Development of a Decision Support System to Facilitate Multi-criteria Decision Making during Humanitarian Operation within a Project Life Cycle

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Abstract. The use of decision support systems is an important part of supply chain management. Quick and adequate decision making is sometimes difficult to achieve. Three issues arise: how to gather relevant data and use past experiences, how to make the decision when many criteria have to be taken into account, and how can we ensure that the decision making process is quick. Those three issues are currently faced by many companies, and some solutions have already been proposed in the literature. Yet, in some cases, it is difficult, if not impossible to apply those solutions. Humanitarian organizations, for example, have difficulties to build on past experiences. Quick decision making in this sector is vital. The purpose of this paper is to design and develop decision-making tool to support the performance of humanitarian logistics. A case study at the French Red Cross will validate this proposal.

Keywords: Decision support system, supply chain management, humanitarian logistics, multi-criteria decision making

1 Introduction

Crises happen. Earthquakes, floods, conflicts, chemical leaks are but a few examples of disasters, which affect organizations. We are unable to know for certain when a disaster will occur or how violent it will be. To assist the population affected by disasters, to send relief items and supplies, but also doctors and other human resources, a supply chain is set up. Moreover, the decision need to be quick. Resources need to be sent within five days after the disaster to enable an effective disaster relief. They are usually pre-positioned in strategic places to reduce the lead time during those crucial days. Usually, the choice regarding the usage of one warehouse instead of another and the choice regarding the mean of transportation used are overlooked because quickness has precedence over any other indicator such as costs or environmental impact. Yet, nowadays, humanitarian organizations undergo an increased pressure to improve their processes.

Humanitarian organizations differ from private companies in many ways. Among others, this sector is historically focused only on its currents action, on the day to day work needed to attend affected people. The funding of operations comes before any long term project, such as the development of Computer Based Information System (CBIS). In addition, the high turnover of staff reduces the possibilities to build knowledge on past experience, especially since few or no data are recorded from past operations. The inconsistent and uncertain environments in which organizations operate also complicate the situation, as data is difficult to collect and analyze. Last, but not least, the decision making process needs to be quick due to the lives at stake.

Currently, many organizations are becoming more interested and aware of the importance of supply chains and try to find ways to make humanitarian logistics [10] more efficient and suitable. The scope of supply chain management being broad, for the purpose of this study, we focus on humanitarian logistics, and especially on transportation. Most of the existing research in humanitarian field are focusing on the efficient understanding of the core capabilities of humanitarian logistics and the understanding of processes of disaster relief. Our proposal is to go beyond this theoretical approach and propose a simulation tool to facilitate.

2 Research background

To describe the current situation on decision-making of humanitarian sector concern in academic research, we have reviewed the articles related on project life cycle management, performance indicators in this sector, Multi-criteria via decision making and Decision Support System (DSS). In this part, the literature is analyzed and synthesized according to the main research areas needed to design and develop a multi-criteria decision support system for humanitarian sectors.

2.1 Project life cycle management (PLM)

Another element contributing significantly to the originality and innovative nature of our project is our intention to build our study with a project life cycle management (PLM). Indeed, up until now, many stakeholders, from donors to researchers focus on one specific phase of disaster relief operations, usually one of the two first phases (preparedness or immediate response). According to Zhou et al.[11], "it is clear that the existing literatures mostly deal with a specific activity in the emergency response process. Researchers care more about emergency logistics". Our intention with this proposal is to fill this gap, and take a project life cycle approach to map out the steps needed to complete humanitarian operations with specific targeted results.

In our study, we can map all the processes in one project life cycle, from the initiation until the closing or operations. This PLM approach fits to the humanitarian sector and their way of operating. Indeed, they set up operations in a specific country, were a crisis occurred, and they proceed step by step to send to assist disasters victims, until operations are closed, usually a few months after. Humanitarian operation life cycle and some factors that humanitarian workers must consider are illustrated in Fig.1. Indeed, during operations, the quantity and quality of available data changes, and so does the priorities of each performance factor (Fig.1.)[2].

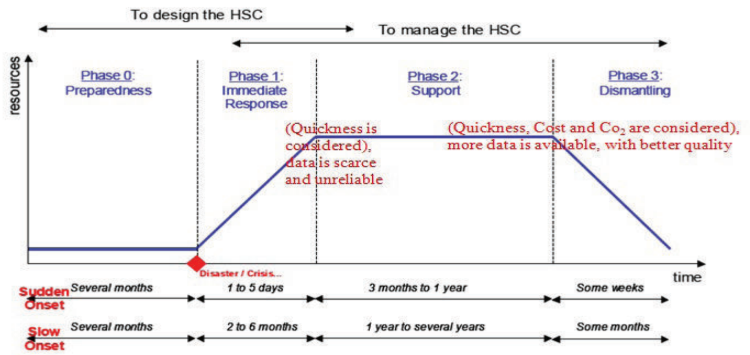


Fig. 1. Humanitarian Operation life cycle

2.2 Multi-criteria via decision making

There are several critical success factor in the context of humanitarian and supply chains. According to [9] there are ten critical success factors consisting in strategic planning, resource management, transport planning, capacity planning, information management, technology utilization, human resources management, continuous improvement, supplier relations and supply chain strategy.

