UNIVERSITY "ST.KLIMENT OHRIDSKI"- BITOLA

FACULTY OF TECHNICAL SCIENCES - BITOLA
DEPARTMENT OF TRAFFIC AND TRANSPORTATION

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AUTOSUMMARY OF THE PhD DISSERTATION

CREATING A MODEL FOR OPTIMIZATION OF A WAREHOUSE FOR HUMANITARIAN LOGISTICS

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CONTENT

INTRODUCTION

The increased need for effective disaster response, in terms of directing the right resources to the right people and the effective response to disasters through optimal use of resources, rises the need to create a model for optimization the location of a warehouse that will meet the needs of the humanitarian logistics.

Due to the importance of the correct model regarding the improvement of problems with the facility location during emergency humanitarian logistics, this document 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. The focus lies in constructing a model that includes the identified important factors and creating a tool that can be used even in a variable environment. In this doctoral dissertation are presented the steps for creating a model for selecting the location of an object - a distribution center/warehouse for humanitarian logistics.

The flows of goods in millions and billions of tons transit regional, national and international spaces. They are a consequence of the constant growth of spatial, temporal and quantitative transformations in the uninterrupted variability of packing, loading, transport, storage, reloading, transport, unloading, storage, delivery, etc. The activities of spatial, temporal, qualitative and quantitative transformation of commodity flows cause enormously high operating costs, material, energy, transport costs, manipulative damage, high cost of engaged capital, etc. Carriers of the realization of commodity flows are logistics chains and logistics systems.

Warehouses as part of logistics chains should be researched and analyzed in terms of the possibility of their rationalization, faster flow of goods, increasing the efficiency of logistics systems, harmonization of logistics processes and cooperation of participants in logistics chains. The classification according to the structure, size, function, purpose, specialization for certain goods and certain cargo units indicates to the wide range and importance of these points for the rational realization of the transport chains.

This PhD dissertation consists of 8 chapters, 246 pages, 29 figures and 19 tables. Reference literature contains 126 references. Both attachments are intended to define the database used and further explain individual parts of the paper. During the preparation of this dissertation many research papers are achieved to be published and presented in international scientific journals and conferences. The list of published papers is following:

1. E. Hamza Sherif, I. Cvetanovski, "Crucial steps for planning and designing a warehouse or distribution center to achieve effective flow of materials", Proceedings of The 13th MAC 2018, ISBN: 978-80-88-88085-21-8, Multidisciplinary International Academic Conference, October 12-13, 2018, CSVTS – Czech Association of Scientific and Technical Societies, Prague, Czech Republic. Indexed EBSCO и NKC - National Library of the CR;
   link:https://books.google.mk/booksid=AD5yDwAAQBAJ&pg=PA86&lpg=PA86&dq=emel+hamza&source=bl&ots=FrJsESr29Q&sig=ACfU3U37BlGezr7NgV1B2ojWRYWKo03w&hl=en&sa=X&ved=2ahUKEwiEx92rzJ_qAhXFrHEKHWMnABY6AEwDHoECAgQAQ#v=onepage&q=emel%20hamza&f=false

2. E. Hamza Sherif, I. Cvetanovski, "A support tool for making facility localization decisions computer-based during crisis management" , Proceedings of The 16th MAC 2020, ISBN: 978-80-88085-28-7, Multidisciplinary International Academic Conference, 24th - 25th January, 2020 Czech Techical University in Prague. Indexed in EBSCO и NKC - National Library of the CR;
   link:https://books.google.mk/booksid=nVPMDwAAQBAJ&pg=PA15&lpg=PA15&dq=emel+hamza&source=bl&ots=BftiAELhW&sig=ACfU3U3ehABQAQOvxTp72BjDKgnmmRdXHg&hl=en&sa=X&ved=2ahUKEwiEx92rzJ_qAhXFrHEKHWMnABY6AEwDXoECAoQAQ#v=onepage&q=emel%20hamza&f=false

3. E. Hamza Sherif, I. Cvetanovski "A warehouse location optimization model for emergency humanitarian logistics for Republic of North Macedonia", 3rd International Scientific Conference "TRANSPORT FOR TODAY'S SOCIETY", Bitola, accepted and expected to be presented when postponed-conference will be held.
   Link: http://ttsconf.org/

1. SUBJECT, OBJECTIVES, HYPOTHESIS, USED METHODOLOGY, STRUCTURE AND RESULTS FROM THE RESEARCH

The motive for the proposed research is the storage centers in humanitarian logistics. Humanitarian logistics operates under special conditions facing financial issues, irregular demand, time constraints and infrastructure challenges. The design of the humanitarian supply chain therefore differs greatly from that in the commercial sector. Not only is the demand often difficult to foresee, but the different stakeholders involved complicate the issue further . The complexity increases by the fact that stakeholders on different levels can harbour different strategies and make different optimizing decisions. Preparatory operations must be thorough to prevent some of the connected risks. The preparation process can include assessing infrastructural challenges, specifying needs, pre-positioning relief items, developing strategies and concepts.

Choosing the optimal location of the facility is a step towards an efficient supply chain and can reduce costs as well as response time during each operation. The growing need for an effective disaster response in terms of directing the right resources to the right people and responding effectively to disasters in terms of optimal use of resources, gives rise to the need to create a model for optimizing the location of a storage center/warehouse that will meet the needs of humanitarian logistics. Having in mind the above, the SUBJECT OF RESEARCH of this doctoral dissertation is to research the possibilities for creating a model for optimization of a warehouse in humanitarian logistics.

The purpose is therefore to develop a simulation-based model for generating and evaluating the configurations of warehouse locations in the humanitarian sector. To meet the goal, factors that affect general warehouse localization must first be identified. The first research question is consequently:

What factors should be taken into account when developing a model for warehouse network optimization in the humanitarian context?

Second, the model should be constructed in a way that is beneficial to humanitarian organizations in different contexts. The second research question is:

How should the model be adapted to meet the different needs of humanitarian organizations?

The focus lies on constructing a model that incorporates the identified important factors and creating a tool that can be used even in a changing environment.

The theoretical goal of the doctoral dissertation is to use scientific methodology to set the main aspects, tasks, functions, levels and modern concepts for model construction and strategy for warehouse optimization in humanitarian logistics.

This doctoral dissertation is an attempt to make a detailed presentation of the supply chain management in humanitarian logistics and to determine the optimal location of a warehouse, by applying and developing a scientific methodology for optimal planning, designing and developing a location optimization model and creating a realistic logistics strategy.

Hypothesis of research. Based on the research objectives, the below hypothesis were tested and proven:

THE MAIN HYPOTHESIS is: the developing of a warehouse optimization model as part of a humanitarian supply chain will ensure the application of the model's logistics strategy in real conditions, ensuring system applicability, sustainability and durability.

Special hypothesis:

- *The considered aspects, concepts, tasks, functions and levels to realistically reflect the behavior of the supply chain management procedures and warehouses as their element;*
- *The new model and the new logistics strategy will fully contribute to the quality of services after the optimization of warehouses with humanitarian function.*

Methods and techniques of research: during the preparation of this dissertation, in order to achieve the goals and target results, quantitative and qualitative methods were used, i.e.: methods for data collection and analysis, methods of classification, description and comparison, inductive and deductive method, method of abstraction, concrétisation and generalization, modeling methodology. A series of mathematical, computer, and statistical methodologies and procedures have been used, with a full systemic approach.

To implement the model, the programming language VISUAL BASIC and FLP Spreadsheet Solver - a working tool from Microsoft Excel were used. The research address the UNHCR charity, and the results will be used by the Crisis Management Center to make decisions in dealing with and preventing crisis situations.

2. LOGISTIC CHAINS – SUPPLY CHAIN MANAGEMENT

The second chapter deals with the technological-economic essence and the problems for realization of the transport chains / supply chains in general and in the humanitarian logistics.

The transport chain is an integrated chronological order of all the individual processes necessary to transport material goods from producer to consumer, and the technological connection of the members of the chain is arranged in a single process of change in time and space, achieving high effects. It follows that the main purpose of the transport chain is the transport of goods "from door to door" using one or more types of transport minimizing the costs of transportation, storage and load-unloading manipulation and their technological integration.

3. LOGISTIC CENTERS AS PART OF TRANSPORTATION CHAINS

The third chapter examines and analyzes the logistics chains and logistics systems, in terms of the possibility of their rationalization, faster flow of goods, increasing the efficiency of logistics systems, harmonization of logistics processes and cooperation of participants in logistics chains.

Carriers of the realization of commodity flows are logistics chains and logistics systems. These two areas are explored and analyzed in terms of the possibility of their rationalization, faster flow of goods, increasing the efficiency of logistics systems, harmonization of logistics processes and cooperation of participants in logistics chains.

