Computer and Decision Making

An International Journal

www.comdem.org
eISSN: 3008-1416

An Integrated Approach for Ammunition Depot Location Selection and Ammunition Distribution Network Design Based on P-Median and Vehicle Routing Problems

Aygün ALTUNDAŞ[1,*]
[1] *Department of Industrial and Systems Engineering, Turkish Military Academy, National Defence University, Ankara, Turkey*

ARTICLE INFO

Article history:
Received 22 August 2024
Received in revised form 13 September 2024
Accepted 21 September 2024
Available online 21 September 2024

Keywords:
P-median problem, Capacity-constrained vehicle routing problem, Ammunition depot location selection, Ammunition distribution network design

ABSTRACT

During the war, the safe provision of the required ammunition at the desired place and time can affect the fate of the war and even the country. Determining the number and locations of ammunition depots needed in the war is as important as planning their distribution. Ammunition supply has always been a force multiplier for military units. Although the timely delivery of ammunition to the unit is not sufficient for success on its own, it is an important factor. These two issues are directly related to each other. This study presents a two-stage methodology to solve the problems in question. In the first stage, it was decided which of the 3 different types of depots, whose establishment locations were known with the p-median model, would be opened, and the unit-depot assignments were determined. In the second stage, the distribution network design for the distribution of ammunition from the ammunition depot to the deployed artillery units was realized with the Capacity-Constrained Vehicle Routing Problem (CCVRP) model. This methodology was tested for a fictitious situation where the geographical location and numerical information of the depots and artillery batteries were generated generically. By solving the mathematical model in the General Algebraic Modeling System (GAMS) program, it was determined which depot should distribute how many vehicles to which artillery batteries, and the results were presented visually.

1. Introduction

During a war, the safe provision of the necessary ammunition at the desired place and time can affect the fate of the war and even the country. Determining the number and locations of ammunition depots needed in a war is as important as planning their distribution. These two issues are directly related. Countries calculate these requirements and complete their preparations before the war by benefiting from their past war experiences and the experiences of other countries [1]. Combat units can use various transportation lines and vehicles to reach the materials they need in the operational environment. In this process, the distribution of the materials needed from factories,

* *Corresponding author.*
E-mail address: aaltundas@kho.msu.edu.tr

https://doi.org/10.59543/comdem.v1i.10539

main depots and secondary depots can be done by land, air and sea. One of the most consumed and most needed materials in the combat environment is ammunition.

The selection of the number and location of ammunition depots is an important problem affecting the ammunition distribution plan [2]. The success of ammunition distribution directly affects the success of the battle. A unit that runs out of ammunition is doomed to surrender in a battle environment. Artillery ammunition is also an indispensable part of the battlefield as a fire support element in war [3]. Its ability to fire at the enemy from a distance makes it an indispensable element of war. The safe transportation of materials with weight and carrying limitations, such as artillery ammunition, requires detailed planning. Therefore, ammunition distribution network design and planning is an important area of research in military logistics [4].

In order to solve these problems, a two-stage methodology is presented in the study. In the first stage, it was decided which of the 3 different types of depots, whose establishment locations were known with the p-median model, would be opened and the unit depot assignments were determined. In the second stage, the distribution network design for the distribution of ammunition from the ammunition depot to the deployed artillery units was carried out.

Ammunition supply has always been a force multiplier for military units. Although the timely delivery of ammunition to the unit is not sufficient for success on its own, it is an important force multiplier. Artillery units are positioned along a certain line so that they can support the operational area with their fire. Failure to deliver ammunition to these units, which are dispersed over a wide area, creates a high cost and a vital risk, such as losing the war. For this reason, proper planning and more effective use of resources are of great importance in terms of winning the war [5]. Considering this entire process, it should not be overlooked that a distribution plan should be designed that is appropriate to the physical capacities of the vehicle to be transported.

This distribution network design was created with the CCVRP model. With this model in the literature, it was aimed to determine the shortest path to distribute the required amount of ammunition from the depots determined in the p-median model to the artillery batteries and to find the number of vehicles that should be in the depots. This methodology was tested for an imaginary situation where the geographical location and numerical information of the depots and artillery batteries were generated generically. The results were obtained by coding with the GAMS. By solving the mathematical model in the GAMS program, it was determined how many vehicles should be distributed to which depot and which artillery batteries, and the results were presented visually.

As a result, a comprehensive analysis is presented that integrates the depot location selection on the planning and management of ammunition distribution during combat. In the following sections of the study, information is given on p-median problems, vehicle routing problems are examined, literature review is presented and the application and results are reported and discussed.

2. P-Median Problems

Facility location problems deal with the placement of a certain number of facilities in some of the potential locations determined to meet customer demand in a way that minimizes or maximizes the objective function and assigns customers to the facilities [6-7]. Determination of facility location points requires a comprehensive and long process as it is affected by many decisions such as operational and logistics [8]. P-Median problems are also one of the subtypes of facility location problems.

