Multi-Objective Resources Scheduling Model in Humanitarian Logistics Considering Secondary Disaster

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Abstract

In times of crisis or disasters, such as during a war or in response to a catastrophe, humanitarian assistance and disaster relief are provided. Instead of solving structural issues of global poverty, deprivation, or inequality, humanitarian aid is sent to tackle local areas and repatriate refugees at the rate of sudden incidents, unlike normal aid programs in a region.The goal of this study is to establish a conceptual framework for managing the logistics of humanitarian assistance and disaster relief. A key feature of emergency disaster logistics management is the optimum distribution of emergency services. In the current processes, most of them are single-objective and probable secondary disasters are frequently ignored, which urgently need to be changed. In this paper, the multi-objective (transportation time and cost) resource scheduling model considering possible secondary disasters is formulated, and the GRG no-linear method is used to solve the problem. The numerical simulation provides proof of its effectiveness and efficiency. Furthermore, the research offers and analyzes how to put into practice an efficient system for humanitarian logistics management to help Bangladeshi people boost their efficiency in relief efforts.Finally, the findings of the experimental scenarios showed that, relative to the current system, the overall results obtained from the analysis were adequate, irrespective of whether secondary disasters unfolded sooner or later. In practical applications with large-scale scenarios, our method and algorithm can always be incorporated.

Keywords
Humanitarian Logistics, Secondary Disaster, GRG no-linear, VRP and Multi-Objective Function

1. Introduction
Over recent decades, persuasive data and debate have shown that the number of disasters around the world has risen at an alarming pace. Globally, growing attention has been drawn to how to enhance the efficiency of humanitarian assistance and disaster relief.According to EM-DAT, there have been 15189 natural disasters recorded during 1951-2020 and 3698 natural disasters recorded during the last decade (2011-2020) worldwide; among them,1,565 disasters are in the Asia continent (EM-DAT, CRED / UCLouvain, Brussels, Belgium 2021). In this decade, a massive disaster (drought) occurred in India in 2015 and this exists through late 2016. A total of 330 million people were affected. And in terms of mortality and economic damages, the Tsunami in Japan, back in 2011 was more

destructive. A total of 19,846 people died and a severe economic loss of 210 million USD. So, the disasters have negative impact in our society. But the disasters are increasing day by day over the past years. The data shows in Figure 1 illustrate this quite clear.

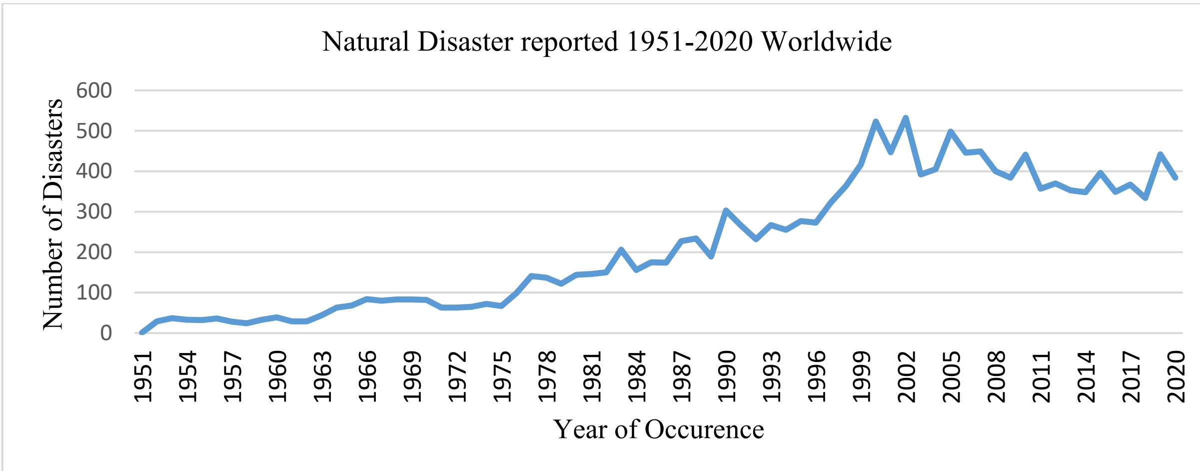

Figure 1. Worldwide natural disaster reported from 1951-2020

From the above figure 1, it showed that natural disasters significantly increased from 1951 to 2020, which includes tropical cyclone in the Riverine flood in Pakistan (2011), Drought in Vietnam (2015), Flood in China (2016), Tropical cyclone in Haiti (2016), Earthquake in Nepal (2018), Tropical Cyclone in the USA (2017), Tsunami in Indonesia (2018), Cyclone in Bangladesh (2020).