Logistics centers as an idea and a real form have existed for decades, but their founders, function, structure and development goals, over time take different forms in terms of terminology and technology, both in name and function.

The warehouses in the logistics system are points where the material flows meet. The warehouses synchronize the processes of movement and storage of goods and overcome time and capacity inconveniences. They provide secure system performance. The function and purpose of the warehouse determine its location as well as the technique that will be installed in it. The subject of research of this doctoral dissertation is the warehouses in humanitarian logistics. Humanitarian logistics is defined as the process of evacuating people from areas affected by disaster to a safe place and includes planning, implementing and controlling efficient, effective flow and storage of goods and materials, collecting information from the point of view of the crisis. to the point of their use, in order to protect and rescue persons and material goods affected during a crisis situation.

4. GENERAL INFORMATION ABOUT THE PROTECTION / RESCUE AND CRISIS MANAGEMENT SYSTEM

Chapter four provides a general overview about protection / rescue and crisis management system, defines the terms protection and rescue, and explains the principles, objectives, and tasks of protection and rescue. Then the Profile of the Crisis Management Center is displayed through the tasks, function and goals, its regional organization and international cooperation. Through the example of a humanitarian organization, the United Nations High Commissioner for Refugees (UNHCR) are identified problems and obstacles in the current state of humanitarian logistics management and location of warehouses.

Protection/rescue is the monitoring of sources of danger, their detection and finding optimal measures, procedures and means to counter and eliminate the consequences that have caused them. In order to achieve effective and efficient protection and rescue, it is necessary to know the sources of danger, the types of threats and to develop a realistic perception of the dangers, threats and risks caused by accidents. Sources of threat are forces that have the potential to act, can act, or act. They can be perceived as dangers, threats and risks.

In order to successfully deal with natural disasters and other accidents within the framework of protection and rescue, it is necessary to develop and establish appropriate principles, goals and objectives. The Crisis Management Center is responsible for coordinating its and all other necessary activities with all participants in the crisis management system, providing continuous communication and cooperation for data collection and information, informing and proposing measures for risks and dangers that may endanger the security of the Republic of North Macedonia.

5. A WAREHOUSE LOCATION OPTIMIZATION DURING HUMANITARIAN LOGISTICS

In Chapter Five, empirical findings are analyzed and compared with theory in order to optimize the location of a warehouse for humanitarian logistics. The analysis leads to the choice of model and construction of the model.

The modeling process contains four activities: Problem Definition, Data Collection, Analysis and Model Construction. Each activity has its own output: Problem, System and Data, Model Frame, and Model. Figure 5.1 below presents the research process.

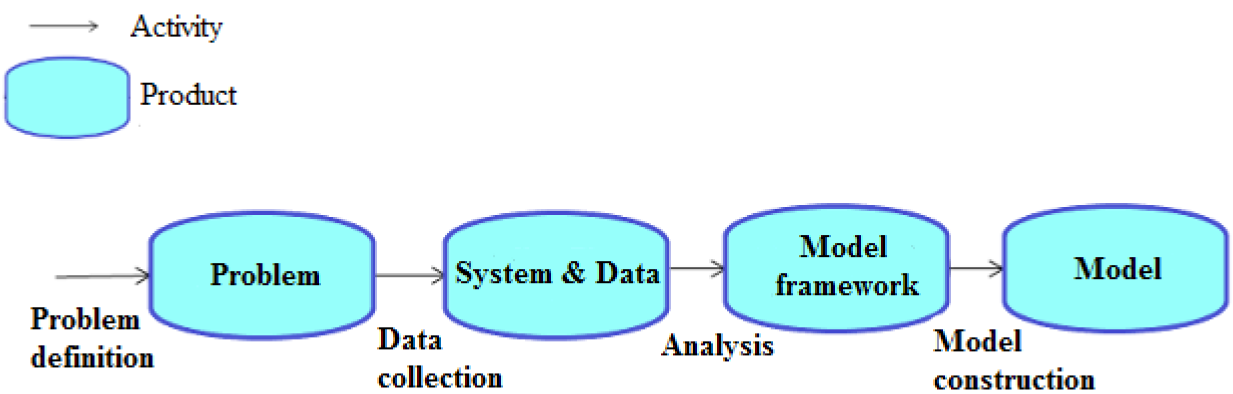


Figure 5.1.: *Processes and activities*

In the process of developing a model, the first step is to understand and define the problem. Therefore the project was initiated by analysing prior studies, and holding exploratory interviews in order to define the problem at hand and materialize the purpose of the thesis.

The initial review of the literature served to create an initial research understanding of humanistic logistics and to create a theoretical framework. The Chopra and Meindl (2004) framework for network design was used as a complete framework for the theory. To gain a broad base of knowledge, many different sources were used and their views were structured and embedded within. The focus of the literature study lay on the various factors that determine how a network should be designed.

Data collection had two purposes; collect data on the UNHCR distribution system and find relevant data on model construction. There are two different types of data, qualitative and quantitative, that differ in nature and can offer different perspectives during the analysis. Qualitative data explores human elements and experiences, rather than focusing on numerical values. When qualitative data are collected, the thoughts of individuals and their interpretations of the processes are collected and analyzed. Qualitative data collection can be done using tools such as interviews, notes, conversations, recordings and photographs in order to turn the world into a series of representations. Quantitative data, on the other hand, are numerical data that can be analyzed using mathematically based methods.

Quantitative data collection can be done by collecting and analyzing secondary data, as well as conducting experiments, research and simulations. the reliability of its result. To meet the purpose of the thesis accurately and answer the research question, it was considered that optimal data collection, which includes quantitative and qualitative data, consideration is optimal.

The data collection process is divided into five different steps. The first step is data from field research in Dadaab and Nairobi, Kenya. These field surveys provide an empirical depth in which the goods were tracked through the UNHCR's hand-to-hand distribution system. Although the thesis does not focus on the flow of supplies at that level, the information is valuable because 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 held to provide a broad empirical basis for analysis. The questions are in the Attachment to the doctoral dissertation. The last step was a request for statistical data, where quantitative data from the CMC were requested and obtained electronically. Figure 5.2. below shows the steps of the data collection process.

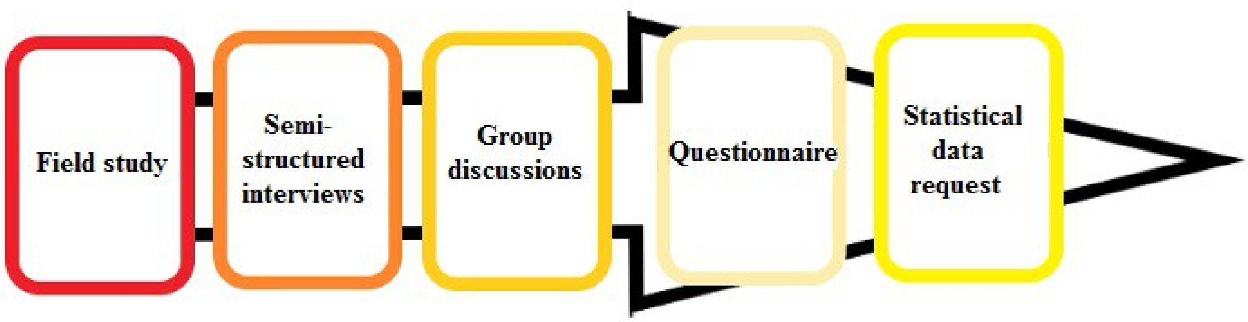


Figure 5.2.: *Steps of data collection, own creation*

In addition to general research interviews, more focused interviews were also conducted. The design of the focused interviews was semi-structured to answer certain questions, but at the same time to elaborate aspects that might otherwise be overlooked. Unstructured group discussions organized by the CMC and the Pelagonija Region Development Center contributed to increase knowledge about the organization and their challenges. Through the technical / 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 disasters caused by human factor" (held on June 7, 2019 in Bitola) contributed to establishing a strategy for humanitarian logistics.

To ensure a reliable PhD dissertation, data source testing, analysis of similar models, and the construction phase of an interactive model were performed. A mixed method for collecting data with qualitative data from observations and interviews was selected, as well as quantitative data from statistical data on demand and physical flow. The debriefing was done by both experts in the field of logistics and by experts in the field of modeling.

The methodology point focused on explaining the activities carried out in order to complete the research and ensure its credibility. Mixed data collection was selected to include both qualitative and quantitative data.