The P-median problem was developed by Hakimi in 1964. [9]. The goal is to locate the “p” facilities that minimize the total weighted distance between demand points and facilities [10]. In the problem, demand points are usually assigned to the nearest facility. However, in cases where there are constraints such as capacity and cost, demand points can also be assigned to more distant facilities [11]. In other words, it is concerned with the placement of p facilities that will serve n demand points on the network in a way that minimizes the weighted cost of the entire system [9]. The indices, parameters and decision variables used in the model developed to solve P-Median problems are given in Table 1.

Table 1. P-Median Problem Parameters and Decision Variables

İndices	**Explanation**
i	Customers
k	Facilities
Parameters	**Explanation**
w_i	Request of customer i
d_{ik}	Distance of customer i to facility k
p	Number of facilities to be opened
Decision Variables	**Explanation**
x_{ik}	If customer i is assigned to facility k, then 1, other 0
y_k	If facility k is opened, then 1, other 0

$$min\ z = \sum_i \sum_k w_i d_{ik} x_{ik} \tag{1}$$

$s.t.$

$$\sum_k x_{ik} = 1, \ \forall i \tag{2}$$

$$x_{ik} \le y_k, \quad \forall i, k \tag{3}$$

$$\sum_k y_k = p \quad \forall k \tag{4}$$

$$x_{ik} \in \{0,1\}, \quad \forall i, k \tag{5}$$

$$y_k \in \{0,1\}, \quad \forall k \tag{6}$$

Equation number 1 is the objective function and the total distance weighted by the demands of the units is minimized. Constraint number 2 ensures that each customer is assigned to exactly one facility. Constraint number 3 ensures that a customer is assigned to that facility if facility k is opened. Constraint number 4 ensures that a p number of facilities are opened. Constraints number 5 and 6 are constraints that indicate the type of decision variable. This model can be customized and used according to the requirements of the problem. Since there are different opening costs and different storage capacities for different types of facilities in the application, improvements have been made to the model to meet these requirements.

3. Vehicle Routing Problems

Vehicle routing problem (VRP) is the problem of determining routes that meet all the needs of demand points under given constraints and minimize transportation costs or distance/time traveled, carried out by vehicles, each departing from its own supply point and returning to a supply point [12]. VRP first took its place in the literature with the study titled "The Truck Dispatching Problem" by Dantzig and Ramser in 1959. In this study, the first mathematical programming solution model was established for gasoline distribution to gas stations. [13-14]. Vehicle routing problem is an important problem area that can be adapted to different assumptions and new problems. Therefore, there are many sub-problem types. CCVRP is one of them. [15-16].

In CCVRP, the demands of the customers are clearly known and there is also a single depot and the vehicles with the same capacity start from there. The total demand of the customers on a route does not exceed the capacity of the vehicle following that route. The aim of CCVRP is to minimize the total travel distance of the vehicles so that all the demands of the customers are met without exceeding the capacity of the vehicles. [17]. The indices, parameters and decision variables used in the model developed to solve such problems are given in Table 2.

Table 2. CCVRP Parameters and Decision Variables

İndices	**Explanation**
i,j	Nodes
k	Vehicles
Parameters	**Explanation**
w_i	Request of node i
d_{ij}	Distance of node i to node j
Q_k	Capacity of vehicle k
Decision Variables	**Explanation**
X_{ijk}	If vehicle k goes from node i to node j then 1, other 0

$$\min z = \sum_{i\in N}\sum_{j\in N}\sum_{k\in K} d_{ij}x_{ijk} \tag{7}$$

$s.t.$

$$\sum_{\substack{j\in N\\ i\neq j}}\sum_{k\in K} x_{ijk} = 1, \qquad \forall i\backslash\{Depot\}$$
(8)

$$\sum_{i\in N_c}\sum_{j\in N} w_i x_{ijk} \leq Q_k, \qquad \forall k \tag{9}$$

$$\sum_{j\in N_c} x_{0jk} = 1, \qquad \forall k \tag{10}$$

$$\sum_{i\in N_c} x_{i0k} = 1, \qquad \forall k \tag{11}$$

$$\sum_{i\in N} x_{irk} - \sum_{j\in N} x_{rjk} = 0, \qquad \forall r\backslash\{Depot\}, \forall k$$
(12)

$$\sum_{j\in N_c}\sum_{k\in K} x_{0jk} \leq K \tag{13}$$

$$\sum_{i\in N_c}\sum_{k\in K} x_{i0k} \le K \tag{14}$$

$$U_{ik} - U_{jk} + N x_{ijk} \le N - 1, \quad \forall i,j \backslash \{Depot\}, \forall k \tag{15}$$

$$x_{ijk} = 0 - 1, \quad \forall i,j,\forall k, i \neq j \tag{16}$$

$$U_{ik} \ge 0, \quad \forall i, \forall k \tag{17}$$

Equation number 7 is the objective function and minimizes the total distance traveled. Constraint number 8 ensures that each customer is visited once. Constraint number 9 prevents the amount of load carried in the vehicle from exceeding the vehicle's capacity. Constraints number 10 and 11 ensure that there is one incoming and one outgoing connection from the depot for each vehicle k. For this reason, the number of connections made to the depot is twice the number of vehicles. Constraint number 12 regulates the flow. If there is a vehicle arriving at a point, the vehicle must leave that point. Constraint number 13 ensures that a maximum of K vehicles can leave the depot. Constraint number 14 ensures that K vehicles departing from the depot return to the depot at the end of the route. Constraint number 15 prevents the formation of sub-tours. Constraints number 16 and 17 show the types of decision variables.

