APPLICABILITY OF LAST MILE HUMANITARIAN LOGISTICS OPTIMIZATION FOR NATURAL FLOOD DISASTERS: A SYSTEMATIC REVIEW

Dissanayake A T *(ayoma91@gmail.com)*
Department of Industrial Management, University of Kelaniya, Sri Lanka

Rupasinghe T D *(thashika@kln.ac.lk)*
Department of Industrial Management, University of Kelaniya, Sri Lanka

ABSTRACT

Disaster management can be considered as a critical measurement of the ability of communities to effectively protect their people and infrastructure and rapidly recover from the disaster. In the Disaster management context, managing Humanitarian logistics plays a critical role. Where Humanitarian logistics is dealing with planning, implementing and controlling the efficient, cost effective flow of goods, materials and information from the point of origin to the point of consumption with the intention of alleviating the suffering of victims. But still most of humanitarian aids organizations lack the resources to analyze disaster related data and effectively manage logistics and rescue victims in a disaster. For any kind of disaster relief operations last mile is considered to be very critical place in humanitarian logistics management because it is the place where humanitarian aids distribution to victims is happening. When considering about global disaster context, floods can be considered as one of the most common and frequent natural disaster world population are faced. Therefore objective of this study is to analyze the applicability of last mile humanitarian logistics optimization for natural flood disasters and provide future research directions for last mile humanitarian logistics management operations in order to provide better service to victims of flood disasters and improve the performance of last mile operations.

Key words: *Disasters, Humanitarian logistics management, last mile distribution, Optimization, Performance measures.*

INTRODUCTION

According to the definition of International Federation of Red Cross and Red Crescent Societies, "A disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Though often caused by nature, disasters can have human origins". In general, disasters can be categorized in to two namely natural disasters (Cyclones, tornadoes, hurricanes, landslides, earthquakes, tsunamis, volcanic eruptions, and floods) and manmade disasters (war, terrorist attacks and so on). Irrespective of the type of the disaster, Disasters can be considered as a critical measurement of the ability of communities to effectively protect their people and infrastructure and rapidly recover from the disaster. When we are going back to past few years, we experienced many natural disasters worldwide and these disasters raised demand for Humanitarian logistics management in order to alleviating suffering of the victims of the particular disaster. Where "Humanitarian logistics is dealing with planning, implementing and controlling the efficient, cost effective flow of goods, materials and information from the point of origin to the point of consumption with the intention of alleviating the suffering of victims. The humanitarian logistics management function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, customs and clearance" (Thomas, 2004). In Humanitarian logistics management process or any Humanitarian supply chain, last mile plays very critical role irrespective of the type or nature of the disaster. Because, if a last mile of any supply chain becomes a bottleneck, it affects the performance and main objectives of whole humanitarian supply chain. More

importantly, if last mile operations become a bottleneck the victims will suffer and there can be an increase in the casualties due to the disaster.

When considering about global context, Flooding is the most common environmental hazard worldwide. This is due to the vast geographical distribution of river floodplains and low-lying coastal areas. It is difficult to define exactly a flood is. It is largely classified as 'an overflowing of water onto normally dry land [Natural Disasters Association] . A flood occurs when water overflows or inundates land that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. Coastal flooding occurs when a large storm or tsunami causes the sea to surge inland. A 2007 report by the Organization for Economic Cooperation and Development found that coastal flooding alone does some $3 trillion in damage worldwide. Therefore, when considering about the global context floods can be considered as one of the most frequent disasters in the world wide which made a huge impact on the functioning of normal life of the affected people.

Therefore, the main objective of this article review and peer reviewed literature is investigating to identify, what have been done in order to optimize humanitarian supply chain and especially to optimize last mile operations, identify pitfall of them and Gaps in last mile humanitarian operation management. Finally this study provides, summarized view of last mile humanitarian operation optimization for future researches.

METHODOLOGY

Inclusion and exclusion criteria

The inclusion criteria for the studies included in this review were as follows: (1) the domain of the article was related to humanitarian logistics management and disaster management; (2) the primary focus of the article was to understand the type of disasters and difference between humanitarian supply chain and commercial supply chain; (3) the article was published in a peer-reviewed journal; (4) the article detailed the methodology of the study reported; and (5) the article was available in English. Articles were excluded if their content is not align with Optimization, Performance measure and key decision areas in order to improve performance of humanitarian supply chain.