Following the framework described in the methodology part, a literary study was conducted to find two theoretical frameworks. First, a short section that defines the supply chain that will be used to set the scope of the research. Then a supply chain mapping frame is selected, which helps the system structure. The focus then shifted to network design frameworks. The different types of decisions for localization of facilities and how they affect the organization are described. Then, a network design framework is selected and used to verify how design decisions are made. A large number of mathematical models are presented that can be used for facility location problems.

6. ПРОЦЕСИ ВО ОРГАНИЗАЦИИТЕ ЗА МАПИРАЊЕ НА СИНЦИРОТ НА СНАБДУВАЊЕ – ЕМПИРИСКИ СТУДИИ

Chapter 6 shows the processes in organizations that serve to map the supply chain - the results of empirical studies through processes in the UNHCR. Then the structural features, management processes, and network design are given, with their parts like: supply chain strategy, regional facility configuration, desirable locations, and location selection.

Since the 1950s, the number of natural and man-made disasters has increased exponentially, and the problem of site selection has become the preferred approach to dealing with the problems of humanitarian logistics. To address this challenge, the correct algorithm and the heuristic algorithm are combined as the main approach to solving these problems. Due to the importance of accurately applying the algorithm for solving location problems in humanistic logistics, this paper aims to investigate the location problems of facilites related to humanitarian logistics based on both types of data modeling and problems, and to examine the situation before and after disasters in relation to the location of facilities, such as the location of distribution centers, warehouses, shelters, waste disposal sites and medical centers. The research will consider the four main problems highlighted in the literature review: problems with the location of deterministic objects, problems with the location of dynamic objects, problems with the location of a stochastic object, and problems with the location of robust objects. For each problem will be evaluated, the type of location of the object, the type of data modeling, the type of disaster, decisions, goals, limitations and methods of solution, while real-world applications and case studies will be presented later. In the end, the shortcomings of the research will be identified and reviewed in order to further develop more effective disaster operations in further research studies.

Due to the growing seriousness of recent disasters, research has focused on crisis management in dealing with humanitarian logistics, with optimization, decision-making and simulation being proposed as the main approaches. Disaster research tends to apply modeling and optimization to solving emergency humanitarian logistics problems.

In this PhD dissertation, the models for optimization of the location of humanitarian logistics facilities are examined. To develop the literature database, models for optimizing the location of humanitarian logistics facilities were searched in magazines, books and conferences and then classified according to the object location problem and optimization categories: deterministic, stochastic, dynamic and robust. Finally, applications and case studies were reviewed. Because the aim of this paper focuses on the correct algorithm or mathematical modeling techniques when optimizing the location in humanistic logistics, only those documents that proposed the type of the correct algorithm of mathematical technique are included in the research.

Models for site optimization for emergency humanitarian logistics vary depending on:

- the objectives for planning the location of the facility,
- situation (security, uncertainty and data risk),
- duration (short-term or long-term),
- number of locations,
- service, and
- required types of goods.

7. DEVELOPING THE MODEL FOR OPTIMIZATION OF A WAREHOUSE LOCATION FOR HUMANITARIAN LOGISTICS

Chapter 7 shows the process of developing a model for optimizing the location of a warehouse for humanitarian logistics and parameters that are particularly important for analysis. This chapter shows in detail the functioning of the model through FLP Solver for special geographical regions in the Republic of North Macedonia, as well as the optimal solution for the location of storage centers for humanitarian logistics for the entire RNM.

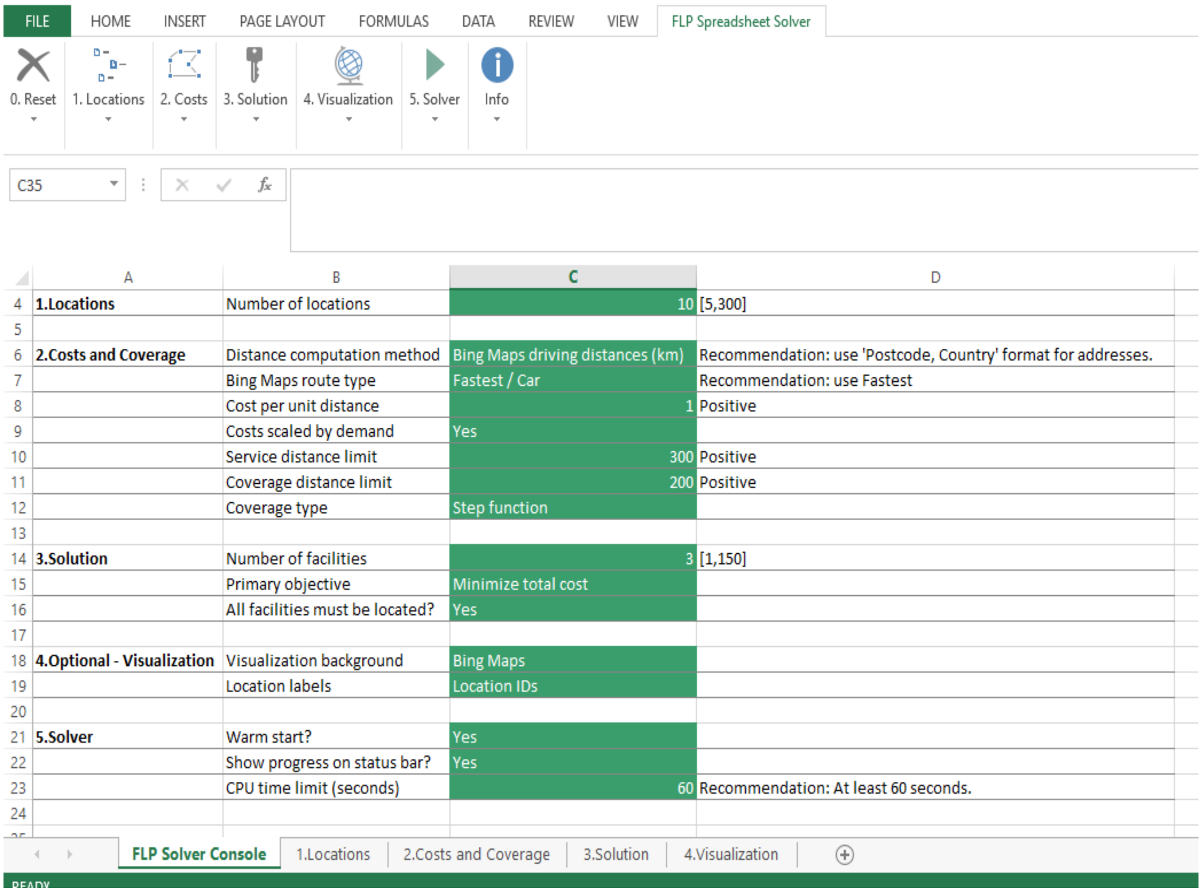
Initially, as we saw in the previous chapter, a comparison was made of a number of models based on the general requirements that the model of the humanitarian organization may have. A model is selected and network design decisions are discussed based on the model. The specific requirements for the model are then identified, including the factors to consider. The analysis focuses on these two initial parts. Then, it is practically described how the model is built, a part that focuses on building the model. The weaknesses of the model are discussed at the end. The selection of the model is made from a general humanitarian perspective, but the specific requirements of the model are based on the analysis in the fourth chapter.

The model is based on Excel, which must be used for the model to work. The model is based on the capacity model of the location, but can be changed to match the context of the organization where it will be applied. It is a warehousing tool that optimizes the warehouse network by minimizing costs, while ensuring that total demand is met. It uses linear programming with the Simplex method to find the optimal solution.

The model uses Solver functions to find the optimal solution. The basic Solver from Excel allows only 200 decisive variables, which are too restrictive and the application of a plugin as an add-on is necessary. The plugin is called OpenSolver and there are no restrictions on the number of variables.

7.1. Description of the main dialog box of the information system

The FLP (Facility Location Problem - Spreadsheet Solver) Excel Worksheet consists of five parts. The first part deals with locations, where the number of desirable locations for the construction of a storage center for humanitarian logistics can be entered. As can be seen from Figure 7.1.1. the number of locations allowed by the worksheet is from 5 to 300 locations. The model can be extended to a number of possible locations, but then the processing time of the data using Excel would be higher and errors could occur, so it would be optimal to take a number of locations that would be between 5 and 300. As for the number of locations less than 5, then the procedure of optimizing the location of an object can be done with manual calculations or with a simpler computer command.