If we consider one of the most important factor, transportation planning, then both long-term and short-term decisions are made. For those decisions, many factors or criteria have to be taken into account. Which one should we focus on?

Quickness or rapid response time of delivery is one of many key performance indicators (KPI) for humanitarians supply chains [1]. Indeed, the timely delivery of critical goods has always been a crucial element of an effective disaster response[3]. The transportation costs are also needed because of the characteristic of non-profit organizations. As the major income comes from donations, it is uncertain. We should consider this issue because recently there has been an increased pressure on non-profit humanitarian organizations to held them accountable of spending their donors' money wisely. This is a universal indicator which should be included [1]. Nowadays, the environmental impact is also emerging as a key performance indicator. The CO_2 emission, also called carbon footprint, is the main factor affecting transportation. The value of Carbon

Footprint is one of many factors which can show how much of equivalent tons of carbon dioxide (CO_2) is emitted [5]. As a result, quickness, cost and CO_2 are the main criteria (KPI) of humanitarian logistics for our model.

When we consider these criteria in each phase of the humanitarian operation life cycle in Fig.1, the importance of each criteria evolves. Whereas quickness has precedence during the first two weeks, costs and CO_2 are also important later on. During each phase of the cycle, the weight of each criteria is changed. To choose transportation means and suppliers locations in each phase, we have to consider those three criteria, but with different weights. One approach for decision maker such as multi-criteria decision analysis (MCDA) and Analytic hierarchy process (AHP) decision model should be considered.

2.3 Decision support system (DSS) and management information system (MIS)

To face the lack of available information, we propose to build a system to facilitate planning, preparing and managing operations. The system collects raw data and transforms it into information, as information is a crucial part to support the decision making process. This is the purpose of the following section.

In our study we aim to develop a multi-criteria decision support system within a project life cycle. We will analyze the factors which should and can be used to support the decision making process. We will work on available internal and external data, but also propose a solution to better take into account the knowledge of past operations. Then we will design and apply a multi-criteria decision support system for one specific organization: the French Red Cross. This study designed to address a need in a specific sector, can then be generalized to fit with other organizations, or private companies. The third and fourth section provide some inputs with regards to the system we are designing and its expected results.

3 Humanitarian logistics management application

As we mentioned earlier in introduction, due to the limitation of time in during international disaster relief operations, it is hard to manage operations and make a good decision, especially in terms of logistics. For example, at a humanitarian organization, when a crisis happen, a project is planned and the decision maker tries to find the best way to make decision regarding the choice of adequate transportation means, material, medicines, food and supporting staff. What should they do to ensure that their decision will be correct and proper for rescuing people in a limited time?

Problem in the determination of performance in Humanitarian Logistics is quite complex. Both quantitative and qualitative data have to be taken into account, they are unclear, scarce, and often uncertain. Although we can measure the amount of delivery time, cost, and CO_2 from a calculation tool but quantitative data such as criteria weight may have changed overnight (Fig.1.) that must be considered. It is a complex decision making problem.

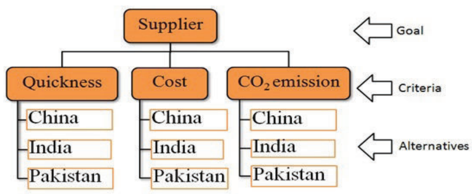
The second problem is how to combine quantitative data and qualitative data in one output value? The value should be quantitative data because it is easy to compare and make decision. One of the possible approaches is AHP model. Indeed, according to [7] AHP was designed for complex problems in situations which involve a number of conflicting criteria, alternatives and defined attributes. It also can reduces the complexity of decision making in reliable way. For these reasons we choose AHP to implement our decision model.

According to AHP decision steps so we need to decompose our model into the following steps.

1. Structure the decision hierarchy of humanitarian logistics.

The goal composed of "Which supplier, warehouse and vehicles should be selected in each project?" are the goal. For supplier is illustrated in Fig.2. The criteria of case study in our scope are time response (quickness), Cost, CO_2. The alternative, The supplier composed of China, India and Pakistan. These preliminary data have already been gathered thanks to interviews at the French Red Cross offices.

2. Construct a set of pairwise comparison matrix for supplier goal with three main criteria. The priority of weights (W_1,W_2 and W_3) will be given by FRC logistics specialist. There is illustrated on Fig.2



Criterion	Quickness	Cost	CO_2
Quickness	1	W_1	W_2
Cost	$1/W_1$	1	W_3
CO_2	$1/W_2$	$1/W_3$	1
Eigenvector	EQn	ECost	ECO_2

Fig. 2. Supplier AHP decision model and a pairwise comparison matrix of supplier

All elements in the matrix is normalized and consistency ratio checked, then get three eigenvectors consist of EQn, ECost and ECO_2.

