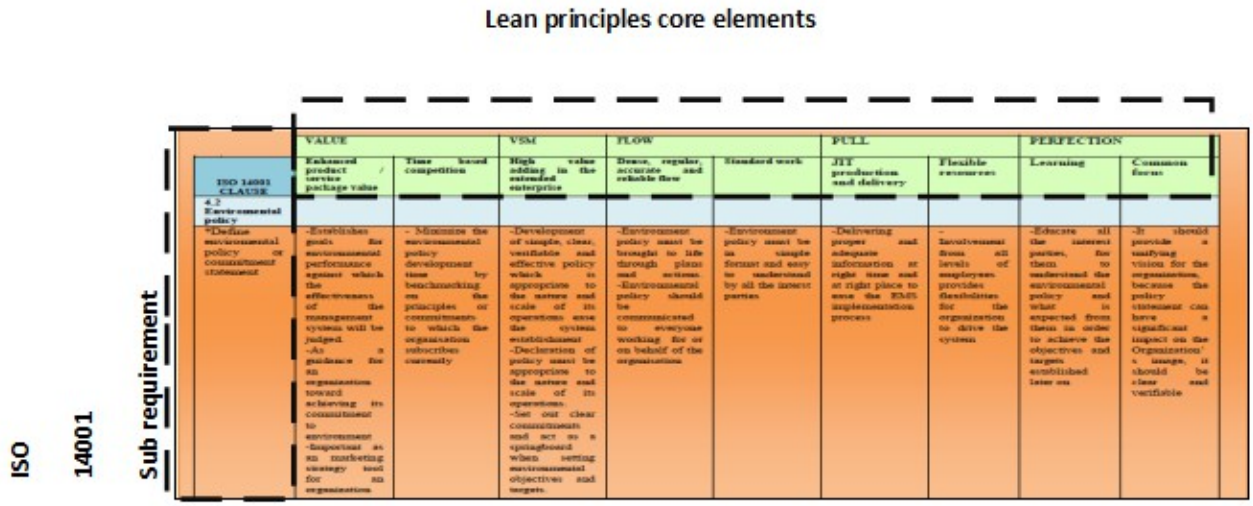

Figure 2. Integration uses Cross tabulation method

4. Result and discussion

The 18 main requirements of ISO 14001 standard were identified in phase 2 for framework development. These requirements were adopted from the ISO 14001:2004 standard. Table 3 shows the 18 requirements of ISO14001 standard. Based on the ISO 14001:2004 standard, the 18 requirements were further refined into 42 sub requirements. Table 4 shows an example how the main requirements were refined into sub requirements. The refinements of the clauses were done by the researcher together with EMS expert from an OEM industry.

The identified sub requirements were then analysed using the WH question methodology. Yang et. al., (2003), mentioned a question and answer event shows a great consistent similarity to all its elements in discussing the correspondence of WH-questions. The purpose of this analysis is to understand in detail on each sub requirements. Six questions were developed to analyse each sub requirements. The questions are as per below:

- **Who** is responsible for implementation of the requirements?
- **How** to establish the requirements?
- **Where** the requirements were applied?
- **When** the requirements need to be implement, control and valuate?
- **Why** the requirement needed?
- **What** is the impact of the requirement to organizations?

The handbook of environmental management system was used as main reference to answer all the WH questions. Table 5 shows an example on how the questions were answered for the

requirements. The WH question analysis validated by an EMS expert from manufacturing industry.

In phase 3 of framework development, the characteristic of Lean principles were identified through extensive literature reviews and questionnaire survey. The important elements of Lean principles such as the requirements, critical success factors, elements of continuous improvement and elements of sustainability were identified in this phase. The information gathered in this phase was useful for the researcher in the integration phase.

However for the phase 4, the five principles of lean were detailed out into nine core elements which give a better view of each principle. The framework for this phase was adapted from Pichhi (2001) research paper. Table 2 represents the core elements of lean principles.