	A	B	C	D
4	**1.Locations**	Number of locations	10	[5,300]
5				
6	**2.Costs and Coverage**	Distance computation method	Bing Maps driving distances (km)	Recommendation: use 'Postcode, Country' format for addresses.
7		Bing Maps route type	Fastest / Car	Recommendation: use Fastest
8		Cost per unit distance	1	Positive
9		Costs scaled by demand	Yes	
10		Service distance limit	300	Positive
11		Coverage distance limit	200	Positive
12		Coverage type	Step function	
13				
14	**3.Solution**	Number of facilities	3	[1,150]
15		Primary objective	Minimize total cost	
16		All facilities must be located?	Yes	
17				
18	**4.Optional - Visualization**	Visualization background	Bing Maps	
19		Location labels	Location IDs	
20				
21	**5.Solver**	Warm start?	Yes	
22		Show progress on status bar?	Yes	
23		CPU time limit (seconds)	60	Recommendation: At least 60 seconds.
24				

Figure 7.1.1.: *View of the main worksheet from FLP Solver*

The second part is about costs and coverage (Costs and Coverage). This section includes:

- Distance calculation method (Bing Maps / Google Maps), 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 kilometer (this value is taken as positive although it refers to costs and in our case is taken as 1 Euro per km);
- Restriction of service distance limit (Service distance limit - is a limit in kilometers that is set as the maximum upper limit to which a certain storage center would serve. When validating and

implementing the model in RNM an upper limit is set as 300 km);

- Coverage distance limit (Coverage distance limit - is a limit that is placed on each of the locations where they could cover the demand, in our case it is limited to 200 km, all locations that will be more than 200 km will not be served by that storage center and will not be taken into account in further calculations).
- Type of coverage (Step function - each location of demand is served step by step).

The third part concerns the solution. Three parameters are entered in this section, as follows:

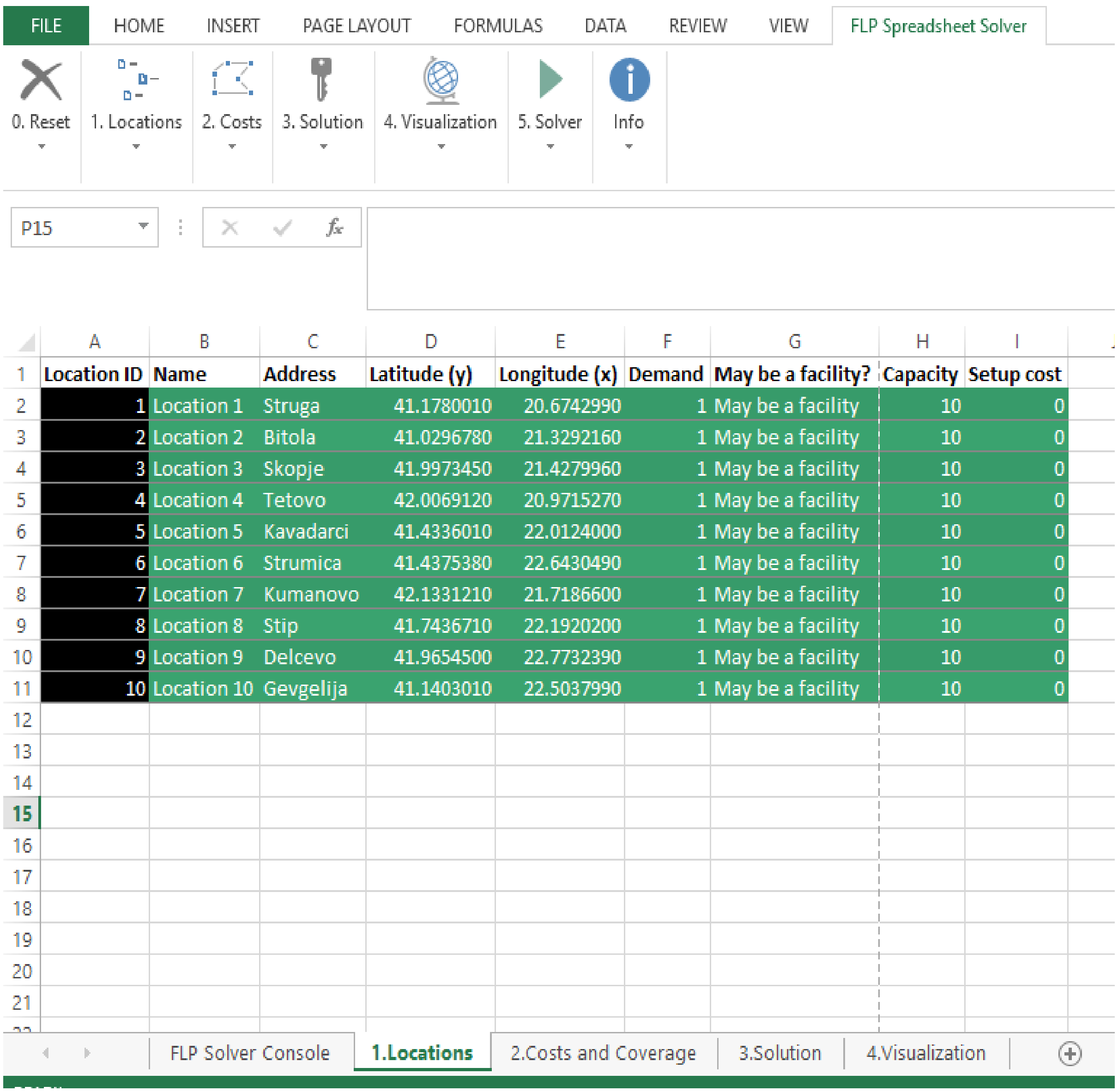
- number of objects (Number of facilities [1,150] - the solution can be an integer greater than 1 and with a maximum value of 150 of the possible 300 locations);
- Primary objective (Primary objective - Minimize Total costs, Maximize Demand Covered, Minimize Maximum Service Distance)
- Should all objects be located (From the drop-down menu to this cell, select whether we want all objects to be located in a specific location, select Yes or No. (All facilities must be located> Yes / No)).

The fourth part of the worksheet refers to Visualization. This is an optional tool that visually displays the result on a map. For this purpose, Bing Maps / Google Maps maps or some other image that we think should be placed in the background of the results (set through the Insert menu from Excel) are used. The same visual display shows the locations that are selected as well as the locations that are served (through arrows - shown below in the results section).

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

During the validation and implementation of the model in our conditions, i.e., in the area of Republic of North 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 function without errors. At the top of the worksheet there are the standard tools that appear on each document created in Excel Microsoft Office,: document name, minimize, maximize, close and menus like FILE, HOME, INSERT, PAGE LAYOUT, FORMULAS, DATA, REVIEW and VIEW.

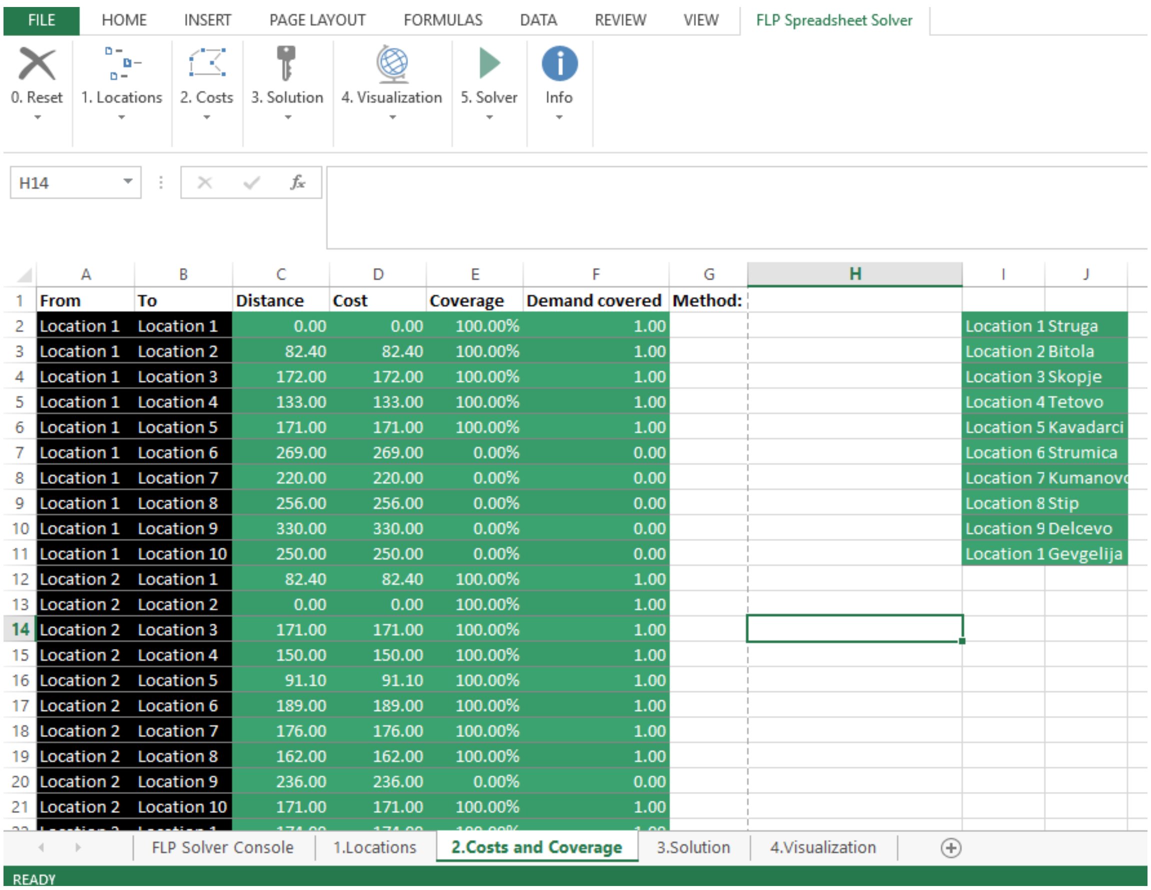
At Figure 7.1.2. a worksheet with the ten locations - cities from the Republic of Northern Macedonia (Struga, Bitola, Skopje, Tetovo, Kavadarci, Strumica, Kumanovo, Stip, Delchevo, Gevgelija) is shown. A number is given for each city (Location 1, Location 2,… Location 10).



