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## Understanding Role of Lean in Humanitarian Supply Chain

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### Abstract

This is an explorative paper, which seeks to explore how we can create an efficient humanitarian logistics & supply chain applying the concepts of Lean Management. The Supply Chain becomes an integral part of the operation, especially during humanitarian operations as many sectors come together to respond. These sectors include the government sector, armed forces, private sector, non-government sector, and individuals. To bring together all actors, we need the help of technology along with Lean Management Principles. Hence, one of the main aspects of humanitarian operations that we will consider is the coordination and correlation of the supply chain and logistics that can be facilitated by Lean principles combined with modern technology. We study the top-ranking journals published on the subject of Humanitarian Operations and Lean Management. We review the period from 1995 until 2018 to understand and study the top-ranking journals. A set of keywords are used to shortlist the relevant articles. The study aims to add knowledge for researchers, practitioners and policymakers.

*Keywords:*

*Lean Humanitarian, Operations Management, Humanitarian Supply Chain, Lean Supply chain, Humanitarian Operations management*

### 1. Introduction

Natural disasters are something that the world cannot avoid. A natural disaster can take different forms and usually results in loss of life and economic damage. The management of a natural disaster poses immense challenges and requires adequate resources.

Lately, due to various factors, the humanitarian operations in the wake of a disaster are facing more and more resource constraints particularly during the recent period of economic recession. Though we have come a long way from the recession, it's after-effects are still lingering and demonstrated by the reticence of organisations to take part in humanitarian work. This has affected non-profit

organisations by cuts to programmes, reduction in salaries, reduced workforce, and delays to vendor payments.

When it comes to managing humanitarian operations in natural disasters, even a very simple scenario turns usually into a complex one, so the conduct of humanitarian operations has gained exponential importance from a logistics, academic and practitioner perspective. The various aspects cited as challenging during humanitarian operations include the estimation of demand, smooth collaboration of the supply chain, identification and understanding of moving along the life-cycle and post-disaster reconstruction. The logistics strategy specially created during any humanitarian operations should be customised to promptness (i.e. promptness to respond effectively). This promptness is the key to save time and in turn, save a precious life!

The Agile Supply Chain is a concept that can be used to understand the humanitarian supply chain better. According to Christopher (2000), organisations are seeking to find ways to reduce the risk attached to the often lengthy, slow-moving logistics involved. These are also called “Pipelines”. These can become unsustainable, compelling organisations to relook into their established supply chain and create an agile supply chain. Agility is a business-wide capability that enters into the various systems of the organisation like organisational structures, information systems, logistics processes and mindsets. Supply Chain Agility has emerged as a conspicuous branch of research as it deals with the following aspects of the supply chain: the less predictable backdrop, the volatile demand and the high requirement for variety.

Another concept that can be used is “Lean”, commonly referred to as “Lean Manufacturing” or “Lean production” (Chugani et al, 2017). The Lean philosophy is based on tackling seven types of waste which are: excessive production, extra inventory, waste of time due to slow processing, employee or equipment motion resulting in waste, over-processing, and lack of value to the product due to product damage in transportation or waste due to defects.

“Leanness” and “Agility” have two different meanings. They are in fact two different philosophies. Leanness is about doing more with less. It exhibits the “Zero-Inventory” Just-in-time approach. Leanness, in fact, can be called an element of Agility under certain circumstances. Lean works best when the backdrop is predictable, the demand is of a high volume and there is a low requirement for variety. The Agile and Lean philosophies may be different, but they are not mutually exclusive. In fact, studies say that they may have peaceful co-existence and enhance the effectiveness of the emergency supply chain. Several studies identify the phases of Humanitarian Logistics in which agility and lean are required.

The Green impact on Lean is discussed in the top-ranking Operations and Quality Management literature. It introduces the concept of an environment-friendly elimination of any waste. Lean principle objectives are aligned with the objective of saving resources, which is considered as eco-friendly. Hence, the term was coined as “Green-Lean”. This paper also reviews how the Green impact on lean can help in a humanitarian supply chain.

The objective of the paper is to review the work that has been done on how a Humanitarian Supply Chain works, particularly in the context of the Lean Supply Chain. The focus of this paper is:

1. Can lean principles be implemented in the Humanitarian Supply Chain?

2. Can the Humanitarian Supply Chain be more stable and sustainable with the implementation of lean principles?
3. Can the Lean-Humanitarian Supply Chain cater end to end, which means it services from the donors end to the receiving end?

The paper looks at the relevant literature to obtain an understanding of the relevant concepts and background information on humanitarian supply chain and Lean Management. The “Humanitarian Logistics” refers to systems which are used to organise and distribute resources during the most difficult situations like natural or man-made disasters. It involves warehousing, procurement, and funding with a special focus on pre-disaster preparation as these challenging scenarios lead to sudden unpredictable spikes in demand, difficulty in accessing locations, and utter disruptions to normal life (James and Laura, 2017). A current focus in humanitarian assistance is to take into consideration some of the major issues like population growth, increase in food prices, scarcity of water and energy. Therefore, we need a humanitarian logistics approach which eliminates waste and is efficient. In fact, the logistical capabilities required by aid agencies should be identified for the large-scale and sudden onset of natural disasters. Unlike the traditional practice which is based on a principle of planning ahead which is derived from the trends and forecasting data, the turbulent environment deals with the challenge of creating the capability that will support rapid response to the events as they happen without wastage.

