

## **A Review on Main Challenges of Disaster Relief Supply Chain to Reduce Casualties in Case of Natural Disasters**

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<b>PAPER INFO</b>	<b>ABSTRACT</b>
<p><b>Chronicle:</b> Received: 13 April 2017 Revised: 12 July 2017 Accepted: 14 August 2017 Available : 14 August 2017</p> <p><b>Keywords :</b> Disaster Relief Supply Chain Logistic. Disaster Relief. Management. Relief.</p>	<p>Iran is among the ten disaster-prone countries and, in terms of the earthquake, it has been ranked the sixth in the world. Although the damages caused by the disasters are not irreversible from different aspects, they could be minimized by performing appropriate preventions as well as preparing plans to counteract the impacts of such incidents. According to the increasing trend of disasters and crises, which hardly damage businesses and communities, providing relief supply chain for crisis situations (HDRSC) is necessary and vital in the wide field of supply chain management (SCM). Even though considerable attempts have been performed in the field of supply chain focusing on the disaster relief, few studies have addressed its complex features and properties. This paper concentrates on the activities such as demand determination and supply chain coordination by field study and best review of best-related research. This research provides a framework for supply chain managers in crisis, who face similar problems in other environments, with valuable insights.</p>

### **1. Introduction**

Despite of recent technological advances, one of the main barriers to the sustainable development in different countries is suffering from natural disasters (earthquake, flood, storm, lightning, avalanche, tornado, fire, volcanic burst, etc.) as well as unnatural ones (war, terrorist attacks, road accidents, industrial accidents, political issues, immigration, homelessness, etc.). Unpreparedness and inappropriate confrontation against these disasters impose heavy damages and losses to nations and their properties, which might sometimes be irrecoverable.

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What happens in a part of the world, influences the other parts' activities. When disasters and crises take place continuously in a part of today's world, their economic, social and emotional effects are not limited to the part facing them directly, but their second and third order effects remain in the form of a wave in supply chains all over the world. In 27<sup>th</sup> of August 1883, explosion and eruption in Krakatoa, Indonesia left 100000 dead behind and the explosion had been heard from 3000 miles away. Weeks later, people in Australia, Netherland, Berlin, and New York realized the real details of the disaster [2]. On Friday 11<sup>th</sup> of March 2011, east coasts of Japan were destroyed by Tohoku earthquake and tsunami. Many people around the world watched the disaster online. Therefore, disasters and crises generate effects requiring immediate action aiming the reduction of such effects (social, humanitarian and economic), while speeding up the recovery process. HDRSC (Humanitarian disaster relief supply chain) lays in the heart of such challenges.

According to investigations, Iran is among the first ten disaster-prone and the six earthquake-prone countries of the world. Random and unpredictable nature of natural disasters (especially earthquake) requires designing thorough crisis management plans in order to reduce the risks and alleviate the sufferings caused by crises. In fact, the main purpose of relief responses and reactions is to better plan the encountering measures during these types of phenomena and increase public awareness to be able to decrease the deaths and injuries as well as reducing property loss [3].

Among natural disasters, three of them, namely earthquake, flood, and drought, are the most frequent happening in Iran. According to the international institute of seismology and earthquake engineering, nearly 83% of the population in Iran live in areas with a relatively high probability of the earthquake, while 51% are subjected to flood. Deadly earthquakes in Iran are because Iran is located on one of the two large seismic belts in the world, known as Alpa. Also, numerous faults exist in Iran plateau.

In addition, based on geological studies, it would not be beyond expectations if one deadly earthquake took place in Tehran at least every 151 years. Considering the last earthquake in Tehran (being larger than 7 in Richter scale) occurred 168 years ago, and that several crucial faults are located around Tehran, one could expect the possibility of a deadly earthquake every moment in Tehran district. This problem, together with Tehran's conditions in different fields having unprincipled structures, population concentration, political-cultural concentration and probable damages to water, electricity and gas lines after the earthquake, it could be deduced that Tehran's earthquake could also be deadlier such that based on existing reports, it could be considered as one of the largest disasters of the world from humanitarian and financial losses point of view.

Since spreading and intensity of natural disasters are increasing due to reasons such as population growth, climate changes, and global integration, it is predicted that current aids are insufficient. On the other hand, nature of natural disasters requires that they are responded in short periods of time. During such urgent and complicated situations, decision makers should quickly and effectively respond to the logistic problems and transfer suffered people from exposed areas to specified centers and this will not be possible without precise planning and systematic relief network.

