

A warehouse location optimization model for emergency humanitarian logistics for Republic of North Macedonia

Emel Hamza Sherif¹ and Ile Cvetanovski²

Abstract – The increased need for effective disaster response, rises the need of creating a model for optimization the location of a warehouse for humanitarian logistics. The model presented in this paper can be used for selecting the location of a warehouse for humanitarian logistics in the Republic of North Macedonia.

Keywords – Facility location, humanitarian logistics, warehouse.

I. INTRODUCTION

Due to the importance of the correct model regarding the improvement of problems with the facility location during emergency humanitarian logistics, this paper aims to conduct research on location problems of facilities related to emergency humanitarian logistics based on the types of data modeling and the types of problems and to examine the conditions before and after the disaster in relation to the location of the facility, while retaining the locations of storage facilities such as the location of distribution centers and warehouses. In this paper is presented a model that includes the identified important factors and a tool that can be used even in a variable environment for selecting the location of an object – a distribution centre/warehouse for humanitarian logistics in the Republic of North Macedonia.

II. REQUIRED SOLUTIONS WITHIN THE TRANSPORTATION CHAIN

A. Required solutions within the transportation chain

Warehouses as part of logistics chains need to be explored and analyzed in terms of their rationalization, faster flow of goods, increased efficiency of logistics systems, harmonization of logistics processes and co-operation of logistics chains. The classification by structure, size, function, purpose, specialization of certain goods and certain freight units points to the wide range and importance of these points for the rational realization of transport chains.

¹Emel Hamza Sherif, Crisis Management Center – Resen, Republic of North Macedonia, emelhamza@gmail.com,

²Ile Cvetanovski, Faculty of Technical Sciences, Department for Transport and Traffic Engineering - Bitola, Republic of North Macedonia, ile.cvetanovski@tfb.uklo.edu.mk

Choosing the right location for the facility is one important step for an efficient supply chain and can reduce costs as well as the response time of each operation. The growing need for effective disaster response in terms of targeting the right resources to the right people and efficient disaster response in terms of optimal resource utilization rises the need to create a model for optimization the location of a storage center that will meet the needs of the warehouse humanitarian logistics. Disaster relief organizations tend to use ad hoc methods, such as experience and intuition, when they are making location decisions. Ad hoc methods are used because quantitative methods that take into account the characteristics of the landscape environment have not yet been developed or practiced. The use of Ad-hoc methods can lead to cost inefficiencies and slow response.

The prior literature review served to create an initial basis for understanding humanitarian logistics and to provide a theoretical framework.

B. Data collection steps

The data collection process is divided into five different steps as it is shown at Fig.1 bellow. The first step is data from field studies. These field studies give an empirical depth in which the goods were tracked through the UNHCR hand-to-hand distribution system. Although this paper does not focus on the flow of supply at that level, the information is valuable as it sets the context in which humanitarian organizations operate. In addition to the data obtained from the UNHCR, semi-structured interviews and group discussions were also held that provided a broad empirical basis for analysis.



Fig.1. Data collection steps

Group discussions organized by the Crisis Management Center (CMC) and the Center for Development of the Pelagonija region made a contribution, which increased the knowledge about the organization and their challenges. The technical and operational presentations of the project activities

of the J-CROSS (program for Joint cross-border cooperation for protection of the population from natural disasters and catastrophes caused by man-made) contributed to the formation of the strategy for humanitarian logistics.

A number of potentially important factors influencing the model were identified on the basis of the literary study. These factors were summarized in the questionnaire that was sent to a large number of people at the CMC. The goal was to identify the factors relevant to the organization. Respondents were selected from different positions within the CMC and from different backgrounds to get the widest possible information.

The last step was a request for statistics, where quantitative data from Crisis Management Center of North Macedonia were requested and obtained electronically.

III. MODEL CONSTRUCTION

The model is based on theoretical framework analysis and empirical studies. The outcome of the analysis determines which model should be constructed and how it should be modified in order to adapt it to the need of the Crisis Management Center. This process includes four main phases. The first one is the definition of the problem, then the main phase occurs during the data collection process. Collection and processing of data has the main impact in the model. The model is based on theoretical framework analysis and empirical studies.

The model is built in Microsoft Excel, using the Solver tool. The program could be done on another platform, but it has several advantages with Excel. For starters, this is a program that is widely used and usually installed by everyone computers. Furthermore, it is a well-known program with which the user feels comfortable. Finally, Excel has a programming language installed, VBA, which provides a number of functions.

Excel and VBA can also be designed to allow the user to control the model through buttons, shapes or dialog boxes, or to make a report from the simulation, where the optimal flow and price or time. This feature is important to answer the second research question. Model building in Excel also has some drawbacks: Excel cannot create reports as databases; may require a large portion of hard disk space; small changes can change the whole model; Error searching can be time consuming.

