Journal of Optimization and Supply Chain Management

JOSCM

2024, Volume 1, Issue 2, pp. 110-119
ISSN-Print: 3079-1022
ISSN-Online: 3079-1030
https://joscm.refconf.com

A Mathematical Model Using AHP-Based Parameters for Solving Location-Allocation Problem

Begüm Yanıkoğlu [a*] and Damla Kizilay [a]

[a] *Industrial Engineering Department, Izmir Democracy University, Izmir, Turkey*

Abstract

This study includes the strategic placement of emergency supply centers that serve as temporary warehouses within a region, ensuring quick access to affected individuals in disaster scenarios. In this context, the aim is to decide which warehouses will be opened and assigned to the disaster area(s) in case of an emergency, by minimizing the weighted distance. The Analytical Hierarchy Process (AHP) is utilized to determine the weights of possible warehouses considering various features, such as cost, capacity, ease of transportation, and more. Subsequently, a mixed-integer linear mathematical model was developed, focusing on minimizing weighted distances while solving the location allocation problem. Various scenarios were investigated to identify potential disaster area locations and the number of warehouses to be opened. The study differs from other studies in the literature by determining the weights of the criteria used in facility location selection using survey results and applying multi-criteria decision-making (MCDM) methodology. The results of MCDM provide weights of potential warehouses and are used as input to the mathematical model, which aims to minimize the weighted distance. The developed mixed integer linear programming (MILP) model was solved optimally, and the results obtained for all scenarios were analyzed to ensure that the warehouse location and assignment decisions were made quickly and efficiently in emergencies. Geographical and logistic scenario analyses based on Izmir province go beyond theoretical results and turn out to be practical and useful applications.

Keywords: AHP; Humanitarian Logistics; Location-Allocation; Mixed Integer Linear Programming Model.

Introduction

Today, the frequency and impact of natural disasters are increasing. Therefore, the planning and management of emergency relief operations is becoming more complex. In this context, in the event of a potential disaster, it is critical to effectively allocate emergency supply centers in a given region and quickly reach those in need (Tezcan et al., 2023). For instance, in the healthcare sector, the positioning of medical warehouses is of great importance for the effective delivery of medical products during disaster situations (Nebati, 2024). At this point, it is crucial to select the correct location for these centers to be used in emergencies. Nebati (2024), focused on the selection of medical warehouse locations in their study, and unlike our study, differences were observed in the type of warehouse and the method used. The Hesitant Fuzzy SWARA method was employed as the methodology. In addition, the study was limited to the importance of location selection criteria, no location selection was made for any possible scenario, and no mathematical model was used. Ergün et al. (2020) emphasized the importance of choosing the right location for the warehouses in emergencies. According to the authors, incorrectly determining the location of warehouses means

---

*Corresponding author email address: begum_4@hotmail.com

DOI: 10.22034/ISS.2024.8212.1016

that aid cannot be sent to the disaster area or the aid sent does not reach the correct destination. In their study, the authors carried out collecting aid coming from various regions, provinces, or city centers to these warehouses after any disaster and then delivering them to the disaster points. The selection of these certain warehouses is crucial to prevent possible chaos after the disaster and clarify the aid points. Similarly, another study was conducted to provide rapid and effective assistance to victims after a disaster and aimed at positioning blood banks to serve the nearest hospital requests with minimum response time (Habibi & Panjaitan, 2022). However, the difference between our study and this study is that in our study, the weights of the alternative options were used when choosing locations. These weights were determined by the analytical hierarchical process (AHP) method applied as a result of the survey.

