SYSTEMATIC REVIEW OF DEVELOPMENT OF NATURAL FLOOD DISASTER RESPONSE PLANNING SYSTEMS TO OPTIMIZE THE LAST MILE HUMANITARIAN LOGISTICS

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ABSTRACT

Disasters 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. But still most of humanitarian aids organizations and communities are lacking the resources to effectively manage logistics and rescue victims in a disaster. This causes performance issues within the humanitarian supply chain and creates incompetence in achieving the desired levels of needs fulfillment of the victims of the disaster. For a disaster relief operations, last mile is considered to be very critical place in humanitarian logistics management due to it is the place where humanitarian aids distribution to victims is happen. Therefore, it has a significant impact on the performance of humanitarian supply chain. In global disaster context, floods are considered as one of the most frequent natural disaster world populations are faced. Therefore, objective of this research is to carry out a systematic review of the literature and design a computer-based optimization tool efficiently and effectively manage last mile humanitarian logistics for Flood disaster response situation in order to address above mentioned issued faced in the disaster relief operations. This design of the optimization tool mainly addresses the issues related to demand management, supply management and needs fulfillment in disaster relief operations by utilizing its main three components, Needs assessment component for accurate needs assessment of disaster victims , Resource allocating component to effectively allocate resources for demand location and the Route planning and vehicle allocation component is to allocate vehicles effectively and to search shortest route between demand locations and supply location. Effectively development of this optimization tool into a software system will address the aforementioned issues faced by the humanitarian aid organizations and help better provide service for the victims of the natural flood disasters around the world.

***Key words*:** Disaster management, Humanitarian logistics, Last mile operations, Needs assessment, Demand management, Supply management

1. 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”. Irrespective of the disaster type, victims of the disaster required help from other to recover from disaster and start their normal life functions. There Humanitarian logistics plays critical roles in alleviating suffer of the victims of the particular. 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 suffer of victims. The humanitarian logistics management function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, customs and clearance”.

When considering about global context, Flooding is the most common environmental hazard worldwide. A 2007 report by the Organization for Economic Cooperation and Development found that coastal flooding alone does some $3 trillion in damage worldwide.

In a disaster situation Humanitarian aid organization play role of a middle-man between donor and victims of the disaster. There humanitarian aid organizations are responsible for providing effective and efferent service to

victims within the resource constraints and uncertainty by reaching right place at right time at right cost. In achieving this goal, last node of the humanitarian supply chain plays a critical role. If the last node of the humanitarian supply chain becomes a bottle neck, it affects performance of the whole supply chain and it may decides number of people survive after the disaster. Also tracking and tracing the humanitarian logistics are very important to ensure the reach ability of logistics to the victims. When it comes to the practical situations, Most of the NGOs are using paper based systems to manage humanitarian logistics that made whole management process less effective and efficient. And also it duplicates the functions, increases the cost of doing operations and may waste some of donations they got [1].

Therefore, this research is to carry out a systematic review of the literature and design a computer-based optimization tool efficiently and effectively manage last mile humanitarian logistics for Flood disaster response situation, in order to address above mentioned issued faced in the disaster relief operations. The design a computer-based optimization tool brings operation research technology into last mile humanitarian logistics planning will help humanitarian organizations to provide better service to victims at the same time by providing real value for donors who donate for victims of particular disaster

2. METHODOLOGY

2.1 Problem Definition

The last mile humanitarian logistics distribution problem determines the best resource allocation among potential aid recipients in flood disaster affected areas and accurate need assessment of flood victims that minimize the cost and the time of logistics operations, while maximizing the benefits to aid recipients in an environment that has limited resources in terms of time, supplies, personnel, vehicles, transportation and communication infrastructure. More specifically this study address the aforementioned problem in a form of software package that provides,

1. Accurate need assessment for the victims of particular demand location
2. Delivery schedules
3. Vehicle routes for humanitarian aids transportation
4. Humanitarian aids allocation for demand points

Design of the aforementioned software package will be describe bellow (refer fugure01).

2.2. Design of the Optimization Tool

Disaster preparedness stage is highly interconnected with the disaster respond stage when providing a better service to the victims. Therefore, this software package requires set of pre collected data for its functioning and details of required datasets are describe below alone with the components that there are using.

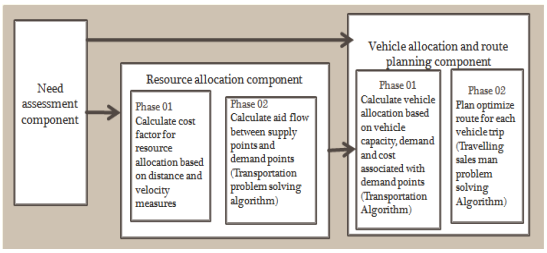

Figure 1: Design of the optimization tool

2.2.1. Needs Assessment Component

Needs assessment is considered to be most critical and as well as difficult task in an immediate disaster responding stage, due to various reasons. Here victims are categorized in to four clusters based on their physical characteristics for the need assessment process. Then introduce two types of need packages namely basic needs package (needs occurs right after the disaster) and other needs package (needs occurs with some time pass after the disaster) for each cluster of victims. Items in these needs packages are change based on the demographical and social and other conditions of the affected area. Then needs assessment process is done based on the pre define needs package and number of victims belong to each cluster in the each camp. Weather to use basic needs package or use both packages are decided based on the severity of the disaster. Further details of the victims clustering and needs packages are describe below.