Search strategy

For Article searching purpose mainly Emerald insight and Science direct online journal databases were used. Searching is done using following phases: (1) Disasters (2) Disaster management (3) Humanitarian logistics management (4) Last mile operations (5) Optimization (6) Performance measures in humanitarian supply chain. In this review, consider articles that focus on Optimization, Performance measure in a humanitarian supply chain and key decision areas in order to improve performance of humanitarian supply chain (Which will be referred as key decisions). And each study is analyze against wheatear it is conducted by considering whole humanitarian supply chain or only last mile operations of humanitarian supply chain. Finally 14 articles were selected for the review.

Results

From the 14 selected articles, 10 were focused to whole humanitarian supply chain and other 4 focused on especially last mile operations of humanitarian supply chain. Additional to aforementioned scope 6 articles were discussing about optimization of humanitarian supply chain, another 6 were discussing about performance measure and 5 articles were discussing

key decisions area related to humanitarian logistics management process. Table 1 will demonstrate the above categorization of articles and Table 2 given below will summarize key findings/Results of 14 articles reviewed.

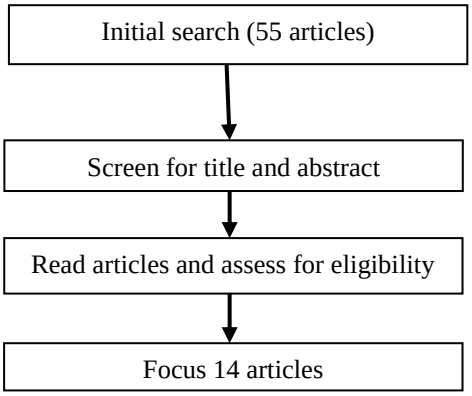

Figure 1 Article selection process

Table 1 Article categorization

Author	Analysis Area			Scope	
	Optimization	Performance measures	Key Decisions	Whole Humanitarian supply chain	Last mile operations
P.V Hentenryck	•			•	
Anisya et.al		•	•	•	
LN Van Wassenhove		•	•	•	
Roy et.al	•		•		•
Santarelli et.al		•		•	
Abidi et.al		•		•	
Azzi et.al	•				•
Balcik et.al	•				•
Benita et.al		•		•	
Schulz et.al		•		•	
Mete et.al	•				•
Vallim Fo et.al	•			•	
Kova´cs et.al			•	•	
Hale et.al			•	•	

Table 2 Summary of Articles reviewed

Author	Analysis Area	Objectives	Search criteria	Method	Key findings/ Results
P.V Hentenryck	Optimization	Articulates the role of optimization for disaster management and its inherent	Searched using the keywords natural disasters and optimization	Study number of case studies related to natural disasters, some of which in deployment, to	A vision for disaster management with 7 functionality layers. These layers indicate the magnitude of the task ahead and the wealth of scientific problems raised

		complexity.		highlight the benefits of optimization. It concludes by articulating a potential long-term vision for computational Disaster management and some of the broader computational challenges.	by computational disaster management. Functionality layers are as follows, • Infrastructure and geo space modeling • Sensing and monitoring • Data acquisition, fusion and aggregation • Behavioral modeling • Simulation and forecasting • Optimization and decision support • 3D visualization and scenario exploration
Anisya et.al	Key decisions	Identify the core challenges in humanitarian supply chain from the practical point of view	Searched using the keywords natural disasters and humanitarian supply chain, challenges	Study number of case studies and field experience and identify key challenges in humanitarian supply chain and suggest strategically actions to overcome identified challengers.	humanitarian Logistics challengers, • Lack of Recognition of the Importance of Logistics • Lack of Professional Staff • Inadequate Use of Technology • Lack of Institutional Learning Limited Collaboration Strategies to overcome aforementioned challenges, • Creating a professional logistics community • Investing in standardized training and certification • Focusing on metrics and performance measurement • Communicating the strategic importance of logistics • Developing flexible technology solutions
LN Van Wassenhove	Performance measure,	Identify the applications of	Searched using the Keywords	Based on study of key commercial	• Discuss applicability in pre-positioning in