The Humanitarian and Disaster Relief Supply Chains (HDRSC) have some unique characteristics, which place emphasis on the consideration of the measurement of life and death (Day et al, 2012). The crucial factors supporting life and preventing death include very high precision decision-making and understanding. The complex humanitarian crisis scenario is mainly dominated by factors of invisibility, implying the incapability to anticipate the factors influencing the emergency; hence, there exists a non-unique supply chain (Oloruntoba and Gray, 2006). The diversity of the formation of the supply chain includes the function of location, the nature or severity of the disaster, potential responder units, anticipated needs, and prescribed procedures (Day et al, 2012). The Supply chain itself faces challenging scenarios during humanitarian operations. It becomes unstable very often because the populations affected have a weak voice in expressing their needs, which can lead to, for example, the convergence of donations clogging up the transportation network. Complex issues can challenge the specific functions referred to as Humanitarian Logistics (Kunz et al, 2017). It takes immense skill and knowledge to create an efficient supply chain without wasting precious resources in today’s world.

Kovacs and Spens (2009) opine that there are serious challenges during the emergency phase, as there remains a shortage of resources dedicated to the disaster-stricken environment. Usually, the inflow of resources are observed after the disaster has taken place. A lot depends on the decision of the donor organisations and autonomy regarding the kinds of goods and services that will be donated in response to the disaster. These decisions need to integrate to form an efficient supply chain to cater to the people at risk, without wasting precious resources. The humanitarian operation, therefore, comes with a lot of uncertainty regarding the victims, disaster timing, location, donor’s contribution, infrastructure and relief group composition. To form an efficient supply chain these level of uncertainties can pose as an unfathomable challenge (Day et al, 2012).

According to Van Wassenhove (2006), humanitarian logistics includes the entire supply chain lifecycle from preplanning to termination or transformation. The parameter of overall priorities changes continuously after the aftermath. Relief operations relies on speed for success helping to save lives and reduce human suffering. Though earnest efforts are made to push the initial supplies to the affected area at the earliest opportunity, efforts can often be thwarted due to inaccessibility of the affected area. Therefore, the desired speed is usually not attainable. As soon as the infrastructure is sorted, the focus quickly shifts to removing people to safety. Every stage is overwhelmed with a sea of changes due to the changing disaster scenario. The unknown groups of individuals or newly formed organisations or clusters extend help in different ways. If there is proper coordination and information sharing amongst them then it can make more effective relief operations (Van Wassenhove, 2006; Altay and Pal, 2014), but in reality, these groups most often lack coordination and communication which may result in interruption and disruption to their hard work and sincere efforts.

Furthermore, lack of coordination leads to duplication of effort, wasted resources and slows down the relief response (Altay and Pal, 2014). At times the emergence of self-initiated participants contributes to the increase in resources and can smooth possible organisational conflict and support relationship building. Press coverage and publicity is also a major factor, which influences the humanitarian logistics in a conspicuous way. For example, the press can bring to public attention areas that require a rapid response and highlight issues, breaking down problems in relation to the operations and performance of supply chains. Press coverage can also generate more donations. On the other hand, press coverage and publicity can divert attention to less important activities as well as creating competition for press time amongst the participating organisations resulting in difficulties in co-ordination (Day et al, 2012).

There is currently little-published work focusing on the detailed understanding and improvement of the nature of the supply chain management for Humanitarian Aid (HA). The understanding of the Humanitarian Supply Chain emerges from an understanding of commercial supply chains (Ho et al., 2002).

A study undertaken by Gunasekaran and Ngai (2003) identified some of the main functions critical to a small logistics company. They are Strategic Planning, Inventory Management, Transportation Planning, Capacity Planning, and Information Management. According to Razzaque and Sheng (1998), the Critical Success Factors (CSFs) were related to the outsourced logistics, communication of the ideas, relationships, customer-centric outlook, the importance of human factor and setting of standards and working. Again, according to Power et al. (2001), there are seven independent variable groups in the agile Supply Chain. They were Human Resource Management (HRM), computer-based technology (Information Management), resource management (inventory management), continuous improvement, supplier relations (collaborations), just-in-time methodology and technology utilisation. Moreover, when we look at the CSFs for knowledge management in small and medium enterprises we can identify 11 factors grouped under the following broad activities: strategic planning, resource management, information management, HRM and continuous improvement.

Hence, from the above literature, we can identify 10 CSFs that are relevant to establishing a Supply Chain, which will be efficient and successful. These can also be used to measure the degree of success

of the HA Supply Chain. Pettit and Beresford (2009) state that there may be difference in the circumstances in establishing an HA Supply Chain, but the basic activities within those chains do not widely differ in the fundamentals of the commercial Supply Chain. In fact, the two distinguishing features are, firstly, the diversity in HA community and secondly, the high-stress conditions that form the Humanitarian Supply Chain. We assess the relevant CSFs from the 10CSFs in HA Supply Chain Management.