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	41.4375380	22.6430490	1	May be a facility	10	0
7	Location 7	Kumanovo	42.1331210	21.7186600	1	May be a facility	10	0
8	Location 8	Stip	41.7436710	22.1920200	1	May be a facility	10	0
9	Location 9	Delcevo	41.9654500	22.7732390	1	May be a facility	10	0
10	Location 10	Gevgelija	41.1403010	22.5037990	1	May be a facility	10	0

Figure 7.1.2. Locations Worksheet view From

From Figure 7.1.2. it can be seen that the worksheet with locations consists of a table that has 9 columns and 10 rows - one for each location. In columns A and B are given the ordinal numbers for each of the locations, in column C are given the addresses of the locations, in our case they are the names of the cities themselves. If the coordinates of the locations are determined automatically with Bing Maps, then the addresses in the form of - zip code, city should be entered in this column. But if the coordinates are entered manually through data from Google Maps, then the names of the locations can be as we want (it is possible to use Cyrillic letter). Under columns D and E are the latitude and longitude data we have found automatically via Bing Maps or manual filling via Google Maps. Columns F, G, H, and I refer to “Demand”, “Can It Be facility”,“Capacity” and “Establishment costs” respectively. The fields in the table are filled in according to the real situation, and then these data are used to calculate the most optimal location for the construction of a warehouse that will serve during a crisis situation / natural disaster.



	A	B	C	D	E	F	G	H	I	J
1	From	To	Distance	Cost	Coverage	Demand covered	Method:			
2	Location 1	Location 1	0.00	0.00	100.00%	1.00			Location 1 Struga	
3	Location 1	Location 2	82.40	82.40	100.00%	1.00			Location 2 Bitola	
4	Location 1	Location 3	172.00	172.00	100.00%	1.00			Location 3 Skopje	
5	Location 1	Location 4	133.00	133.00	100.00%	1.00			Location 4 Tetovo	
6	Location 1	Location 5	171.00	171.00	100.00%	1.00			Location 5 Kavadarci	
7	Location 1	Location 6	269.00	269.00	0.00%	0.00			Location 6 Strumica	
8	Location 1	Location 7	220.00	220.00	0.00%	0.00			Location 7 Kumanovo	
9	Location 1	Location 8	256.00	256.00	0.00%	0.00			Location 8 Stip	
10	Location 1	Location 9	330.00	330.00	0.00%	0.00			Location 9 Delcevo	
11	Location 1	Location 10	250.00	250.00	0.00%	0.00			Location 1 Gevgelija	
12	Location 2	Location 1	82.40	82.40	100.00%	1.00				
13	Location 2	Location 2	0.00	0.00	100.00%	1.00				
14	Location 2	Location 3	171.00	171.00	100.00%	1.00				
15	Location 2	Location 4	150.00	150.00	100.00%	1.00				
16	Location 2	Location 5	91.10	91.10	100.00%	1.00				
17	Location 2	Location 6	189.00	189.00	100.00%	1.00				
18	Location 2	Location 7	176.00	176.00	100.00%	1.00				
19	Location 2	Location 8	162.00	162.00	100.00%	1.00				
20	Location 2	Location 9	236.00	236.00	0.00%	0.00				
21	Location 2	Location 10	171.00	171.00	100.00%	1.00				

Figure 7.1.3: *"Costs and coverage" worksheet*

The third worksheet from the FLP Solver model deals with the cost and demand coverage. A table consisting of six columns shows the distance between the locations. That is, the first columns show the possible relations between the locations. In our case, these are the relations between the ten cities of the Republic of North Macedonia. The third column C shows the kilometers. the distance between the special locations. It can be noticed that the distance is 0 km, when it comes to the location of the site itself. If in other fields / cells we have numerical data that is mileage measured with the help of Google Maps.

Column D refers to the cost of implementing that mileage. Since in the first working sheet for costs per kilometer we determined to take 1 euro / km, the values in this column are obtained by multiplying the values in column C by 1, ie. are equal to those of column C.

Column E shows the percentage values for the demand coverage domain from a particular location. We can see that the data in these cells have a value of 100.00% or 0.00%. This is due to the limit set in Worksheet 1, where we set a maximum limit of 200 km. That is, it means that those locations that are more than 200 km away from each other, in the column will have a value of 0.00%, i.e. that location cannot serve the location at a distance of / over 200 km. For example, Location 1 with Location 6,7,8,9,10 has a distance of more than 200 km (269 km, 220 km, 256 km, 330 km, 250 km respectively), therefore in cells in column E it has a value of 0.00%. In column F there will be a value of 1 if the demand is satisfied or 0 if the demand at that location is not satisfied.

The third worksheet refers to "Solution" (Figure 7.1.4, Figure 7.1.5., Figure 7.1.6.). After entering the data for all the parameters of the model, then the Solution command is pressed and the solution is displayed in a new worksheet. Because in the first worksheet of the FLP Solver document we chose to have 3 locations out of a possible 10, and the solution will be given for the three locations in the same worksheet.

