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Optimum Locating of Disaster Containers

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ABSTRACT: Determining the optimum locations of Disaster Containers (DC) that will help to minimize the risk of death in disasters and it is very important in disaster management. In that reason, it is targeted to survive the greatest number of disasters in possible disasters. For this purpose, it is very important to determine the locations of a certain number of disaster containers in advance during the preparation phase.In this study, it was aimed to determine the optimum locations of six Disaster Containers with coverage of 3 km for 56 settlements located in the central district of Düzce province. The study was modeled on the basis of P-median, Uncapacitied fixed charged and maximum coverage facility location models. The generated model is analyzed by Lagrange and Genetic Algorithm optimization methods.In the analysis of the study, the Sitation facility location software was used. As a result, the optimumlocation of disaster containers; Çamköy, Esentepe, Koçyazı, Burhaniye, Aziziye and Azmimilli settlements. The results of the work were shared with the disaster coordination authorities.

Keywords:*Facility Location Problems, Optimization Methods, Disaster Containers*

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I. INTRODUCTION

Today, production/service facilities are available in the most appropriate conditions, optimumlocation problems include widely studied topics in operations research field. These topics are; emergency service systems, security centers and fire intervention centers, hospitals, sports centers, recycling facilities, nuclear power plants(Darende, 2009: 1). Another area of application of the facility location problems is the location of the disaster containers planned to be installed in order to minimize the casualties and injuries that the people of the region can be exposed immediately after the disasters.

Disaster Containers are things that increase the likelihood of survival in disasters when we are prepared and ready to use. The locations of these constructions should be determined in a most convenient way at the moment of disasterand public should know which container to take aid. Disaster containers should be located with using scientific techniques in each settlement disaster plan.

In the literature, no studies have been done to optimize the location of disaster containers, although there have been few studies to make optimum placement of such plants using hybrid optimization methods.

In the study, a model for the optimumlocation of disaster containers was created. This model was analyzed using Lagrange from classical methods and Genetic Algorithm from modern methods.Analyzing the model with two different methods is very important in terms of validity and reliability.In addition, using P-median, Uncapacitied fixed charged and Maximum coverage modelshas increased theoriginality of study.

When considering the social benefits of the study; the public will be able to know which containers they can use in disasters, and the disaster coordination center (DCC) will not be able to work from the extreme intensity. The data for this study can be updated and used for other settlements.

The study is mainly based on the comparison of the solution performance of the classical and modern optimization methods on the facility location problems. It is thought that the research on optimum location of disaster containers will contribute to the literature as a new and useful study and its reflection will provide social benefits for the people of the region.

In the second part of the study, the relevant literature was searched. In the third part, the method and methodology of the study were emphasized. In the fourth chapter, applications and findings are given. In the fifth and last chapter, the results of the study was reviewed and some suggestions for further studies have been made.

II. LITERATURE REVIEW

Unfortunately,Turkey is on destructive faults about earthquakes. The inadequacy of the earthquake and other natural disasters is evident in the 1999 Marmara earthquake and the Van earthquake that followed.It is the duty of all citizens to be prepared for possible deaths in disasters, especially in earthquakes.One of the most striking applications in this sense is the optimum location of disaster containers that contain almost all the first aid materials needed for emergency assistance. Figures 1 and Figure2 show sample disaster containers.

Figure 1. Example of *A* Disaster Container

Figure 2. Inside of A Disaster Container

The first study in the literature on the optimum location of facilities was made by Alfred Weber at the beginning of the twentieth century. Weber succeeded in locating one of the three demand points in 1909 as a service provider to the other two, creating the least logistical cost. Weber designed a model that would reduce the total length between the demand points and the facilities to be serviced while achieving this objective (Jamshidi, 2009).

Private and public businessesshould be very careful when making facility location decisions. For this reason, the optimum location of facilities is relatively long-term decision. It has become increasingly important to locate facilities in the most appropriate places in the economic life of the 21st century, in which competition between businesses is increasingly and financial decisions are very important (Correia et al., 2009).

Several classification schemes have been proposed for facility location problems. Among them, the classification used in the literature is often used Sule’s in 2001. In Sule (2001), the problems of optimum location of facilities are divided into five basic categories as mentioned below (Sule, 2001: 22);

1. P-median Problems,
2. P-center Problems,
3. Capacity Unrestricted Facility Location Problems,
4. Capacity Constrained Facility Location Problems,
5. Quadratic Assignment Problems

(Durak and Y*i*ld*i*z, 2015) used a *P*-median facility location model in order to find the optimum numbers and locations of depots of a food company. They also shared the results of the study with the company authorities.