**Table 1.** Seven wastes of Lean principals and the phases of the Humanitarian Supply Chain

Seven types of Lean wastes	Pre-Preparation	Rapid Response	Reconstruction
Excessive Production	Inventory Planning involves the two aspects: the existing inventory within the Organization and the inventory that is in the country and can be accessed at short notice. Pre-Planning will optimize the resources. (Long and Wood, 1995; Chugani <i>et al</i> , 2017; Chandes and Pache, 2010). This is relevant because, when it comes to production, there needs to be a balance between demand and supply. A pre-planning for an emergency can be very useful as it can save a lot of precious time and save lives in return without any unnecessary wastage of stock. However, when we consider an emergency, we consider a lot of unpredictability. Calculating the correct amount for production is difficult.	When the knowledge of the inventory available is easily accessible, it will help to reduce wastage of any excessive Production. (Long and Wood, 1995; Chugani <i>et al</i> , 2017). This is relevant because a rapid response depends on the availability of stock during an emergency. If there is the unavailability of resources, then catering to the disaster-stricken in the unpredicted scenario is highly impossible.	'A shift from push to pull has seen a change in sourcing from buy-to stock to buy-to-deliver, as there is a shift from agility maxim in disaster relief to a more pre-planned lean approach in reconstruction phases (Taylor and Pettit, 2009). The relevance of this aspect is that for the reconstruction phase we need a lot of stock. This inflow from the pre-planning stage. A proper plan can provide a robust support in the reconstruction phase by eliminating waste.
Extra Inventory	Organisations should take a long-term approach to cope if an emergency arises. (Long and Wood, 1995). Capacity Planning plays a very important role to enable Rapid Response. (Gunasekaran and Ngai, 2003). Strategic planning can assist agencies involved in humanitarian aid by developing an effective inventory strategy that can lead to pre-positioning. (Kovacs and Spens, 2007; Chugani <i>et al</i> , 2017; Garza-Reyes, 2015)). The relevance of this aspect is that through lean management, we can have control over how much extra inventory can be created to serve an emergency. If we can work out the right kind of plan to pre-position extra inventory in such a way that an emergency can be met without any wastage is a critical aspect of the humanitarian supply chain.	When there is the planning of the inventory that can be accessed at a short notice, it will enable a Rapid Response of Inventories and enable a robust humanitarian Supply Chain. (Long and Wood, 1995; Gunasekaran and Ngai, 2003; Garza-Reyes, 2015). For any kind of rapid response, it is essential that inventory is available immediately. It makes the humanitarian supply chain efficiency. This not only allows a successful receiving end of the supply chain but also helps in saving precious time.	The more locally the resources and warehouse are accessible the more quality reconstruction can be done as per local Vs global sourcing is considered. (Long and Wood, 1995). This is relevant as local inventory would reduce cost, which acts as a game-changer during the emergency scenarios.

<p>Waste of time</p>	<p>Corporate strategy to be made which involves transport and warehousing, Location and Distribution centre, which involves either centralised or localized distribution centre for faster Response. (Long and Wood, 1995). Pre-Planning of Human Resource Management, Inventory Planning, Transport Planning all leads to saving of time, energy and Resources. (Perry, 2007; Kovacs and Spens, 2007).</p> <p>As time is one of the main factors that control the humanitarian operation, it is very essential that pre-planning is absolutely made on time-saving techniques. Implementing the various lean techniques in which we can save time will create a robust humanitarian supply chain.</p>	<p>The Pre-Planning of the various aspect that creates a robust Humanitarian Supply Chain can provide an edge of Rapid Response in The Humanitarian Supply Chain. (Long and Wood, 1995). The very essence of rapid response is based on saving time. This calls for the major implementation of the lean techniques as saving time is saving lives. The more we make a lean process for the humanitarian supply chain the more time saving it will be.</p>	<p>Optimisation of time can be achieved by eliminating wastage of time in sourcing. It can be transport, food, clean water or health services etc. The decision on what is procured and from where is important. The reconstruction phase is essentially the phase, which is more time-consuming. During this phase, any time saved is a milestone achieved. The lean techniques that help to build back the disaster site are essential to creating a robust humanitarian supply chain.</p>
<p>Employee or Equipment motion resulting in waste</p>	<p>Different resources to be allocated in the pre-planning phase so that organizations can cope up with an emergency. (Long and Wood, 1995)</p> <p>The relevance of this in the pre-planning stage is immense. A meticulous application of lean techniques to allocate the employee or equipment motion and avoid any waste is a very sought after the lean technique, as it gives the direction to the humanitarian supply chain.</p>	<p>When an efficient allocation of Human resource and Equipment is made during the planning phase, it will eliminate the extra time required to build a new team to tackle the emergency scenario. (Long and Wood, 1995; Perry, 2007). Rapid response can be rendered when we already have a designated employee or equipment channelization. Its smooth motion without any wastage leads to a rapid response scenario.</p>	<p>Suppliers as vendors manage the sourcing of workforce and equipment. Hence, the lean principles can help by assessing the local partners like faith-based organizations like churches, or Red Cross societies, or activate dormant resources, that can align and provide efficient reconstruction. Also providing training to the involved staff not only assures continuity in aid programs but also the development of the resilient population. (Kovacs and Tatham, 2009; Oloruntoba and Gray,2006)</p> <p>The relevance of this aspect during the reconstruction phase is very immense, as this phase needs the help of uninterrupted flow of the employee or equipment motion. Implementation of the lean techniques to eliminate any waste, which is an output of the flow of employee or Equipment motion, will lead the reconstruction in a higher dimension.</p>
<p>Over Processing</p>	<p>Significant Channelising of resources including Human Resources can lead to a robust Humanitarian Supply Chain. (Perry, 2007; Kurdve et al, 2014)</p> <p>In any organization when anything is over-processed, it leads to a waste of time because it includes duplication of work,</p>	<p>A meticulous Allocation of Human and other Resources management can lead to a Rapid response, which is the utmost requirement during emergency situations. (Perry, 2007)</p> <p>This over-processing has huge relevance in the rapid</p>	<p>The elimination of over-processing any stage will lead to the reduction of price and the capacity to cater adequately to the disaster-affected area without any duplication. (Long and Wood, 1995)</p> <p>Over-processing during the reconstruction phase is very</p>