Facility location problems involve the selection of the most suitable location for the targeted objective under certain constraints such as ease of access to demand points and cost-effectiveness (Durak & Yıldız, 2016). Facility location problems are very important for businesses and disaster management in terms of selecting the location of the facility, warehouses, and transshipment points (Aydınoğlu et al., 2021). In this study, the selection among alternative warehouses was planned within the framework of the weighed distance minimization objective function. Since the weights of alternative warehouses were determined according to a wide variety of criteria, the AHP method, one of the multi-criteria decision-making methods (MCDM), was used at this stage. MCDM methods used in decision analysis involve the evaluation of alternative options by considering more than one criterion (Bayram & Eren, 2023; Yapıcı et al., 2020). Derse, (2022) conducted a study on warehouse location selection in disaster management and adopted two different MCDM methods such as Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) together. Another study focused on the location-allocation problem in disaster management and used different MCDM methods i.e., AHP, TOPSIS, COPRAS, and BORDA to determine emergency assembly areas (Atmaca et al., 2023). The MCDM methods were highly used in the literature including location-allocation problems (Eelagh & Abbaspour, 2024). Turan & Bulak (2023) studied the problem of location determination in emergency management, and they aimed to determine the most important factors using Criteria Importance Through Intercriteria Correlation (CRITIC) and Range of Value (ROV) methods. As a result of the study, distance to transportation was determined as the most important factor. Similarly, in our study, proximity to main roads is included as one of our criteria which also gained the highest weight values after applying the AHP method. Both studies showed that the most important factor is based on the ease of transportation. Another study that used MCDM methods for disaster warehouse location selection suggested that the criteria for selecting the ideal disaster warehouse should be carefully examined and analyzed to ensure the timely and accurate delivery of necessary supplies (Ergün et al., 2020). The warehouse selection was conducted using Multi-Attribute Utility Theory (MAUT) and SAW (Simple Additive Weighting) methods, illustrating a different methodological framework. Another study focused on the location selection of distribution centers (warehouses) for obtaining relief supplies (Guo & Matsuda, 2023). The criteria affecting the location selection were ranked using AHP, and the distribution centers were ranked and selected using the Weighted Aggregated Sum Product Assessment (WASPAS) and k-means-based evaluation.

A very similar study in literature considers the location-allocation problem to determine the location of the emergency shelters and make suitable assignments between these shelters and the residents (Kılcı et al., 2015). The emergency is experienced as a cluster coverage problem and mixed integer linear programming (MILP) model is used to model the problem. It is very similar to our study but the authors consider shelters for the residents so they try to cover a certain area considering the shelter capacities. In our study, the facility locations to be determined will ensure that emergency supply materials are stored and delivered to the residence. In another study where the cluster coverage problem was used for warehouse location selection in the event of a disaster, scenarios were created and analyzed for different distance measurements (Sarıkaya & Koç, 2024). Our study distinguishes itself from the existing literature by employing a unique objective function and a tailored combination of decision-making methods.

In our study, first, the alternative warehouses (facilities) in Izmir, which was selected as a pilot province that could serve as emergency supply centers were listed. These warehouses consist of universities, sports halls, and stadiums. Then, the AHP method was applied to rank these warehouses by considering six different criteria such as their distance to the city center, usage cost, total number of public transportation types around them, population of the district where they are located, their capacity, and their distance to main roads. The obtained ranking scores of the warehouses are used as their weights in the developed MILP model, which provides the assignment of warehouses to the disaster areas and aims to minimize total weighted distances between them. Therefore, the final motivation is to provide quick solutions in emergencies. The determined warehouses will be known by the people and organizations who want to send aid. In this way, the supplies will be prevented from being lost, stolen, or looted. Therefore, in this study, within the scope of the location allocation problem; it is planned to select the most suitable warehouse with the facility location problem and to assign the selected warehouses to the disaster areas with the allocation problem.

This study differs from similar studies in literature in several important points. First, alternative aid centers for a possible disaster situation were determined and compared using the survey method. At this stage, each alternative center was given a weight (point) using the MCDM method, and thus the most suitable centers were ranked. Then, a mathematical model was developed by considering both the weights of the determined centers and their distances to the disaster areas. The developed model was solved and optimal results were obtained quickly. Another important difference of our study is that, by obtaining the results in a very short time, aid centers were determined quickly in the event of a disaster and the time required for emergency aid to reach the disaster area on time was shortened. In addition, by selecting Izmir as a pilot city, alternative centers and disaster areas were analyzed geographically and logistically through scenarios. This, unlike the theoretical approaches in the literature, allowed for practically applicable results to be obtained.

The remaining parts of the paper are as follows. The following section includes the problem definition and mathematical model where the purpose of the problem and the developed MILP model under certain assumptions are explained. Then the Analytic Hierarchy Process section explains the steps of the AHP method, which was utilized in this study as one of the MCDM methods. The Computational Results section is divided into three parts; data generation, visual representation of a solution, and the summary of all results obtained by the MILP model. Finally, in the Conclusion section, the concluding remarks and future research are proposed.