5. Literature Review

The primary duty of states is to ensure the security and welfare of their citizens. Ammunition depot location selection and ammunition distribution network design are some of the critical issues for states in fulfilling these duties. Researchers have used many different methods and conducted studies in different disciplines to solve these problems.

When ammunition depot site selection studies are examined, it is seen that many researchers have worked with Multi-Criteria Decision Making Methods (MCDM), Geographical Analysis System (GIS) and Mathematical Modeling (MM) approach. In some of the studies, the methods were used together and the results obtained with MCDM or GIS were used as weights in the MM. The aim of these studies is generally the best depot site selection that meets the criteria and the minimization of cost and risk.

In ammunition distribution network design studies, solutions have generally been sought with MM and heuristic algorithms (HA). The aim of most of these studies is to minimize total distribution and loading times. The studies examined in the literature review are summarized in Table 3.

Table 3. Literature Review

Year	Author	Research Topic	Method
1988	Cain [18]	Ammunition Distribution Network Design	MM
2002	Sabuncuoğlu vd. [19]	Ammunition Distribution Network Design	Simulation
2003	Bell [20]	Ammunition Depot Location Selection - Ammunition Distribution Network Design	SA
2003	Gue [21]	Ammunition Distribution Network Design	MM
2004	Clark vd. [22]	Ammunition Distribution Network Design	MM-SA
2004	Powell D.S. [23]	Ammunition Distribution Network Design	MM
2006	Lenhardt [24]	Ammunition Distribution Network Design	MM
2006	Sahin [125]	Ammunition Distribution Network Design	MM

2007	Çağrıcı H. [26]	Ammunition Depot Location Selection	SA
2010	Jinjun vd. [27]	Ammunition Depot Location Selection	MM
2011	Toyoğlu vd. [28]	Ammunition Distribution Network Design	MM
2016	Gigovic vd. [29]	Ammunition Depot Location Selection	GIS-MCDM
2018	Kabak vd. [30]	Ammunition Depot Location Selection	MM-MCDM
2018	Qi vd. [31]	Ammunition Distribution Network Design	MM
2019	Akgün vd. [32]	Ammunition Depot Location Selection - Ammunition Distribution Network Design	MCDM
2021	Shi vd. [33]	Ammunition Depot Location Selection	MM-SA
2023	Shi vd. [34]	Ammunition Depot Location Selection	MM

After the literature review, it was seen that the number of studies that solve the ammunition depot location selection and ammunition distribution network design from a holistic perspective is very limited. It is evaluated that this study will contribute to the literature with the holistic perspective provided by determining the unit-depot assignments using the p-median model while making the ammunition depot location selection and using the results here as input to the vehicle routing problem model used in the second stage.

6. Application

The selection of ammunition depot locations and the correct determination of unit-depot assignments are among the important planning that must be done in peacetime. With correctly selected depots and correctly made unit-depot assignments, the time required to meet a possible ammunition need is considerably shortened. In addition, the optimal distribution network design made according to unit-depot assignments minimizes the time required to meet this need.

In the study, firstly, a p-median model customized to the problem was used for ammunition depot location selection. By using the p-median model, a flexible solution was provided as the number of facilities to be opened could be determined by the user and the assignment of units to be supplied with ammunition from the depots to be opened to the depots was directly realized. In the application, unit-depot assignment of 28 depots and 49 artillery units of 3 different types, whose locations were determined generically, was realized. The index, parameter and decision variables in the mathematical model used are shown in Table 4.

Table 4. Parameters and Decision Variables

İndices	**Explanation**
i	Units
k	Depots
Parameters	**Explanation**
f_k	Cost of opening a depot k
Q_k	Capacity of depot k
w_i	Request of unit i
d_{ik}	Distance of unit i to depot k
p	Number of depots to be opened
c	fixed cost for unit distance
Decision Variables	**Explanation**
x_{ik}	If unit i is assigned to depot k, then 1, other 0
y_k	If depot k is opened, then 1, other 0

$$min\ z = \sum_i \sum_k w_i d_{ik} c x_{ik} + \sum_k f_k y_k \tag{18}$$

$s.t.$

$$\sum_k x_{ik} = 1, \ \forall i \tag{19}$$

$$x_{ik} \le y_k, \quad \forall i, k \tag{20}$$

$$\sum_k y_k = p \quad \forall k \tag{21}$$

$$\sum_i w_i x_{ik} \le Q_k, \ \forall k \tag{22}$$

$$x_{ik} \in \{0,1\}, \quad \forall i, k \tag{23}$$

$$y_k \in \{0,1\}, \quad \forall k \tag{24}$$

Equation number 18 is the objective function and minimizes the total cost and consists of 2 items. The first item is the fuel cost weighted by demand, and the second item is the facility opening cost. Constraints number 19, 20 and 21 ensure that each customer is assigned to 1 depot; if a depot is opened, a unit is assigned there and p number of depots are opened, respectively. Constraint number 22 prevents the demands of the units assigned to the depots from exceeding the depot capacity. Constraints number 23 and 24 are constraints that show the decision variable types.