Reducing the scope from foreign to Bangladesh, Bangladesh is amongst the most vulnerable countries to witness very frequently severe natural disasters, such as floods, cyclones, earthquakes, landslides, arsenic hazards, etc., with the tropical environment and fragile landforms, combined with high population density, deprivation, ignorance, and lack of adequate facilities (Hossain and Miah2011). Bangladesh experienced almost 125 natural disasters during the last two decades.Two major disasters in 2007 should not be overlooked, and they are a tropical cyclone and a flood. So, disasters in Bangladesh are also increasing alarmingly. Below figure 2 shows a brief image of natural disasters in Bangladesh.

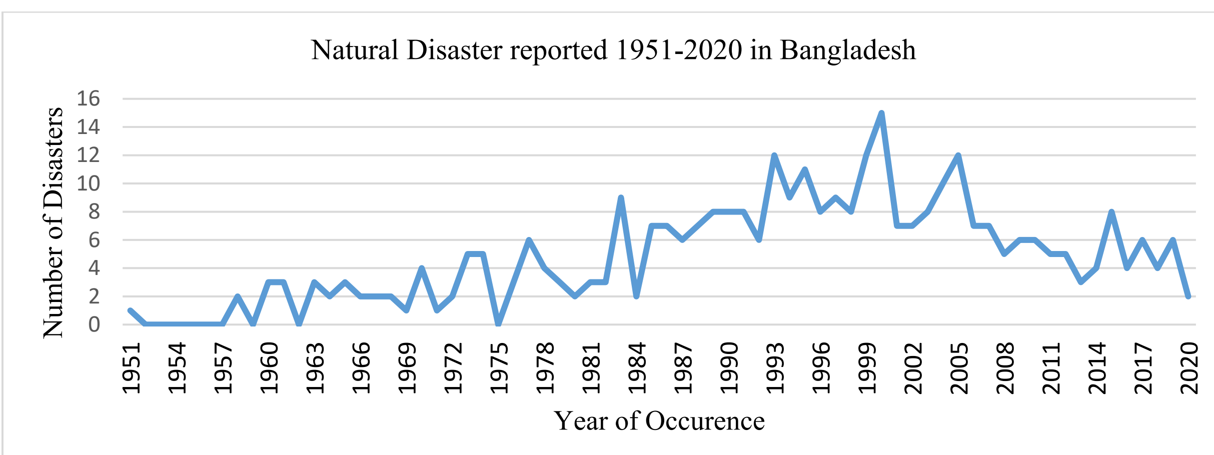

Figure 2. Natural Disaster reported from 1951-2020 in Bangladesh

From the above Figure 2, natural disasters in Bangladeshexperienced greater fluctuations between the years of 1951and 2020, which includestropical cyclone (2001), Flash flood (2002), Riverine flood (2005), Strom (2006), Landslide (2008), Tropical cyclone (2013), Earthquake (2015), Flood and Strom (2018,2020). In 1999, there were almost 15 disasters, which is greater in the date range,was significantly reduced to 2 disasters in 2020.

Disaster effects are not only associated with accidents, fatalities, and damaged infrastructure in the short term, but also abate improvements in economic and social conditions in the long term (Ergun et al. 2010). While we cannot avoid disasters from happening, their consequences can be minimized by numerous means, including research on humanitarian and disaster operations. For example, because of logistical problems with restricted facilities, assistance does not enter disaster areas.Humanitarian logistics has received increasing interest through both logistics academics as well as practitioners as a direct consequence of the Asian tsunamis in 2004 (Kovács and Spens 2007). Humanitarian logistics stands for disaster control through the creation of a comprehensive effective and efficient plan (Noham and Tzur2018).