Problem Definition and Mathematical Model

This study includes a location-allocation problem that aims to determine the optimal warehouse selection for humanitarian aid logistics in the event of a possible disaster. For this purpose, AHP is used to determine the weights of temporary warehouses considering several criteria and a mathematical model based on the P-median problem to minimize the weighted distances of the warehouses to the disaster areas where they will be assigned. Izmir province was selected as the plot area and alternative buildings in Izmir were listed. This list is composed by considering possible alternative buildings that could be used as temporary warehouse areas after the disaster. The assumptions of the problem are as follows:

- The number of warehouses to be selected is determined in advance.
- The total capacity of the warehouses to be selected is sufficient for the aid materials to be collected.
- All needs of the aid points assigned to any warehouse are met from this warehouse.
- Aid materials can be transmitted between warehouses.
- All alternative warehouses have the authority to be opened.
- Warehouses are not homogeneous; they all have different weights according to their characteristics. These weights are calculated with AHP.
- The properties of the warehouse with more weight are better.

A MILP based on the p-median facility location problem was developed. All the indices, parameters, and decision variables are given in this section. The objective function of the model and the constraints were explained after the equations.

Indices

i: Index of potential disaster areas ($i=1,2,3\ldots N$)

k: Indeks of warehouses ($k=1,2,3\ldots M$)

Parameters

N: Total number of potential disaster areas

M: Total number of temporary warehouses

P: Total number of emergency supply centers (warehouses) requested to be opened

$d_{i,k}$: Distance of potential disaster area i from temporary warehouse k.

w_k: Weight of temporary warehouse k.

Decision Variables

$$x_{i,k} = \begin{Bmatrix} 1, \text{if potential disaster area i is assigned to warehouse k} \\ 0, \text{otherwise} \end{Bmatrix}$$

$$y_k = \begin{Bmatrix} 1, \text{if the temporary warehouse k is opened} \\ 0, \text{otherwise} \end{Bmatrix}$$

Objective Function

$$\text{Min} \quad \sum_i^N \sum_k^M (1/w_k) \times d_{i,k} \times x_{i,k} \tag{1}$$

Constraints

$$\sum_{k=1}^M x_{i,k} = 1, \ \forall i = 1,2,3 \dots N \tag{2}$$

$$\sum_{i=1}^N x_{i,k} \geq y_k, \ \forall k = 1,2,3 \dots M \tag{3}$$

$$x_{i,k} \leq y_k, \ \forall i = 1,2,3 \dots N \text{ ve } \forall k = 1,2,3 \dots M \tag{4}$$

$$\sum_{k=1}^M y_k = P \tag{5}$$

$$x_{i,k}, y_k \in [0,1] \text{ and } \forall i = 1,2,3 \dots N, \forall k = 1,2,3 \dots M \tag{6}$$

The objective function (1) expresses the weighted distance minimization of warehouse locations to the possible disaster areas. In this calculation, the weights of the temporary warehouses were taken inversely and made suitable for the minimization purpose. Since the properties of the warehouses with the higher weight are better than the other, the distances in the minimization objective function are divided into these weights. Constraint (2) ensures that each potential disaster area is assigned to a single warehouse. By providing all the needs of every disaster area from a single warehouse, both complexity and chaos will be prevented and there will be no disaster area left without a supply center. Constraint (3) ensures that if any warehouse is opened, it must serve at least one disaster area. This constraint indirectly makes capacity planning. The number of warehouses that need to be opened is a number that the decision maker gives as input to the problem (P). This number is determined according to the magnitude of the disaster, the disaster areas, and the amount of needs. In other words, meeting all the needs of the disaster areas will only be possible by using all the opened warehouses. Constraint (4) indicates that a disaster area can only receive help from an open warehouse. If the warehouse is not open, it is out of service and cannot send help to any disaster area from there. Constraint (5) ensures that a specified number of warehouses are opened. Constraint (6) provides the sign restrictions of the variables.

Analytical Hierarchy Process

AHP uses a hierarchical structure leveled as criteria, sub-criteria, and alternatives under a goal determined by the decision maker. Weights of the criteria are created, and the most appropriate alternative is tried to be determined (Bayram & Eren, 2023).

A hierarchical structure is created in AHP to determine the weights of the alternative warehouses. The decision hierarchy of our problem is shown in Figure 1. This study determines six criteria for the alternative warehouses, such as capacity, cost, transportation options, distance to the city center, proximity to main roads, and district population. There may be many alternative warehouses in the problem, however, since this study is considered within the scope of Izmir province, it was conducted for 22 alternative warehouses located in Izmir. While determining these alternative warehouses, areas that can be quickly converted into warehouses and used after a disaster were considered. Therefore, universities, sports halls, and stadiums located in Izmir province were determined as emergency supply centers.

