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An Implementation of a Decision Model: A National and International Relief Operation Comparison

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Summary. Recently natural disasters have emphasized the importance of emergency relief operation logistics for both international and national relief operations. Quick and adequate decision-making in humanitarian logistics is vital, but sometimes hard to achieve, so the logistics decision model under time constraints is necessary. This paper presents the logistics decision-making throughout the operational humanitarian life cycle of the French Red Cross to the Haiti earthquake 2010 and Thai Red Cross to the Nan flooding 2011. The two case scenarios are presented and implemented a decision model which is proposed in the previous study. The comparison of two relief operation is analyzed and discussed.

Key words: Humanitarian Supply Chain Management (HSCM); Humanitarian Logistics (HL); Humanitarian Operational Life Cycle (HOLC); Red Cross; Multi-Criteria Decision Making (MCDM)

1.1 Introduction

Due to the concept of disaster response, the rescuers need to reach the beneficiaries or people in need within a short time with the right equipment and in the right place under volatile environmental conditions. These situations make humanitarian Logistics (HL) unique and increase a vital consideration in decision support in HL in both research and practical fields. The scope of humanitarian logistics is broad. The purpose of this study, we continue work with our recent study [1]. The contribution which presents that paper is in the application used in the humanitarian operation life cycle [2] for the decision-making situation of the French Red Cross (FRC) operation. We consider humanitarian operations as a four-phases process and analyze the fundamental factors which should and can be used to support the decision making process during each of those phases. Likewise, a multi-criteria

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decision model using an integration of Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approaches is proposed in order to select warehouse, supplier, and vehicle.

In this paper, the logistics decision model is enhanced to implement exportable to other similar decision situations. Two scenarios are used to test how sensible of the decision model. To understand relief operation and decision of unlike scale humanitarian organizations, the actual decision in the past that match decision in which phase of the HOLC is demonstrated. Moreover, As a guide in choosing the most appropriated alternatives when taking more criteria into account, not only the quickness that already known as the most important criterion in the response phase. The decision-making in Haiti Earthquake 2010 relief operation and Nan Flooding relief operation of Thai Red Cross (TRC) is analyzed and compared. These two operations are presented which could be a precursor of a logistics decision prototype model throughout the life cycle of humanitarian actions from the phase 0 preparedness phase, phase 1 immediate response phase, phase 2 support phase and phase 3 dismantling phase.

1.2 A Logistics Decision Model

The phases of disaster relief in humanitarian supply chains can be seen in terms of a four-phase cycle [3], [2]. As the supply chain moves though the various life cycle phases (as called humanitarian operational life cycle (HOLC)). Basically, crisis or disaster situation evolves all the time, making it difficult to manage [4]. Also, the priority of each decision criteria can be expected to change according to phases. In this study, phase 0 is preparing available relief items in humanitarian organizations existing warehouses. The decision can make at the beginning or during this phase because this phase can last quite a long time. Preparing the availability of transport and analysis can be performed by a supplier. In the event that is is quite important, the choice of decision model in this phase would be different from the other phases. The requirements of feasibility are presented in this phase. In phase 1-2, when a crisis occurs during the first week, humanitarian organizations proceed step by step to send assistance to disasters victims or beneficiaries, this phase aim to minimize human and property losses [5]. phase 3, before operations are terminated, usually a few months after. The operation is still demanding, this phase is focused on dismantling and recovery.

According to the previous of this study [1], An integrated of the multi-criteria decision making approaches is chosen in order to answer the question "Which warehouse, supplier and vehicle should be selected from or to the destination of the beneficiaries?". AHP method is chosen to scale the weights of the criteria in the decision model. The outcome of the AHP method is further continued using TOPSIS to rank the possible alternatives and get the ideal optimized solution [6].

In addition, during the relief operation of a life cycle, there are three factors (also called criteria) that the logistics staff have to consider; quickness (Qn), cost and carbon footprint (CO_2). The quantity and quality of available data changes in each

phase, and so do the priorities of each performance factor. In the step of criteria weighting, due to the following reasons, a few criteria (qualitative data) have been used in the decision model because the decision situation over all phases are needed to complete the life cycle. These criteria reflect transportation sustainability. Also, many review papers help to confirm that key performance needs to be considered [7]. In this study, the three selected criteria are required for weight judgment from the decision maker, the priority of criteria in each phase is different. The summary of alternatives selection is shown as Table 1.1.