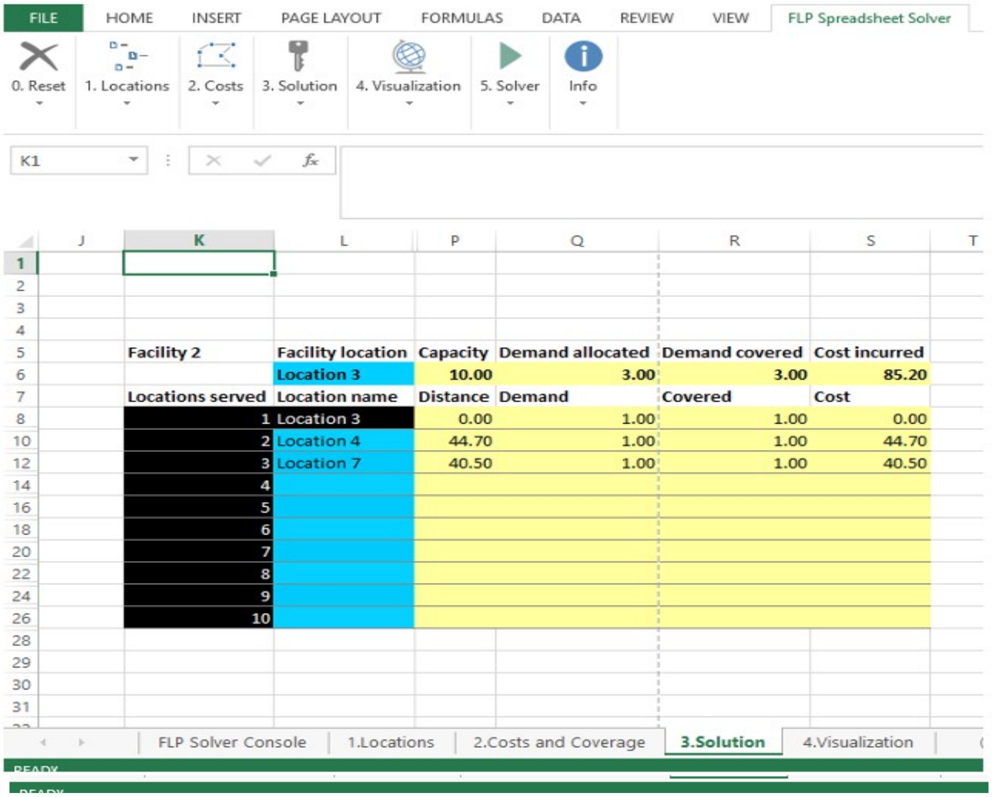


Figure 7.1.4 .: *The solution for the first location*

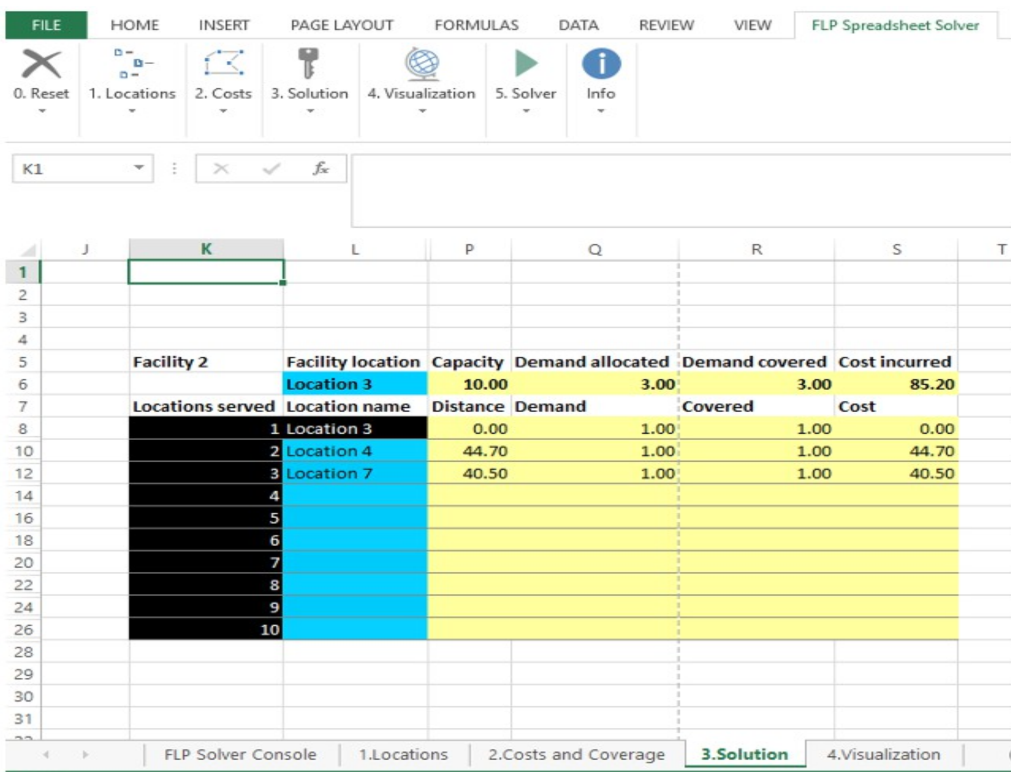
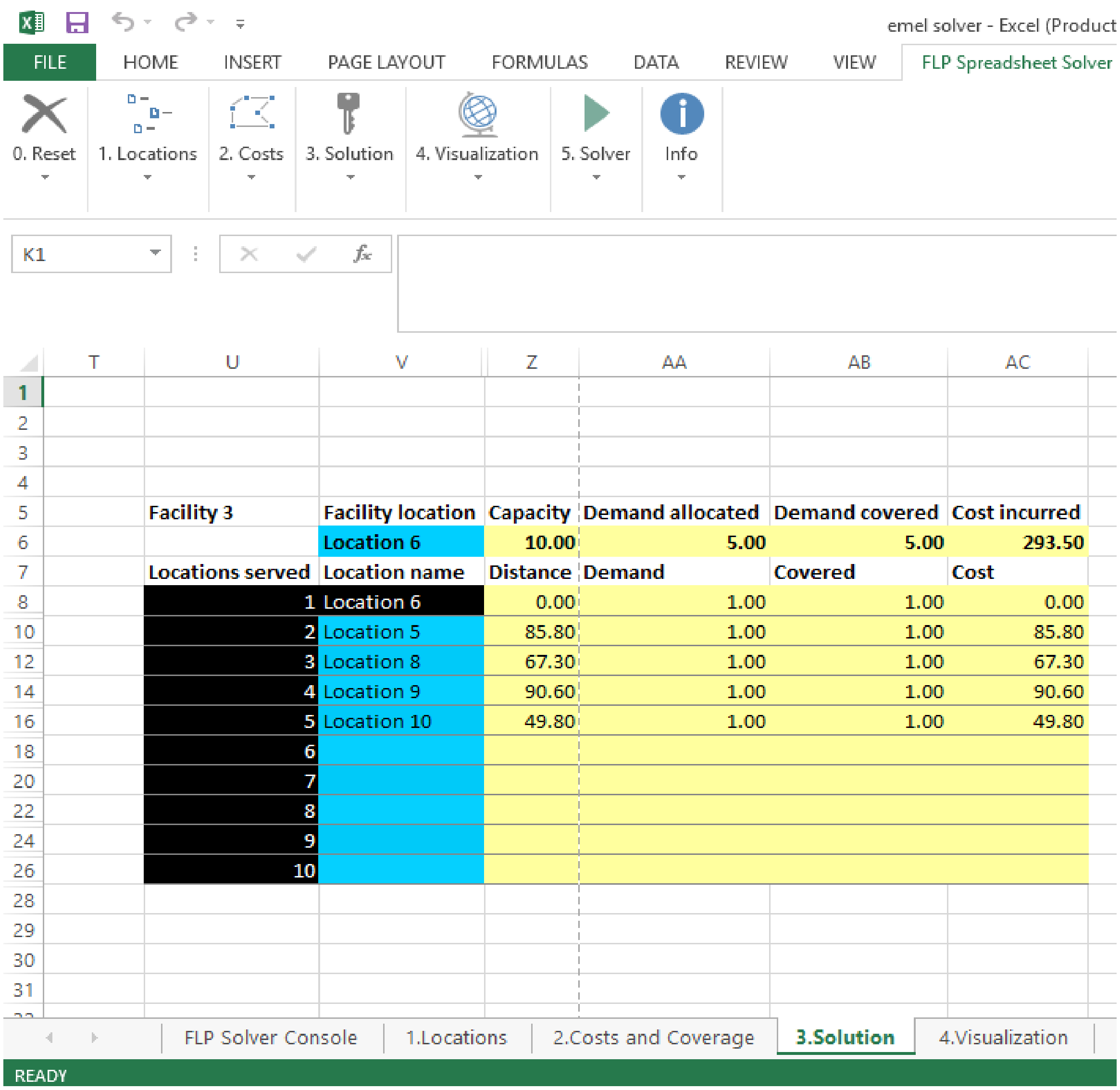


Figure 7.1.5 .: *The solution for the second location*



	Facility 3	Facility location	Capacity	Demand allocated	Demand covered	Cost incurred
		Location 6	10.00	5.00	5.00	293.50
	Locations served	Location name	Distance	Demand	Covered	Cost
	1	Location 6	0.00	1.00	1.00	0.00
	2	Location 5	85.80	1.00	1.00	85.80
	3	Location 8	67.30	1.00	1.00	67.30
	4	Location 9	90.60	1.00	1.00	90.60
	5	Location 10	49.80	1.00	1.00	49.80
	6					
	7					
	8					
	9					
	10					

Figure 7.1.6 .: *The third location solution*

Figures 7.1.4., 7.1.5 and 7.1.6 show that under the field Facility Location the appropriate selected location is displayed, which will be the seat for the storage center that should serve the neighboring locations. When the function of the goal is to minimize the total cost of supply at 10 locations with 3 locations with storage centers, we get the results shown in the images above. That is, the warehouse from Location 1 will serve locations 1 and 2, the warehouse in Location 3 will meet the needs of Location 3, Location 4 and Location 7, if the last Location 6 will meet 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 the total costs being minimal.

If we want to visualize the results, the Visualization command is used, we will get the visual display as shown in Figure 7.1.7.