PDCA	REQUIREMENT	ISO 14001 CLAUSE
PLAN	1	4.1 General Requirement
	2	4.2 Environmental policy
		4.3 Planning
	3	*4.3.1 Environmental Aspects*
	4	*4.3.2 Legal and Other Requirements*
	5	*4.3.3 Objectives, Targets, and Programs*
DO		4.4 implementation and operations
	6	*4.4.1 Structure and Responsibility*
	7	*4.4.2 Competence, Training, and Awareness*
	8	*4.4.3 Communications*
	9	*4.4.4 EMS Documentation*
	10	*4.4.5 Control of Documents*
	11	*4.4.6 Operational Control*
	12	*4.4.7 Emergency Preparedness and Response*
PDCA	**REQUIREMENT**	**ISO 14001 CLAUSE**
CHECK		4.5 Checking
	13	*4.5.1 Monitoring and Measurement*
	14	*4.5.2 Evaluation of Compliance*
	15	*4.5.3 Non-conformances, Corrective and Preventive Action*
	16	*4.5.4 Control of Records*
	17	*4.5.5 Internal Audit*
ACT	18	4.6 Management Review

Table 3. 18 requirements of ISO14001 standard

REQUIREMENT	ISO 14001 CLAUSE	SUB-REQUREMENTS
1	4.1 General Requirement	1.Establish, document, implement and continually improve EMS and how to fulfil the requirements
		2.Define and document the Scope of EMS

Table 4. Refinement of ISO14001 standard requirements

	ISO 14001 CLAUSE	
	4.1 General Requirement	
WH QUESTIONS	1. Establish, document, implement and continually improve EMS and how to fulfil the requirements	2. Define and document the Scope of EMS
WHO (Responsible)	-Top Management	-Top Management and Management Rep
HOW (Establish)	-Create awareness of EMS from top to bottom management -Provide training and appoint representation from all levels of the business unit	-Identify the area, process, activities and etc, in an organization that EMS applied
WHERE (Application)	-Whole organization, others working on behalf of the organization and available for public	-Area, activities, process and etc that EMS is applied
WHEN (Formation, implementation, controls and valuation)	-Initial stage of EMS implementation	-Initial stage of EMS implementation
WHY (Purpose)	-To create awareness of the EMS standards, use as a guidance or reference in EMS implementation and also continually improve to sustain the EMS.	-Management can be more focused and ease to manage all the aspect that significant for the environment.
WHAT (Impact)	-Create awareness on environmental management to stay competitive in the market -Social responsibility	-Create awareness on environmental management to stay competitive in the market -Social responsibility

Table 5. WH Question Analysis

In phase 5 of framework development, the sub requirements of ISO 14001 standard were integrated with the core elements of Lean principles. This was done by crossing each sub requirements of ISO 14001 standard with the core elements of Lean principles. According to Pichhi (2001), crossing the variables is one of common techniques which has been used to cross-tabulate variables in his studies. This researcher has used this technique to design the system and select, adapt or create techniques which are coherent with lean philosophy.

The 42 sub requirements of ISO14001were represented in rows and the Lean core elements were represented in columns. As an example, ISO 14001 sub requirement 1 (SR1) was crossed with lean core element 1 (CE1), then crossed with CE2 until CE9. The same steps were used for rest of ISO 14001 sub requirements. Appendix B shows the matrix of how the ISO 14001 sub-requirements cross-tabulated with lean core elements.

The handbook of EMS and information gathered through extensive literature reviews were used as reference during the cross-tabulation processes. Appendix C shows an example on how the sub requirements of ISO 14001 standard were integrated with the lean principles core elements.

5. A proposed framework for sustainability management – Lemis

The belief held for a long time was that Lean principles and ISO 14001 had different goals and thus they could not be integrated (Maxwell, 2005). This made companies develop an EMS and Lean culture differently. However, studies have shown that there is a close link between environmental management and reducing wastage in organizations (Deming, 2004). Therefore, governments and researchers have advocated for the integration of Lean principles with organizations' green initiatives.

Integration of Lean and ISO 14001 standard requires the application of Lean principles in the implementation of the standard.