Table 1.1. All possible alternatives of the decision model

Phase	Situation	Input data	Parameters	Number of alternatives
0	Request from warehouse	w_x, items, $w_{qn}, w_{cost}, w_{co_2}$	s(m), v(o)	s(m)× v(o)
0	No request (but need to prepare)	items, $w_{qn}, w_{cost}, w_{co_2}$	s(m), w(n), v(o)	(s(m) × w(n))+(s(m)× v(o))
0	No any request (do not need to prepare)	- -	- -	- -
1	Emergency	D, items, $w_{qn}, w_{cost}, w_{co_2}$	w(n), v(o) or s(m), v(o)	w(n)× v(o) or s(m)× v(o) -
2	Support	items, $w_{qn}, w_{cost}, w_{co_2}$	w(n), v(o) or s(m), v(o)	w(n)× v(o) or s(m)× v(o) -
3	Dismantling	items, $w_{qn}, w_{cost}, w_{co_2}$	w(n), v(o)	w(n)× v(o)

The remarks of this proposed model are listed as:

- Hypothesis: Relief items are managed and decided by humanitarian staff.
- Limitation : Inventory management is not considered in the proposed model.
- Input/output data: s_x, w_x and v_x = order of supplier, warehouse and vehicle.
- Parameters m = number of existing suppliers, n = number of existing warehouses, o = number of existing vehicles.
- D is a destination location.
- Items are total delivered items weight (kg).
- $w_{qn}, w_{cost}, w_{co_2}$ are criteria weights of quickness, cost and CO_2.

For all circumstances of our case studies, the data will be gathered by interviewing the head of logistics. Data has also come from the literature and expert researchers in the field of HL and humanitarian agencies. In this model, there are suppliers, warehouses and vehicle means considered as alternatives possibilities in each phase, all needed data is calculated as follows;

1. Distance (km): distance between departure location to destination location calculated by Harversine formulas [8].
2. Quickness (Lead time (hrs)): duration of journey depends on the distance between place of departure and place of arrival and speed average vehicle (Ilyushin Il-76 aircraft [9], Railway (UIC) [10], Handymax Bulk Carrier[11]).
3. Cost: cost of delivery (€) depends on weight of the relief items (DHL France and DHL international rates) [12].

4. CO_2 emissions (Carbon Footprint (Tonnes CO_2 emissions)): amount of CO_2 emissions from travel depends on the CEF (Carbon Emission Factor) of the activity-based method [13], and ratio of CO_2 emission of each mode of transportation (Air, Railway and Sea) [12].

The proposed decision model, mentioned earlier, needs to be broken-down into steps according to the AHP method and follow the steps of the TOPSIS method [1].

1.3 An Implementation of the Logistics Decision Model

In order to implement the proposed model in practice, the decision model has been categorized into 2 scenarios;

1.3.1 Scenario I: An international Relief Operation of FRC with Haiti Earthquake 2010 throughout HOLC

In this study, we are working with a specific company in a specific sector; the humanitarian sector. The French Red Cross (FRC) is a part of the International Red Cross and Red Crescent Movement (ICRC), founded in 1864. In the logistics sector of the FRC there are three current suppliers. First, is in Beijing, China (s_1). Second, is in New Delhi, India (s_2). Third, is in Islamabad, Pakistan (s_3). Also, there are four current warehouses; Pirac (w_1), Pirops (w_2), Piroi (w_3) and Paris (w_4). They have sent resources and coordinated 72 projects in 39 countries (2013) [14] (since initial operation until 2013). This preliminary data has already been gathered thanks to interviews with the head of logistics of the FRC.

Table 1.2. The alternative numbers in Scenario I (FRC)

Phase	**Situation**	Input data	Parameters	Number of alternatives
0	Request from warehouse	w_x, items, $w_{qn}, w_{cost}, w_{co_2}$	s(3), v(3)	9
0	No request (Normal)	items, $w_{qn}, w_{cost}, w_{co_2}$	s(3), w(4), v(3)	21
1	Emergency	D, items, $w_{qn}, w_{cost}, w_{co_2}$	w(4), v(3) or s(3), v(3)	12 or 9
2	Support	items, $w_{qn}, w_{cost}, w_{co_2}$	w(4), v(3) or s(3), v(3)	12 or 9
3	Dismantling	items, $w_{qn}, w_{cost}, w_{co_2}$	w(4),v(3)	12