	Key decisions	commercial sector logistics management practices for humanitarian logistics management and cross learning potential for both humanitarian and commercial sector logistics management	emergency relief operations, humanitarian logistics, supply chain management	and humanitarian logistics practices and case studies.	humanitarian logistics management. • Discuss agility and adaptability for commercial logistics management
Roy et.al	Key decisions, Optimization	Define the last mile relief distribution in humanitarian supply chain and develop a logistical framework by identifying the factors that affect this process	Searched using the Keywords last mile relief distribution, logistics, supply chain management	Based on interviews conducted with field officers and the data analyses, identify which are the critical factors for last mile relief distribution of disaster relief operation	Define four types of decisions which affect last mile humanitarian operations and factors affecting those decisions. • Inventory decision • Facility location decision • Transportation decision • Distribution decision
Santarelli et.al	Performance measure	Develop an applicable performance measurement system to measure the performance of humanitarian supply chains during both disaster situations and development	Searched using the Keywords humanitarian supply chain, performance measurement, key performance indicator	Based on literature review and empirical opinions.	Defined a performance system focusing on Humanitarian supply chains during both disaster situations and development. The system can be used as a basis to measure performance of humanitarian organizations in terms of response time, Service quality and technical and cost efficiency.
Abidi et.al	Performance measure	literature review to qualitative content analysis in order to determine main managerial	Searched using the Keywords Humanitarian logistics, performance measurement	The existing literature is categorized in several attributes like general trends of performance measurement	Performance measurement in the humanitarian logistics is still a gap within logistics research, especially compared to the commercial logistics sector

		problems and major findings in performance measures in humanitarian logistics management		in humanitarian logistics, stage of disaster, research methodologies, key performance measures, performance measurement systems and the relationship with internal and external stakeholders.	
Azzi et.al	Optimization	Optimize material deliveries Involved in a relief operation and explore the impact of variations in available logistics assets. Study based on 2011 Haiti earth quake	Searched using the Keywords Last Mile Distribution, Humanitarian logistics, Transportation	Case study of 2011 Haiti earth quake	Mathematical optimizes model for resource allocation and vehicle routing decisions. And also discuss the real feasibility of a co-transportation in humanitarian relief operations. Moreover research computes the performance achieved by the delivery system when a co- distribution of different kind of products is applied in real.
Balcik et.al	Optimization	Develop an analytical framework to assist relief decision-makers in making effective and efficient distribution decisions across the last mile	Searched using the Keywords Last Mile Distribution, Humanitarian Relief Chains	Based on literature review and empirical opinions.	analytical framework to assist relief decision-makers in making effective and efficient distribution decisions across the last mile while minimizing the sum of transportation costs and penalty costs for unsatisfied and late-satisfied demand. The study show how the proposed model optimizes resource allocation and routing decisions and discuss the tradeoffs between these decisions on a number of test problems. And also discuss identify opportunities for the use of intelligent transportation systems in last mile distribution
Benita et.al	Performance measure	Compare performance measuremen	Searched using the Keywords	The performance measurement	A comparison of performance measurement in the

		t in the humanitarian relief chain with performance measurement in the commercial supply chain, develop performance metrics for the humanitarian relief chain, and present a framework that can be used as a basis for a performance measurement system in the relief sector.	Supply chain management, Performance measures	analysis is developed through extensions on an existing performance measurement framework. Details regarding relief chain system were obtained through off-site and on-site interviews with relief professionals from World Vision International.	humanitarian relief chain with performance measurement in the commercial supply chain, new performance metrics for the humanitarian relief chain, and a performance measurement framework for the relief chain.
Schulz et.al	Performance measure	Developed a tool for International Federation of Red Cross and Red Crescent Societies (IFRC) to guide and monitor the continuous performance improvement of their (regional) logistics unit(s) on a daily basis.	Searched using the Keywords Performance management, Continuous improvement	Starts with a description of the situational background of the IFRC. In a second step, it briefly portrays the theoretical concepts of continuous improvement and of the Balanced Scorecard and highlights the extension of existing literature on performance measurement in general and humanitarian logistics in particular.	The process of designing and implementing (tools for) a performance measurement and management system can and should be kept simple. Important for the success of the process is the integration of key stakeholders throughout the entire process as well as the simplicity and user friendliness of tools and system
Mete et.al	Optimization	Develop a robust decision support mechanism to transport medical supply	Searched using the Keywords disaster management, emergency management	Based on literature review.	A robust decision support mechanism, which is serviceable under the wide variety of possible disaster types and magnitudes through a mixed integer programming models for

					loading and routing of vehicles to transport medical supplies for disaster response, which requires the evaluation of up-to-date disaster field information, as well as disaster preparedness .
Vallim Fo et.al	Optimization	Develop an Optimization models to determine location of healthcare facilities	Searched using the Keywords facility location, optimization models	Based on literature review and analysis of real world scenario.	Optimization models to determine location of healthcare facilities
Kova´cs et.al	Key Decisions	Understanding of planning and carrying out logistics operations in disaster relief	Searched using the Keywords Logistics data processing, Disasters	Based on literature review	A framework distinguishing between actors, phases, and logistical processes of disaster relief. Drawing parallels of humanitarian logistics and business logistics, the paper discovers and describes the unique characteristics of humanitarian logistics while recognizing the need of humanitarian logistics to learn from business logistics.
Hale et.al	Key Decisions	Propose a decision process for establishing an efficient network of secure storage facilities that can effectively support multiple supply chain facilities	Searched using the Keywords Supply chain management ,Contingency planning, Storage, Disasters	Use the five-stage disaster management process for supply chains as the framework for a proposed decision process for secure site locations. The decision process Disaster Management Guide with a set cover location model from the location sciences field to help establish a network of secure site locations.	Secure site selection process can balance operational effectiveness and cost-efficiency by identifying the minimum number and possible locations of off-site storage facilities