	<p>accomplishing unnecessary tasks etc. When accurate lean techniques are implemented to remove these wastes by sharing updated information from the donor organizations can help create a robust supply chain. Therefore, a pre-planning is essential to understand how we can get real-time updated data to remove these kinds of wastes and create a crisp humanitarian supply chain.</p>	<p>response phase as when anything is over-processed it wastes precious time. It leads to a lot of unnecessary and ugly situation if we lose time during emergency scenarios. Therefore, the pre-planning of lean implemented process eliminating over-processing will be highly valuable during the time-constricted environment.</p>	<p>dangerous as it is at this phase that all the donor organizations need to work in tandem to each other. It needs to be well-coordinated to be fast and efficient. If we have a system, which gives real-time updated information, then we can eliminate over-processing in every stage and create greater coordination between the donor organisations.</p>
Waste due to defects	<p>The disaster relief "Push" Strategy which depends on the "Lead Times" for the supply of critical items. These planning can help in rapid response phase so that we can minimise waste due to defects. (Gunasekaran and Ngai, 2003). Defects can be a serious drawback for the humanitarian supply chain and can lead to a very unstable humanitarian supply chain. Therefore, we need a conspicuous pre-planning to implement the lean techniques that can arrest defects and waste due to defects.</p>	<p>The "Just-in-Time" can be an appropriate method for the Humanitarian Supply Chain when it comes with defect-free resources. This will result in Rapid Response during a Humanitarian Supply Chain. (Gunasekaran and Ngai, 2003) The relevance of this aspect is that during an emergency we undertake the Just-in-time approach and during this phase, if we get stock, which includes a huge amount of defects, then it leads to wastage and failure of rapid response. Therefore, it is essential to implement lean techniques to provide inventory, which is perfect.</p>	<p>Reconstruction Phase requires reduced cost and adequate supplies in good condition to cater to the increasing demand at the disaster site. (Long and Wood, 1995) The reconstruction phase requires an immense amount of defect-free inventory. Therefore, the lean methods implemented correctly can produce the required defect-free stock and disburse it to affected site for the reconstruction.</p>
Lack of value to the product in transportation	<p>Unlike the smoothness, during normal conditions, the Humanitarian Supply Chain deals with the destabilized infrastructure. Role of Planning Transport can lead to Optimisation of Transport during Humanitarian Operations. (Gunasekaran and Ngai, 2003; Garza-Reyes, 2015) The logistics take the centre stage when the emergency arises. A clear pre-planning can provide an efficient humanitarian supply chain.</p>	<p>The Optimisation of Transport can be very Helpful for the Humanitarian Supply Chain. This will result in Rapid Response during a Humanitarian Supply Chain. (Gunasekaran and Ngai, 2003; Garza-Reyes, 2015) The transport during rapid response phase is the game changer. It is very difficult to manage a rapid response and smooth logistics during the emergency. So, effective lean implementation can provide effective logistics for the emergency.</p>	<p>Transport is one of the factors that faces immense competition by various Humanitarian organizations. So the optimisation of transport is required to save humanitarian operation from the immense increase in price and eventually the financial dearth. (Chandes and Pache, 2010) To optimise transport we need to implement the lean principals. This will not only make the humanitarian supply chain strong and reduce the cost.</p>

## 2. Research Methodology

A Literature review seems to be a valid approach for this study, as it is a necessary step in structuring a research field and forms an integral part of any research conducted (Easterby-Smith, 2002). This will help to identify the conceptual content of the field. This research, therefore, follows a systematic literature review approach, which is based on collecting and analysing a set of published journals. This study aims to follow a similar structure and methodology of selected articles from selected

journals as suggested in Garza-Reyes (2015). The approach to the research methodology is summarised below.

- i. Classification Context: We select and define the classification context to be applied in the literature review to structure and classify the material. There are two contexts: The problem context methodology /and the approach context.
- ii. Material Evaluation: The material is analysed and sorted according to the classification context. This allows the identification of relevant issues and the interpretation of the results. Problem context and related methodology /approaches allow classification of the reviewed literature, which can be derived deductively or inductively.
- iii. Article selection Mechanism: This research is focused on high-ranking journals to establish the positive role of Lean in Humanitarian operations. Some journals are included which is of lower-ranking but are very relevant to our topic. We have used the Emerald database and selected the relevant articles using the keywords. Much research has been done on Humanitarian Supply Chain but we find an absence of focus on the implementation of Lean in the humanitarian supply chain and Logistics. The objective is to bridge this gap.

Table 2 presents a summary of the research methodology by segregating the process of creating the Unit of Analysis, Type of Analysis, Period of Analysis, and the searched Journals used for this study.

**Table 2.** Summary of research methodology

<b>Unit of Analysis</b>	The sources include high ranked Peer review ABS journals in the operations and quality management area and publish papers on Lean management, Humanitarian Supply Chain, Humanitarian Aid, Humanitarian Logistics etc.
<b>Type of Analysis</b>	Qualitative
<b>Period of analysis</b>	Not specific due to the limited number of Journals that are published.
<b>Search Source</b>	Journals Listed in 2018 List and a few additional relevant journals. Authors have used the following terms and their combination to shortlist the articles of evaluation
<b>Key Words used</b>	Lean Humanitarian, Operations Management, Supply Chain, Humanitarian Logistics
<b>Journals selected for the study</b>	European Journal of Operational Research
	IEEE
	International Journal of Operations & Production Management
	International Journal of Physical Distribution & Logistics Management
	International Journal of Production Research
	International Journal of Quality & Reliability Management
	Journal of Business Logistics
	Journal of Cleaner Production
	Journal of Humanitarian Logistics and Supply Chain Management
	Journal of Manufacturing Technology Management
	Journal of Operations Management
	Journal of Supply Chain Management
	Journal of the Operational Research Society
	Production and Operations Management
	Supply Chain Management: An International Journal
	Industrial Marketing Management
	Internal Journal of Services Technology and management
	International Journal of Lean Six Sigma

Table 3 lists the articles as per the journals. The articles were searched based on the relevant keywords. The articles abstract were thereby scanned and articles were shortlisted based on the relevance to the research issue, particularly with reference to “Lean” and “Humanitarian Logistics and supply chain”.