The characteristics of the 3 different types of warehouses used in the model are shown in Table 5.

Table 5. Ammunition Depot Features

Depot Type	Cost of Opening a Depot	Net Volume (m^3)	Depot Nodes
Type 1	500000	174	11,12,14,16,20,21,22,26
Type 1	750000	459	1,5,6,7,8,9,10,15,23,27,28
Type 1	900000	686	2,3,4,13,17,18,19,24,25

The ammunition required by the artillery units is stored in 0.053 m3 chests, in 2 pieces. Since the net volume of the depot types and the volume of the ammunition chest are known, the capacity of each type of depot is found as 6566, 17320, 25886 units, respectively. These values are used as inputs for the capacity in the model. c=3 is accepted and a distance matrix is created between each depot and each unit and used in the model. The demands of the units are randomly generated from the Uniform (600,1100) distribution generically. Unit and depot points are shown in Figure 1. The points marked in red indicate candidate depot locations, and the points marked in blue indicate randomly generated unit points.

Figure 1. Depots and Units Location (Generically produced)

When the model was run with the input values detailed above, the results in Table 6 were obtained.

Table 6. First Stage Results

Number of Depots to be Opened	Total Cost
1	No solution founds.
2	17222073,30
3	15140682,00
4	13455867,50
5	13050276,70
6	12767352,80
7	12837648,05
8	12982996,70
9	13159015,60

According to the solutions reached, it was concluded that the demands of the unions could not be met by opening 1 warehouse. Different solutions were reached according to different values of the number of facilities to be opened. When the total costs of these solutions were examined, the highest cost solution was obtained when the number of facilities to be opened was 2, and this cost decreased as the number of facilities to be opened increased. However, at a certain point, the lowest cost was reached, and it was concluded that the cost increased in the number of facilities after this value. The graph showing the costs of the solutions reached is shown in Figure 2.

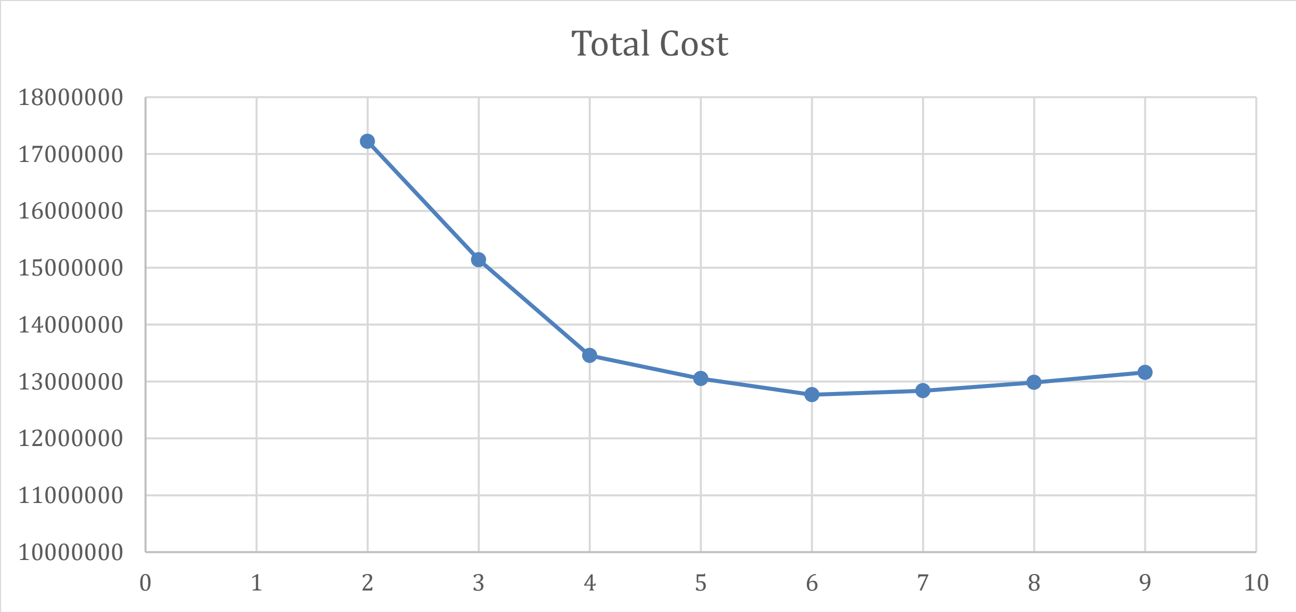

Figure 2. Vehicle Numbers and Total Cost

When the figure is examined, it is seen that the best solution with the lowest total cost is provided by opening 6 warehouses. The details of this solution are given in Table 7.