In Bangladesh, the government allotted 35 cr. BDT in cash and rice (3,00,000 metric ton), wheat (1,00,000 metric ton), and different types of food items in the fiscal year 2013-2014 (Department of Disaster Management 2013). The government of Bangladesh developed many shelters in disaster-prone areas. Human beings should prepare countermeasures by building infrastructure and preparing relief operations in advance to minimize the negative impacts of disasters (Farahani et al. 2011). But there is no plan or methodology or mathematical model in the pre- or post-disaster stage to rebuild the structure, in which place shelter should be built, convey foods and facilities, distribution center, proper routing plan, facility location, vehicle capacity, and routing, cost allocation. It is imperative to maximize the location and quantity of relief materials to meet the immediate needs of victims in the shortest possible period and with the least resources to minimize community vulnerability (Geng et al.2020).

Besides that, it is obvious in Bangladesh to incite a secondary disaster after a primary disaster has been placed. According to the recent report of EM-DAT, CRED/ UCLouvain, Brussels, Belgium (2021), two consecutive disasters in Bangladesh held in May 2015 have severe losses economics. Due to its proximity to the Bay of Bengal and funnel shape coastal area, it is very vulnerable to disaster. During or after the disasters, road collapse or break down, heavy rainfall, floods are the main obstacles to conveying humanitarian aid to the places of disaster in Bangladesh. So, effective, and efficient vehicle routing can alleviate the suffering and destruction of disaster. However, there has been no research work founded in Bangladesh (partially in the world) considering secondary disasters in resource scheduling. We aim to convey humanitarian aid with a proper mathematical model of resource scheduling considering secondary disasters to vulnerable people within the shortest time to minimize disaster sufferings and maximize their demand fulfillment.

In this paper, we build a multi-objective Vehicle Routing Problem (VRP) model to convey the resource from the multiple-distribution center to multiple vulnerable areas in emergency response. Humanitarian assistance will be sent from various emergency distribution centers to different disaster areas. We also research the impact of secondary disasters that occur separately in disaster areas with certain probabilities. The follow-up disasters of these secondary disasters will not be considered concurrently, for convenience. We divide the criteria into primary disaster demand and secondary disaster demand and presume that they are independent of each other. In the meantime, manufacturers are available and are obligated to provide some amount of assistance without advance notice. We model the multi-objective Vehicle Routing Problem (VRP) considering both primary and secondary disasters. The objective function contains the minimization of transportation, RDC setup, inventory holding cost, and transportation time of vehicles from DC to vulnerable areas of both primary and secondary disasters. The constraints are also involved in these multiple limitations.

1.1 Objectives

To evaluate the various models that have been developed or used, and then to develop an appropriate humanitarian aid and disaster relief logistics management system. Then, collecting data on Bangladeshi populations, and then evaluating and determining their status. Defining strategies for implementing an efficient structure to strengthen their logistics management in humanitarian assistance and disaster relief and transmitting the results to the citizens of Bangladesh.

2. Literature Review

A disaster is a significant disturbance that causes widespread human, material, economic or environmental losses over a short or long period that exceeds the capacity of the affected community or society to cope with the use of its resources (Wikipedia contributors 2001). Researchers have been researching disasters for more than a century, and disaster science has been institutionalized for more than 40 years (Renu2010).

Humanitarian logistics has been defined as a process and structure responsible for providing humanitarian approaches to help vulnerable individuals (Salehi Sadghiani et al.2015). The center of attention of humanitarian logistics is to the welfare of affected persons invaded by disasters (Holguín-Veras et al. 2012). If a resilient humanitarian logistics network is designed considering both operational and disruptive risk, it secures the covey of essential goods to the beneficiaries(Nezhadroshan et al. 2020). A significant number of qualitative studies have been conducted that are useful for estimating the parameters of the humanitarian logistic (e.g.,Tofighi et al.2016; Sahebjamnia et al. 2017; Samani et al. 2018). In humanitarian logistics, there are many problems related to in this field, such as evacuation planning (Goerigk et al. 2014), and Vehicle routing problems (Talebian Sharif and Salari 2015).