Although damages caused by such events are not recoverable, especially financially and mentally, the damages could be minimized taking predictive measures and preparing appropriate plans to be well prepared for encountering such disasters. Since intensity and the level of exposed area of such events are high, large volumes of aid and rescue operations are urgently required after the occurrence, while regular aid centers, which supply the city requirements in normal situations, are often insufficient for quick responses to the produced requests during such events.

Furthermore, it should be also be noticed that dealing with victims, transporting necessary items, offering Medical first aids, and transferring the injured to relief centers within the required time frame, mainly the first 72 hours after the disaster (the golden relief time), are of great importance in reduction of loss and disabilities caused by such events [10].

Therefore, the main necessity lies in the difference between crisis and normal situations. One major required action necessary for crisis situations is to optimize the distribution and assignment of resources among people. Time applies the crucial effect on the increasing number of rescued people by relief activities. Since the precise determination of the demand for critical items during disasters, among which medicine is the most important one, is indeed difficult and impossible in almost all the cases, the complexity of the situation yet increases. In fact, the main challenge of the crisis situation comparing with normal conditions is the severe uncertainty as well as the limited time window of helping the victims.

This paper started with the opportunities and importance of crisis supply chain. It is attempted to detect how the crisis supply chain is distinguished. In the case of crisis situations, many fields are exposed to risk, the most critical of which is the staff lives. By designing, implementing and managing the crisis supply chain, specifically its logistic, one could not only reduce the costs but also save more lives. The main challenge that this paper is focused on, is to integrate the field studies and academic research about the supply chain management in critical condition and present hybrid findings for managerial insights.

## **2. Related concepts**

### ***2.1. Supply Chain Management (SCM)***

A supply chain includes all stages that, directly or indirectly, play roles in meeting a customer's demand. In an ordinary supply chain, raw materials are sent by providers to factories and, then, the products produced in the factories are delivered to central warehouses and distributor ones and, from there, they are transferred to retailers and, eventually, are delivered to the final customer, which is the consumer. Therefore, a commodity passes through different stages of the chain to reach the consumer. In some stages, the good is stored and in others, it is shipped. The Supply chain members are generally as follows:

Providers, Stocks of raw materials, Distribution centers, Distributors, Retailers and Final customer.

Fig 1 shows the schematic of a supply chain:

Activities of the supply chain start with the customer order and end when the customer pays the expenses of the received commodity or service and the final product is delivered to him. The difference between the money spent by the customer with the total costs spent by the whole chain to produce and distribute the commodity shows the chain profitability [7]. Accordingly, the success of a chain is defined by its profitability and the supply chain management requires managing the flows between the stages as well as inside each stage of the chain, in order to maximize the total profit. Therefore, supply chain management would be definable as below:



**Fig 1.** General structure of a supply chain

A set of guidelines for integration of the chain members (providers, producers, distributors, retailers and final customer) whose purpose is to reduce the system costs and to increase the level of service to customers [17]. From this definition, two following points are comprehended:

First, the supply chain management pays attention to any approach that leads to the reduction of costs and plays a role in meeting the customer's needs, including the provider and production facilities to raw material stocks of distribution centers as well as retailers and products' stock. In fact, in some supply chain analyzes, it is necessary to focus on providers and customers due to their critical role in supply chain formation.

Second, the main purpose of the supply chain management is to increase the effectiveness as well as to reduce the costs within the whole system. By employing well-known approaches in supply chain management, the total cost of the system, including transportation, stock, material handling, etc., could be decreased. However, this does not emphasize that only transportation, stocks, and other similar costs are reduced, but the supply chain management attempts to improve the whole system efficiency and also to level up serving the customer by employing a systematic approach.

Since supply chain management emphasizes on the integration between the providers, distributors, and the final customer, it covers most of the company's activities at different levels, from strategic levels to tactical and operational ones [12].

