

# A Multi-Echelon Network Distribution Model For Emergency Resource Planning

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## Abstract

Resource planning in emergency management is a challenging task as it involves disaster situations where the demands are rapidly increasing and the resources are scarce. Conventional planning involves a centralized network structure where resources are distributed through a few prepositioning facilities located near to the disaster regions. In this research, we develop a novel multi-echelon network distribution structure for emergency resource planning. The structure at its highest echelon consists of a set of potential Supply Points (SPs), where resources are purchased and consolidated which is more practical in comparison to the conventional centralized structure. SPs are considered as typically large facilities in metropolitan cities in and around the potential disaster region from where the resources are distributed to the prepositioning facilities in order to be able to supply the materials immediately after the disaster in the area. The proposed structure also allows direct shipment of resources from SPs to the disaster regions in the response stage which is more close to the reality. Under the network structure, we formulate a new two-stage stochastic mixed integer programming model for an integrated emergency preparedness and response planning. The objective is to obtain the optimal allocations of the resources along with locations of the SPs and prepositioning facilities to satisfy the demand of disaster victims in a timely and cost-effective manner. We assume demand for supplies in the disaster hit areas are aggregated at locations called Aggregated Demand Points (ADPs). For the current study, the demands at the ADPs are obtained with a set of disaster scenarios each with a probability of occurrence. To develop the resource allocation model, we consider two distribution stages that are decided simultaneously: pre-disaster and post-disaster stages. In the pre-disaster stage, the analysis provides the location of SPs and the pre-disaster purchasing amounts to be acquired at the SPs. All or part of the purchased resources are positioned in prepositioning facilities located at selected ADPs. In the post-disaster stage, detail distribution of the resources to satisfy demands following the disaster event is considered. The demands in the post-disaster stage are met through pre-positioned resources at the prepositioning facilities and additionally, if required, through the direct shipments of resources from the SPs. We consider limited post-disaster purchasing opportunities at SPs as the quantities are to be purchased during a short and chaotic period. The optimization model proposed in this research consists of logistics and deprivation costs. The logistics costs include cost of provisioning, prepositioning, and delivering the resources. The deprivation costs represent the cost of not providing or delays in providing the supplies at the point of demand. The model is tested in a network for numerical analysis. The result shows that multiple SPs in the proposed network distribution structure helps to overcome the possible resource disruption that occurs with single sourcing in the centralized structure, resulting decrease of the demand shortage. Sensitivity of the model with different pre-disaster and post-disaster purchasing conditions at SPs are also discussed in order to represent realistic disaster scenarios. (Acknowledgement: Qatar/QNRF/NPRP Project: 5-200-5-027)