DISCUSSION

After reviewing content of above mentioned 14 articles in related to Optimization, performance measure and key decision area affects the performance of humanitarian logistics management process. Reviewer can observe that many optimization related studies are only focusing on disaster responding and preparedness stage even through disaster life cycle has disaster mitigation, preparedness, response and reconstruction stages. When considering about the performance improvements of humanitarian supply chain LN Van Wassenhove discussed the role of Operational research in performance improvements of humanitarian supply chain and provide directions (which are mentioned below) for Operational Research for archive performance objective of humanitarian supply chain.

- Supply chain design and management (processes)(donor issues, last mile problems, cross learning possibilities with the private sector, the military and humanitarians)
- Systems and technology (Disaster Management Information Systems, Knowledge Management, Communities of Practice)
- Project management (life cycle issues)
- Risk management (risk analysis, vulnerability assessment mapping, and supply chain robustness issues)
- Coordination and strategic alliances (partnering) (between humanitarian organizations, with industry, with the media)
- Performance measurement and scorecards (reporting, accountability and continual improvement)
- Process standardization and control (tools and behavior (eg TQM, Six Sigma, training)

Not only Operational research but also Information technology and modern technologies have a greater potential in optimizing and improving performance of a humanitarian logistics management process. A study conducted by Howden in 2009 discusses about potential of Information technology in making effective and efficient humanitarian operations in a disaster situation. Therefore, using information system in humanitarian aid operations can yield following benefits.

- Enhance needs assessments by ensuring that field staff knows what supplies are available for beneficiaries, either in local warehouses, pre-positioned emergency stocks or from local and international markets.
- Share lists of supplies available in both local and international markets, including prices and lead times, logisticians to empower program staff to better plan their procurement activities.
- Keep program staff informed of procurement activities will help to develop an understanding of the constraints within logistics and create trust.
- Provide budget holder more accurate financial information regarding funds which are committed within the procurement process, to avoid the over or under spending of budgets.
- Provide warehouse inventory reports to program staff to allow them to take more responsibility for their supplies, and ensure that they are utilized effectively.
- Share information on the distribution of supplies to allow program staff to better monitor and evaluate activities and avoid the need for duplicate record keeping between logistics and programs.
- More accurately divide logistics overhead costs such as warehouse rental, transportation and logistics staff wages into program budgets according to the activities logistics is supporting.

Balcik et.al's study discusses about abilities of intelligent transportation systems in optimizing last mile distribution. Such as, vehicle status monitoring ability, Transportation infrastructure networking, ability to effectively plan supply allocation and so on.

According to the above analysis and study conducted by LN Van Wassenhove, there are lack of studies related to last mile humanitarian operations related to optimization, performance measure and performance improvement decision making even though last mile plays critical role in humanitarian logistics management process irrespective of the nature of the disaster . As discussed above if a last mile of any supply chain becomes a bottleneck, it affects the performance and main objectives of whole humanitarian supply chain. More importantly, if last mile operations becomes a bottleneck victims will suffer and there can be an increase in the suffering and casualties due to the disaster.

According to the world natural disaster statistics floods are considered to be the most frequent natural disaster that worldwide population is facing. Therefore, when considering the natural disaster related humanitarian logistics management, there is a raising demand for conducting researches in order to address last mile humanitarian logistics management process especially considering the natural flood situations.

When optimizing last mile humanitarian logistics management operation in a flood situation can be done by addressing following research questions.

- How to conduct last mile demand and supply management in a flood respond situation?
- How to conduct a most accurate need assessment for disaster location?
- What factors are needed to optimize?
- What performance measures are required to provide better service to the affected victims?

When finding answers to above mentioned Research questions as similar to humanitarian supply chain, Operational research, Information technology and other modern technologies related researches can be utilized for last mile humanitarian operations. As mention in above needs assessment is a very critical and difficult task in humanitarian logistic management process. In order to address this question, future researcher can introduce the needs packaging system in order to serve the victims better.