Main barriers for integrating the supply chain are as following:

- 1- It is possible that the members of a supply chain have different and incompatible goals. For instance, the providers would usually want the producers to buy a large amount of commodity with constant volume and flexible delivery date. However, the producers are supposed to be flexible with respect to the customer's needs as well as demand variations, since production decisions are often made without exact information about the demand.
- 2- Producers' Capability in adopting the supply and demand is highly dependent on their ability to change the size of order lot and, for this reason, they are willing to buy in smaller lot-sizes and with variable volumes. Similarly, the producers' purpose in high volume productions is usually in contrast with the purpose of distributors and shopping centers, since they always want to reduce their stock and increase their order frequency, which could lead to increased

transportation costs. When a variation is applied in the demand at the end of the chain, i.e. from the customer side, all members of the chain should vary themselves according to the applied variation. However, a long period of time is required to have this variation applied across all levels of the chain since this variation accompanies a time delay. The main problem is that the demand fluctuation gets more intense as the chain start is approached. This phenomenon is called Bullwhip effect in the supply chain [17].

## **2.2. Crisis Management Cycle**

The crisis management cycle has four steps as listed in the following [15]:

### **2.2.1. Expectation and Prediction Step**

In this Step, conducting the following items is necessary:

- Exact identification of probable mass disasters and developing a geographical map of areas at risk according to the type of disaster, severity, and probability of occurrence.
- Developing preventive guidelines about structures (private and public), urban facilities, infrastructures, and national treasures.
- Supervising the execution of guidelines
- Identification of technical predictive ways, tools, and required instruments for predicting the mass disasters
- Public training in order to enhance the public awareness for the probable mass disasters and suitable individual behaviors in case of incident
- Training the special national and local staff related to type of probable disaster according to local facilities and requirements
- Providing necessary equipment for help and rescue and founding permanent relief and rescue basements within national borders
- Developing permanent plans of precautionary and predictive action in national level
- Developing mandatory evacuation plans when necessary and predicting location, facilities, and tools as well as necessary instruments after population evacuation.
- Regular study on possibility of evacuation of endangered areas and varying the land utilization with respect to type of the probable mass disaster
- Regular study of crisis management and deciding at crisis situations and practicing the crisis management guidelines

### **2.2.2. Warning against Crisis Step**

In this step, all the following should be conducted:

- Determining ways of warning in case of danger of any mass disaster
- Providing warning tools
- Public training of the signals of mass disaster
- Guidelines for rescue and safety from mass disasters in case of incidence

### 2.2.3. Rescue Step

This step includes the following:

- Identification of the location, severity, and the disaster domain.
- Declaration of public mobilization according to severity and the mass disaster domain.
- Dispatch of special relief staff, necessary tools, and working instruments.
- Immediate protection of damaged areas from hygienic point of view and performing social and legal controls on quick transferring of sufferers to prepared centers
- Search and rescue operations
- Evacuation of bodies and burying them along with conducting necessary hygienic actions
- Evacuation of remainders to points pre-designed in step of expectation and prediction
- Formation of temporary and permanent camps
- Providing the camp residents with daily requirements and essential facilities
- Evacuating properties and dividing them
- Quick reopening of roads and constructing temporary landing runways for helicopters and airplanes
- Founding field hospitals
- Wide social, mental, and behavioral relief actions
- Executing evaluations of rescue and identification of defects and limitations

### 2.2.4. Normalization and Release Step

In this step the following actions are performed:

- Short term relief actions
- Mental and behavioral actions
- Mid-term relief actions
- Calculation of damages and financial as well as humanitarian losses
- Inspection of all urban and infrastructural structures and facilities as well as national treasures and estimating the amount of imposed damages as well as the probability of intensification of losses in the future and their repairing and reconstructing ways.
- Research on evaluating the damages and ways of normalization

### 2.2.5. Characteristics of the Crisis Logistic System

In recent decades, the logistic system has become inevitable for organizations and has found a role in the organization's costs basket, such that activities of the logistic system could significantly affect the effectiveness and efficiency of the organization.

Expectations and demands of sufferers as well as the relief and rescue groups as the consumers and final user of the commodities, equipment, and support services could be categorized in various subjects. The major expectations from the logistic system are providing the required equipment as well as essential qualitative and quantitative supports within the required time frame and at the appropriate place.

By preparing and planning appropriately, the logistic system provides a suitable base for association and application of providers' maximum power and potential, such that it could not only attract their confidence but also provides the sufferers and relief groups with equipment and commodities with appropriate speed and quality and at the required time and place. This goal could not be achieved unless a logistic system with crisis management-compatible features is formed and it is handled with integrated management using modern and efficient information technologies. The effectiveness of the logistic system could be determined via its preparation, speed, and reactivity.