In humanitarian relief operations, VRP is more tactical and critical. In the VRP context, Using GMG non-linear operation, Berkoune et al. (2012) propose a greedy heuristic and genetic algorithm to minimize the total duration of all trips in a multi-trip, multi-product, and multi-depot VRP. Camacho-Vallejo et al. (2015) proposes a bi-level programming model in which the objective is to minimize the transport time from an international aid agency to a storage center and then to a disaster-affected area from this center. As a dynamic optimization of vehicle routing during disaster response, Maghfiroh and Hanaoka (2018) developed humanitarian logistics. Under demand uncertainty, their proposed model optimized the heterogeneous vehicles, multiple trips, and location of facilities with different accessibilities.

Usually, large-scale disasters and traumatic incidents lead to a severe shortage of vital resources, posing a major challenge in allocating scarce resources to improve the efficiency of immediate logistics activities among the numerous affected regions (Yu et al. 2018). To minimize the distress caused, the logistical mobilization of resources to provide relief for disaster victims and the proper preparation of these activities are crucial (Rodríguez-Espíndola et al. 2018).A bi-objective robust immediate resource allocation model was formulated by Hu et al. (2016) to optimize the effectiveness and fairness of an allocation strategy for which a bi-objective heuristic particle swarm optimization algorithm was established to check the model's Pareto frontie. Das and Hanaoka (2014) proposed an agent-based model to analyze the effects of fleet allocation to optimize social benefits. Because of the worsening health conditions, Xiang and Zhuang (2016) researched a medical resource allocation question and proposed a novel queueing network model to optimize the service rate.

There are several ways available in the literature as to how to deal with the multi-objective factor in the development of humanitarian logistics. Yuan et al. (2013) studied the qualifications of rescue workers for various rescue assignments. Garrido et al. (2015) presented a multi-objective model for multi-objective emergency logistics issues to assist decision-makers in the logistics of a flood emergency to minimize the unwanted effects of such events. The goal of the model was to optimize inventory levels for emergency supplies and the availability of vehicles to supply sufficient supplies. An integrated multi-objective optimization model that combines resource allocation with emergency distribution was presented by Huang et al. (2015), in which a time-space network was used to integrate frequent data and decision updates into a rolling horizon approach. Three objective functions, i.e., lifesaving utility, delay cost, and fairness, are included in the model.

J. Li and Chen (2014) and Zhang et al. (2012) presented that many natural disasters have threatened lives and property in recent years, causing widespread concern and exposing populations to secondary disaster possibilities. In current emergency resource allocation methods, human resources and possible secondary disasters are often neglected (Zhang et al. 2017). Besides, many of the requirements of the secondary disaster points prompted by the primary incidents provide more emergency aid challenges Zhang et al. (2012). The existing methods become most practical when secondary disasters will have considered, compared with the current method that does not consider secondary disasters. Zhang et al. (2015) introduces a multi-stage assignment model to respond to the disaster chain for rescue teams and develops three priority scheduling strategies identified under the concept of a burden-benefit agreement. To solve the above multi-objective integer nonlinear programming model, NSGA-II, C-METRIC, and fuzzy logic methods were developed.

3. Model Formulation and Methods

3.1 Notations and terminology

I Set of suppliers indexed by $i \in I$
J Set of candidate RDCs indexed by $j \in J$
K Set of AAs by primary disaster indexed by $k \in K$
v Set of AAs by secondary disaster indexed by $v \in k$
L Set of the size of RDCs indexed by $l \in L$
S Set of possible scenarios indexed by $s \in S$
C Set of commodities indexed by $c \in \{1, 2, 3\}$
E Set of vehicles $e \in \{1, 2, 3\dots z\}$

3.2 Parameter

P = Probability of secondary disaster to happen
D_{ec} = Demand of commodity c at AA, k
D_{vc} = Demand of commodity c at AA, v
V = Average velocity of the vehicle
u = Total number of AA
f_{jl} = Fixed cost for opening an RDC of size l at location j
C_{cij} = Transportation cost for a unit commodity c from supplier i to RDC j
C_{cjk} = Transportation cost for a unit commodity c from RDC j to AA k
C_{cjv} = Transportation cost for a unit commodity c from RDC j to AA v ($v \in k$)
d_{ijc} = Distance of supplier i to RDC j
d_{jkc} = Distance of RDC j to AA, k
h_{cj} = Inventory holding cost for a unit commodity c at RDC j
G_{ci} = Capacity of supplier i for commodity c