Even in such a small example (Table 1.2), many alternatives are possible, and the decision has to be made several times during each phase. For each decision, there are between 39 (9+9+9+12) and 57 (21+12+12+12) alternatives. In addition, to demonstrate the situation in a real case, a relief operation by the FRC will be analyzed. For Haiti earthquake 2010 relief operation, the FRC has collected the data of all sent relief items during last 2 years, including size and total weight information. To implement in the decision model, all relief items sent are divided into each of the four phases operations. Overall, this allows us to make decisions at

Table 1.3. The results of the Haiti Earthquake (2010) FRC relief operation:

Phase	Duration	Situation	Optimal alternatives			No. alter	Items	Criteria weights		
			from	to	by		(kg)	w_{qn}	w_{cost}	w_{co_2}
0	Several months	No request (normal)	s_1: China	w_3: Piroi	v_3: Sea	21	31,801	0.077	0.615	0.308
1	12-16 Jan 2010 [15]	Immediate Response	w_1: Pirac	Port au Prince	v_1: Air	12	38,162	0.723	0.083	0.193
2	17 Jan - 16 Feb 2010	Support	w_1: Pirac	Port au Prince	v_1: Air	12	490	0.368	0.493	0.139
3	After 16 Feb 2010	Dismantling	Port au Prince	w_1: Pirac	v_2: Rail	12	450	0.072	0.452	0.476

every stage of the operation life cycle. A summary of the logistics decision model with all criteria weighting applied to the Haitian operations is provided next.

As shown in Table 1.3 for phase 1-3, the highest ranking, w_1 is always the most appropriate warehouse for supply the relief items to Port-au-Prince, Haiti. The optimal alternative during phase 1, chosen by the proposed decision model, is warehouse (Pirac) by air. In the real situation, if the decision-maker does not choose w_1, it is due to two reasons. The first reason, phase 0, w_1 is not ready to supply the relief items or the second reason, the decision-maker lacks knowledge and experience for warehouse selection in a rush may choose other warehouse, such as w_2 (Sete, France). In the worst case scenario, w_3 is selected, even though the cost may be less than w_2, it is more time consuming than w_2 and w_1, which will hugely affect life saving efficiency.

1.3.2 Scenario II: A National Relief Operation of TRC with Nan Floods 2011 throughout HOLC.

The Thai Red Cross (TRC) is a humanitarian organization in Thailand under the support of the Thai government and the king of Thailand. The TRC with Friends In Need (of "Pa") Volunteers Thai Red Cross Project, Thai Red Cross Society is selected and presented a national relief operation level, only in Thailand [16]. In the logistics sector of the TRC, there are three current warehouses. Lampang (wt_1), Ubon Ratchatanee (wt_2) and Sattaheap (wt_3). This preliminary data has been gathered thanks to interviews with Prof. Pichit Suvanprakorn M.D., Vice President of Friends in Need (of "Pa") Volunteers Foundation of the TRC. A summary of the TRC alternatives numbers is shown in Table 1.4.

Table 1.4. The alternative numbers of Scenario II (TRC)

Phase	Situation	Input data	Parameters	Number of alternatives
0	Not any requests	-	-	0
1	Emergency	D, items, $w_{qn}, w_{cost}, w_{co_2}$	wt(3), vt(3)	9
2	Support	items, $w_{qn}, w_{cost}, w_{co_2}$	wt(3), vt(3)	9
3	Dismantling	items, $w_{qn}, w_{cost}, w_{co_2}$	wt(3), vt(3)	9

In each TRC relief operation, the decision has to be made for at least one time decision in each phase, there are 27 (9+9+9) alternatives. The flooding in Thailand during the second half of 2011 was enhanced by and likely the result of persistent monsoonal rains combining with the remnants of a series of tropical cyclones [17]. The possible alternatives are included with all existing suppliers and warehouses. In this case as data got from the TRC, There is no data for the preparedness phase (phase 0) then, all output from phase 1-3 are presented in Table. 1.5.