### 3. Investigating the literature on Relief Actions in Respond Phase

Looking thoroughly to the research in the field of supply chain and crisis logistic, one could categorize the problems presented in the crisis logistic literature into the following groups [2]:

- Locating the relief facilities
- Stock management
- Flow in the network
- Navigating the transportation tools

Generally, the relief logistic models could be divided into three overall categories with respect to the type of their goal:

i) *Minimizing the costs*

Minimizing the costs include the costs after the incident and before it. For example, the costs of establishing storage spaces, storage of relief items, transportation costs, operational costs, and etc. whose presence in function of most multi-goal models of relief logistic is considerable.

ii) *Maximizing the sufferers' satisfaction through maximizing the justice in relief distributing*

In the literature of relief logistic, minimizing the unanswered demand and expectation time for receiving help are two parameters effective on increasing the satisfaction of the sufferers. On the other hand, maximizing the satisfaction of the sufferers all through the relief network would lead to maximizing justice in distributing relief and, therefore, both these expressions are used in relief logistic literature [2].

Some authors [10, 18, 15], used minimization of average or total time of commodities delivery and/or, on average, the latest time of commodities delivery to the demanded points to investigate justice in relief distribution; where these types of goals would eventually lead to faster distribution of relief with higher transportation costs. Chang et al.[4], have considered weighing the travel time by means of the delivered commodity and Duran et al.[19], considered minimizing the total cost of delivering operation of the commodities together with minimizing total time required for commodity delivery. On the other hand, the authors of [11] and [14] attempted to minimize the maximum unanswered demand together with minimizing total time required for commodities delivery.

However, in all the above multi-objective models, the cost minimization function has also been considered as an objective function. On the other hand, the authors of [5-6] mentioned the unanswered

demand. Yi and Özdamar [17] mentioned the concept of distribution in delivery and minimization function of total unanswered demand in their models and considered the novel idea of displacing equipment between medical centers in order to better serve the sufferers.

Weisz and Taubman [16] examined global disaster relief efforts of the past decade through a review of the literature and from observations made in the field [16]. Taylor and Arthanari proposed a new structure of existing information systems and communications networks in disaster conditions. This architecture has additional capabilities that enable a 'low cost version' of relief supply chain [13].

iii) *Maximizing the capability of the travel assurance*

Van Hentenryck [15], used the possibility of reaching the vehicles to pre-defined destinations to maximize their reliability. In addition, they used the minimizing costs and minimizing unanswered demands functions in their multi-objective model as well.

In new researches Goli and Alinaghian represent a new mathematical model for emergency supply the needed products in crisis. In this research minimizing last visit time is the objective. By this objective the variance of the relief time in crisis condition can be reduced and it can be a criteria for justice in relief distribution. [8]. In a similar research Alinaghian and associations present new novel metaheuristics to find the best possible location routing solutions in crisis condition by considering a disaster relief supply chain [1].

Huang et al. [9] investigate on disaster relief facilities to improve satisfactions. They present a bi-level programming approach is developed to location facilities at each level and address the complexity due to the interdependency. In order to optimization this matter they present a heuristic algorithm to optimize this problem [9].

## **4. Method**

The method employed in the present study is theoretical where library method has been used to collect information. Here, the crisis and its management have been initially studied in a supply chain and the main focus has been on the management approach. On the other hand, principal issues of natural disasters' management have been discussed.

### **4.1. Field study**

The results of this research are based on field study and review the research. The findings, as well as group analysis by the authors, is summarized a below:

Before investigating the crisis management approach in a case of natural disasters, the crisis and its logistics are studied at first with the main aim concentrating on the characteristics.

Furthermore, the principles of logistic management of natural disasters are studied and the main cycle of this type of management and its applicable methodology are discussed as well, due to the nature of disasters and their management approach in a timely manner.



#### 4.1.1 Crisis Logistic findings

It has been predicted that until 2125, above 5 billion people will live in urban areas around the world from which 81% will reside in less developed cities and this could induce challenges for urban planners and managers [4]. Undoubtedly, the major influence of accelerated growth of urbanization and uncontrolled growth of urban spaces would be impairing of the service distribution system and malfunctioning of the service system. Therefore, the optimal pattern of living in urban communities would require suitable planning in the cities. One of the important goals of urban designers is creating an urban space where all citizens could easily have access to city services since accessibility represents the quality of an urban space [4]. The crisis logistic includes all processes of providing, supplying, transporting, storing, and distributing commodities, equipment, services, and all necessities of the sufferers as well as relief groups, which should be achieved in minimum time, at suitable places, and in essential amount.