After the hierarchical structure is created, pairwise comparison matrices are created between the alternatives according to each criterion. The scores of the alternative warehouses for each criterion were obtained as a result of the survey. Within the scope of the survey, pairwise comparisons were made between the alternatives for each criterion. The geometric averages of the coefficients obtained as a result of these pairwise comparisons were taken and the score of each alternative for each criterion was calculated. Similarly, the pairwise comparison was executed for these six criteria and the weight of each criterion was determined. Due to the unit differences in the values used for different criteria, the normalization is conducted and the relative importance weights of the warehouses are calculated. Then, the matrix consistency is calculated to determine the accuracy and consistency of the values determined by the respondents of the survey. The holistic priorities of the alternatives are calculated by multiplying their values for each criterion by the weight of the criteria. Finally, the alternative warehouses are given a score and ranked according to these scores.

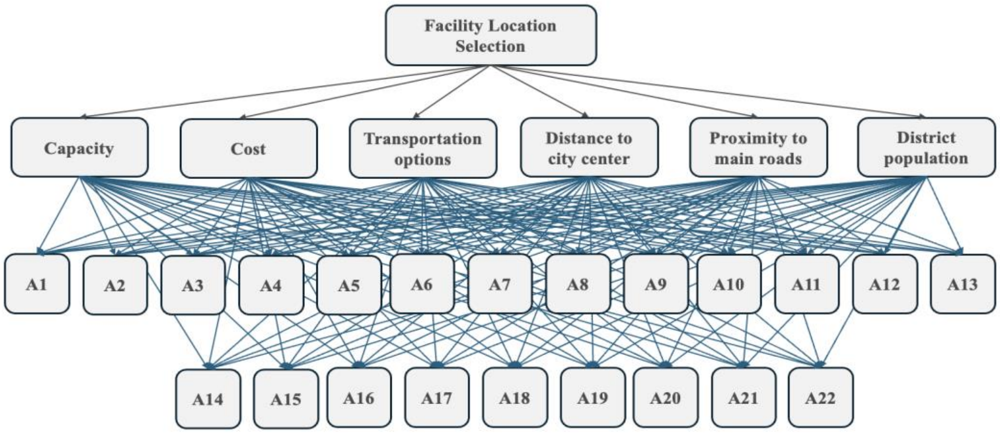

Figure 1. Decision Hierarchy of the AHP Method.

According to the figure, the capacity criterion considers the size of the warehouse. The larger the warehouse, the more aid will be stored, thus serving more than one disaster area. In addition, as the capacity expands, the classification of the aid materials brought to this warehouse will also become easier. The transportation options criterion is the number of alternative transportation options such as buses, metro, ferries, and trams close to the warehouse location. Since it is not known what type of natural disaster will occur, it is assumed that the more different types of transportation around the warehouses to be assisted, the easier it will be to access the disaster areas from the warehouse. Distance to city center criterion takes into account the distance of the warehouse location to the city center. It was determined by considering that the people and organizations that will provide aid will be located mostly in the city center. The proximity to main roads criterion was determined to understand the accessibility of each warehouse. Considering that aid/supply from different regions would come via these main roads, it was thought that it would be advantageous for the warehouse to be located close to these roads. If the population of the region where the warehouse is located is high, the number of possible aid coming to the warehouse from the people of that region will increase. Therefore, the district population criterion was also considered. In the calculation of the cost criterion, the normalized values of the other criteria were used. Because it is thought that the cost of a facility increases as its capacity increases, as it gets closer to the city center, and as the number of people living in that area increases. In addition to these criteria, additional costs are also included in the calculation if the facility is not a government institution and is affiliated with a private institution. The following calculation (7) for the cost criterion was used.

$$\text{Cost} = (2 \times \text{Capacity}) + \text{Distance to City Center} + \text{District population} + (4 \times \text{Normalized Private Institution Fee}) \qquad (7)$$

Computational Results

The MILP model developed in this study was solved using OPL CPLEX Studio IDE 22.1.1 and optimal results were obtained within seconds. The weights of the warehouses used in the objective function of the MILP model were obtained using Microsoft Excel with the AHP method.