(Arslan and Yildiz, 2015) determined the most suitable facility locations within the framework of determined criteria by using the maximum coverage model for the optimum location of causality collection centers (CCC), which are considered to be established within a certain region of the Düzce province.

(Yürük and Erdoğmuş, 2015) used the K-means clustering analysis method to determine the optimum biogas location used as an input of animal wastes in Düzce and found the most suitable biogas facility.

2.1. P-median Facility Location Model

P-median facility location problems are the optimum location model that mainly reduces the weighted cost of the p plants that serve n nodes.These models' mean cost; such as length, time, and transportation costs between the node points and the locations to be served.

Such problems, which are the main goal of reducing total cost, are also called "problem of minimizing total expenditure" or "Weber problem" (Daskin, 1995: 54–56).

Considering the above mentioned feature of the p-median facility location model, the number of possible solutions of ann node and a model consisting of pdemand points to be located is given in Equation (2.1).

$$\binom{n}{p} = \frac{n!}{(n-p)!p!} \quad (2.1)$$

The formulation of the P-median facility location model developed by Rolland et al. (1996) based on the structure of the model created by ReVelle and Swain is as follows (Bastı, 2012).

Objective Function,

$Min \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \, d_{ij} \, x_{ij}$ (2.2)

Constraints:

$\sum_{j \in J} x_{ij} = 1 \quad , \quad \forall i \in I$ (2.3)

$x_{ij} - y_j \leq 0 \quad , \quad \forall i \in$ ve $\forall j \in J$(2.4)

$\sum_{j \in J} y_j = p$ (2.5)

$X_j \in \{0,1\} \forall j \in J$ (2.6)

$y_{ij} \in \{0,1\} \quad \forall i \in I \quad \forall j \in J$ (2.7)

Decision Variables:

$$x_{ij} = \begin{Bmatrix} 1 & , & If\ i\ is\ satisfied\ by\ the\ request\ j \\ 0 & , & otherwise \end{Bmatrix}$$

$$y_j = \begin{Bmatrix} 1 & , & If\ the\ facility\ j\ is\ located\ in\ the\ candidate\ location \\ 0 & , & otherwise \end{Bmatrix}$$

2.2. Genetic Algorithm Optimization Method

The Genetic Algorithm process begins with an initial group of randomly selected individuals. Every individual in this community can be thought of as small objects that help to create alternative solutions for the problem of optimization that is supposed to be analyzed. New individuals who are compatible with the environment emerge with repeated Genetic Algorithms. Whenever a new generation is assessed, control criteria are used that are more selective and compatible with the previous generation. Then the genetic process is used to generate the next generation of genealogy. Repeats connected to these genetic operators only come to an end when conditions of termination occur (Sakawa, 2002: 11).

2.3.Maximum Coverage Problem (MCP)

The facility location problem is the close proximity of the demand points to the service offered by the majority of suppliers. In this case it is possible to examine coverage problems in two parts. These are;Set Covering Problems, which is the model covering the alldemand, and Maximum Covering Problems, which aim to cover the most appropriate number of demands (Owen and Daskin, 1998).

The main purpose of the maximum coverage problems identified by ReVelle and colleagues for the first time in 1974 is to provide the maximum number of demand services considering the optimum service distance (Dc) for a fixed number of facilities.

Below is the operation of the Maximum Coverage Model (ReVelle *et al.*, 1974):

Objective Function:

$$Max \sum_{i \in I} hi\ zi$$

Constraints:

$$zi \leq \sum_{j \in N_i} x_j \ , \quad \forall i \in I \quad (2.8)$$

$$\sum_{j \in N_i} x_j \leq p, \quad j \in J \qquad (2.9)$$

$X_j \in \{0,1\}, \quad \forall j \in J \qquad (2.10)$

$Z_i \in \{0,1\}, \forall i \in I \qquad (2.11)$

Decision Variables:

$$z_i = \begin{Bmatrix} 1, & If\ i\ is\ satisfied\ with\ the\ request \\ & 0, otherwise \end{Bmatrix}$$

$$x_j = \begin{Bmatrix} 1, & If the facility\ j\ is\ located\ in\ the\ candidate\ location, \\ & 0, otherwise \end{Bmatrix}$$

III. METHODOLOGY

3.1. Research Model

In this study, it was aimed to determine the locations of optimum six disaster containers which satisfy the existing criteria within 3 km coverage of different locations on 56 settlements located in Düzce city center. In this direction, the study was modeled on the basis of P-median, Uncapacitied fixed charged and maximum coverage facility locationmodels. This model has been analyzed by Lagrange and Genetic Algorithm optimization methods.

