Study on The Location of Emergency Logistics Center Under Public Health Events -- A Case Study of Huai'an City

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Abstract: In early 2021, COVID-19 broke out in Wuhan, Hubei province. The location of emergency logistics centers in the emergency logistics management of public health emergencies is very critical, which greatly affects the emergency efficiency of materials in the hands of the demand. Reasonable positioning of emergency logistics center can minimize losses, so the location of emergency logistics center is the core issue of emergency logistics. This paper studies the location of emergency logistics center for public health events, and establishes a multi-objective decision-making model with the largest coverage, the highest time efficiency and the lowest time cost to solve practical problems. Taking Huai'an City as an example, this paper empirically studies the multi-objective location model of emergency logistics center under public health events, and uses the depth first search method (DFS) And lingo software to select the best location. At the same time, it further proves that the multi-objective decision-making model constructed in this paper is more scientific and efficient, saves cost and reduces transportation time, which provides a certain theoretical reference for the location research of emergency logistics center under public health events in the future.

Keywords: public health events, Emergency logistics, site selection

1 INTRODUCTION

At the beginning of 2021, the COVID-19 epidemic broke out in Wuhan, Hubei Province. In the emergency logistics management of this public health emergency, the location of the emergency logistics center is very critical, which greatly affects the emergency efficiency of those who meet the demand for materials. Reasonable positioning of emergency logistics center can minimize losses, so the location of emergency logistics center is the core issue of emergency logistics. This paper studies the location of emergency logistics center for public health events, and establishes a multi-objective decision-making model with the largest coverage, the highest time efficiency and the lowest time consumption cost to solve practical problems. Ma Lirong, Yin Yaojie [1] [2] and so onproposed under satisfies the multiple constraints the artificial immune algorithm to carry on the solution to the model. Lai Zhizhu, Wang Zheng, Ge Dongmei, Chen Yulong [3] established the deterministic model and robust optimization model of multi-objective emergency logistics center location. Liu Zhuo [4] establishes a deterministic location model of the emergency logistics center. At present, there are some research gaps in the research results, which need to be further improved. The location decision of emergency logistics center is a multi-objective planning problem that can

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minimize the economic cost, shorten the emergency service time and reasonably over-cover the key areas.

2 BUILDING MODELS

The multi-objective decision-making model established in this paper is based on the relevant principles of coverage model [5], and the main assumptions are as follows: (1) The distribution of emergency logistics centers is in point form. (2) The actual distance from the emergency logistics center to the demand point is known. (3) The transportation time of vehicles in the emergency logistics center is positively correlated with the cost. (4) The emergency logistics center has enough goods to provide the required materials for the demand points. Establish multi-objective planning model. The model symbols in this paper are defined as follows Table 1.

Table 1. Table of model variables

Variable	Implications
d_i	Indicates the number of emergency logistics centers that can cover demand point i
g_i	Indicates the minimum number of service points required for demand point i
t_{ij}	Represents the driving time of the vehicle from the standby site j to the demand point i
T	Indicates the longest vehicle travel time from site j to demand point i
K	Shows the minimum number of emergency logistics centers to be established. Expressed as the final result numerical value of multi-objective decision model
W_i	Represented as the weight of demand point i
λ	Means the range that the emergency logistics center can cover when it reaches the demand point i within the specified driving time
θ	Indicates the longest vehicle travel time required between the demand points i that can be covered by the alternative site j
A_i	To indicate whether the standby site j establishes an emergency logistics center
B_{ij}	Indicates whether the demand point i is assigned to the standby site point j of the emergency logistics center

When A_j is 1, it represents the establishment of emergency logistics center at the alternate site j, When A_j is 0, it means that the emergency logistics center is not established at the standby site j. When B_{ij} is 1, it represents that demand point i is allocated to emergency logistics center location point j, When B_{ij} is 0, it means that demand point i is not allocated to emergency logistics center location point j.