Parameter Generation

In this study, different scenarios were considered by taking into account the pilot city Izmir. Thus, three different numbers for potential disaster areas (5, 10, 20) and three different number of warehouses planned to be opened (2, 3, 4) were considered. The potential disaster areas are divided into two groups. The first group includes scattered locations around the Izmir city center. The second group consists of clustered locations in nearby regions. All the locations are generated randomly within a 50 km radius of the city center, so between (0, 50). For the clustered potential disaster areas, the locations inside the same cluster were generated randomly within a 5 km radius (between (0, 5)) of a location, that is also generated within the borders of Izmir province. For both groups, 15 data sets were prepared by creating 5 different combinations from each scenario, composing a total of 30 data sets. The generation of potential disaster areas was done with a C++ language that generates random coordinates within the coordinate boundaries of Izmir province. Alternative warehouse locations are not generated, the actual locations of the potential warehouses in Izmir are used. The distances from the disaster areas to alternative warehouse locations were calculated by Manhattan distance. Calculations were made according to the latitude and longitude of the locations.

Results of the AHP Model

The AHP model is applied to determine the weights of the alternative warehouses based on six different criteria. There are 22 alternative warehouses in the plot area of İzmir, and their values for each criterion are collected from open-source data on the websites of the warehouses or the search engine. Then these values of the alternative warehouses were normalized since there are different units for each criterion. Also, the profit or cost criteria are checked whether the criteria are directly or inversely proportional to the objective of the problem, and a normalized matrix was formed in Table 1. When the criteria are examined, we can see that three of the criteria are profit-based: Capacity, transportation options, and district population; and the other three criteria are cost-based: Proximity to main roads, distance to city center, and cost. All criteria are calculated to be profit-based during this normalization, so reverse normalization is applied to some criteria. Also, the weights of the criteria are determined as a result of a survey and normalized.

Table 1. Normalized Decision Matrix for Each Alternative and Criterion

Criteria	**Proximity to main roads (m)**	**Capacity (m^2)**	**Distance to the city center (km)**	**Cost**	**Transportation options**	**District population**	**Weights of the Warehouses**
Weights	**0.327**	**0.194**	**0.166**	**0.123**	**0.103**	**0.086**	
W1	0.126	0.226	0.025	0.007	0.043	0.063	0.10
W2	0.045	0.367	0.021	0.005	0.021	0.073	0.10
W3	0.049	0.000	0.033	0.040	0.064	0.067	0.04
W4	0.002	0.229	0.005	0.008	0.021	0.011	0.05
W5	0.141	0.140	0.011	0.012	0.021	0.030	0.08
W6	0.008	0.012	0.008	0.066	0.021	0.029	0.02
W7	0.032	0.001	0.023	0.004	0.043	0.011	0.02
W8	0.253	0.000	0.181	0.003	0.064	0.046	0.12
W9	0.070	0.005	0.030	0.004	0.043	0.063	0.04
W10	0.012	0.007	0.027	0.004	0.021	0.073	0.02
W11	0.045	0.000	0.212	0.015	0.085	0.046	0.06
W12	0.002	0.001	0.004	0.197	0.021	0.015	0.03
W13	0.023	0.001	0.110	0.025	0.064	0.046	0.04
W14	0.027	0.001	0.049	0.041	0.085	0.046	0.04
W15	0.026	0.001	0.014	0.063	0.043	0.048	0.03
W16	0.024	0.001	0.106	0.026	0.085	0.046	0.04
W17	0.010	0.002	0.018	0.047	0.021	0.063	0.02
W18	0.014	0.001	0.029	0.038	0.021	0.073	0.02
W19	0.049	0.002	0.033	0.039	0.064	0.067	0.04
W20	0.030	0.004	0.048	0.040	0.085	0.046	0.04
W21	0.010	0.001	0.008	0.103	0.043	0.029	0.02
W22	0.001	0.002	0.003	0.213	0.021	0.012	0.03

After obtaining the normalized values for all alternative warehouses, the resulting scores are calculated by obtaining the weighted sum of all rows. Then these scores are used as the weights of the warehouses in the developed MILP model.

Visual Representation of the Solution

In order to show a visual representation of the optimal solution, a sample dataset that consists of 22 temporary warehouses and 5 potential disaster areas was chosen from all instances. The number of temporary warehouses to be opened has been accepted as 2. The problem is solved for both scattered and clustered disaster areas optimally. Figures 2 and 3 show the locations of the temporary warehouses with the scattered and clustered disaster areas, respectively. In the figures, locations indicated by crosses represent disaster areas, and locations indicated by houses represent alternative warehouses. All locations are located within the province of Izmir, and the geographical locations of all locations are depicted approximately in a way that they are consistent with each other. Opened warehouses are depicted as larger than others. The assignment between the opened warehouses and disaster areas is shown with arrows.

