Humanitarian Logistics - Literature Review

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1. Humanitarian Logistics

1.1. Humanitarian logistic development

Global warming is the major cause for increasing the frequency and severity of weather-related hazards (Arnold et al., 2005). Some hazards can be predicted and this includes avalanches, droughts, famines, hurricanes, and tornadoes, among others. In contrast, some disasters cannot be predicted and this includes earthquakes. World Bank identifies natural disaster hotspots, areas at relatively high risks of losses from one or more natural hazards (Arnold et al., 2005) and assigns hotspot index for each zone. Therefore a policy need to be prepared for a hazard. Humanitarian logistics focuses on particular task in disaster management and aims in providing relief. Humanitarian organizations are supposed to make decision under certain humanitarian principal including Humanity, Impartiality, Neutrality, Independence, and Empowerment. Short description of these principals has given below

- **Humanity**: Human suffering should be addressed wherever it is found. The dignity and rights of all victims must be respected and protected
- **Impartiality**: Humanitarian assistance should be provided without discriminating as to ethnic origin, gender, nationality, political opinions, race or religion. Relief of the suffering of individuals must be guided solely by their needs and priority must be given to the most urgent cases of distress.
- **Neutrality**: Humanitarian assistance should be provided without engaging in hostilities or taking sides in controversies or a political, religious or ideological nature
- **Independence**: The independence of action by humanitarian agencies should not be infringed upon or unduly influenced by political, military or other interest.
- **Empowerment**: Humanitarian assistance should strive to revitalize local institutions, enabling them to provide for the needs of the affected community. Humanitarian assistance should provide a solid first step on the continuum of emergency relief, rehabilitation, reconstruction and development.

However, it is observed that a logistics manager compromised the standard procedure of humanitarian logistics. Limitation of mathematical modeling is a major cause of the compromise. Existing mathematical models are not robust enough to tackle the challenges of the relief distribution. Altay and Green (2006) provide a holistic review of the Operational Research/Management Science (OR/MS) model in disaster operation management until 2004. After that, Galindo and Batta (2013) extensively reviewed the progress on disaster operation management after 2004. Both resources confirm that quantitative modeling in humanitarian logistics is necessary for successful relief operation and allocation. The importance of quantitative modeling of relief allocation to areas suffering from disasters was introduced couple of decades ago by Knott (1988). A simple linear programming model was implemented for supporting relief routing during famine in Africa. After that, a number of researchers tended to formulate the resulting relief transportation issues as multi-commodity, multi-modal flow problems with time windows (Haghani and Oh, 1996). Considering the multi-commodity supply problems under emergency conditions, three linear programming formulations are proposed by Rathi et al. (1992), where the routes and the supply amount carried on each route are assumed to be known in each of the given origin?destination (O?D) pairs. Their purpose, in reality, is to assign a limited number of vehicles loading multiple types of goods in given pairs of origins and destinations such that the induced multi-commodity flow problem is solved with minimal penalties caused by delivery inefficiency (e.g., early and late delivery as well as shipping in non-preferred vehicles). Ozdamar et al. (2004) propose a logistics model to minimize total unsatisfied demand without considering equality of delivery. Beamon and Kotleba (2006) propose a relief inventory management model for stochastic demand that aims to reduce inventory cost for long-term support for victims in Sudan; while Das and Hanaoka (2014) extend the relief inventory model to consider stochastic demand and lead time for a large-scale disaster. Alongside, several researchers integrate pre- and post-disaster conditions to the model formulation. Balcik and Beamon (2008) formulate a facility location model for storing relief, and the model aims to maximize the demand coverage of the facility. Campbell and Jones (2011) incorporate facility failure risks in formulating facility locations and optimal stocking quantity. Several papers propose two-stage models aiming to minimize warehouse operation cost and post-disaster operation cost (Bozorgi-Amiri et al. 2013; Mete and Zabinsky, 2010; Rawls and Turnquist, 2010). Adivar and Mert (2010) introduce a fuzzy linear programming for relief collection from international communities after a disaster that minimizes logistics cost while maximizing credibility. In Fiedrich et al. (2000), a dynamic combinatorial optimization model is proposed to find the optimal resource rescue schedule with the goal of minimizing the total number of fatalities during the search and rescue (SAR) period, that is, the first few days after the disaster. The model proposed by Fiedrich et al. (2000) aims to merely deal with rescue resource allocation problems. Sheu (2007 and 2010) introduce a novel approach of relief allocation depending on relief urgency. The model of Sheu (2007) consists of five steps: (1) Demand calculation, (2) Affected area grouping, (3) Ranking of area group, (4) Group based relief distribution and (5) Dynamic relief supply. Ozdamar and Demir (2012) propose a vehicle routing model that aims to minimize travel time and incorporates the idea of hierarchical cluster.