This calls for the organization to think of the ISO 14001 implementation as a product or service which has to be produced based on Lean principles (Russell, 2008). Thus the five principles of Lean are applied in every aspect of implementing the ISO 14001 standard.

Lean principles when applied to ISO 14001 standards lead to the achievement of more value by an organization in the implementation of its environmental programs. This value stems from the definition of clear environmental goals and establishment of environmental outcomes against which managerial decisions can be assessed (Cowley, 2007). This integration is especially important because the ISO 14001 standard does not define outcomes for measuring environmental performance (Russell, 2008). Moreover, they make the standard more actionable through the establishment of an action plan with specific roles and responsibility to implement it and a waste free manner.

Integration of Lean philosophy and ISO 14001 standards involves linking the nine core elements of lean with the implementation of the ISO 14001 standard and names it as LEMIS model as shown as Appendix D. For instance, a clear definition of the organization's environmental policy will help to improve the firm's environmental performance. Fast-tracking the implementation of such as policy will make the organization beat its competitors by winning customers who are more environmentally sensitive. This aspect relates to time-based competition under Lean principles (Covington, 2008). Moreover, the establishment of a clear environmental policy and educating employees on the same leads to consistent performance of the organization on the environment front. This aspect relates to the core elements of standard work, high value adding, learning, and reliable flow in Lean philosophy (Cheng, 2008). Thus, integration of Lean with an ISO 14001 standard essentially entails applying the core elements of the philosophy in the implementation of the standard.

The inputs of the LEMIS model are organizational goals for an effective EMS and enhanced environmental performance. These goals are important in helping the organization to enhance its reputation in the marketplace for being environmentally sensitive (Cheng, 2008). These goals are facilitated by Lean principles which help to remove wasteful processes in the EMS by

encouraging perfection in every aspect of the system. The outputs of the integration model are an effective EMS and better environmental outcomes by an organization.

Before developing the inputs of the LEMIS model, the organization has to come up with an environmental policy. This policy is then converted into an action plan with clear and measurable goals which become the inputs of the model (Russell, 2008). The goals are aimed at reducing the environmental impact of all the organizational processes.

As a result of the integration of Lean principles with the ISO 14001 standard, the output of the LEMIS model includes a more effective and efficient EMS and better performance of the organization on the environmental front (Cowley, 2007). Effectiveness of the EMS is enhanced by clearly defined goals and the establishment of measurable environmental outcomes. These factors in turn lead to better environmental performance of the organization.

The deliverables of the LEMIS model are a more effective EMS which is well understood by all employees in the organization and higher environmental performance by the organization since all of the firm's operations will have a common focus on reducing the impact of its operations on the environment (Bansal & Bogner, 2002).

An EMS that is based on the guidelines of the ISO 14001 standard only may not be effective as the standard does not specify environmental outcomes to be used to measure the organization's performance. Integrating the standard with Lean principles, however, leads to the creation of these measurement standards for evaluating the organization, making its environmental efforts more realistic, focused, and attainable (Cragg, 2005). The LEMIS model also eliminates any wasteful processes in the organization's implementation of the standard thus leading to higher environmental performance.

6. Critical success factors of implementation of the Lemis model

Several critical factors that determine the success of implementing of lean principles with ISO14001 integration identified. Management commitment, communication, training, teamwork, quality commitment, employee welfare and employee involvement, amongst other factors; are classified as the most pertinent issues critical for the successful integration of lean principles in ISO 14001. From the summary of studies done by researchers in Table 6, the management approach success factor emphasized on the commitment and support from top management was seen to be a successful implementation of this integration model. However the communication must be consistent and sharing best practices throughout the departments or business units and all employees in the organization. Employees need training to build the skills and educate for quality work and creating a sense of self belongings by engaging them in small group activities and team works. This creates better understanding between employees and management, which will be helpful in future stages and make employees a decision maker

than an ordinary worker. Each individual has an important part to play in increasing the quality of products and share any responsibility for the quality of products. All employees are aware of their responsibility in an organization and work closely with others.