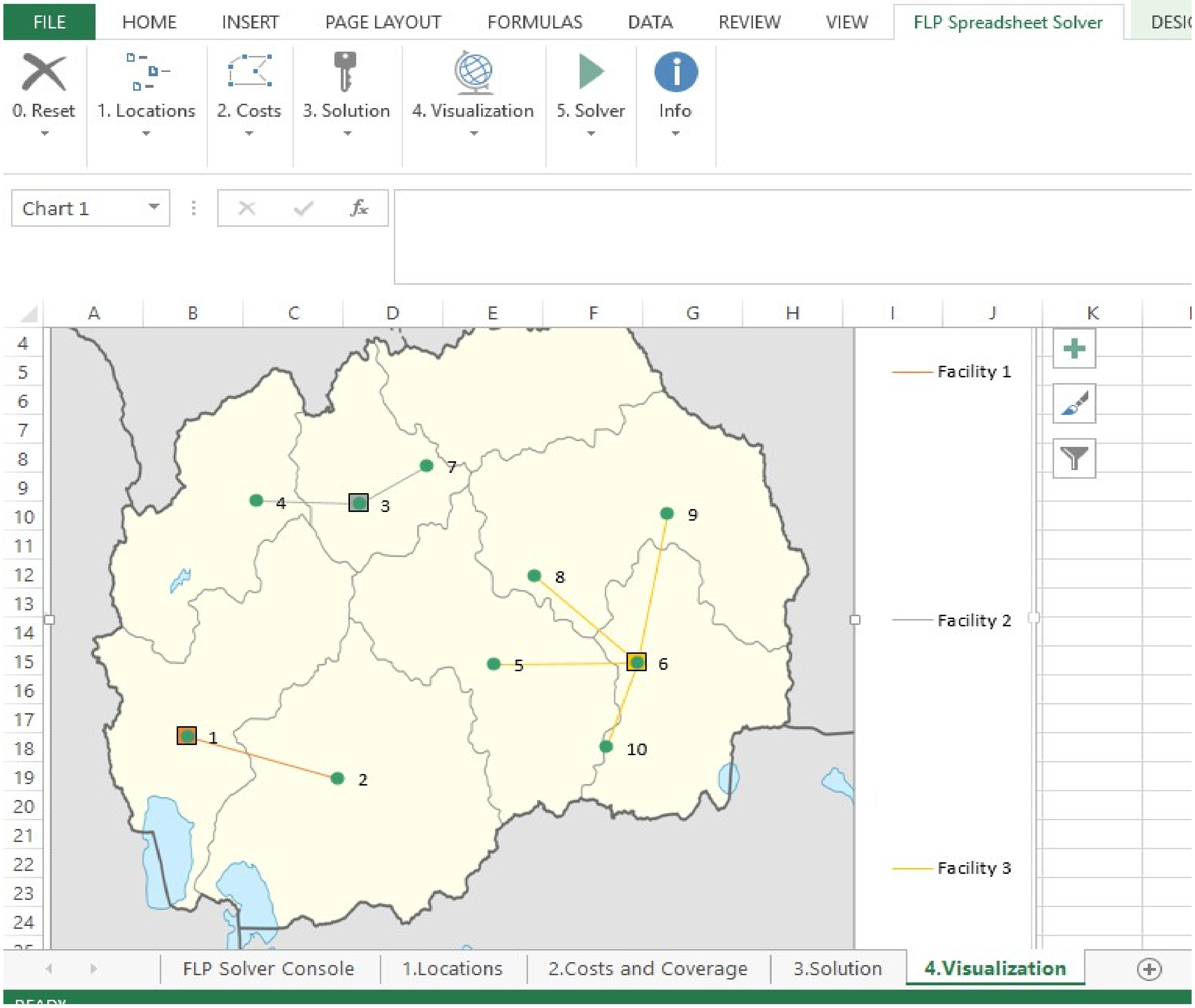


Figure 7.1.7 .: *Visual display of the results*

8. STRATEGY FOR HUMANITARIAN LOGISTICS AND RECOMMENDATIONS FOR FUTURE DEVELOPMENT OF THE MODEL

The eighth chapter deals with the strategy for humanitarian logistics and recommendations for improving the model, while giving future recommendations for improving the model. Strategic planning involves defining a mission, setting goals, formulating a strategy and making a plan or multiple plans of strategic importance. Protection and rescue planning is planned for the development of protection and rescue, operational and current planning in the short to medium and long term according to the principles, norms and procedures of the system of planning, programming and budgeting.

In future research, the problems with the location of objects can be applied to many techniques, such as decision making and simulation. Then, the optimization models could also be used for dynamic or robust modeling of locations in humanistic logistics, which would enable the inclusion of uncertain time periods, uncertain environment, risk for the location of objects, disturbances, different patterns of fluctuation and expansion of objects.

The relationship between the types of locations for objects and the stages of disasters is shown in Figure 8.1.1. Disasters can be divided into pre-disaster (for mitigation and preparation) and post-disaster (reaction and recovery). In the mitigation phase, future research could try to address the dangers by moving residents away from the risk area (arc (1)). Because security planning is a long-term plan, dynamic and robust models can be adapted to mathematical models. In the preparation phase, the research could examine optimal planning and preparation of sites for facilities such as warehouses, shelters, permanent distribution centers and permanent medical centers, in order to increase the chances of survival and minimize financial and other losses.

Stochastic, dynamic and robust object planning models can be used to respond to real situations. For example, because distribution warehouses should be located near the sites of disasters, but still be in a safe area, because they are the places of receipt for goods and donations (domestic and international), for suppliers and NGOs, research can focus on when to transport the goods. Ye et al. [49] Both Paul and Hariharan [76] developed a deterministic and robust model for warehouses in emergency humanitarian logistics, but did not include a stochastic or dynamic model (arc (2)). For the response phase, emergency decision makers will have to play a major role at this stage in the management of available resources, while the disaster is still ongoing. This phase is called the "ongoing disaster" phase. At that time, emergency decision makers are involved, but they only make decisions when unexpected events occur or when emergencies occur. At this stage, the most important factors are the shelters and health centers that can respond to the demand and ensure that the wounded are transferred to medical centers. When permanent medical centers are located in risk areas, the medical center should be able to evacuate patients to shelters as soon as possible. Therefore, permanent medical centers should be located in safe areas, so further research could examine where to locate or dislocate permanent medical centers. Immediately after the disaster, temporary shelters should be identified quickly, so emergency decision makers should be able to identify the appropriate evacuation shelters as soon as possible (arc (3)). Finally, in the recovery phase, the research could examine the optimal locations for temporary distribution centers to ensure good distribution of goods, as well as to determine the optimal placement of temporary medical centers to ensure rapid handling of the injured. Dynamic centers for temporary distribution and medical centers have been proposed, but none of them included the robust model. In addition, problems with a sudden object are not widely used in disaster research, so while examining the optimal locations of objects as close as possible to disaster areas, thinking about objects away from potential epidemic zones such as control centers of disease and prevention (an epidemic can occur after a disaster) and landfills to remove debris have not been fully studied (arc (4)). The relations at this stage should be further examined because the warehouses send goods (food, medicine, clothing, etc.) to the shelters and medical centers (medicines, medical equipment). Also, when an epidemic occurs, both permanent and temporary medical centers send patients with disease or infection to disease control and prevention centers.

Although the model is flexible and can be made to fit a variety of contexts, there are still a few elements that can be developed further. Currently, the model is designed for streams that pass through three levels. For flows passing through multiple levels more than the supply chain, the model needs to be developed to fit that configuration. It would be quite easy to program-wise, but the bigger the problem, the more computing power is needed to support the calculations. Furthermore, there are several events that can be done at cost. Costs could be divided in order to make a clearer structure of the various cost drivers. However, this will make the model less useful. Another development would be to quantify the various qualitative factors in the model. This would mean that instead of having a setting where the model does not address a particular location, because the model is currently constructed, it can be penalized with increased costs. The model would thus be more flexible. Another aspect is the mode of transport - in the current model there is no difference in the modes of transport used.

One interesting addition that can be made in relation to costs is if the organization that uses the model has a specific budget that is allowed to be used. The model can then be applied to find the best network with the upper limit for total costs. Another possible type of development is the connection of this model with other complementary models. The gravity model can be used in parallel with this model to obtain a wider simulation. Incorporating demand-driven models would mean that incoming data demand could be more sophisticated. Models that update the actual shipping costs between network locations could also refine input data.