3. Construct a set of pairwise comparison matrices pairwise comparison matrix for alternative (Supplier : S_1,S_2 and S_3) with each main criteria. The priority of weights (w_1,w_2 and w_3) will be given by our information system automatically which will be discussed next. All elements in the matrix is normalized and consistency ratio checked, then get three eigenvectors consist of $EQnS_1$, $EQnS_2$ and $EQnS_3$.

4. Repeat step 3 with remaining criteria (Cost and CO_2)then we will get parameters in following : $ECostS_1$, $ECostS_2$, $ECostS_3$, ECO_2S_1, ECO_2S_2 and ECO_2S_3.

Our formulas are

- S1 =($EQnxEQnS_1$)+($ECostxECostS_1$) +($ECO_2xECO_2S_1$)
- S2 =($EQnxEQnS_2$)+($ECostxECostS_2$) +($ECO_2xECO_2S_2$)
- S3 =($EQnxEQnS_3$)+($ECostxECostS_3$) +($ECO_2xECO_2S_3$)

We can make comparison and get optimize supplier from this simple model.

5. Repeat step 2, 3 and 4 with the other goal ("Which warehouse and vehicles?")

then we will also get the optimize of warehouse and vehicles.

From these model we can simulate and get the ideal optimize results that we should select but in fact we have to think in advance and plan to manage uncertain situations or the riskiness that may occur. For our study we are undergoing in this issue.

Due to their characteristics, non-profit organizations may not collect data in a proper way to enable their analysis and usage directly for decision making. Our aim is to provide a DSS which will facilitate data collection and management, and store information that we can use in a complex decision model for our DSS. This DSS will quickly provide possible alternative decisions to users, with their main advantages. The components of our application for the French Red Cross decision support system are inspired from [8]. The decision support methodology and knowledge management activities come from [4]. Both are illustrated in Fig.3.

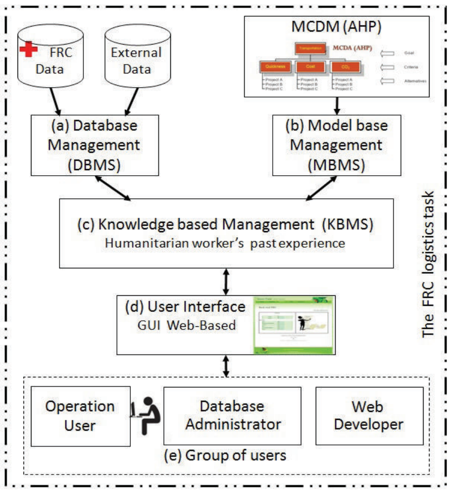


Fig. 3. A framework of decision support system

The framework of the DSS we propose the consists of five main components

(a) DBMS: We design and develop fundamental database by using relational database. Logistics data is provided by the FRC directly, such as disaster relief, departure location (supplier, warehouse) and destination location, vehicle type, fuel, selected item (first aid kit, food, medicine). External data has been selected the necessary data such as the value of emission factor from existing data in reliable sources.

(b) MBMS: We construct a decision model by using AHP approach. Mapping of elementary criterion and alternatives, In case of supplier choosing. It is illustrated in Fig.2.

(c) KBMS: We will combines information from DBMS and MBMS, including past experiences of logistics worker. This phase is undergoing.

(d) UI: We choose to develop a GUI web-based application to manage and simulate information flows of our DSS.

(e) Group of Users : We divide users into three groups : operation user, database administrator and web developer.

We already developed the first version of web-based application for the logistics department of FRC. It is working on client-server model. The DBMS and MBMS are embedded on server-site and scoped in supporting the decision-making process in the tactical level and the operation levels.

4 The first result and expected results

This first tool has been chosen to show the value added of our proposal, with a simple and straightforward application. It corresponds to the specifications required at the FRC. Some web pages are already done as illustrated in Fig.4. Further work is undergoing to include the other performance dimensions and enable an agile response according to the life cycle phase.

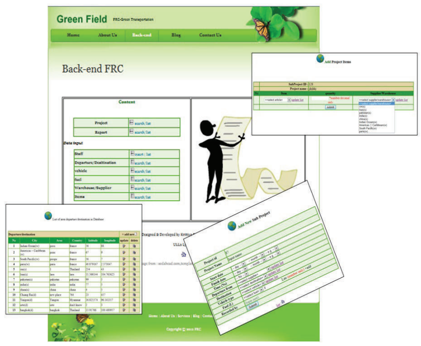


Fig. 4. FRC logistic management application

5 Conclusion

Presently, The work of humanitarian organizations is an increasingly important mission, especially during disaster relief operations. The main issue faced by humanitarian workers is the lack of decision support systems to improve, facilitate and accelerate the process of decision making.

In the near future, we will model the specific AHP decision model. We also plan to design and apply a case study approach to gain some crucial knowledge from involved logistics experts. Then we will continue to develop the DSS application in every needed function and make it fit to user requirements as defined by our case study.

6 Acknowledgment

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