Table 7. Best Solution Results

Number of Depots to be Opened	Depots	Assigned Units	Total Cost
6	1 (Type 2)	29, 30, 31, 32	12767352,80
	5 (Type 2)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 46	
	13 (Type 3)	18, 19, 20, 21, 22, 24, 25, 27, 33, 34	
	18 (Type 3)	36, 37, 38, 41, 42, 43, 44, 45	
	21 (Type 1)	17, 23, 26, 28, 35, 39, 40	
	23 (Type 2)	47, 48, 49	

When the details of the solution are examined, the lowest cost assignments were made by opening the warehouses numbered 1, 5, 13, 18, 21 and 23. One of these warehouses is type 1, three are type 2 and two are type 3. While many more units were assigned to some warehouses, fewer units were assigned to some warehouses. It is considered that the reason for this is both the different capacities of the warehouses and the regional concentrations that occur due to the random determination of the locations of the units. The visualization of the unit-warehouse assignments is given in Figure 3. In the figure, the colors green, yellow, brown, black, turquoise and purple are used for Warehouse 1, 5, 13, 18, 21 and 23 to show the unit-warehouse assignments, respectively.

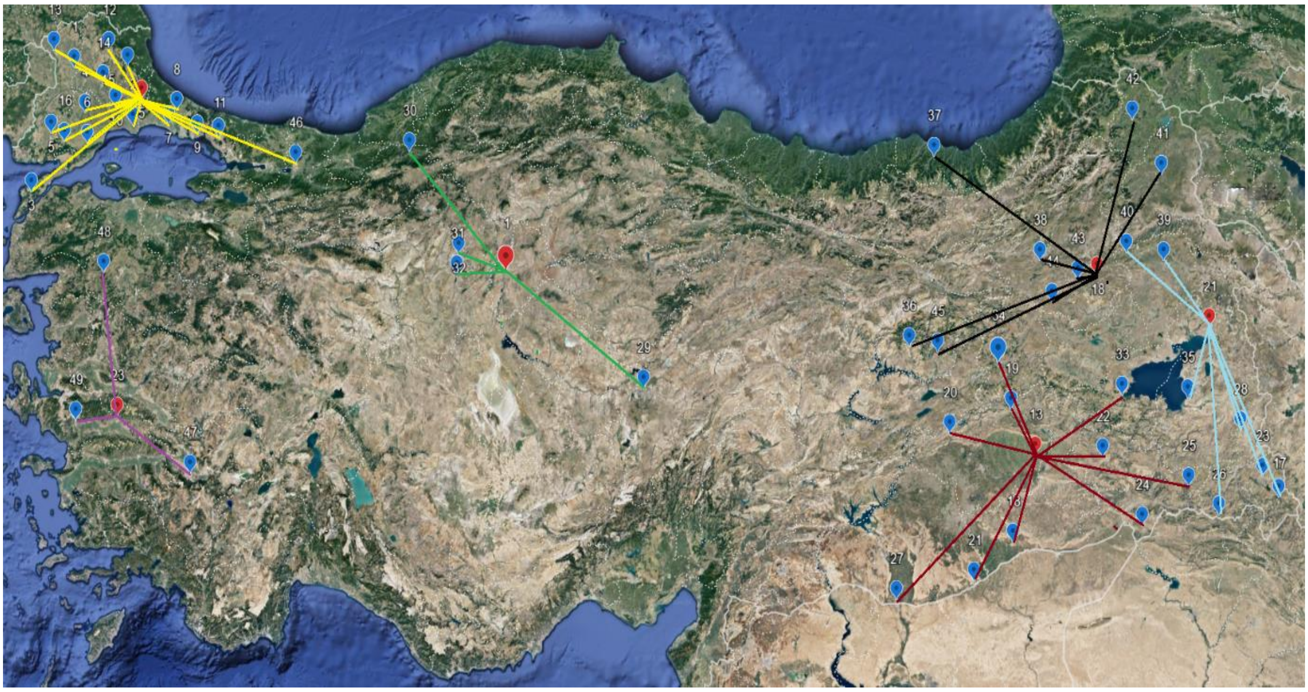

Figure 3. Depots Location and Unit-Depot Assignments

When the solution is examined visually, it is concluded that the units are assigned to warehouses that are relatively close to them and that both capacity compatibility and the lowest cost are provided among many warehouses while this assignment is being made. In this context, the methodology applied has produced appropriate solutions for the problem in the first stage.

In the first stage, the number of facilities to be opened and the unit-warehouse assignment were carried out with the p-median model. According to the optimal solution, the demands of all units are met with minimum cost with the 6 warehouses to be opened. In the second stage, the model of the capacity-constrained vehicle routing problem was used to create a minimum-cost distribution plan from these 6 warehouses to the units they serve and to find the required number of vehicles. Since the container volume of the vehicle to be transported is 33 m3, the number of ammunition that can be carried was calculated as 1700 and used as input in the model. Ammunition demands were determined as the same input values used in the previous model. With this approach, it was aimed to provide the 2 models integrated with each other.