Goal function:

$$minC_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} W_i t_{ij} B_{ij} \tag{1}$$

$$minC_2 = \sum_{i=1}^{n} W_i d_i \tag{2}$$

$$minC_3 = T \tag{3}$$

Constraints:

$$\sum_{j=1}^{m} A_i = K \, , \sum_{i=1}^{n}\sum_{j=1}^{m} t_{ij} \le g_i T \, , \sum_{j=1}^{m} B_{ij} \ge g_i + d_i \tag{4}$$

$$(A_j,\ B_{ij}) \in \{0,1\}, \sigma_i \ge 0, \forall i \in n \, , \, j \in m \tag{5}$$

Model solving method In this paper, the location model is solved by DFS and Lingo software [6]. Depth-first search method, also known as depth-first traversal method, is expressed as DFS in English, and depth-first search method (DFS) is a recursive process.

3 EMPIRICAL ANALYSIS

According to the Huai 'an Statistical Yearbook of the National Bureau of Statistics in 2020, Huai 'an City is divided into seven areas to be selected according to administrative divisions, including Huai 'an District, Huaiyin District and Qingjiangpu District, with a registered population of 4,932,600. It can be seen from Table 2 that Huai 'an City can be divided into seven emergency demand areas according to administrative areas, and it is planned to select K locations from the seven candidate addresses to establish emergency logistics centers. Take the proportion of the population of each demand area to the total population of Huai 'an as the weight 0.22, 0.16, 0.18, 0.07, 0.17, 0.13, 0.07. Travel time data from each candidate location to each demand area is obtained from Baidu map and Gaode map, and calculated according to the center of each demand area, as shown in Table 2.

Table 2. Travel time from each candidate address to each demand area X_j=1min

	i_1	i_2	i_3	i_4	i_5	i_6	i_7
j_1	0	43	52	65	55	93	60
j_2	43	0	55	51	43	93	92
j_3	52	55	0	47	56	79	74
j_4	65	51	47	0	60	55	50
j_5	55	43	56	60	0	107	110
j_6	93	93	79	55	107	0	58
j_7	60	92	74	50	110	58	0

Firstly, based on the traditional coverage location model, determine the number of emergency logistics centers (that is, determine the value of K) to be established in seven candidate addresses. In order to achieve the effect of emergency rescue, according to field research, the travel time between each demand area and the emergency logistics center should not exceed 60 minutes. According to the driving time from each candidate address to each demand area, the data of each demand area that can meet the driving time within 60 minutes from the site selection point is sorted out. Calculation process In order to get the specific site selection scheme, it is necessary to determine the site selection number K in the model. Therefore, in this section, the corresponding mathematical model is established according to the coverage of the location, so as to determine the specific number of emergency logistics centers needed in Huai 'an City, Jiangsu Province. When a is 1, it means that an emergency logistics distribution center will be established at this alternate site j. When a is 0, it means that no emergency logistics distribution center will be established at this alternate site j. The optimal solution of this model can be obtained as follows $A_1=1$, $A_7=1$, That is, the best plan is to establish two emergency logistics centers in seven candidate areas.

3.1 Determine the site selection scheme

In order to use Lingo software to solve this model conveniently, the multi-objective decision model is transformed by objective function constraint method. The objective function C_3 requires that the maximum time from the emergency logistics center to the demand area be minimized, and the maximum service time can be taken here. The objective function requires the minimum quantity of demand and supply places. Therefore, the objective function C_3 in the original model is retained, C_2 and C_3 are constrained, and the original multi-objective model is transformed into model P-1:

Goal function:

$$minC_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} W_i t_{ij} B_{ij}, T \leq \lambda \leq 110 \quad (6)$$

Constraints:

$$\sum_{j=1}^{m} A_i = K \quad (7)$$

$$\sum_{j=1}^{\mathrm{m}} W_i d_i \geq \theta, \sum_{j=1}^{m} B_{ij} \geq g_i + d_i \quad (8)$$

$$A_j\text{-}B_{ij} \geq 0 \quad (9)$$

$$(A_j,\ B_{ij}) \in \{0,1\}, \sigma_i \geq 0, \forall i \in n, j \in m \quad (10)$$