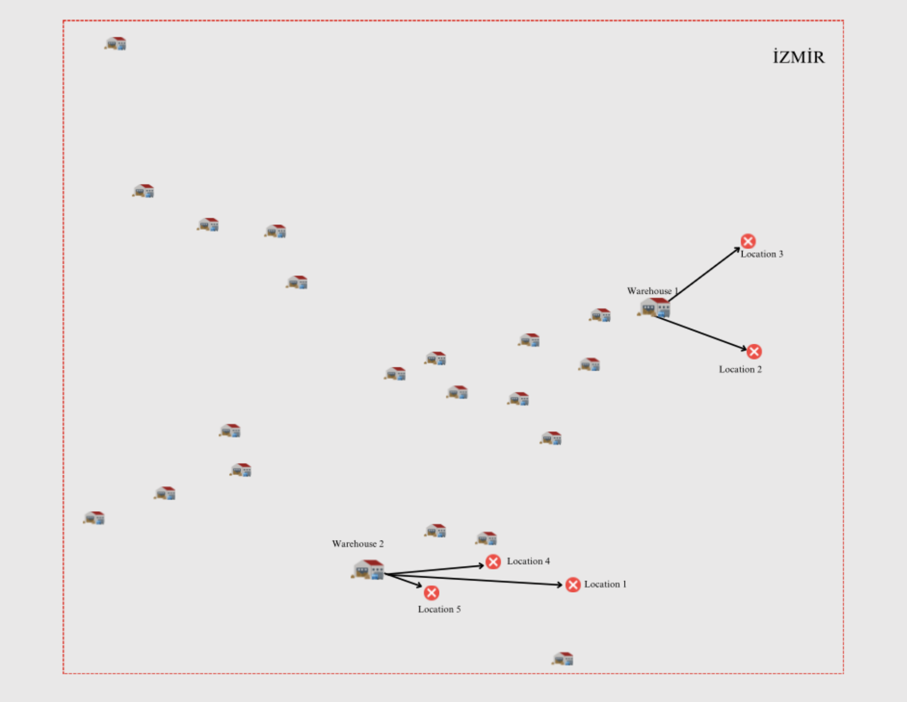

Figure 2. Visual Representation of Location-Allocation Problem for Scattered Disaster Areas

As seen in Figure 2, when there are scattered disaster areas, opened warehouses are also scattered and positioned in a way that they are close to disaster areas. At this point, the effect of the minimize distance objective function is seen. However, although there are closer warehouses to disaster areas 1 and 4, the warehouse that is farther away is selected. At this point, the effect of the warehouse weights obtained from AHP is seen.

In Figure 3, which is an example with clustered disaster areas, the warehouses closest to these clusters were opened and the problem tended to assign all disaster areas to the same warehouse. Since each opened warehouse must be assigned to at least one disaster area, an assignment was made for warehouse number 1 as well. These examples prove that the problem works correctly and logically.

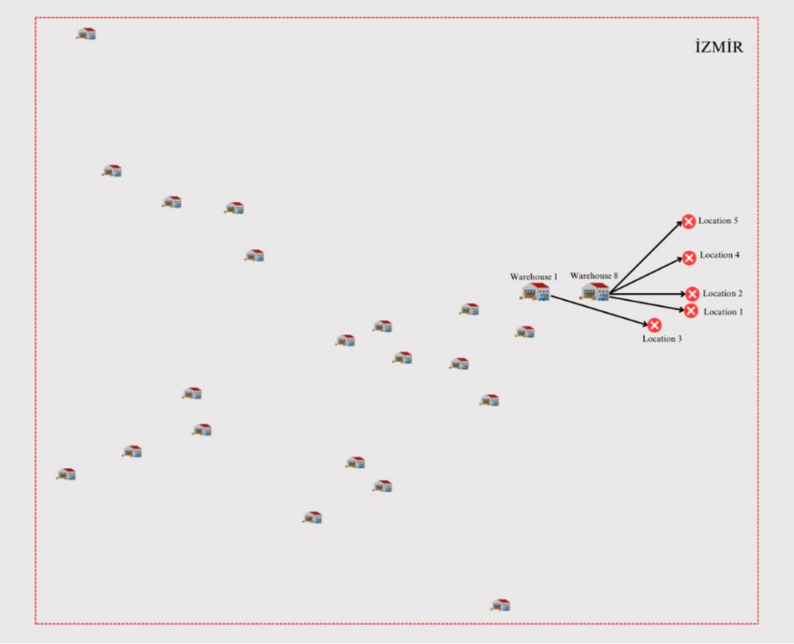

Figure 3. Visual Representation of Location-Allocation Problem for Clustered Disaster Areas.