The model in question was run separately for the 6 depots that needed to be opened. The model was tested with different vehicle numbers, the minimum number of vehicles that needed to be in each depot was found and the shortest distance ammunition distribution network was created. The results are given in Table 8.

Table 8. Second Stage Results

Depot	Number of Vehicles Required	Vehicle Route	Total Distance
Depot 1	3	1-29-1	530,55
		1-31-1	
		1-32-30-1	
Depot 5	10	5-11-5	1111,50
		5-13-5	
		5-4-10-5	
		5-16-6-5	
		5-1-14-5	
		5-46-7-5	
		5-B5-3-5	
		5-12-15-5	
		5-2-5	
		5-8-9-5	
Depot 13	7	13-34-13	849,15
		13-20-13	
		13-19-13	
		13-24-25-13	
		13-18-13	
		13-21-27-13	
		13-33-22-13	
Depot 18	4	18-44-38-18	699,75
		18-43-37-18	
		18-45-36-18	
		18-41-42-18	
Depot 21	4	21-17-26-21	970,20
		21-35-28-21	
		21-39-21	
		21-40-23-21	
Depot 23	3	23-49-23	493,20
		23-48-23	

When the distribution network design is implemented in the 6-depot solution, it is seen that the distribution can be carried out with a minimum distance with a total of 31 vehicles. When the solution is examined, the first striking point is that the ammunition distribution network created for Depot 5 requires 10 vehicles. However, considering that the number of units assigned to this depot is 17, it is evaluated that this situation is explainable. In order to check whether the solution is consistent, the routes for each depot are shown in Figure 4. In the figure, in order to better show the vehicles on the routes, the colors yellow, blue, red, black, turquoise, purple, orange, pink, brown and green are used for the vehicles in each depot, respectively.

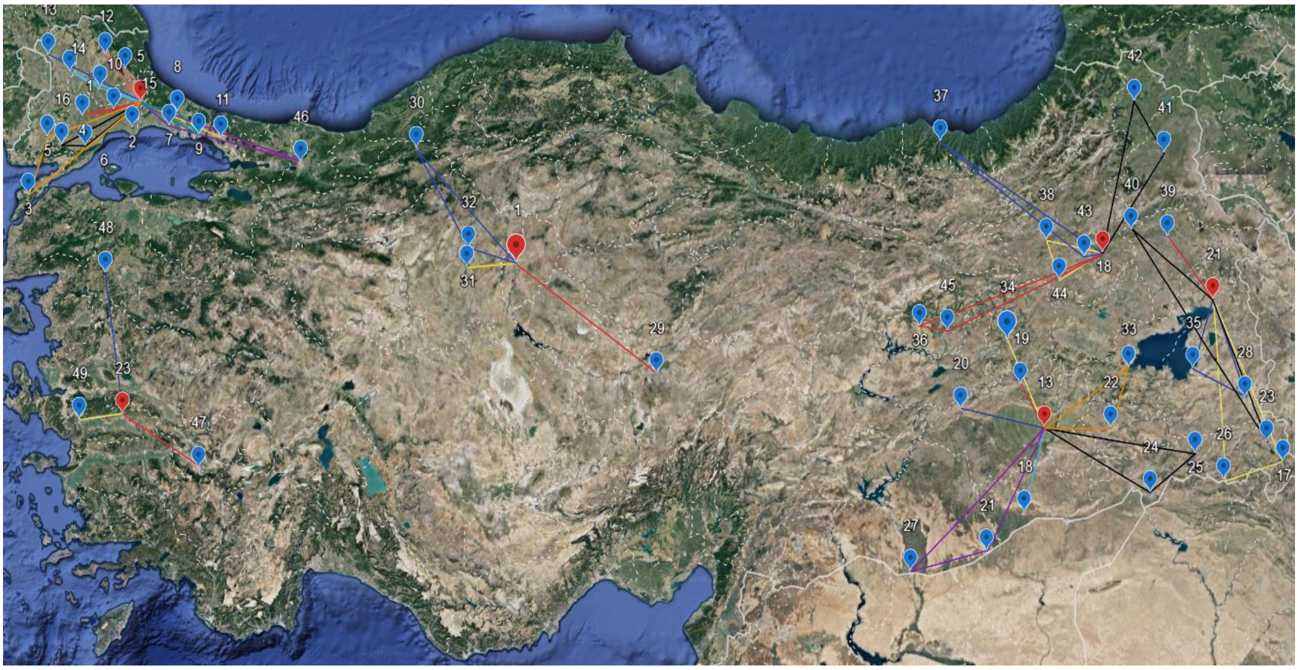

Figure 4. Ammunition Distribution Network

When the figure is examined, it is seen that the routes start and end at the depots for each vehicle, the capacity of the vehicle is not exceeded and the distribution sequences with the shortest distances to the units are created. It is evaluated that the solution reached is suitable for the relevant problem and the methodology used in the study provides results that meet the requirements of the problem.