This shortlisting process resulted in a sample of 61 articles that were finalised for this study. As per Berenson and Levine (1989) for accurate analysis, 10% of usable articles should be considered. However, since the numbers are limited all the articles were considered. Table 4 tells us the number of articles in each Journal and provides information as to the Journals that have contributed to a higher number of articles. The maximum articles come from the “International Journal of Physical Distribution and Logistics Management” followed by the “Journal of Humanitarian Logistics and Supply Chain Management”.

**Table 3.** Shortlisted articles as per the Journals

Name of Journal	Name of Article
Industrial Marketing Management	The Agile Supply Chain: Competing in Volatile Markets
European Journal of Operational Research	Emergency response in natural disaster management: Allocation and scheduling of rescue units
IEEE	Opportunities and challenges of distributed manufacturing for humanitarian response
Internal Journal of Services Technology and management	A consideration of the relevance of lean supply chain concepts for humanitarian aid provision
International Journal of Lean Six Sigma	Investigating the green impact of Lean, Six Sigma, and Lean Six Sigma: a systematic literature review
International Journal of Operations & Production Management	Cross-functional executive involvement and worker involvement in lean manufacturing and sustainability alignment
	Decision-Making and Operations in disasters: Challenges and Opportunities
	Lean manufacturing in temperature-dependent processes with interruptions
	Operations management research: contemporary themes, trends and potential future directions
	The relevance of humanitarian logistics research: best practices and way forward
	Strategic adoption of logistics and supply chain management
	Sustainable operations management: recent trends and future directions
	The role of a group working in assembly organization
International Journal of Physical Distribution & Logistics Management	"(Le)agility in humanitarian aid (NGO) supply chains
	A model to define and assess the agility of supply chains: building on humanitarian experience
	Critical success factors in agile supply chain management - An empirical study
	Critical success factors in the context of humanitarian aid supply chains
	Green, lean, and global supply chains
	Humanitarian logistics in disaster relief operations
	Humanitarian logistics: the role of logistics service providers
	Identifying challenges in humanitarian logistics
	Natural disaster management planning
	Outsourcing of logistics functions: a literature survey
	The successful management of a small logistics company
	Transforming humanitarian logistics: the journey to supply network management
	Trends and developments in humanitarian logistics - a gap analysis
International Journal of Production Research	Empirical research on supply chain management: A critical review and recommendations
International Journal of Quality & Reliability Management	Disaster Relief Supply Chain Quality Management (DRSCQM)
Journal of Business Logistics	Defining Supply Chain Management
	Responding to Disruptions in the Supply Network-From Dormant to Action
	The logistics of famine relief
Journal of Cleaner Production	Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain
	Lean and green – a systematic review of the state of the art literature
	Lean and green integration into production system models – experiences from Swedish industry
Journal of Humanitarian Logistics and Supply Chain Management	Agile and lean principles in the humanitarian supply chain: The case of the United Nations World Food Programme

	An integrated approach to agility in humanitarian logistics
	Game theory applications in humanitarian operations: a review
	Humanitarian logistics and supply chain management: The start of a new journal
	Humanitarian supply chain strategies – a review of how actors mitigate supply chain risks
	Measuring humanitarian supply chain performance in a multi-goal context
	Research in humanitarian logistics
	Services operations management and humanitarian logistics
	Supply chain agility in humanitarian protracted operations
	Systemic barriers and enablers in humanitarian technology transfer
	The value of fourth-party logistics services in the humanitarian supply chain
<b>Journal of Manufacturing Technology Management</b>	Investigating humanitarian logistics issues: from operations management to strategic action
<b>Journal of Operations Management</b>	The genealogy of lean production
<b>Journal of Supply Chain Management</b>	Humanitarian and Disaster Relief Supply Chains: A Matter of Life and Death
<b>Journal of the Operational Research Society</b>	Blackett memorial lecture humanitarian aid logistics: Supply chain management in high gear
<b>Production and Operations Management</b>	Improving Humanitarian Operations through Technology-Enabled Collaboration
	Information Diffusion among Agents: Implications for Humanitarian Operations
	Lean and Green? An Empirical Examination of the Relationship Between Lean Production and Environmental Performance
	Temporary Hubs for the Global Vehicle Supply Chain in Humanitarian Operations
<b>Supply Chain Management: An International Journal</b>	A commentary on agility in humanitarian aid supply chains
	Aggregated construction supply chains: success factors in the implementation of strategic partnerships
	Humanitarian aid: an agile supply chain?
	Humanitarian Supply Chain Performance Management: A Systematic Literature Review
	Humanitarian supply chain use of cloud computing
	The growing scale and scope of the supply chain: a reflection on supply chain graduate skills