#### 4.1.2. Planning in Crisis Logistic

In order to plan and manage the crisis logistic, the following conditions should be met:

- 1- For this procedure, all information are supposed to be available accurately and completely as well as on time.
- 2- Capable and idea full planners with sufficient knowledge should be in service of the system. Experienced people should be employed for planning since experience factor is determining in making final decisions.
- 3- The crisis logistic management system should always be equipped with best methods and prediction techniques as well as required information in order for the prediction of future necessities to be performed easily.
- 4- A powerful crisis logistic is highly in need of strong and uniform information systems.

### 5. Methodology

As mentioned above, time is a critical factor in the crisis supply chain; therefore, in this study, a proposed research plan is developed using the two-stage expert-led approach for detecting the major challenges of the crisis supply chain in order to reduce the service time. The first step is to identify and prioritize the challenges ahead of the relief supply chain. The second step is employed for validation, clarification, and specification of the important challenges.

#### 5.1. *The Main Identified Domains*

Four important domains of challenges where the researchers could help the crisis supply chain have been obtained from the two-step methodology. These four domains are as follows: (1) Visibility of demand and determining the requirements, (2) information management and coordination between relief activities (in a variant environment), (3) planning the crisis relief, and (4) communications management and developing trust in the supply chain. Although some other domains are of importance in this area, these four domains are the most significant and applicable ones in reducing the relief time. In the following, these four domains have been discussed.

## ***5.2. Visibility of Demand and determining the requirements***

Identification of the customer's demand at crisis conditions is one of the most difficult activities in the set of actions of crisis relief; therefore, acquiring reliable information about the demand at crisis conditions is one of the main concerns of crisis management; since determining the demand during the initial hours of the crisis is very difficult and, in many cases, requires days and months of investigations. Since crisis management is trying to specify the exact amount of demand and necessity, lot of time would be lost and, therefore, the crisis losses would increase.

## ***5.3. Information Management and Coordination between Relief Activities in Variant Environment***

Challenge of information flow management and coordination between activities among relief staff is considered as one of the important concerns in the relief phase. The modified coordination including money flow and resources flow, such as relief services and critical commodities stock, is a crucial requirement in crisis supply chain management. Improving coordination between commodities flows and resources is tightly related to enhancement of information sharing and communications within the supply chain.

## ***5.4. Planning the Crisis Relief***

Planning for crisis has been demonstrated as an essential issue. Although the lifetimes of crisis plans are short, validation of important parts of the plan is necessary for preparation and prevention from getting surprised when encountering crises. All communicative hardware and software should be prepared enough for any crisis at any time. In other words, each of the chain members should be in thorough coordination with each other. This is important from this aspect that in case of crisis, no time should be lost for coordination of the chain members and relief activities should start right after crisis (respond phase).

## ***5.5. Communications Management and Developing Trust***

Trust and good communications are positive factors in performance of supply chain in the crisis scenario. Trust is one of the important components in good performance of the crisis relief operations. A key and crucial question here is how these communications should be formed. Training association and cooperation in using pre-defined patterns is one of the most suitable ways for improving communications and developing trust among the crisis chain members.

## **6. Results and Discussions**

A huge necessity is felt for new researches and studies in the supply chain within the four challenge domains (Visibility of demand and determining the requirements, information management, and coordination between relief activities (in a variant environment), planning the crisis relief and communications management and developing trust in the supply chain). These research domains are not only connected to the branch of philanthropy supply chain and HDRSC, but also to the studies in the area of SCM.

At the beginning, convergence affects the information management and coordination of relief activities, such as communications management and trust development. Secondly, uncertainty affects the problems such as visibility of demand, determining the requirements, and planning the crisis relief. Finally, the emergency organizations create challenges for information management and coordination among relief activities, crisis relief planning, and communications as well as trust development management.

Although some initial attempts have emerged within the crisis supply chain field in these problems, none of these four challenging domains have naturally been a part of previous studies and they have been a part of a bigger branch of SCM. However, until now, SCM has not investigated these issues sufficiently in the form of crisis relief. These observations could explain why the crisis supply chain requires a development beyond traditional logistic borders.

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