2. Variation of facility location model in preparedness

Facility location models are several types on the criteria of their objectives, constraints, solutions, and other attributes. Different classifications of facility location models for distribution systems have been proposed in the literature (Klose and Drexl, 2005). The short description of different types of model are described below.

Topological characteristics: Topological characteristics of the facility and demand sites lead to different location models including continuous location models, discrete network models, hub connection models. In each of these models, facilities can only be placed at the sites where it is allowed by topographic conditions.

Features of facility: Features of facilities also divide location models into different kinds. For instances, facility restrictions can lead to models with or without service capacity. Capacity constraints also cause variations in location models (i.e., un-capacited or capacited). Location models can be further divided by the type of supply chain considered (i.e,. single-stage model vs. multi-stage model). Single-stage models focus on service distribution system with only one stage, whereas multi-stage models consider the flow of service through several hierarchical levels.

Input parameter: Another popular way to classify the location models is based on the features of the input parameters to the problem. In deterministic models, the parameters are forecast with specific values and thus the problems are simplified for easy and quick solutions. However, for most real-world problems are unknown and stochastic/probabilistic in nature. Stochastic location models capture the complexity inherent in real-world problems through probability distributions of random variables or considering a set of possible future scenarios for the uncertain parameters.

Objectives: The objective is an important criterion to classify the location models. Covering models aim to minimize the facility quantity while providing coverage to all demand nodes or maximize the coverage provided the facility quantity is pre-specified. The objective of covering models is to provide ?coverage? to demand points. A demand point is considered as covered only if facility is available to service the demand point within a distance limit. P-center models have an objective to minimize the maximal distance (or travel time) between the demand nodes and facilities. They are often used to optimize the locations of facilities in the public sector such as hospitals, post offices and fire stations. In the location literature, the P-center model is referred to as the min-max model since it minimizes the maximal distance between any demand points and its nearest facility. P-median models attempt to minimize the sum of distance (or average distance) between demand nodes and their nearest facilities. Companies in the private sector often use P- median models to make facility distribution plans so as to improve their competitive edge.

3. Our contribution for humanitarian logistics improvement

Network uncertainty: Transport network uncertainties represent the most common issue in relief distribution and are crucial for humanitarian logistics. Network information is not readily available in the aftermath of a disaster and it therefore takes several days to obtain route-maps. Uncertainties arises from several sources. For instance, (1) Unexpected events can also occur while vehicles are en route. Vehicles require maintenance after driving for hours on rough and damaged roads. (2) The service network (including work-shops or filling stations) creates additional difficulties for vehicle operation. (3) Road accessibility changes frequently and unpredictably due to the features of the terrain. (4) A number of commercial transport providers voluntarily support relief work aftermath of large-scale disasters. These organizations (commercial transport providers) are not secured by any contracts with aid organizations. They can withdraw their support during any stage of the relief operation. (5) According to the field survey in Bangladesh, NGOs do not possess vehicles and hire vehicles instead. They, if situation allows, share transportation with other NGOs or donors.

Demand uncertainty: Demand estimation is a crucial task aftermath of a disaster. The complexity in demand assessment arises about what, and how much is needed and who needs what. The situations become complicated with the presence of artificial demand (i.e., requests for aid from people who are not disaster-affected). It becomes traumatic in poor country. If hazards affect the poor society, donors face difficulties in distinguishing disaster-generated-needs (i.e., affected by disaster) from regular-needs (i.e., non-affected by disaster). According to field survey in Bangladesh, donor organizations use their local-knowledge to predict the relief demand, and NGOs that do not have branch offices in hazard areas face difficulties in identifying demand locations and quantities. Some NGOs admits that victims in accessible areas get more relief than those in remote areas. Drezner et al. (2006) propose a model for casualty collection points and use the deterministic approach for a mini-max regret multi?objective model. The proposed model aims to minimize the maximum percent deviation of individual objective function values. Lodree and Taskin (2008) address the inventory planning problem encountered by donor organizations using variants of the news-vendor model. Proactive actions to maintain inventory levels are compared with financial investment in an insurance policy. Demand is described as having a uniform distribution in the model. Salmeron and Apte (2010) use a stochastic optimization model for resource planning prior to a disaster. The model includes different degree of severities in different regions after a hurricane. The degree of severities differentiates the demand in one zone to another zone. Sheu (2010) proposes a model of data-fusion for treating multi-source information.

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