3.3 Decision Variables

Q_{ijc} = quantity of product c taken from supplier i to RDC j
Q_{jkc} = quantity of product c taken from RDC j to AA, k
Q_{jvc} = quantity of product c taken from RDC j to secondary AA, v ($v \in k$)
Z_{jl} = Binary decision variable (1 if RDC j is selected; 0 otherwise)

3.4 Objective Functions:

Minimization ofCost(Y_1)

- Transportation cost from supplier to RDC (TC_1) $=\sum_{i,j,c,k} (D_{kc} * C_{cij}) + \sum_{i,j,c,v} (P * D_{vc} * C_{cij})$
- RDC Setup Cost (SC) $= \sum_{j,l} (f_{jl} * Z_{jl})$
- Transportation cost from RDC to AA ((TC_2) $=\sum_{j,k,c} (D_{kc} * C_{cjk}) + \sum_{j,c,v} (P * D_{vc} * C_{cjv})$
- Inventory holding cost at RDC (ICR) $= \sum_{j,k} (D_{kc} * h_{cj}) + \sum_{j,v} (P * D_{vc} * h_{cjv})$

Objective Functionfor Cost $Y_1 = ICR+SC+TC_2+TC_1$ … … (1)

Minimization of Time(Y_2)

Objective Functionfor Time $Y_2 = \sum_i t_{ij}$ … … (2)
Therefore,
Minimize $Y = w_1 * Y_1 + w_2 * Y_2$ … … (3)
Subject to,

1. $Q_{ijc} = Q_{jkc} + Q_{jvc}$ ... ... (4)
2. $Q_{jkc} \geq D_{kc}$ … … (5)
3. $Q_{jvc} \geq D_{vc}$ … … (6)
4. $G_{ci} \geq Q_{ijc}$ … … (7)
5. $D_k \leq l$ … … (8)

Here equation 1 indicates the objective functions to minimize costs. All the costs (Transportation cost, RDC Setup Cost, Inventory holding cost) have been calculated in the equation. Equation (2) indicates an objective function to reduce total transportation time. Equation (3) indicates the combined weighted objective function to minimize both time and cost.This objective function needed to be minimized subject to some constraints. Equation (4) is the conservation of flow constraints which means that the quantity that goes into the distribution centers and the amount of relief that comes out of the distribution centers should be equal. Equation (5) refers to demand constraints for primary demand and equation (6) refers to extra demand for secondary disasters. Equation (7) refers to the capacity of the central warehouse and equation (8) is capacity constraints for distribution centers.

3.5 Solution Approach

To solve the mathematical model, we have developed an optimization model in excel solver. For this purpose, we have followed the following workflow:

1. Selecting central warehouse, distribution centers, and affected area.
2. Measure the distance from the central warehouse to RDC and RDC to the affected area using google map
3. Collecting average travel time from distribution centers to affected areas.
4. Collecting population data and percentage of the affected population in both primary and secondary disasters.
5. Calculating demand based on the percentage of the affected population.
6. Formulate a mathematical function for calculating all the costs and the total of them.
7. Formulate mathematical function for calculating total traveling time needed for delivering the reliefs.
8. Make a separate function that connects the above two functions (cost and time function) with weight. This would be our main objective function to minimize.
9. In excel solver we need to input all the constraints.
10. After selecting objective function, decision variable, and their constraints we can solve this problem in Generalized Reduced Gradient (GRG) non-linear algorithm.