Team members' opinions and ideas are considered before making a decision. The management should consider the welfare of employees and do everything possible to reduce or eliminate layoffs in this process. The involvement of employee is important, employees should give more planning and quality responsibility, encouraged to involve in the production process and all employees' suggestions are objectively evaluated. Figure 3 illustrates the elements of critical factors for a successful of lean principles and ISO 14001 integration.

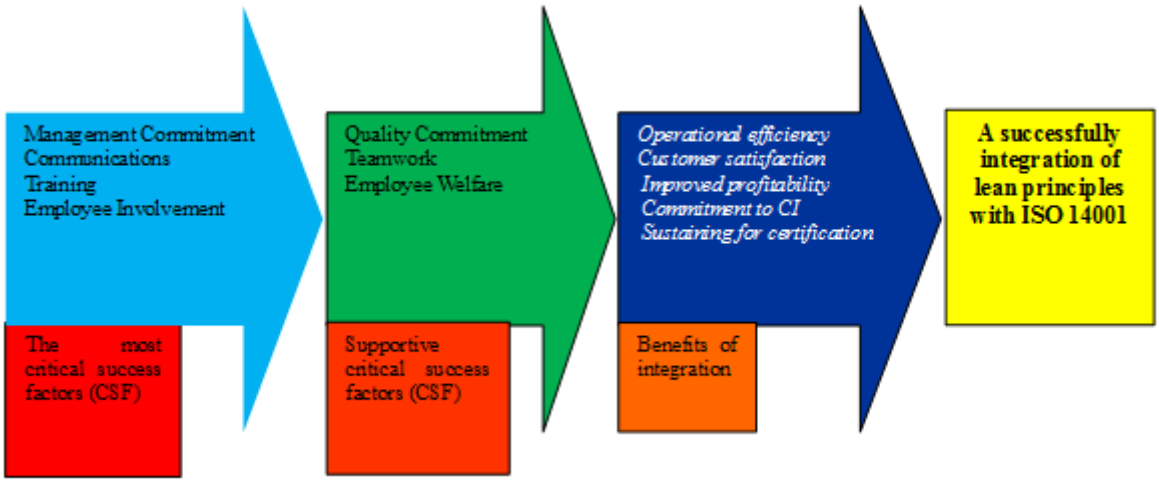

Figure 3. Elements of critical factors for a successful of lean principles and ISO 14001 integration

Critical Success Factor	ISO 14001 implementation	Lean implementation
1. Top Management Commitment	Ambika & Amrik (2004), Clement (1996), Joyce (2009), Kuhre (1995), Lim-Teck & Lee (2001), Nalini & Bonnie (2004), Pun, Hui & Lee (2001), Wee & Quazi (2005), Zutshi & Sohal (2004)	Achanga, Shehab, Roy & Nelder (2006), Forrester & Soriano-Meier (2002), Khim & John (2009), Ross & Associates (2004), Sebhatu & Enquist (2007), Worley & Doolen (2006),
2. Communication	Ambika & Amrik (2004)	Khim & John (2009), Sebhatu & Enquist (2007), Worley & Doolen (2006)
3. Training	Lim- Teck & Lee (2001)	Achanga et al. (2006), Boyer (1996), Sebhatu & Enquist (2007)
4. Teamwork	Ambika & Amrik (2004), Clement (1996), Zutshi & Sohal (2004)	Achanga et al. (2006), Boyer (1996)
5. Quality Commitment	Clement (1996), Kuhre (1995), Lin (1995),	Boyer (1996)
6. Employee Welfare	Ambika & Amrik (2004), Thornton (2000), Wee & Quazi (2005)	Kumar, Garg & Garg (2009)
7. Employee Involvement	Pun et al. (2001)	Emiliani & Stec (2005), Ross & Associates (2004)

Table 6. Critical Success Factors for Lean and ISO 14001 implementation

7. Conclusion

This research investigates how the ISO 14001 standard can be made more sustainable by integrating it with Lean principles. The principles which focus on eliminating wasteful organization processes can be integrated with ISO 14001 to make it more efficient and effective in its application to organizations' EMS systems. The research explains how the core elements of lean philosophy can be linked to ISO 14001 in a joint LEMIS model, the inputs and outputs of the model, and the expected outcomes.