Criteria of created model;
K1: Settlement Population
K2: Facility distance to the nearest health facility
K3: Distance to the disaster coordination center (DCC) of the facility settlement
K4: Facility Distance to main roads

Alternatives are accepted as centers of 56 settlement units located in the center of Düzce. The mathematical model of the study (3.1) is given by considering the criteria and alternatives in the model of optimumlocation of disaster containers.

$$Y = 0.5 * p + 0.15 * d_1 + 0.2 * d_2 + 0.15 * d_3 \qquad (3.1)$$

Y = Location of disaster containers
P: Settlement population
d_1: Distance of the settlements to the nearest health facility
d_2: The distance from the settlements to the disaster coordination center (DCC)
d_3: Distance of the facilities to the main roads

In the above model, coefficients such as 0.5, 0.15, 0.2 are the weights of the relevant criteria. These weights were determined in the light of literature studies and interviews with the authorities.

3.2. Collection of Data

The primary and secondary data were used to obtain the data. 56 settlements located in the center of Düzce province were accepted as probable facilities. The information about facility locations was obtained from Düzce Disaster Management and Düzce Municipality. Coordinates of all settlements have been determined through the Google Maps program as secondary data. In this study, especially six disaster containers were proposed. This is because it is considered appropriate for the province of Düzce when the authorities evaluate the establishment costs of such facilities.

3.3. Analysis and Interpretation of Data

In order to optimize the location of a certain number of disaster containers in the study, the model was analyzed by considering the classical and modern approaches and the results were compared and optimum location was achieved. There are different software available to solve such facility location problems. Some of them are C, C^{++}, Matlab and *Sitation*. In this study, *Sitation* Facility Location Software program was preferred for ease of use.

IV. IMPLEMENTATION

4.1. Assumptions of Research Model

The assumptions of the model for the optimumlocation of Disaster Containers are as follows:

1. The optimum location of containers depends on the length between the facilities and the settlement population.
2. The number of disaster containers to be discovered is known.
3. There is no capacity limit in service provider containers.
4. Container construction costs are not considered.

5. Population of settlement units is taken as basis.
6. Problem structure is disjoint.
7. Possible locations of containers are known.

4.2. Constraints of the Research Model

• The model of the study is designed with plain data and there may be differences in parameters or variables in order to be applied to general or other settlement areas.

•Distance between disaster containers and settlement units is calculated by "Euclidean distance formula".

• In the study period, the population of each settlement is considered fixed.

4.3. Locating of Disaster Containers with Modern and Classical Optimization Methods

4.3.1. Locating of Disaster Containers with P-median Facility Location Model (Lagrange Method)

When the optimumlocation model of DüzceDisaster Containers is analyzed within the 3 km coverage by the Lagrange optimization method within the framework of the P-median facility location model, the following results are achieved (Figure 3).

Figure 3. P-median, Lagrange Method (Dc = 3 km)Location of Disaster Containers

Extended Location Summary

#	==>	Node #	X-Loc	Y-Loc	Coverage	Name
1	==>	9	31.08	40.50	65.479	Aziziye
2	==>	10	31.09	40.50	65.639	Azmimilli
3	==>	20	31.14	40.51	30.346	Esentepe
4	==>	30	31.09	40.50	67.966	Şerefiye
5	==>	45	31.10	40.50	81.639	Koçyazı
6	==>	48	31.10	40.52	73.012	Çamköy

Total Covered Demands: 84.963

Percent Covered Demands: 100.000000

4.3.2. Locating of Disaster Containers with P-median Facility Location Model (Genetic Algorithm Method) When the optimum facility location model of Düzce disaster containers is analyzed within the 3 km coverage by the Genetic Algorithm optimization method within the framework of the P-median facility location model the following results are obtained(Figure 4).

Figure 4. P-median, *Genetic Algorithm* Method (Dc = 3 km) Location of Disaster Containers

Extended Location Summary

#	==>	Node #	X-Loc	Y-Loc	Coverage	Name
1	==>	13	31.10	40.50	71.356	Burhaniye
2	==>	33	31.09	40.51	66.739	Yeni mah.
3	==>	37	31.14	40.51	35.666	Sallar
4	==>	45	31.10	40.50	81.639	Koçyazı
5	==>	48	31.10	40.52	73.012	Çamköy
6	==>	55	31.09	40.49	63.761	Darıcı

Total Covered Demands: 84.963

Percent Covered Demands: 100.000000

4.3.3. Locating of Disaster Containers by Uncapacitied fixed Charged Facility Model (Lagrange Method)

When the optimum location model of Düzce disaster containers is analyzed within a 3 km coverage by the Lagrange optimization method in the framework of the Uncapacitied fixed Charged facility location model, the following results are achieved(Figure 5).