Table 1.5. The result of relief operation: Nan Floods 2011 TRC operation

Phase	Duration	Situation	Optimal alternatives			No. alter	Items	Criteria weights		
			from	to	by		(kg)	w_{qn}	w_{cost}	w_{co_2}
1	31 July-7 Aug 2011	Immediate Response	wt_1: Lampang	Nan	vt_1: Air	9	9090.28	0.723	0.083	0.193
2	8 Aug 2011 - 16 Feb 2012	Support	wt_1: Lampang	Nan	vt_2: Road	9	116.72	0.368	0.493	0.139
3	After 16 Feb 2012	Dismantling	Nan	wt_1: Lampang	vt_3: Hovercraft	9	107.19	0.072	0.452	0.476

1.4 Discussion and Conclusion

Table 1.6 shows a comparison for the decision model of the FRC and the TRC. the FRC has four warehouses at international level. Two warehouses are located in land, Sete, France (Pirops, w_2) and Paris (w_4). The other two are located on colonized islands. One is in Pointe a Pitre, Guadeloupe (w_1: Pirac) which is located in the Caribbean Sea . The other one is in St. Dennis, which is located on an island close to Madagascar. Also, there are three existing suppliers in three Asian countries because their high productivity rates and low costs.

The comparison of two specific operations is illustrated in Table 1.7. In this scenario, the decision model will consider the warehouses first. If the needed relief items are unavailable in the warehouses, the relief items from suppliers are going to be the next choices. In fact, direct delivery from warehouses to the beneficiaries is an attractive option. In the scenario of the TRC, this project focuses on helping domestic victims. Lampang (North), Ubon Ratchathani (Northeast), and Sattahip (East) are current project's warehouses. To compare with FRC, the FRC warehouses are located in the capital, coastal cities, and island. These make the location of warehouses are suitable for transport both by air or sea. However, the TRC warehouses are scattered throughout the country except the South. In the South of Thailand there are coastal cities which are always affected by monsoons. The relief operations of the TRC are mainly focused on water and food supply, while the relief operations of the FRC are emphasized on providing temporary housing such as tents, shelter, etc.

Due to setting criteria weighting as in the literature mentioned above, we found that phase 1 of the FRC gives the same result of past deciding warehouse and vehicle

Table 1.6. Specification/activities and comparison of FRC and TRC relief operation

No.	Specification	FRC	TRC	Remark
1	Scope of relief operation	International	National	-
2	Considered phases	0-3 (all phases)	1-3	No relief items preparation in TRC
3	Most disaster time lines	Sudden-onset	Slow-onset	-
4	Donor/Supporter	NGOs, private sector government	Government, local private sector, NGOs	-
5	Number of existing warehouses	4 (2 in France and 2 on islands)	3 (1 in North, 1 in Northeast, 1 in Northeast, Thailand)	-
6	Number of cooperated suppliers	3 (all in Asia)	none	-
7	Warehouse Locations	Coast, island	main-land	-
8	Sources of needed data and information	Head of the logistics team of the FRC	Vice President and staffs logistic team of Thai Red Cross Foundation	Direct interview, e-mail and website
9	Transportation means	Air, railway, sea	Air, road, water in land	-

Table 1.7. Specification Haiti earthquake (2010) and Nan flood (2011) relief operation

No.	Specification	Haiti earthquake	Nan flood	Remark
1	Relief items	Tent, shelter, first aid kits etc.	Water, food, first aid kits, etc.	-
2	Most important phase	1	2	Result from the decision model
3	Sized of emergency	Large	Medium/small	-
4	Qn, CO_2	Aircraft (IL 76), rail, sea,	Aircraft (IL 76), truck, hovercraft	-
5	Cost	DHL (euro)	Thai post (baht)	-
6	Distance	Across the country	Domestic	-

operation [1]. For the TRC, we found that the most of phase 2 gives the same result of past deciding warehouse and vehicle operation. This means, FRC selects urgency as the most important factor in the natural disaster. For flood disaster of the TRC operation, the urgency is not the major factor in decision to select warehouses and vehicles. Flooding may be both a sudden-onset and slow-onset disaster. The FRC focuses on agility in response relief operation while the TRC focuses on cost effectiveness or development programs. If the decision-makers need to decide any case in the future, this model can support a more appropriate decision. For both scenarios international and national relief operation, the four-phase operation can be chosen appropriately. But, in fact, there are other factors involved, such as inventory, procurement, unavailability of the optimal warehouse or transportation. As shown in Table phase 3, v_2 (railway) is the optimal transportation. In fact, it may be not possible to travel from w_1 to Haiti across the sea by railway (Table 1.3). So, the decision makers may need to consider the second option, which is the sea instead of the optimal one. In general ranking, sending from the warehouse is better than sending directly from supplier except for w_3. This is because it is the most inappropriate choice of warehouse as it is the furthest away from the field of

operations. In the future study, we intend to enhance the model with additional involved factors such as warehouse, procurement or inventory management criteria to make the model more exhaustive and get close to the real situation.

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