There are several factors which make ISO 14001 standard unsustainable. First, the standard is voluntary which means that it may not be adopted by some organizations, especially those that do not perceive any value in implementing the standard. Some firms have also argued the cost of implementing the ISO 14001 standard exceeds the benefits especially for small firms. However, the main factor making the standard unsustainable is the fact that it does not specify environmental performance measures for organizations. Integrating the standard with Lean principles through the LEMIS model helps to specify these performance measures making the standard achieve sustainability and continual improvement. Organisations over the past few decades have focused on applying the principles of Lean and EMS for a sustainable development and optimising their production resources. The primary objectives behind the application of such standards are both cost savings and environmental considerations. The business models developed along the lines of these principles are guided by the need for continual improvement in production processes. Considering the challenges posed by the rapid changes within the business environment this study contributes to the development of a new framework know as Lean Environmental Management Integration system (LEMIS) that helps the firms in complying with the needs of sustainable growth and development objectives. The study in another way will help or lead more organizations to adopt the EMS and lean principles to fulfil their management objective and social responsibility in terms of environmental issues.

The article concludes by stating that more case studies in this direction are required to be conducted for examining the feasibility of amalgamation and implementing ISO 14001:2004 standards with the philosophy of Lean Principles to enable the achievement of world class standards.

Considering the standards complexity and its characteristics, we can say that important steps have been done, even if compared to other standards. We conclude that a lot is still left, until we have a real case of application covering simultaneously most core elements and ISO 14001 flows.

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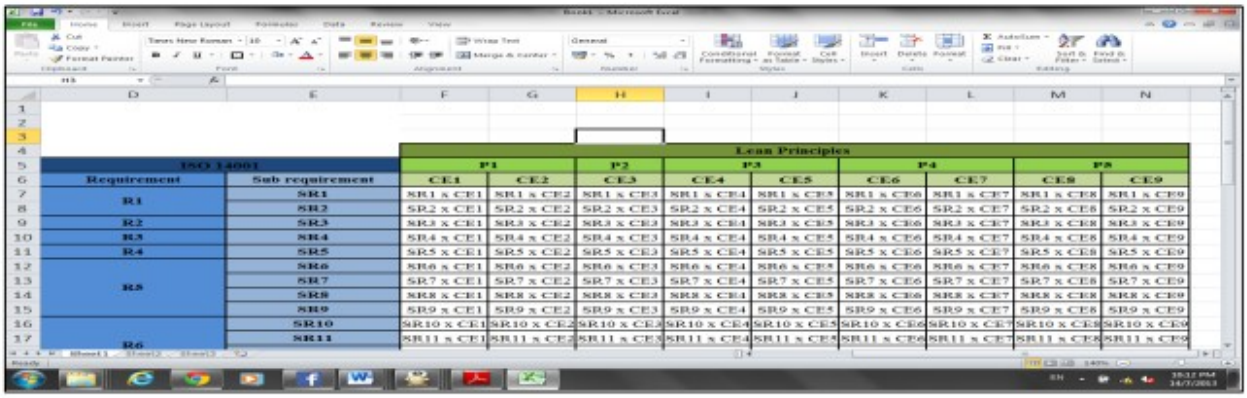
Appendix A. Lean Principles core elements