Results of the MILP Model

The results were obtained for six different combinations each having five instances, so a total of 30 datasets. Table 5 summarizes the results for each combination (Number of Disaster Areas, Number of Warehouses to be Opened, Customer Distribution Types) including the obtained objective function value and the CPU time in seconds. All the results are obtained less than one-hundredth of a second of CPU time.

As can be seen from Table 5, all optimal results were obtained very quickly. As the number of disaster areas increases, it was decided that the number of warehouses that should be opened should be higher. As these numbers increase, the objective function value also increases. This increase is expected since more distance affects the objective function. The increase in the number of disaster areas did not cause a significant change in the CPU time. With preliminary research for the post-disaster period, possible warehouse areas were determined for Izmir province and weighted with the AHP method. After this time, a solution can be obtained very quickly after a disaster that will occur in Izmir province at any time and which facilities should be converted into warehouses can be determined.

Table 2. The Results of the MILP Model for all Datasets

Data	**Number of potential disaster areas**	**Number of warehouses to be opened**	**Scattered or Clustered Customers**	**Objective Function**	**CPU (s.)**
1	5	2	Clustered	6.184	0.017
2	5	2	Clustered	25.629	0.005
3	5	2	Clustered	26.894	0.005
4	5	2	Clustered	20.038	0.004
5	5	2	Clustered	18.669	0.007
6	10	3	Clustered	12.654	0.005
7	10	3	Clustered	55.747	0.005
8	10	3	Clustered	54.632	0.005
9	10	3	Clustered	40.899	0.005

Table 2. The Results of the MILP Model for all Datasets (*Continued*)

Data	**Number of potential disaster areas**	**Number of warehouses to be opened**	**Scattered or Clustered Customers**	**Objective Function**	**CPU (s.)**
10	10	3	Clustered	35.999	0.005
11	20	4	Clustered	27.272	0.008
12	20	4	Clustered	114.122	0.009
13	20	4	Clustered	110.500	0.009
14	20	4	Clustered	82.727	0.008
15	20	4	Clustered	71.251	0.009
16	5	2	Scattered	12.160	0.003
17	5	2	Scattered	15.446	0.004
18	5	2	Scattered	8.122	0.004
19	5	2	Scattered	14.258	0.004
20	5	2	Scattered	8.499	0.005
21	10	3	Scattered	17.922	0.005
22	10	3	Scattered	27.764	0.005
23	10	3	Scattered	24.493	0.005
24	10	3	Scattered	29.999	0.005
25	10	3	Scattered	25.523	0.005
26	20	4	Scattered	42.953	0.008
27	20	4	Scattered	47.440	0.008
28	20	4	Scattered	48.411	0.008
29	20	4	Scattered	49.011	0.008
30	20	4	Scattered	54.427	0.008

Conclusion

In this study, it was decided which of the possible facilities would be selected as temporary warehouses after any disaster and which disaster areas these selected warehouses would serve. This study was conducted to prevent chaos in the city after any disaster, to ensure that aid reaches its destination, and to determine where the people and organizations should send their aid.

Within the scope of the study, weights were determined for the possible warehouses with the AHP method, considering many features such as capacity, cost, proximity to main roads, etc. Later, with the help of the developed MILP model, it was decided which warehouses would be opened and which disaster areas they would be assigned to, in line with the weighted distance minimization objective function.

Izmir was selected as a pilot province for the study and the possible warehouse locations here were used with their real coordinates and features. A total of 30 data sets with different combinations of disaster area number/location and the number of warehouses to be opened were produced. Optimal results were obtained within seconds for all data sets. Thus, Izmir became able to easily and quickly select aid warehouses after any disaster.

In the future, this study can be applied to other regions and provinces, thus providing widespread impact. Integrating the vehicle routing problem into this study will facilitate and accelerate the transportation of aid to disaster areas and will contribute to the community more. At this point, it can be considered to collect and distribute aid between aid warehouses and disaster areas. Moreover, investigating the integration of real-time data (e.g., weather forecasts, traffic conditions, or population movements) can enhance decision-making during emergencies by improving route planning and resource allocation. Additionally, customizing the approach for different disaster types (e.g., earthquakes, floods, or wildfires) could ensure that logistics needs specific to each scenario are addressed effectively. Incorporating sustainable and green logistics solutions, such as using low-emission vehicles or recyclable materials, could minimize environmental impacts during aid distribution. Finally, loading the aid trucks properly is another issue that can be integrated into the problem, ensuring that transportation efforts are efficient and well-organized.