7. Conclusion

The efficient distribution of ammunition to the right place and at the right time has been an important factor affecting the course of war throughout history. The efficient distribution of this distribution is possible in the first stage with the correct ammunition depot location selection and depot-unit assignment, and in the second stage with the correct distribution network design. States carry out comprehensive plans on these issues in order to be ready for a possible war situation.

In this study, a two-stage methodology is proposed for the selection of artillery ammunition used as a supporting element in war. In the first stage, minimum cost depot location selection and unit-depot assignments for 49 units and 28 depots, whose geographical locations are randomly determined, are solved by looking at the p-median problem perspective. As a result, minimum cost depot location selection and unit-depot assignment are realized with a 6-depot solution in accordance with the constraints of the problem. In the second stage, the solutions of the first stage are used as input and thus the aim is to solve the problem with an integrated two-stage perspective. An ammunition distribution network is created for the units assigned to each depot and the minimum number of vehicles required to meet the demands of all units is obtained. According to the results, the demands of 49 units with 31 vehicles for 6 depots are realized with a minimum distance distribution plan.

Since the solution was obtained for a randomly generated problem with 77 points, 28 depots and 49 units, the findings are limited to the results obtained in this problem. It should not be ignored that different solutions will be obtained in problems of different sizes.

In future studies, the results obtained can be compared by changing the methods used in the stages, a distribution network can be created by determining alternative warehouses where the units will be served, and a solution can be produced with heuristic algorithms at the point where the optimal solution cannot be obtained by expanding the dimensions of the problem.

Conflicts of Interest

The author declares no conflicts of interest.

Acknowledgement

This research was not funded by any grant.

References

1. Dağıstanlı, H. A., & Gencer, C. (2023). Hibrit Tehdit Perspektifinden Orman Yangınları ve Türkiye'nin Mücadele Politikası. *SAVSAD Savunma Ve Savaş Araştırmaları Dergisi*(*1*), 35-70. https://doi.org/10.54078/savsad.1377722
2. Dağıstanlı, H. A., & Kurtay, K. G. (2024). Facility location selection for ammunition depots based on GIS and pythagorean fuzzy WASPAS. *Journal of Operations Intelligence*, *2*(1), 36-49. https://doi.org/10.31181/jopi2120247
3. Dağıstanlı, H. A. (2024). Induced Generalized Intuitionistic Fuzzy OWA Operator on GRA Method for Evaluation of Self-Propelled Artillery System: Ammunition Based Computer Assisted Military Experiment . Computer and Decision Making: An International Journal, 1, 23–37. Retrieved from https://comdem.org/index.php/comdem/article/view/10081
4. Erdal, H., Kurtay, K. G., Dagistanli, H. A., & Altundas, A. (2023). Evaluation of Anti-Tank Guided Missiles: An integrated Fuzzy Entropy and Fuzzy CoCoSo multi criteria methodology using technical and simulation data. *Applied Soft Computing*, *137*, 110145. https://doi.org/10.1016/j.asoc.2023.110145
5. Kurtay, K. G., Gökmen, Y., Altundaş, A., & Dağıstanlı, H. A. (2021). SAVUNMA SANAYİİ PROJELERİNİN ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİYLE ÖNCELİKLENDİRİLMESİ VE KARŞILAŞTIRILMASI: KARMA BİR MODEL ÖNERİSİ. *SAVSAD Savunma ve Savaş Araştırmaları Dergisi*, *31*(1), 1-24.
6. Kurtay, K. G., & Erol, S. (2024). Mühimmat geri dönüşüm problemi için depo yer seçimi ve dağıtım ağı tasarımı. Gazi Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, 40(1), 29-42. https://doi.org/10.17341/gazimmfd.1345897
7. Farahani, R. Z., Steadieseifi, M. and Asgari, N. (2010). Multiple Criteria Facility Location Problems: A Survey. *Applied Mathematical Modelling, 34*(7), 1689-1709.
8. Bastı, M. (2012). P-Medyan Tesis Yeri Seçim Problemi ve Çözüm Yaklaşımları. *Online Academic Journal of Information Technology, 3*(7), 47-75.
9. Hakimi, S. L. (1964). Optimum Locations of Switching Centers and the Absolute Centers and Medians of A Graph. *Operations Research, 12*(3), 450-459.
10. Owen, S. H. and Daskin, M. S. (1998). Strategic Facility Location: A Review. *European Journal of Operational Research 111*(3), 423-447.
11. ReVelle, C. S., Eiselt, H. A. and Daskin, M. S. (2008). A Bibliography for Some Fundemental Problem Categories in Discrete Location Science. *European Journal of Operational Science, 184*(3), 817-848.
12. Desticioğlu, B., Kurtay, K. G., Altundaş, A., & Dağıstanlı, H. A. (2021). Hastanelere aşı dağıtımı için uygun rotaların belirlenmesi: Ankara ili örneği. *Politeknik Dergisi*, *26*(1), 231-241. https://doi.org/10.2339/politeknik.1014921
13. Dantzig, G.B. & Ramser, J.H. (1959). The Truck Dispatching Problem. Management Science, 6(1), 80-91.
14. Toth, P. & Vigo, D. "Branch and Bound Algorithms for the Capacitated VRP", In P. Toth, D., Vigo, (Eds.), The Vehicle Routing Problem, Philadelphia, USA, SIAM, 2002.
15. Altundaş, A., Kurtay, K. G., & Dağıstanlı, H. A. (2023). KBRN Kiti Dağıtım Ağı Tasarımı Optimizasyonu İçin Eş Zamanlı Topla Dağıt Araç Rotalama Problemi Yaklaşımı. *SAVSAD Savunma ve Savaş Araştırmaları Dergisi*, (1), 171-196. https://doi.org/10.54078/savsad.1370431
16. Dağıstanlı H.A., "Çok ürünlü çok depolu araç rotalama problemi: askeri ilaç fabrikası örneği", Politeknik Dergisi, 27(3): 1017-1027, (2024). https://doi.org/10.2339/politeknik.1224140
17. Lin, S.W., Lee, Z.J., Ying, K.C. and Lee, C.Y. (2009). Applying hybrid meta-heuristic for capacitated vehicle routing problem. *Expert Systems with Applications*, 36(2), 1505-1512.
18. Cain, M. J. (1988). *A GAMS-based model of the US army wartime ammunition distribution system for the corps level* (Doctoral dissertation, Monterey, California. Naval Postgraduate School).
19. Sabuncuoglu, I., & Utku, D. H. (2002, December). Evaluation of army corps artillery ammunition supply systems via simulation. In *Proceedings of the Winter Simulation Conference* (Vol. 1, pp. 917-920). IEEE.
20. Bell, J. E. (2003). *A simulated annealing approach for the composite facility location and resource allocation problem: A study of strategic positioning of United States Air Force munitions*. Auburn University
21. Gue, K. R. (2003). A dynamic distribution model for combat logistics. *Computers & Operations Research*, *30*(3), 367-381.
22. Clark, S. J., Barnhart, C., & Kolitz, S. E. (2004). Large-scale optimization planning methods for the distribution of United States army munitions. *Mathematical and computer modelling*, *39*(6-8), 697-714.
23. Powell, D. S. (2004). *An optimization model for sea-based logistics supply system for the Navy and Marine Corps* (Doctoral dissertation, This publication is a work of the US Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.).