4. Data Collection and Calculation

Two central warehouses have been considered at Chittagong and Dhaka and five RDCs Cumilla, Barisal, Jashore, Chittagong and Gopalganj. The affected areas are Satkhira, Khulna, Bagerhat, Jhalokathi, Pirojpur, Barguna, Patuakhali, Bhola, Noakhali, Laxmipur, Cox's Bazar, Sandwip, which are the most vulnerable to disasters, as they are coastal regions. All the possible routes and their distances between every two nodes were the initial data that were collected. Google Map was used for this purpose. We have overlooked loading and unloading time. Our vehicles are homogenous. That means all of them carry the same amount of relief. Here demand means a complete package of things like water, food, medicine, etc. Distances among different distribution centers and affected areas considering light traffic are listed below in Table 1.

Table 1. Distances from RDC to Affected Area

Distance matrix	**Regions**											
d(ij)	**Satkhira**	**Khulna**	**Bagerhat**	**Jhalokathi**	**Pirojpur**	**Barguna**	**Patuakhali**	**Bhola**	**Noakhali**	**Laxmipur**	**Cox's Bazar**	**Sandwip**
Cumilla	346	300	293	192	218	240	205	137	100	86	296	145
Barisal	191	145	80	20	53	81	45	113	122	87	388	237
Jashore	130	122	165	290	220	380	410	465	680	605	935	780
Chittagong	430	350	362	270	286	307	270	203	133	153	148	64.9
Gopalganj	165	95	80	185	110	280	350	300	495	420	840	780

Traveling time among the distribution centers and the affected areas are listed below in Table 2. The time was calculated by using Google Map, considering the shortest paths.

Table 2. Travel time from RDC to Affected Area

Time	Regions											
t(ij)	**Satkhira**	**Khulna**	**Bagerhat**	**Jhalokathi**	**Pirojpur**	**Barguna**	**Patuakhali**	**Bhola**	**Noakhali**	**Laxmipur**	**Cox's Bazar**	**Sandwip**
Cumilla	580	520	500	460	530	545	505	300	142	260	445	250
Barishal	265	210	175	45	130	155	105	280	350	270	730	585
Jashore	336	130	136	18	265	331	86	265	545	275	220	403
Chittagong	745	691	695	542	589	604	558	364	181	220	251	175
Gopalganj	378	93	565	425	58	533	513	306	485	508	363	440

Then the population data of each area was collected from respective government official websites. The population of different affected areas are given below in Table 3.

Table 3. Population of the affected areas

Population and affected area	**Satkhira**	**Khulna**	**Bagerhat**	**Jhalokathi**	**Pirojpur**	**Barguna**	**Patuakhali**	**Bhola**	**Noakhali**	**Laxmipur**	**Cox's Bazar**	**Sandwip**
Population	1,985,959	2,318,527	1,476,090	694,090	1,131,758	892,781	1,535,854	1,064,077	3,318,083	1,729,188	2,289,990	350,000

We assume that the affected population in a primary disaster is 40% and 20% more of the population affected in a secondary disaster. Here is the Table 4 of demand in different affected areas for both primary and secondary disasters.

Table 4. Demand table for primary and secondary disasters

Quantity demanded in the different area	**Quantity Demanded (Primary)**	**Quantity Demanded (Secondary)**	**probability of secondary disaster**	**Demand**
Satkhira	794383.6	397191.8	0.3	913541
Khulna	927410.8	463705.4	0.1	973781
Bagerhat	590436	295218	0.9	856132
Jhalokathi	277636	138818	0.3	319281
Pirojpur	452703.2	226351.6	0.6	588514
Barguna	357112.4	178556.2	0.2	392823
Patuakhali	614341.6	307170.8	0.6	798644
Bhola	425630.8	212815.4	0.6	553320
Noakhali	1327233.2	663616.6	0.3	1526318
Laxmipur	691675.2	345837.6	0.7	933761
Cox's Bazar	915996	457998	0.8	1282394

Sandwip	140000	70000	0.9	203000

The distribution center handling cost is given below Table 5.

Table 5. Cost for handling distribution centers

Distribution Centre	Variable Cost	Fixed Cost
Cumilla	$1.50	$ 11,000
Barisal	$0.95	$ 5,000
Jashore	$1.05	$ 9,000
Chittagong	$1.10	$ 8,000
Gopalganj	$1.12	$ 7,000

Inbound transportation distance (Central warehouse to Distribution center) also calculated by using google map (minimal distance) are shown below in Table 6.