Figure 5. Uncapacitied fixed Charged,Lagrange Method (Dc = 3 km) Location of Disaster Containers

Extended Location Summary

#	==>	Node #	X-Loc	Y-Loc	Coverage	Name
1	==>	9	31.08	40.50	65.479	Aziziye
2	==>	10	31.09	40.50	65.639	Azmimilli
3	==>	20	31.14	40.51	30.346	Esentepe
4	==>	28	31.09	40.50	67.966	Kültür
5	==>	45	31.10	40.50	81.639	Koçyazı
6	==>	48	31.10	40.52	73.012	Çamköy

Total Covered Demands: 84.963

Percent Covered Demands: 100.000000

4.3.4. Locating of Disaster Containers with Maximum Covering Facility Location Model (Lagrange Method)

When the optimum location model of Düzce disaster containers is analyzed within the coverage of 3 km by the Lagrange optimization method within the framework of the maximum coverage facility location model, the following results are obtained(Figure 6).

Figure 6. Maximum Covering,Lagrange Method (Dc = 3 km) Location of Disaster Containers

Extended Location Summary

#	==>	Node #	X-Loc	Y-Loc	Coverage	Name
1	==>	12	31.10	40.51	83.702	Beyciler
2	==>	16	31.11	40.50	72.182	Cumhuriyet
3	==>	39	31.11	40.53	55.705	Tokuşlar
4	==>	46	31.10	40.51	76.725	Sancaklar
5	==>	52	31.10	40.52	80.653	Çavuşlar
6	==>	54	31.09	40.52	69.822	Arapçiftliği

Total Covered Demands: 84.963

Percent Covered Demands: 100.000000

4.2. Findings and Comments

It is an accurate and correct decision to carry out the optimumlocation of disaster containers with the scientific methods that have shown the above mentioned analysis results. Otherwise, there is a high probability that the planning and locating made by way of consensus on this issue is faulty. The results of the analyzes made with different methods are summarized in Table 1.

Table 1. OptimumLocation Results of Disaster Containers

Covering Distance	Facility Location Model	Optimization Method	Optimum Facilities	Covering Ratio
3 km	P-median	Lagrange	1. Aziziye, 2. Azmimilli 3. Esentepe 4. Şerefiye 5. Koçyazı 6. Çamköy	100 %
3 km	P-median	Genetic Algorithm	1. Burhaniye 2. Yenimahalle 3. Sallar 4. Koçyazı 5. Çamköy 6. Darıcı	100 %
3 km	Uncapacitied Fixed Charged	Lagrange	1- Aziziye 2- Azmimilli 3- Esentepe 4- Kültür 5- Koçyazı 6- Çamköy	100 %

3 km	Maximum Covering	Lagrange	1. Beyciler 2. Cumhuriyet 3. Tokuşlar 4. Sancaklar 5. Çavuşlar 6. Arapçiftliği	%100

V. RESULTS AND RECOMMENDATIONS

First aid services that are involved in disaster planning for survival and less casualties after the catastrophic destruction are a vital part of disaster plans. In this study, the problem of optimum location of six disaster containers planned to be constructedfor 56 settlements of Düzce province center in case of a disaster.In this study optimum location model analyzed separately by P-median, Uncapacitied fixed charged and maximum covering facility location models. When analyzed by Lagrange from classical optimization methods and Genetic Algorithm from modern optimization methods, the following results are obtained.

1. As the distance between candidate disaster container and settlement units increases, which covered population has increased.
2. For optimum location of disaster container of 3 km and below coverage, the model gives different results when analyzed separately with classical and modern optimization methods.

However, when the coverage maps are examined, in the light of the authorities and related studies, Düzce has the optimum locating plan covering the whole of the central population. These located settlements are Çamköy, Esentepe, Koçyazı, Burhaniye, Aziziye and Azmimilli. Variables such as construction costs and personal constraints can be added to the model of optimum location of disaster containers.

In addition, the generated model can be analyzed by multi-criteria decision making techniques, which are other optimization methods. Even fuzzy logic and artificial neural network methods can be used in current approaches.

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