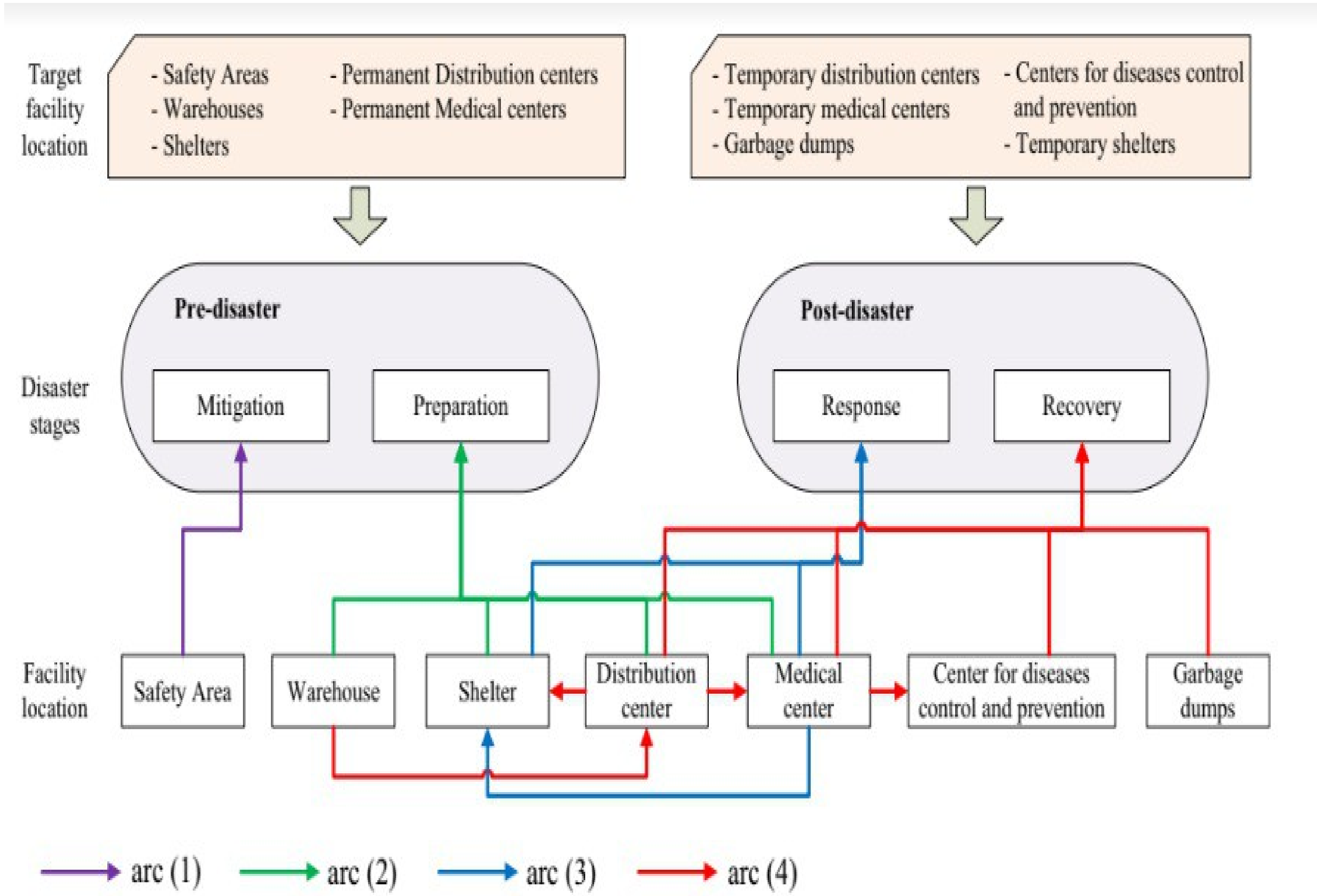


Figure 8.1.: *Relationship model between disaster stages and facility location types (C.Boonmee et al. - International journal of Disaster Risk Reduction 24 (2017) 485-498)*

Problems with the location of facilities can be supported or developed to combine aspects such as routing problems, evacuation problems, problems with the distribution of goods for assistance, problems with transporting the injured, problems with stocks, problems with resource allocation. , problems with problem control, waste management problems and community problems as explained in Zheng et al. In some situations two accidents may occur, such as an earthquake followed by a tsunami. Therefore, more research is needed to look at multi-disaster scenarios. In addition, integrated disaster management is also important in the decision-making process in matters of location for emergency humanitarian logistics. Normally, researchers always focus on each stage, and only a few research studies have focused on crisis management in crisis management. As a result, integrated disaster management is recognized as a major gap to be filled in the future.

The target function model can also be radically designed to create a single or multi-target model that can be single-level or two-level. Most of the targets are focused on minimum time, minimum price, minimum distance, minimum number of located objects and coverage with maximum number of demand points. New target functions could be developed by integrating the object localization problem with the other problems mentioned above. Furthermore, new goals could be developed focusing on environmental impact, safety, risk and ease of access. Restrictions can also be added, such as estimating behavior during evacuation (demand), population age (old and juvenile). For a more realistic approach, researchers need to determine what the uncertainties are, such as demand, supply and time. In addition, quantitative and qualitative measurements can be added to the parameters to provide quality measurements when considering problems with the object's location, such as availability, accessibility, functional capability, and risk. According to informed experts, this is an element that should be emphasized and further applied in the mathematical model. However, the key question is not only “How can we optimize the location of the facility in emergency humanitarian logistics problems", but also “How can we request an appropriate location of the facility in emergency humanitarian logistics problems that we can command and use?“.

Current models for optimizing emergency humanitarian logistics have some limitations due to the large amount of data, so it can be complex to calculate and finding the optimal location can take too much time and computer power. Therefore, in the development of advanced algorithms that can be applied in emergency humanitarian logistics, it is necessary to add to the current stable genetic algorithm, taboo searches, heuristic location-allocation, Lagrangian-heuristics for optimization, waste optimization based on geography, artificial immune systems, and hybrid algorithms.

CONCLUSIONS

The conclusions and answers to the research questions are presented in the last chapter. The doctoral dissertation conceived in this way is a whole for the theoretical setting and practical development of a model for choosing the location of a storage center in the humanitarian logistics framework. To achieve this, the circumstances that required the creation of this type of model were identified and practically conceived with the aim of conducting research on the problems with the location of buildings related to emergency humanitarian logistics based on data modeling types and types of data. problems and to examine the situation before and after the disaster in relation to the location of the facility, while staying at the locations of the facilities for storage of goods such as the location of distribution centers and warehouses. The focus of the model lies in identifying important factors and creating a tool that can be used even in a changing environment. In this doctoral dissertation, the steps for creating a model for selecting the location of an object - a storage center for humanitarian logistics - were shown in details.

The developed model is aimed for the CMC and its needs. Because 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 stakeholders: demand must be met; operations are often performed in unsafe environments; sales and profits do not exist; demand may rise rapidly. For humanitarian organizations that use experience-based ad-hoc methods, the model can provide a quantitative alternative to locating objects. It can enable humanitarian organizations to focus on economy and optimal capacity allocation. Because 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 needs to change. The IF-THEN analysis should be done to help strategic planners determine the location of facilities and the movement route of goods flows. In addition, the model addresses the lack of practice of quantitative methods. By using the model, the problems with the location of the object can receive more attention, because it can build cases around the simulations and provide a picture of potential quantitative improvements.

Several factors have been deliberately left out to maintain a user-friendly style. Since the purpose of the thesis is derived from a question that arises in the humanitarian community, it is recommended that the model be implemented and used as a support tool. The constructed model can be used as part of the development of chains to supply humanitarian organizations with greater economy and responsibility. In order to be able to use the model correctly, users need to collect data on possible locations and their parameters for the specific location. It is vital that the data is accurate and regularly updated. It is advisable for humanitarian organizations to have a joint discussion at the strategic level regarding the qualitative factors that need to be included and how the model should be used. Preferably, a person should be assigned a special to collect the required input data. In such an internal discussion, it should also be identified which additional factors influence localization and whether the parameters involved should be changed.

Furthermore, it is recommended that organizations use the model regularly, as the environment is constantly changing. Demand size and location can easily change when new situations arise. Features of the supplier and warehouse should also be updated. It is acknowledged that the model does not provide a stand-alone solution for the complex system in which humanitarian organizations operate. There are several aspects that are not taken into account as discussed in the chapter on weaknesses. It is therefore advisable to use the model together with other experience-based tools and methods. Further investigation of potential impacts that may cause weakness is also recommended.

The aim of the thesis was "to develop a simulation-based model for generating and estimating the configurations of storage locations in the humanitarian sector." Parallel with writing the thesis and conducting the research, the model is programmed. The result is an Excel-based model that works on input-based simulations and generates optimal storage configuration. It evaluates the solution by submitting the total costs, if applicable, and all flows. The developed model fits well with the problem. Humanitarian organizations do not use a site selection model and have difficulty assessing the current structure because the alternatives are difficult to visualize. Using the model, the alternatives can be easily simulated, which can give organizations a picture of how well the system works today.

Finally, the model plays an important role in providing a central place in supply chain management. With a comprehensive look, a practical solution has been made that can improve the existing system. With the ability to clearly point out the weaknesses of the current system and possible alternatives, the area can be improved.