Table 6. Transportation distances from the central warehouse to RDC

IB Transportation distance (km)	Central Warehouse	
	Dhaka	Chittagong
Cumilla	107	147
Barisal	238	309
Jashore	211	430
Chittagong	248	10
Gopalganj	217	316

We assume that the transportation cost per unit per km is $0.1. So, per unit transportation cost from the central warehouse to distribution centers are given below in Table 7.

Table 7. Transportation cost from the central warehouses to RDC

Cost per unit	Dhaka	Chittagong
Cumilla	$ 10.70	$ 14.70
Barisal	$ 23.80	$ 30.90
Jashore	$ 21.10	$ 43.00
Chittagong	$ 24.80	$ 1.00
Gopalganj	$ 21.70	$ 31.60

Handling cost for central warehouse and capacity of the warehouses are given below in Table 8.

Table 8. Handling cost for central warehouse

Warehouse	Variable Cost	Capacity
Dhaka	$ 2.00	10000000
Chittagong	$ 0.75	7000000

5. Results Analysis and Discussion

We have developed a model for optimizing the stated numerical examples from Bangladesh's perspective. Here is the result we have got after solving the model.

5.1 Numerical Results

The amount of relief transported from two central warehouses, Dhaka,and Chittagong to the distributioncenters. From the below Table 9, it is relatable that no relief was transported to Jashore from either Dhaka or Chittagong. Because Jashore is far away from both Dhaka and Chittagong. Rather, those relief are transported to nearby Barisal and Gopalganj. Among the possible five distribution centers, we have got four distribution centers needed to be opened in the optimal solution. They are:Cumilla, Barisal, Chittagong, Gopalganj.

Table 9.Table of how many reliefs should be transported to which RDC

	Dhaka	Chittagong
Cumilla	7039482	0
Barisal	1191232	0
Jashore	0	0
Chittagong	319281	0
Gopalganj	0	791514

After getting suitable RDC, then we calculated how much relief would have to take away to each affected area. We have used excel solver to optimize the equations and find out the best results. Here, the optimized amount of relief transported from the four distribution centers to the affected area given below in Table 10.

Table 10.Quantity delivered from RDC to Affected Area in the optimal solution

	Satkhira	Khulna	Bagerhat	Jhalokathi	Pirojpur	Barguna	Patuakhali	Bhola	Noakhali	Laxmipur	Cox's Bazar	Sandwip
Cumilla	913541	973781	856132	0	0	0	235	553320	1526318	933761	1282394	0
Barisal	0	0	0	0	0	392823	798409	0	0	0	0	0
Chittagong	0	0	0	319281	0	0	0	0	0	0	0	0
Gopalganj	0	0	0	0	588514	0	0	0	0	0	0	203000

From the above table, it is lucid that most of the relief are transported from Cumilla to disaster affected area, and least amount is transported from Chittagong.Then we calculated the cost for individual segment. All the individual costs and total cost are presented below in Table 11.

Table 11. Table of all the relevant costs

TOTAL COST	**$304,963,438**
DC fixed cost	$31,000
OB Transport	$137,706,427
IB Transport	$136,603,788
Central warehouse maintaining Costs	$17,693,625
DC Handling	$12,928,598

5.2 Graphical Results

As cost is one of the most important parts of conveying reliefs,we draw a cost graph to depict the costliest and least costly segments. The graphical presentation of the result of costs are given below in Figure 3.