**Table 4.** Number of Articles by Journals

Row Labels	Count of Article
European Journal of Operational Research	1
IEEE	1
International Journal of Operations & Production Management	8
International Journal of Physical Distribution & Logistics Management	15
International Journal of Production Research	1
International Journal of Quality & Reliability Management	1
Journal of Business Logistics	3
Journal of Cleaner Production	3
Journal of Humanitarian Logistics and Supply Chain Management	11
Journal of Manufacturing Technology Management	1
Journal of Operations Management	1
Journal of Supply Chain Management	1
Journal of the Operational Research Society	1
Production and Operations Management	4
Supply Chain Management: An International Journal	6
Industrial Marketing Management	1
Internal Journal of Services Technology and management	1
International Journal of Lean Six Sigma	1
<b>Grand Total</b>	<b>61</b>

Wong et al. (2012) systematic literature review categorises articles according to the methodology applied, a journal of publication, and the year of publication. We conduct a similar review and

categorise articles according to the journal of publication in Table 3, which tells us the journals that have provided more information/articles on the relevant topics. The second method of categorization is a number of articles found in journals according to the keywords.

### 3. Findings

We also categorise the shortlisted articles showing the keywords. As articles may contain more than one keyword this defines better the context and scope of the article. This is shown in Table 5. Table 5 gives us a clear picture of how important the topic of Lean implementation is in the humanitarian supply chain.

**Table 5.** Articles are broken down as per their keywords

Name of Article	Agile Supply Chain	Humanitarian Supply Chain	Disaster relief	Lean Supply Chain	Green Supply Chain	Supply Chain Management	Natural Disaster Supply chain	Humanitarian Logistics
"(Le)agility in humanitarian aid (NGO) supply chains	Y	Y				Y		
A commentary on agility in humanitarian aid supply chains	Y	Y						
A model to define and assess the agility of supply chains: building on humanitarian experience		Y						
Aggregated construction supply chains: success factors in the implementation of strategic partnerships						Y		
Agile and lean principles in the humanitarian supply chain: The case of the United Nations World Food Programme	Y	Y	Y	Y	Y	Y		
An integrated approach to agility in humanitarian logistics	Y							
Blackett memorial lecture humanitarian aid logistics: Supply chain management in high gear		Y				Y		
Critical success factors in agile supply chain management - An empirical study	Y					Y		
Critical success factors in the context of humanitarian aid supply chains		Y						
Cross-functional executive involvement and worker involvement in lean manufacturing and sustainability alignment				Y	Y			
Decision-Making and Operations in disasters: Challenges and Opportunities		Y	Y					
Defining Supply Chain Management						Y		
Disaster relief supply chain quality management (DRSCQM)			Y					
Emergency response in natural disaster management: Allocation and scheduling of rescue units			Y				Y	
Empirical research on supply chain management: A critical review and recommendations							Y	
Game theory applications in humanitarian operations: a review		Y						
Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain				Y	Y			
Green, lean, and global supply chains				Y	Y			
Humanitarian aid: an agile supply chain?		Y						
Humanitarian and Disaster Relief Supply Chains: A Matter of Life and Death		Y						
Humanitarian logistics and supply chain management: The start of a new journal								Y
Humanitarian logistics in disaster relief operations								Y
Humanitarian logistics: the role of logistics service providers								Y
Humanitarian Supply Chain Performance Management: A Systematic Literature Review		Y				Y		
Humanitarian supply chain strategies – a review of how actors mitigate supply chain risks		Y						
Humanitarian supply chain use of cloud computing		Y						
Identifying challenges in humanitarian logistics		Y						

Name of Article	Agile Supply Chain	Humanitarian Supply Chain	Disaster relief	Lean Supply Chain	Green Supply Chain	Supply Chain Management	Natural Disaster Supply chain	Humanitarian Logistics
Improving Humanitarian Operations through Technology-Enabled Collaboration		Y						
Information Diffusion among Agents: Implications for Humanitarian Operations		Y						
Investigating humanitarian logistics issues: from operations management to strategic action								Y
Lean and green – a systematic review of the state of the art literature				Y	Y	Y		
Lean and green integration into production system models – experiences from Swedish industry				Y	Y	Y		
Lean and Green? An Empirical Examination of the Relationship Between Lean Production and Environmental Performance				Y	Y	Y		
Lean manufacturing in temperature-dependent processes with interruptions				Y				
Measuring humanitarian supply chain performance in a multi-goal context		Y						
Natural disaster management planning							Y	
Operations management research: contemporary themes, trends and potential future directions		Y						
Opportunities and challenges of distributed manufacturing for humanitarian response		Y						
Outsourcing of logistics functions: a literature survey								Y
The relevance of humanitarian logistics research: best practices and way forward								Y
Research in humanitarian logistics								Y
Responding to Disruptions in the Supply Network-From Dormant to Action		Y				Y		
Services operations management and humanitarian logistics								Y
Strategic adoption of logistics and supply chain management						Y		Y
Supply chain agility in humanitarian protracted operations	Y	Y						
Sustainable operations management: recent trends and future directions				Y	Y			
Systemic barriers and enablers in humanitarian technology transfer		Y						
Temporary Hubs for the Global Vehicle Supply Chain in Humanitarian Operations		Y						
The genealogy of lean production				Y				
The growing scale and scope of the supply chain: a reflection on supply chain graduate skills						Y		
The logistics of famine relief								Y
The role of a group working in assembly organization								
The successful management of a small logistics company								Y
The value of fourth-party logistics services in the humanitarian supply chain		Y						
Transforming humanitarian logistics: the journey to supply network management								Y
Trends and developments in humanitarian logistics - a gap analysis								Y

Chart 1 shows the number of articles published year wise. This categorization gives a good picture of how the articles are published year wise. It shows that efficient humanitarian operation has been studied over the years, with more emphasis after 2010.