24. Lenhardt, T. A. (2006). Evaluation of a USMC combat service support logistics concept. *Mathematical and computer modelling*, *44*(3-4), 368-376.
25. Sahin, S. (2006). *A routing model for ammunition transportation and its application* (Doctoral dissertation, Master Thesis, Turkish Army Military Academy, Ankara, Turkey).
26. Cagrici, H. (2007). Determining the Optimal Locations of Munitions' Warehouse of the Multiple Launch Rocket Systems with Genetic Algorithms. *Master's Thesis*.
27. Wang Jinjun, Yi Jianzheng, Duan Zhiqiang, Zhou Zhiqiang, & Wang Bo. (2010). Research on battlefield survivability countermeasures of field ammunition depot. Equipment Environmental Engineering, 07(003), 96-98
28. Toyoglu, H., Karasan, O. E., & Kara, B. Y. (2011). Distribution network design on the battlefield. *Naval Research Logistics (NRL)*, *58*(3), 188-209.
29. Gigović, L., Pamučar, D., Bajić, Z., & Milićević, M. (2016). The combination of expert judgment and GIS-MAIRCA analysis for the selection of sites for ammunition depots. *Sustainability*, *8*(4), 372.
30. Kabak, M., & Keskin, İ. (2018). Hazardous materials depots selection based on GIS and MCDM. Arabian Journal for Science and Engineering, 43, 3269-3278
31. Qi, O., Shi, W. H., Zhang, L., & Han, J. (2018). Ammunition Delivery Network Optimization Method for Destruction Road Restoring. In *2018 1st International Conference on Engineering, Communication and Computer Sciences (ICECCS 2018)*.
32. Akgün, İ., & Erdal, H. (2019). Solving an ammunition distribution network design problem using multi-objective mathematical modeling, combined AHP-TOPSIS, and GIS. Computers & Industrial Engineering, 129, 512-528.
33. Shi, X., Liu, H., Li, Y., Zhu, B., & Liang, J. (2021, October). Location planning of field ammunition depot for multi-stage supply based on dijstra algorithm. In *Journal of Physics: Conference Series* (Vol. 2068, No. 1, p. 012015). IOP Publishing.
34. Shi, X., Jiang, Y., Feng, Q., Shi, W., & Chai, C. (2023, October). Location Planning of Field Ammunition Depot for Just in Time. In *2023 4th International Conference on Management Science and Engineering Management (ICMSEM 2023)* (pp. 181-191). Atlantis Press.