Principles	Core elements	
VALUE *(P1)*	**Enhanced product / service package value *(CE1)***	Solution that enhances value for the client
		Product variety
	Time based competition *(CE2)*	Production lead time (order to delivery)
		Product development lead time
VALUE STREAM *(P2)*	**High value adding in the extended enterprise *(CE3)***	Value stream redesign eliminating waste
		Suppliers involvement in production and product development systems
FLOW *(P3)*	**Dense, regular, accurate and reliable flow *(CE4)***	Dense flow, with hight adding value time, clear pathways and communication
		Regular flow-paced by client / next process demand
		Accurate and reliable flow
	Standard work *(CE5)*	Work standardization
		Transparency
		Low level decision
PULL *(P4)*	**JIT production and delivery *(CE6)***	Pull versus push system
		No overproduction, WIP (Work In Process) reduction
		Demand smoothing : harmonizing market variations and production flexibility
		Reflecting product variation in short periods of production
	Flexible resources *(CE7)*	Information flexibility
		Equipment flexibility
		Workers flexibility
PERFECTION *(P5)*	**Learning *(CE8)***	Fast problem detection
		Fast problem solving in lower level and solution retention
		Evolutionary learning
	Common focus *(CE9)*	Leadership and strategy
		Structure
		Client and production focus diffusion
		Human respect
		Total employee involvement
		Total system diffusion

Appendix B. Integration using cross-tabulation methods



Legend
ISO 14001 requirement (Rx, x=*1-18*)
ISO 14001 Sub requirement (SRx, x=*1-42*)
Lean principles (Px, x=*1-5*)
Lean principles core element (CEx, x=*1-9*)

Appendix C. Sub requirement 1 integrated with 9 lean principles core elements

ISO 14001 CLAUSE	Lean 1st principle "Value"	
4.1 General Requirement	**Enhanced product / service package value (CE 1)**	**Time based competition (CE2)**
***Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)**	-To stay competitive in the market -Able to deliver the customer needs -To show social responsibilities towards the environment	-Shorten implementation time with proper implementation planning
***Define and document the Scope of EMS (SR2)**	-Implementation of EMS will be more effective since the area, activities or processes involved were defined	-Organization will be more focused and easy to manage all the aspect that significant for the environment within short period of time

Sub requirement 1 integrated with 1st lean principles core elements

ISO 14001 CLAUSE	Lean 2nd principle "Value stream mapping"
4.1 General Requirement	**High value adding in the extended enterprise (CE 3)**
***Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)**	- Eliminate non value added procedures and activities towards effective implementation
***Define and document the Scope of EMS (SR2)**	-Mapping and eliminating unrelated processes, activities and procedures to ensure that management can be more focused and ease to manage all the aspect that significant for the environment.

Sub requirement 1 integrated with 2nd lean principles core element

ISO 14001 CLAUSE	Lean 3rd principle "Flow"	
4.1 General Requirement	**Dense, regular, accurate and reliable flow (CE 4)**	**Standard work (CE 5)**
***Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)**	-Adopting good coordination and planning activities among those involved in the system to enhance the implementation of the system	-Standardization of procedures among the involving parties -Use database to manage data and exchange information's
***Define and document the Scope of EMS (SR2)**	-Clearly define the scope which directly links the management system with the activities, products and services	-Scope should be simple and easy to understand by all interest parties.

Sub requirement 1 integrated with 3rd lean principles core elements

ISO 14001 CLAUSE	Lean 4th principle "Pull"	
4.1 General Requirement	**JIT production and delivery (CE 6)**	**Flexible resources (CE 7)**
***Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)**	-Delivering proper and adequate information at right time and at right place to ease the EMS implementation process	-Involvement from all levels of employees provides flexibilities for the organization to drive the system
***Define and document the Scope of EMS (SR2)**	-Area of scope should be focused and achievable	-Involvement from all levels of employees provides flexibilities for the organization to drive the system

Sub requirement 1 integrated with 4th lean principles core elements

ISO 14001 CLAUSE	Lean 5th principle "Seek for perfection"	
4.1 General Requirement	**Learning (CE 8)**	**Common focus (CE 9)**
***Establish, document, implement and continually improve EMS and how to fulfil the requirements (SR1)**	- Benchmarking on successful EMS practitioners gives a learning opportunity for the involve parties -Provide adequate training for the employees to drive the whole system	-Creating means for all workers participation in processes improvement, including sub-contractors and other interest parties
***Define and document the Scope of EMS (SR2)**	-Ensure adequate trainings are available for the employees to drive the whole system	-Creating means for all workers participation in processes improvement, including sub-contractors and other interest parties

Sub requirement 1 integrated with 5th lean principles core elements

Appendix D. LEMIS Model