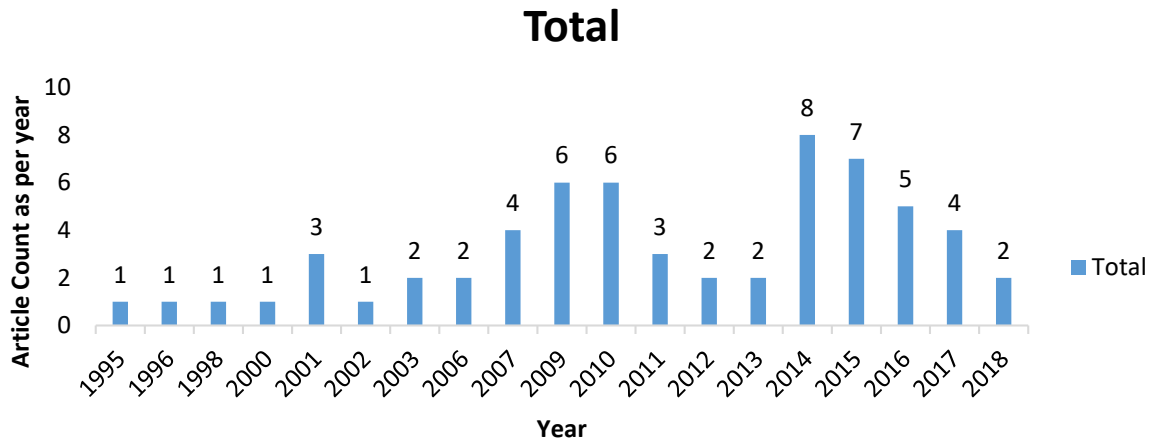


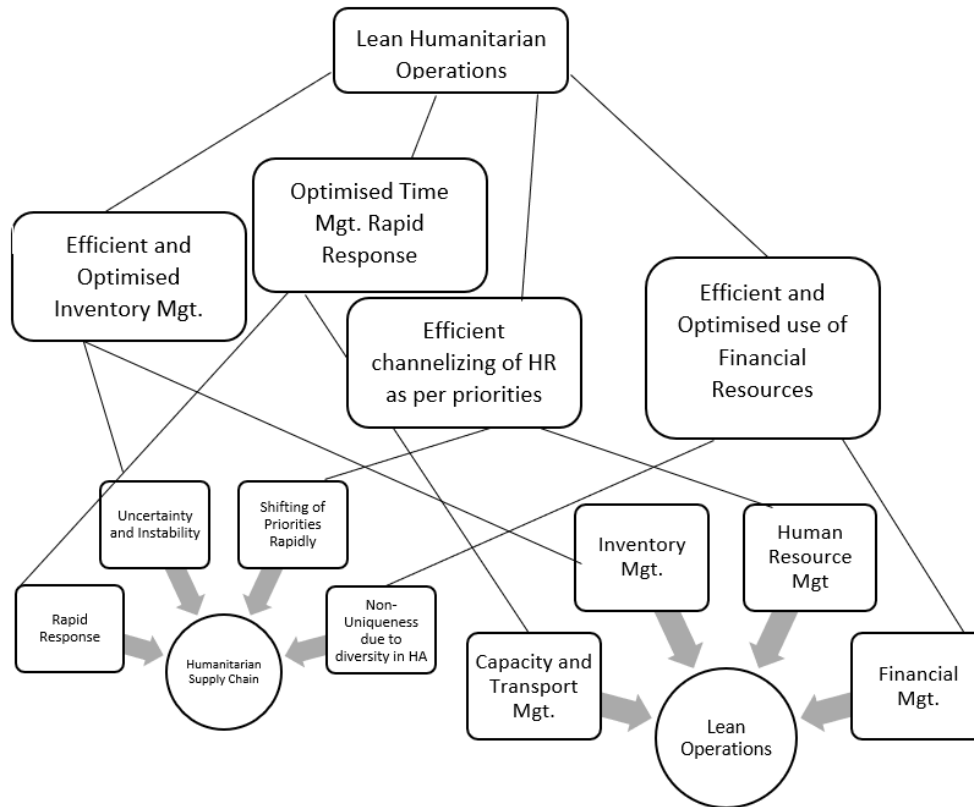
Chart 1. Categorization of articles according to a year of publication

#### 4. Discussion

The review of the literature clearly highlights that though work has been done on Humanitarian logistics and supply chain yet implementation of lean has been difficult. Kovacs and Spens (2007) describe the phases of logistical processes and how the understanding of humanitarian logistics can be drawn from business logistics. According to King et al. (2001), it is emphasised that the adoption of lean practices can directly enhance the quality and quantity of service delivery. It not only uplifts the environmental performance and keeps control over the humanitarian aspect. The study of the collective strategy model in the context of humanitarian logistics has very meticulously shown the benefits derived from the combination of operations management and business logistics. He also states that during both man-made and natural disaster relief programs, the lack of co-ordination amongst the participants hinders the performance in terms of reactivity and reliability. He adopted a collective strategy for the same reason. Studying these, we can say that Lean is a major aspect, which is overlapping in all aspects. The critical success factors put forth by Pettit and Beresford (2009) such as strategic planning, inventory management, transportation planning, capacity planning and, information management; all these involve the concept of Lean, which are understanding the waste, understanding the value chain, process mapping, pull production, and continuous improvement/seeking perfection. When we try to form a supply chain during an emergency we can use the lean principles as the catalyst to optimize the resources to give the utmost that we can to the affected people (Dues et al, 2013).

