



7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, ICBR2017, 27 – 29 November 2017, Bangkok, Thailand

A Model for Humanitarian Supply Chain: An Operation Research Approach

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Abstract

The study presents a mathematical model for identification of the optimum location of a temporary or fixed facility in a certain geographic area being studied. Particularly, it is applied to Humanitarian Supply Chain where it seeks to identify the best location of temporary relief center operations in order to optimize the delivery of relief goods to the randomly dispersed evacuation centers. The paper seeks to optimize the movement of relief goods by minimizing the total transportation cost using Operation Research approach with the integration of Center of Gravity method. The center of gravity approach aims to locate a facility where it reflects equality of distances and demand volume in a network of customers' locations.

A case study was applied to use the model. The results revealed the geographic coordinates of the optimum location of the facility. The identified optimum location will have a total savings of 40% in the total transportation cost. Hence, by a significant reduction of the transportation cost will also mean a significant reduction of response time and delivery time of relief goods because these transportation cost are functions of distances of customers location and a function of volume of customers' demand. The identified optimum facility location could also be a prepositioned location of relief goods covering the affected areas in the city. The proposed model for disaster facility location is easy to use and require simple tasks to implement. The model is readily accessible to managers and planners so it can be used in their planning.

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Peer-review under responsibility of the scientific committee of the 7th International Conference on Building Resilience.

Keywords: Humanitarian Supply Chain, Operation Research, Center of Gravity Method, Facility Location Planning

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1. Introduction

Disaster is a serious disruption of the functioning of a community or society due to hazardous events [1]. The inevitable occurrence of disasters makes everyone to be prepared and resilient. For the past 20 years, humanitarian supply chain concept has been evolving and the current literatures have been addressing the questions of preparation and response phase of the disasters. In the recent year, a government agency in the Philippines named Commission of Audit pointed out some problems in disaster relief operations such as lack of storage facility for the procured supplies [2] and also could serve as repacking facilities for relief goods. The location of fixed or temporary facilities throughout the supply chain network is an important decision problem because it gives form, structure and shape to the entire supply chain system [3]. Actions and decisions within 72 hours to the areas affected are crucial to ensure effective and timely response to the victims of disaster in order to reduce mortality, life threatening morbidity and disability [4].

In order to have a quick response to the victim of disaster is to identify the best location of drop off points of relief goods which where it is closest to the most in need. The facility location should be in Center of Gravity, meaning that that location is the point where it reflects balance and equal weight to all customers' location and demand. This weight is function of two variables namely, customers' distances from the facility location and the customers' demand. This study was taken to know the best location of drop off points of relief items that will increase responsiveness and decrease logistics cost.

2. Related Literature and Studies

Facility location problems have been studied in the field of humanitarian supply chain, in the study of [5] where they surveyed more than 40 journal articles about optimization models for facility problems in emergency humanitarian logistics, it was found out that the major objectives are responsiveness, risks and cost efficiency. The use of temporary storage for emergency relief items is proven to improve the responsiveness, efficiency and effectiveness of humanitarian supply chain [6]. Where to locate a temporary or fixed local relief operation center facility is a strategic decision because it dictates the movement of relief goods and it determines quicker response to the needs of the victims. Adding regional distributional center to manage the delivery of relief goods would be cost efficient with an average cost reduction of 21% in several demand scenarios considered [7]. Several mathematical models have been presented in the literature to identify the appropriate facility locations for efficient supply network [8]. Providing decision support systems for humanitarian logistics managers is important [9]. Other applications of facility location models is on the study to locate health care facilities in Hongkong [10], they consider four objectives and solve the problem using Multiple Objective Optimization and Genetic Algorithm. They generate 100 iterations for each generation of chromosomes and yield optimum location.

The operation research technique with center of gravity approach was not yet applied in the disaster logistics. Looking at the previous studies, it requires high skills to execute the solutions but the paper's proposed approached in disaster logistics is easy to use and requires simple tasks to implement.

3. Methodology

3.1 Operation Research Technique

Operations research is the scientific study of operations for the purpose of better decision making and management [11]. The paper used Operation Research technique to identify an optimum solution by calculating the total transportation cost of the location of the new facility. It seeks to minimize transportation cost which is the sum of the product of customer's volume of demand (v_i) multiplied by the transportation rate to customer's location i (r_i) and multiplied by the distances of each customer location i from the facility location (d_i) as seen in equation (1).

$$\text{Min TC} = \sum_{i=1}^n (v_i * r_i * d_i) \quad (1)$$

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