References

Aydınoğlu, A., Şişman, S., Ergül, İ., & Bovkir, R. (2021). Covid-19 Salgın Döneminde İşletmeler için Ulaşım Ağı Tabanlı Uygun Yer Seçimi Tekniği: Kargo. III. In International Turkic World Congress on Science and Engineering, 757–764.

Bayram, B., & Eren, T. (2023). Çok Kriterli Karar Verme Yöntemleriyle Afet Sonrası Geçici Depo Yeri Seçimi. Acil Yardım ve Afet Bilimi Dergisi, 3(2), 22–30.

Derse, O. (2022). DEMATEL Tabanlı TOPSIS Yöntemi ve Küme Kapsama Modeli İle Afet Lojistiği İçin Depo Yeri Seçimi: Ege Bölgesi Örneği. Kahramanmaraş Sütçü İmam Üniversitesi Mühendislik Bilimleri Dergisi, 25(4), 702–713. https://doi.org/10.17780/ksujes.1159925

Durak, İ., & Yıldız, M. (2016). P- Medyan Tesis Yeri Seçim Problemi: Bir Uygulama. Uluslararası Alanya İşletme Fakültesi Dergisi, 7(2).

Eelagh, M. D., & Abbaspour, R. A. (2024). A location-allocation optimization model for post-earthquake emergency shelters using network-based multi-criteria decision-making. Decision Analytics Journal, 10, 100430. https://doi.org/https://doi.org/10.1016/j.dajour.2024.100430

Ergün, M., Korucuk, S., & Memiş, S. (2020). Sürdürülebilir Afet Lojistiğine Yönelik İdeal Afet Depo Yeri Seçimi: Giresun İli Örneği. Çanakkale Onsekiz Mart Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 6(1), 144–165. https://doi.org/10.28979/comufbed.686301

Guo, Y., & Matsuda, T. (2023). Study on the multi-criteria location decision of wide-area distribution centers in pre-disaster: Case of an earthquake in the Kanto district of Japan. Asian Transport Studies, 9, 100107. https://doi.org/https://doi.org/10.1016/j.eastsj.2023.100107

Habibi, R., & Panjaitan, A. C. (2022). A Model for Blood Bank Facility-Location Problem at Post Disaster Area. ADI Journal on Recent Innovation, 4(2), 128–137. https://doi.org/10.34306/ajri.v4i2.849

Kılcı, F., Kara, B. Y., & Bozkaya, B. (2015). Locating temporary shelter areas after an earthquake: A case for Turkey. European Journal of Operational Research, 243(1), 323–332. https://doi.org/https://doi.org/10.1016/j.ejor.2014.11.035

Nebati, E. E. (2024). Afet Yönetimi Sürecinde Medikal Depo Yer Seçimi İçin Etkili Faktörlerin Değerlendirilmesi. Akademik Yaklaşımlar Dergisi, 15(1-Deprem Özel Sayısı-), 139–149. https://doi.org/10.54688/ayd.1405883

Sarıkaya, H. A., & Koç, M. (2024). Maximal Covering Method in Determining Distribution Centers in Disaster Logistics. Endüstri Mühendisliği, 35(1), 22–60. https://dergipark.org.tr/tr/pub/endustrimuhendisligi/issue/84169/1357156

Tezcan, B., Alakaş, H. M., Özcan, E., & Eren, T. (2023). Afet Sonrası Geçici Depo Yeri Seçimi ve Çok Araçlı Araç Rotalama Uygulaması: Kırıkkale İlinde Bir Uygulama. Politeknik Dergisi, 26(1), 13–27. https://doi.org/10.2339/politeknik.906704

Turan, H., & Bulak, M. E. (2023). An Application of CRITIC and ROV Methods in Choosing Location for Disaster Logistics. Meriç Uluslararası Sosyal ve Stratejik Araştırmalar Dergisi, 7(Özel Sayı), 78–93.

Yapıcı, S., Yumuşak, R., & Eren, T. (2020). Çok Kriterli Karar Verme Yöntemleri ile Medikal Depo Yeri Seçimi. Trakya Üniversitesi İktisadi ve İdari Bilimler Fakültesi E-Dergi, 9(2), 203–221.

Atmaca, E., Aktaş, E., & Öztürk, H. N. (2023). Evaluated Post-Disaster and Emergency Assembly Areas Using Multi-Criteria Decision-Making Techniques: A Case Study of Turkey. Sustainability, 15(10), 8350. https://doi.org/10.3390/su15108350