When we combine the critical success factors and the humanitarian operations to develop a model that shows the factors representing Lean Humanitarian Operations. The model will combine the humanitarian Supply chain with Lean-to form the Lean Humanitarian Supply Chain. The features will entwine operations so that an Optimised Rapid response is possible when there is efficient Capacity and Transport Management. This includes the aspect of eliminating any kind of waste especially time by managing a very optimally located warehousing and transport department. Again, efficient inventory management guided by the Lean principles to avoid waste of any kind and cater to the affected area optimally can support the uncertainty and instability of the humanitarian supply chain. Similarly, channelizing of Human Resources during the emergency and meet up the shifting

priorities without duplication of work and slow and sluggishness of man-made processes can be successful by lean monitored optimised and efficient HRM. An efficient HRM can actually lead to Rapid Response during emergencies. Moreover, when the world faces the resource limitations along with the financial constraints, lean monitored financial management can lead to catering to the huge and diverse challenges of HA. Diagram 1 explains such a scenario.



**Diagram 1.** Factors representing Lean Humanitarian Operations (Source: Created by the authors)

Diagram 1 and the discussion throws light on our research questions. We understand that the humanitarian supply chain which comprises mainly of the three phases (Pre-Planning, Rapid Response and the Reconstruction) can be sustained if there is an efficient implementation of lean principals. If there is proper planning to eliminate excessive production, extra stocking of inventory, waste of time, employee or equipment motion resulting in waste, over-processing, waste due to defects and lack of value to product in transportation then it leads to an efficient pre-positioning and a complete preparation for any emergency that will arise in the future. The rapid response phase can also be best catered when we understand the pre-planning phase and work accordingly. The way the pre-planning phase implements the lean techniques, it becomes an advantage for the rapid response phase to set in automatically and cater to the disaster-stricken population and infrastructure. The highly unpredictable situation can be controlled with a stable humanitarian supply chain in the reconstruction phase as the elimination of the seven types of waste makes it not only stable but also sustainable because the most important thing it saves is the time and finance, which leads to a stable and sustainable supply chain.

The Lean-Humanitarian Supply Chain can service/delivery from the donors end to the receiving end; this covers the elimination of seven wastes in the pre-planning phase and making an effective rapid response process that leads on to an optimized reconstruction phase. Thereby we can say that if the lean principles (i.e. proper capacity and transport management, Inventory Management, HRM and finance management) are blended subtly with the uncertain and volatile scenario, it will result in a Lean Humanitarian supply chain, which is efficient and stable and highly capable of an end-to-end servicing of the disaster-stricken scenario.

This study has improved the understanding of the identified research issues as well as the gaps in the literature that still exist. The gap that we noticeably see is that is it possible to make the humanitarian supply chain Green and lean both at the same time. This still poses a challenge for the humanitarian supply chain. Though the greening is a perspective not unknown to the humanitarian agenda, yet the climate change and urbanization pose a hindrance to this. This is because urbanization enhances the exposure of people to disasters while reducing their mitigation and coping up strategies (Kovacs and spens, 2011). However, implementation of Lean is a major point of focus whether it will make it environment-friendly humanitarian supply chain or not is a question that needs to be explored. To make it a green Lean humanitarian supply chain we need to take into consideration the population circumstances and the location of the disaster.

The other gap that stands out largely is the lack of coordination among the inter-agencies. The mandates in the organizations dictate their diversity in terms of the focus in specific areas. Similarly, the deployment of the relief is also in the specific areas of disaster relief operations. It is still to be tested if the humanitarian organizations that have tied up with the international allies like WFP, FAO, IFAD can bridge the gap in the coordination both in the short-term and long-term perspectives.

The other gap that we consistently find is the technology that can make the humanitarian supply chain equipped to handle data, which is huge and gets updated on a real-time platform. If this technology can involve all the aspects of the humanitarian supply chain so that it can coordinate across all the donors and agencies, it can monitor the logistics and make the humanitarian supply chain robust.

## **5. Conclusions and areas for further research**

We can involve modern technology to tackle the humanitarian aid operation with more efficiency. An accurate data that gives us sufficient knowledge in advance can lead to providing aid at a faster pace, reducing cost by creating a proper and efficient supply chain to cater to the emergency. Technology can also give an accurate view during the reconstruction phase. This will help the participants to chalk out a cost-effective plan, which is sustainable at the organization level. A very apt example of the 2015 earthquake, which devastated large swathes of the country, was one major crisis that used mobile phone data to track down and help refugees. This study published in EPJ Data Science says their work builds on the success of the approach used in Nepal. This is because their technology not only tracks users but also provides insights into people using these phones, which is invaluable in a crisis. It also captures the gender, age and other behavioural traits. These are information, which can suggest the vulnerability of the displaced population.

Our study will help academicians, practitioners and researchers to understand the best way to tackle the humanitarian operations. It is already understood that Lean implementation can contribute to the creation of Green Supply Chains. Lean implementation eliminates the waste that adds no value. When we implement factors like reducing the use of unnecessary resources, recycling materials, cutting down transport time, it can all help in humanitarian operations to create a green Supply Chain. It will not only benefit the people in distress but also it will help the people who are participating to help the affected people. As not much work has been done in this field it is important for us to understand and create more avenues in which this Lean implementation can be done during humanitarian logistics and help save time and lives.

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