CONCLUSION

Last mile of any humanitarian supply chain plays a very critical role in providing better service for victims of particular disaster situation. If a last mile of any supply chain becomes a bottleneck, it affects the performance and main objectives of the whole humanitarian supply chain. More importantly, if last mile operations becomes a bottleneck, victims will suffer and there can be an increase in the suffering and casualties due to the disaster. According to the analysis of above mentioned 14 articles we can observe that Operational research, Information technology and other modern technologies related to researches can be effectively utilized to improve the performance of last mile humanitarian operations and optimize them.

REFERENCES

Anisya S. Thomas,Laura Rock Kopczak,. (2005). "FROM LOGISTICS TO SUPPLY CHAIN MANAGEMENT:THE PATH FORWARD IN THE HUMANITARIAN SECTOR.".

Azzi A., Battini D., Peretti U., Persona A., Sgarbossa F. (2013). "The Haitian case: an application of a last mile distribution model in relief operations." *The 5th International Conference on Operations and Supply Chain Management.*.

B Vitoriano, J Montero, D Ruan . (2013). *Decision Aid Models for Disaster Management and Emergencies*. Springer,.

Benita M. Beamon, Burcu Balcik. (2008). "Performance measurement in humanitarian relief chains." *International Journal of Public Sector Management*,pp.4-25,.

Blecken, Alexander. (2010). *Humanitarian Logistics: Modelling Supply Chain Processes of Humanitarian Organizations.*.

BURCU BALCIK, BENITA M. BEAMON, and KAREN SMILOWITZ. (2008) ."Last Mile Distribution in Humanitarian Relief." *Journal of Intelligent Transportation Systems*,pp 51-63,.

BURCU BALCIK,BENITA M. BEAMON, and KAREN SMILOWITZ. (2008). "Last Mile Distribution in Humanitarian Relief." *Journal of Intelligent Transportation Systems,pp 51-63*,.

businessdictionary.com. 05 08, 2014. http://www.businessdictionary.com/definition/performance-measure.html (accessed 05 08, 2014).

Cozzolino, Alessandra. (2012). *Humanitarian Logistics-Cross-Sector Cooperation in Disaster Relief Management.* Springer,.

Davidson, A.L. "Anisya S. Thomas,Laura Rock Kopczak,. (2006). "FROM LOGISTICS TO SUPPLY CHAIN MANAGEMENT:THE PATH FORWARD IN THE HUMANITARIAN SECTOR.".

Edgar E. Blanco,Jarrod Goentzel. (2006). "Humanitarian Supply Chains: A Review.".

Esther Sangiamkul,Jos van Hillegersberg. (2011). "Research Directions in Information Systems for Humanitarian Logistics." *8th International ISCRAM Conference.*.

Giulia Santarelli, Hella Abidi,Alberto Regattieri,Matthias Klumpp. "A performance measurement system for the evaluation of humanitarian supply chains."

Gustavsson, Lars. "Humanitarian logistics: context and challenges."

Gyo¨ngyi Kova´cs , Karen M. Spens. (2007). "Humanitarian logistics in disaster relief operations." *International Journal of Physical Distribution & Logistics Management*,pp 99-114,.

Howden, Michael. (2009). "How Humanitarian Logistics Information Systems Can Improve Humanitarian Supply Chains:A View from the Field." *6th International ISCRAM Conference* . Gothenburg, Sweden,.

Larson, Paul D. (2011). "Strategic Partners and Strange Bedfellows: Relationship Building in the Relief Supply Chain." In *Relief Supply Chain Management for Disasters*, by Karen M. Spens Gyöngyi Kovács, 2-3..

N Kunz, G Reiner. (2012). "A meta-analysis of humanitarian logistics research." *Journal of Humanitarian Logistics and Supply Chain Management*,pp 116-147,.

optimization. 05 08, 2014. http://www.businessdictionary.com/definition/optimization.html (accessed 05 08, 2014).

Priyanka R,Albores P, Brewster C. "L O GIST IC A L FRAMEWORK F OR L AST MI L E RE L I E F DISTRIBUT ION IN HUMANI TARIAN SUPPLY C H AINS: C ONSIDERAT IONS FROM T H E F I E LD."

Rolando M. Tomasinia , Luk N. Van Wassenhove. "From preparedness to partnerships: case study research on." *INTERNATIONAL TRANSACTIONS IN OPERATIONAL RESEARCH*, 2009: 549-559.

UNDAC. (2011). "Disaster Response Preparedness Mission to Sri Lanka."