However, the advantages mentioned above are considered far more important than the disadvantages. The model includes three levels based on the level identified in supply chain mapping: supplier, warehouse and point of demand. The goods move from the manufacturer to the warehouse then to the point of demand or from the global warehouse to the warehouse in the specific country.

The model works as a Excel worksheet with Solver solution. Excel Worksheet from FLP (Facility Location Problem - Spreadsheet Solver) model consists of five parts. The first part deals with locations (Locations), where the number of desirable locations for the construction of a warehouse can be entered and it allows input from 5 to 300 different locations as shown at Fig.2. The model can be extended to a larger number of possible locations but then the processing time of data with Excel would be larger and errors could occur.

As a result it would be optimal to take a number of locations which will be between 5 and 300. What refers to the number of sites less than 5, then the optimization procedure of location of an object can also be done by manual calculations or by someone simpler computer command. The model will help to choose the optimal location for serving other near locations by optimizing the set function (minimum distance/maximum coverage).

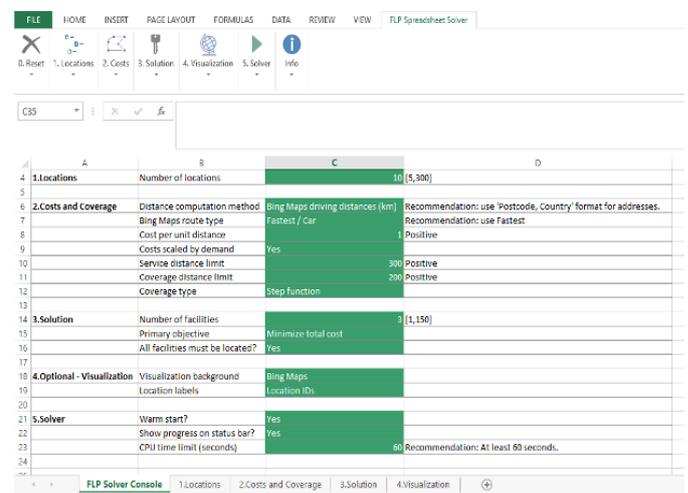


Fig.2. FLP Solver console sheet view

The second part deals with Costs and Coverage. This section includes:

- Distance computation method (Bing Maps/Google Maps), driving distances in kilometers;
- The type of route (Fastest / Passenger vehicle, Fastest / Passenger vehicle in real traffic, Fastest / freight vehicle, fastest / freight vehicle in real traffic);
- Costs per unit distance (this value is taken as positive although it refers to costs and in our case is taken as 1 Euro per km);
- Costs scaled by demand (Yes/No);
- Service distance limit - is a limit in kilometers that is set as the maximum upper limit to which a particular storage center would serve (in this model is set an upper limit of 300 km);
- Coverage distance limit - is a limit that is set at each of the locations where they could cover the demand (in our case it is limited to 200 km, all locations that are farther than 200 km will not be served by selected

storage center and will not be taken into account in further calculations);

- Coverage type (Step function - each location on demand will be served step by step).
- The third part refers to the solution. Three parameters are entered in this section:
- Number of facilities (Number of facilities [1,150] - the solution can be integer number greater than 1 and with a maximum value of 150 of the possible 300 locations);
- Main goal (Primary objective - Minimize total costs, Maximize Demand Covered, Minimize Maximum Service Distance) Minimize total costs, Maximizing the satisfied demand, Minimizing the maximum service distance.
- Do all objects need to be located ? (We choose Yes or No, whether we want all objects to be located in a specific location or no (All facilities must be located> Yes / No).

The fourth part of the worksheet refers to Visualization.

This is an optional tool that is used to visually display the result on a map. Bing Maps / Google Maps or some other image that we think should be placed in the background of the results (are sets via the Insert menu from Excel). The same visual display shows the locations that are selected as well as the locations that are served (via arrows – shown below in the results section).

Finally, the fifth part refers to the Solver tool, where the time for realization of the calculations is set, which should not be less than 60 seconds (recommendation).

During the validation and implementation of the model in our conditions, ie. in the Republic of Northern Macedonia we have selected ten cities that would cover the entire territory of the Republic and the volume of data should not be large so that the system can work without errors.

At the top of the worksheet there are standard tools that appear on every document created in Excel by the Office suite, namely: document name, minimize, maximize, close and FILE menus , HOME, INSERT, PAGE LAYOUT, FORMULAS, DATA, REVIEW and VIEW.

IV. EVALUATION OF THE MODEL

To evaluate the model with data from North Macedonia, we started with 10 locations and set function minimum distance with 3 main locations serving all other. When the number of locations is less than 5, the procedure for optimization of object location can be done with manual calculations or with a more simple computer command.

At Fig.3 is shown the location worksheet which consists of a table with 9 columns and 10 rows – one for each location.