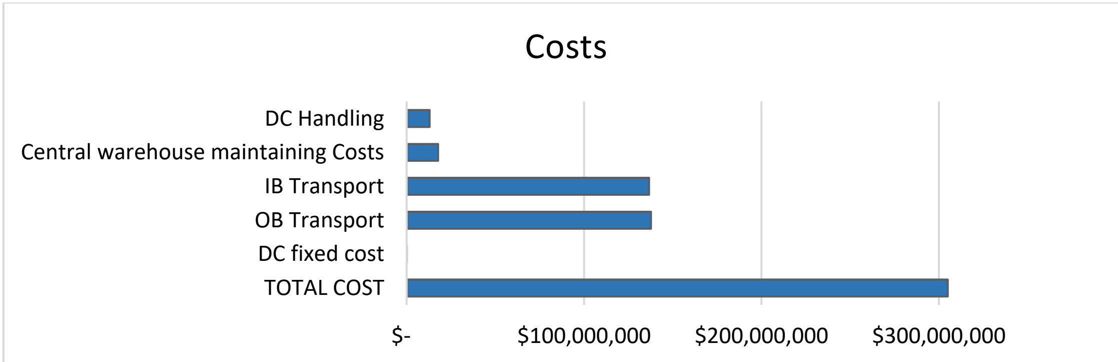

Figure 3. Graphical representation of different cost in our model

Apart from the fixed cost, from the above diagram, it is visible that most of the cost is contributing to OB (Outbound) Transport. On the contrary, DC (Distributing Centers) incurred for lowest cost.

5.3 Proposed Improvements

This study uses a certain percentage of the existing population of the disaster-pone region. It will be more realistic if historical data are incorporated in future work to generate actual demand. Future research can attempt to collect survey data from first responders because the real purpose of distributing products can be hampered by restricted data collection. At present, the goal is to minimize the transportation time and the costs. Other possible targets may be to minimize operating costs given the optimal reaction time and demand level of satisfaction. Besides, since the proposed model is used to establish local operating processes, future research will be able to incorporate this model into robust humanitarian assistance and disaster relief decision support structure.

Meanwhile, to promote the data input and display of results, a graphical user interface could be provided. Then, staff who are not familiar with assessment techniques can use the model. In the end, the proposed report essentially focuses almost exclusively on what the government and other humanitarian organizations can do. Researchers will be able to expand their emphasis in the future on what the Bangladeshi people can do to defend themselves, their families, and their neighbors.

6. Conclusion

To date, there is no specialized journal, nor would we have been able to find any journal or other platform that focuses on humanitarian logistics. The humanitarian logistics field of research is relatively new. After all, one of the noteworthy aspects of the rescue operations following the Asian tsunami in 2004 was the public awareness that logistics played an enormous part in the logistics of humanitarian (Thomas and Kopczak2005). However, several organizations attempt to disregard the role of logistics in disaster relief operations and continue to concentrate solely on fundraising events (Murray2005). Academic research on humanitarian logistics appears to focus on the disaster relief planning process. Even so, in overcoming a disaster, all three phases of humanitarian logistics: planning, immediate response, and reconstruction are critical (Kovács and Spens2007). Therefore, this study centered on the immediate response of the operation of disaster relief by reducing transportation time and relief operation costs after a disaster have been put in place. Besides, incorporating the probability of secondary disasters into the model allows it more to accurately calculate the actual demand produced by the affected individuals.

Optimal preparation for an emergency response would provide timely and appropriate guidance for scientific decision-making and disaster management assistance. The distribution of emergency services is an efficient way to minimize catastrophe costs and casualties. During disaster response, there are several forms and quantities of emergency resource requests in a limited period. In addition, many of the criteria of the secondary disaster locations caused by the primary events include more emergency rescue challenges. In the former literature, there have been no studies found considering both the multi-objective vehicle routing model and the effects and demand generated by the possible secondary disaster in Bangladesh. Available research is focusing on the preparation of disasters, and it is very hard to provide a real-time response or convey emergency aid after a disaster has been put in place. To respond to realistic circumstances and have more reliable and versatile incident management techniques, the decision needs to be strengthened. So, in this thesis, we studied multi-objective vehicle routing problems considering both primary and secondary disasters. The proposed approach is most practical when secondary disasters have occurred, compared to the existing method that does not take secondary disasters into account.

We introduced the secondary disaster possibility in the objective function to build GMG non-linear model for dispatching the humanitarian relief to the affected area. The proposed model will define the demand that helps to measure humanitarian assistance to the decision-maker. This study aims to minimize the maximum transportation time of humanitarian aid transporting vehicles and optimize the smoothness of the relief activity. Our model, therefore, is more in line with the real emergency response and provides the affected person with humanitarian assistance. More proof of efficacy and effectiveness is given by the results of the example of our suggested method's effectiveness. It is a real-time approach and can be comprehensively applied to solve large-sized functional problems.

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