In order to compare the multi-objective decision-making model with the single-objective decision-making model, so as to verify the effectiveness of the multi-objective decision-making model in this paper, that is, only the objective function C2 is considered, the objective function C3 is constrained, and the original constraint conditions are taken into account, and the following single-objective location model P-2 is obtained:

$$minC_2 = \sum_{i=1}^{n} W_i d_i \;, T \le \lambda \le 110 \tag{11}$$

$$\sum_{j=1}^{m} A_i = K \;, \sum_{j=1}^{m} W_i d_i \ge \theta \;, \sum_{j=1}^{m} B_{ij} \ge g_i + d_i \;, A_j\text{-}B_{ij} \ge 0 \tag{12}$$

$$(A_j,\ B_{ij}) \in \{0,1\}, \sigma_i \ge 0, \forall i \in n,\ j \in m \tag{13}$$

In model P-1, If these 13 cases meet condition $g_1=g_2=g_3=g_4=g_5=g_6=g_7=1$; In model P-2, considering the coverage weight of each demand; If the above conditions are not met, this situation is not feasible, and the next situation is entered; When several situations are found to be satisfied, the optimal solution is the minimum C value.

3.2 Analysis of calculation results

However, when the P-2 model is used for site selection, the solutions of the fifth scheme are the smallest, all of which are 0.00. Therefore, the 9th and 13th schemes are the best. Choose $A_3=A_7=1$ among the 7 candidate addresses, namely Qingjiangpu District, and establish emergency logistics center $A_5=A_7=1$ in Jinhu County. That is, Lianshui County and Jinhu County set up emergency logistics centers. The specific data of the optimal scheme in two different cases are shown in Table 3.

Table 3. Comparison of optimal scheme data in two different cases

Model	P-1	P-2	
plan	4	9	13
Travel time from site selection point to i_1	43	52	55
Travel time from site selection point to i_2	0	55	43
Travel time from site selection point to i_3	47	0	56
Travel time from site selection point to i_4	0	47	50
Travel time from site selection point to i_5	43	56	0
Travel time from site selection point to i_6	55	58	58
Travel time from site selection point to i_7	50	0	0
Amount to	238	268	262

From the data in Table 2, it can be seen that in P-2 objective decision model, compared with scheme 13, scheme 9 has a total minimum travel time of 268 from site selection point to demand point, and scheme 13 has a total minimum travel time of 262 from site selection point to demand point, so scheme 6 is better. Next, the P-1 model is compared with the P-2 model. In Scheme 9 and Scheme 4, the total minimum travel time from the location point to the demand point in Scheme 13 is 262, and the total minimum travel time from the location point to the demand point in Scheme 4 is 238, so Scheme 4 is better. Therefore, comparing the two cases, when Huaiyin District and Hongze District are the construction sites of logistics centers, the coverage rate is higher than that of Lianshui County and Jinhu County. Considering the time cost, Huaiyin District and Hongze District in the first case are finally selected as the final site selection points.

4 CONCLUSION

Based on the analysis of the location of emergency logistics center under public health events, this paper puts forward the model hypothesis, establishes a multi-objective decision-making model with the largest coverage, the highest time efficiency and the lowest time consumption cost to solve practical problems, takes Huai 'an City as an example to demonstrate the multi-objective location model of emergency logistics center under public health events, and calculates and solves it by DFS and lingo software. Huaiyin District and Hongze District are finally selected as the final sites. At the same time, it further proves that the multi-objective decision-making model built in this paper is more scientific and efficient, saves costs, reduces transportation time and is the future public health.the research results of this paper have certain practical significance to the material supply under the public health emergency, and to improve the logistics operation efficiency, and provide certain reference for the city to establish the location of the emergency logistics center. There are some deficiencies in this study, and we hope that in the future, the site selection can be refined to specific locations, and more efficient to improve the efficiency of emergency logistics.

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