Location ID	Name	Address	Latitude (y)	Longitude (x)	Demand	May be a facility?	Capacity	Setup cost
1	Location 1	Struga	41.1780010	20.6742990	1	May be a facility?	10	0
2	Location 2	Bitola	41.0296780	21.3292160	1	May be a facility?	10	0
3	Location 3	Skopje	41.9973450	21.4279960	1	May be a facility?	10	0
4	Location 4	Tetovo	42.0069120	20.9715270	1	May be a facility?	10	0
5	Location 5	Kavadarci	41.4336010	22.0124000	1	May be a facility?	10	0
6	Location 6	Strumica	41.4575380	22.6430490	1	May be a facility?	10	0
7	Location 7	Kumanovo	42.1331210	21.7186090	1	May be a facility?	10	0
8	Location 8	Štip	41.7436710	22.1920290	1	May be a facility?	10	0
9	Location 9	Delcevo	41.9654500	22.7792390	1	May be a facility?	10	0
10	Location 10	Gevgelijska	41.1403010	22.5037990	1	May be a facility?	10	0

Fig.3 Locations sheet view

Columns A and B give the ordinal numbers for each location, column C gives the addresses of the locations, in our case they are the names of the cities themselves. If location coordinates are automatically determined by using Bing Maps then addresses should be entered with post code and city. But if the coordinates are entered manually via data from Google Maps than the location names can be as we like as. Columns D and E are latitude and longitude data that we have found automatically through Bing Maps or manually filled via Google Maps. Columns F, G, H and I refer to „Demand“, „May be a facility“, „Capacity“ and „Setup costs“ respectively.

The fields in the table are filled in according to the actual situation, and then these data are used to calculate the most optimal location for the construction of a storage center that will serve in a crisis situation or a natural disaster.

When the set function is to minimize the total cost of supplying 10 locations with 3 storage locations, we obtain the results shown in the figure 4. That is, the facility at Location 1 will serve Locations 1 and 2, the facility at Location 3 will meet the needs of Location 3, Location 4 and Location 7, and the last facility at Location 6 meets the needs of Location 6, Location 5, Location 8, Location 9 and Location 10. The results show that all Locations are satisfied with the choice of Locations 1, 3 and 6, with total costs being minimal.

V. CONCLUSION

The model that was created is geared towards Crisis Management Center and its needs. As the UNHCR is an example of an organization in the humanitarian sector, the model suits every organization in a similar situation. The specific constraints that form the model apply to all humanitarian actors: demand must be met; operations are often performed in uncertain environments; sales and profits do not exist; the demand can increase rapidly. For charities using ad-hoc experience-based methods, the model may provide a quantitative alternative to facility location. It can allow aid organizations to focus on cost-effectiveness and optimal capacity allocations. Because the planning is fundamental, the tool can support the development of well-functioning networks before a disaster occurs, or at least an idea of how the network should change.

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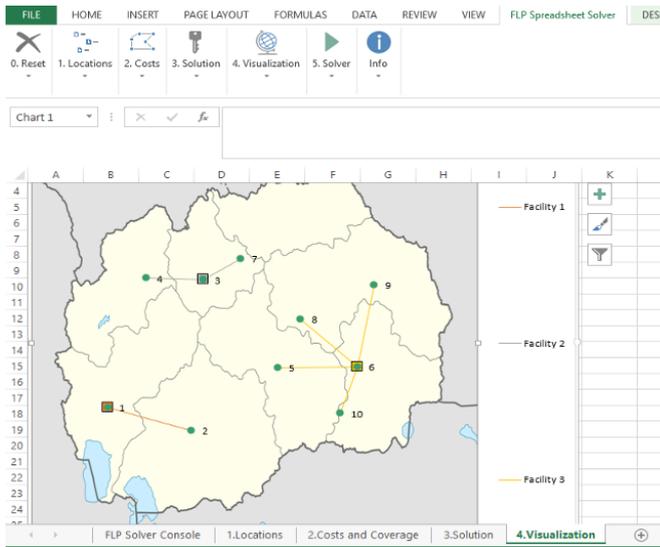


Fig.4. Locations sheet view

There are several practical aspects to consider during the implementation of the model. First, the lifespan of facilities can have a major impact on decisions. This is an important point for humanitarian actors who own their own warehouses. Although the demand is constantly changing, the facilities have a certain lifespan and can not be easily transferred without cost. For actors who do not own the warehouses, this is not a problem.

Second, cultural implications should not be truncated. This is an important point for humanitarian actors because they are often close to each other. Managers need to communicate with surrounding facilities to identify potential ones synergistic effects or adverse effects that may occur.

Third, the quality of life issues affects the workforce and performance. For humanitarian actors, who often work in remote areas and in difficult conditions, this is an important aspect to keep in mind. Workers' mentality is changing and people's attitudes towards sacrifice can change.

Finally, tax breaks and tariffs should not be forgotten. If the organization is exempt from tax, the issue is an exemption that can be costly and time consuming. If the organization is not exempt, the problem arises just like in a commercial company.