Victim clusters

- Infants
- Pregnant mothers
- Old and sick people
- Normal people

Needs of above clusters has slight variations due changes of physical characteristics of each cluster of people.

Needs Packaging system

Here introduce two types of victim needs packages namely basic needs and other needs. Because there are different urgency for fulfilling needs and needs are changes based on the severity of the flood situation.

2.2.2. Resource allocation component

Resource allocator component determine the humanitarian aid item flows between supply points and demand points in a flood disaster situation. This resource allocator component consists of two phases and each phase will describe below.

Phase 01-In a disaster situation time require performing the relief operations is a very critical measure, because speed humanitarian operation affects the survival of victims of disaster. Therefore this phase calculate approximate time factor based on distance and velocity measures between demand and supply points. Above time measure will be use as a cost measure for the resource allocation in latter phases.

Phase02-This phase is developing a plan to distribute optimum aids quantity to the victims who are in different camps based on the time measures calculated in the previous phase. For the calculation process this phase will be utilize operational research Transportation problem solving algorithm in order to determine initial resource allocation for demand points. Here main objective is to minimize time required to transport humanitarian aid items between supply points and demand point. Therefore Transportation problem solving algorithm will be using time measures calculated in above phase 01 as a cost of transportation (As mention in earlier time is very critical resource in disaster relief operation environment). In additional, to the results from phase 01 below datasets will use for the calculation purpose.

- Output of the needs assessment component
- Capacities of supply locations
  This data set required data related supplying capacity of each supply points with respected to the items they can supply

Mathematical formulation of Phase 02

i- index for supply point i=1,2,…m
j- index for demand point j=1,2,…n
X_{ij}- Number of units flow from supply point i to demand point j
C_{ij}- Time required to travel between supply point i to demand point j
S_i- Supply capacity of supply point i
D_j _Demand in the demand point j

Objective function:

$$\text{Min} \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij}$$

Subjected to:

$$\sum_{i=1}^{m} X_{i\,i} \leq S_i$$
$$\sum_{j=1}^{n} X_{ij} \leq D_j$$

2.2.3. Vehicle allocation and route planning component

This phase is dealing with each supply point; here this overall component will decide number of vehicle trips required to transport aid items for demand locations and optimum route a particular vehicle trip should travel. For that this component is consist of two phases and each phase is describing below.

Phase 01-This phase calculate the number of vehicle trips required and amount of aid items should carry by each vehicle trip to which demand locations in order to cater to total demand of victims who are allocated to the particular supply point. Calculation process require vehicle capacity, set of demand locations assign for the supply point, time measures require to transport aid items from supply location to demand locations. The calculation process in this phase is done in following manner,

1. Calculate number of vehicle trips required based on vehicle capacity and the total demand assign to the supply point
2. Prepare time matrix by repeating number of vehicle trips time measures between supply point and demand points
3. Apply transportation problem solving algorithm in prepared dataset

Mathematical formulation of vehicle allocation phase

i- index for vehicle i=1,2,…m
j-Index for demand point j=1,2,…n
X_{ij}- Number of units flow from supply point i to demand point j

C_{ij}- Time required to travel between supply point i to demand point j
S_i- Vehicle capacity of supply point i
D_j _Demand in the demand point j

Objective function:

$$\text{Min} \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij}$$

Subjected to:

$$\sum_{i=1}^{m} X_{i\,i} \leq S_i$$
$$\sum_{j=1}^{n} X_{ij} \leq D_j$$

Phase 02-This phase provides optimum route for the each vehicle trip. If a vehicle assigns more than one demand location for a trip, optimum route is calculated by using time measure related data and travelling sales person algorithm.

Mathematical formulation of path determining phase

i- index for location i=1,2,…m
j-Index for location j=1,2,…n
X_{ij}- {1 travel from location i to j
0 Otherwise

Objective function:

$$Min \sum_{i=1 j\neq 1}^{m} \sum_{j=1}^{n} T_{ij} X_{ij}$$

Subjected to:

$$\sum_{i=1 i\neq j}^{m} X_{i\,i} = 1$$
$$\sum_{i=1 i\neq j}^{m} X_{ij} = 1$$

In the development process assume one transportation mode use for relief operations and each supply point has vehicles with same capacity. Ignore planning horizons and vehicle condition and driver related factors for the calculation process.

3. CONCLUSIONS

This study identified optimization requirements in last mile humanitarian operation environments are converted into a design of an optimization software package. That facilitate, need assessment of disaster victims, prepare relief items delivery schedules, determine optimum vehicle routes for humanitarian aid items transportation and the amount of emergency supplies delivered to demand locations during disaster relief operations within number of constraints. Effectively development of this optimization tool into a software system will address the identified issues faced by the humanitarian aid organizations and help better provide service for the victims of the natural flood disasters around the world.

4. FUTURE WORK

In future this research study can be extended in following methods in order to improve accuracy of the last mile humanitarian logistics management optimization process and strength the design of the optimization tool.

- Expand the design in order to consider different mode of transportation like water, land and air transportation modes and incorporate planning horizons concept in to the tool.
- Incorporate driver related and vehicle related factors into the modal

By incorporating these changes into this study could improve and the strength of the design of the optimization tool. Ultimately this tool design into a software system will help to best serve victims of different type of disasters.

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