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Study on the Location of Emergency Resources Distribution Center Based on FAHP

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Abstract. Combining with the quest character of the emergency resources distribution, the paper designs the location of the emergency resources distribution center evaluation index system and ascertains the weight of every evaluation index with fuzzy analytical hierarchy process (FAHP), and establishes a synthetic evaluation method of the index system. From this, we can get an effective way of the location of the emergency resources distribution center when the emergency happens.

Keywords: emergency resources, distribution center, location, FAHP.

1. Introduction

Under the circumstance of emergency incident, the supply of the emergency resources influences the rescue activity and the people's daily life condition in the disaster region, and it is important to choose a proper emergency resources distribution center to meet an emergency supplies to quickly respond to meet the quest of the quick response and the quick service of emergency resources. After disaster happening, we should have to choose one or more resources distribution center to carry on high effectively rescue work. The location decision of emergency resources distribution center is very important for the effectively rescue work and the rational location can ensure the time limited efficacy of the emergency resources supply to avoid more losing. It's signality for taking the research of emergency resources distribution center location.

2. The Impact Factor for the Location of Emergency Resources Distribution Center

Under the general circumstance, the location factor of the common logistics distribution center is political factor and economic factor, and the economic factor contains decisive function. But in the factor of an emergency resources distribution center' location, economic factor consideration less, but safe factor, economic factor, technique factor and social factor are the main factors[1] that meet the usefulness and time limited efficacy.

2.1. Social factor

The location of the center may not be seated at the region which has had a most serious disaster, probably be seated in a region which is not very serious but good for the whole rescue. The social factor can be embodied in following indexes: (1) infrastructure: the region which the infrastructure is damaged lesser is advantageous to meet emergency quick supplies, and carry on the emergency rescue work. (2) Coordination with other resources: because the emergency distribution center is built up at the time, to develop its biggest function we have to be in conjunction with a work with other resources.

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2.2. Economic factor

Although the weak economic character is the notability character of the emergency logistics, in the whole emergency rescue process, the deliver process should also give attention to economy in the supplies. And the less which the emergency delivery need from the whole rescue system, the more resources will be got at other sides.

In the process of rescue, economic factor mainly measure from the loss estimated and running expenses. Among them, under the situation that taking no account of other factors, the loss is smaller, the operation condition of emergency logistics center will be better. Smaller running expense means smaller pressure to the emergency rescue system, and it brings convenience to the whole emergency rescue, make the funds to be used at the most demanded places.

2.3. Safe factor

In the safe factor of the location of the emergency resources distribution center, some is artificial factor, can be avoided in the process of rescue, but some factors outrun the artificial control scope, and only can be cut down by forecasting. The safety factor contains following indexes: (1) weather condition: weather condition in the district is an important aspect of safe factor. (2) Geology condition: after disaster taking place, the center should be seated at a region which is far away from the bad geology condition region. (3) Hydrology condition: it always has disease, epidemic after the disaster occurring, and it's important to choose the safe riverhead to keep the distribution center running.

2.4. Technique factor

In the process of emergency rescue, the advanced technical usage can reduce faults and save time and we can carry on the efficiently rescue through some precisions operations. The technique factor can embody as following indexes: (1) the loading measures: The loading measures has great influence to the storage and delivery of the emergency supplies. (2) Degree of the transportation covering: it decides the service area of the distribution center. (3)Transport delay: The disaster occurrence may make the road transportation inconvenience and caused conveyance delay, accurate judgment and decrease the delay is a successful key to rescue.

2.5. The establishment of the index system of the emergency resources distribution center location

To sum up, we can get the index system of the emergency resources distribution center' location as fig.1 at the last page:

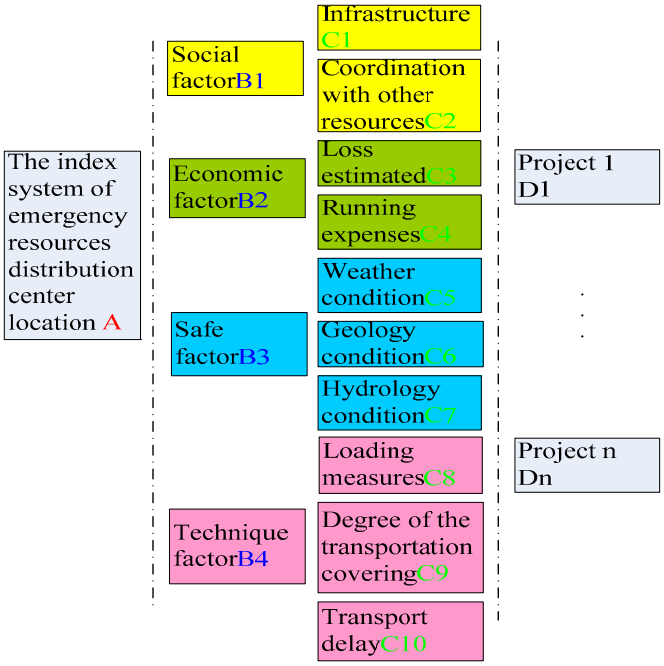

Fig. 1: The index system of emergency resources distribution center location

3. Location of Emergency Resources Distribution Center Based on FAHP

The familiar method of distribution center's location is continuous model; discrete model and comprehensive factor analyze method. These methods have some localization and can't give attention the entire quest in the location of emergency resources distribution center. This paper adopts the FAHP which can resolve the difference problem of matrix consistency and people' thinking and more fuzzy the indexes are, the more useful of the method is.

3.1. The base step of FAHP

(1) Building up the arrangement structure model of the decision. Through the amylases of the problem, we can fix up the index and delaminate the evaluate indexes. The tiptop is the aim, and the mesosphere which c an be one bed or more is the factor about the aim, the bottom is the entire projects.

(2) Building up the superiority relation matrix which is against the super stratum factor. Postulate the element B is relation to next bed element C; we can build up the superiority relation matrix through comparing the important degree. The element in the matrix expresses subjection of the important degree which an element in C compares with the element in B, this matrix is fuzzy mutual matrix and the value of the subjection degree can consult tab.1.

Tab. 1: Subjection degree

Calibration	Definition
0.5	The same
0.6	A little important
0.7	Obvious important
0.8	Much important
0.9	Extreme important
0.1, 0.2, 0.3, 0.4	r_{ij}=1-r_{ji}

(3) Changing the superiority relation matrix into fuzzy consistent judgment matrix. We can know that the superiority relation matrix is fuzzy mutual matrix and we should change it into fuzzy consistent judgment matrix, sum the row elements as $r_i = \sum_{k=1}^{m} f_{ik} \ (i = 1, 2, \cdots, m)$, changes as followings $r_{ij} = \frac{r_i - r_j}{2m} + 0.5$, and then we get the fuzzy consistent judgment matrix $R = (r_{ij})_{m \times m}$.

(4) carry on the layer single compositor, using the fuzzy consistent judgment matrix to calculate the order (value) of each element in each layer, using the expression as follows [4]:

$$w_i = \frac{1}{n} - \frac{1}{2\alpha} + \frac{1}{n\alpha} \bullet \sum_{k=1}^{n} r_{ik}, i \in \{1, 2, \cdots, n\} \tag{1}$$

Explanation: n—the rank of the fuzzy consistent judgment matrix

α—the measurement units of two element difference in importance degree, $\alpha \geq \frac{n-1}{2}$

(5) carry on the whole compositor. At the base of the layer single compositor, integrating with the value matrix and the experts' grade, we can get the evaluate number of each subject to choose the best project.

3.2. Application

According to the theory of FAHP and the analyses of the location factors of emergency resources distribution center, on the assumption that some department organize some expert to choose 1 distribution center out of 4 in rescue and relief work and mark for the above 10 indexes as the tab.2:

Now use FAHP to solve problem as the tab.2.

Firstly, build up the layer evaluation model. The tiptop is the best choice, the second layer is the factor which should be considered in the location of emergency resources distribution, the third layer is the concrete indexes (10 in total), the under layer is the projects which are being chosen.

Secondly, build up the superiority relation matrix and the mutual superiority relation matrixes are shown as tab.3-7:

Thirdly, change the superiority relation matrix into fuzzy consistent judgment matrix as the tab.8-12 show:

Tab. 2

First layer A		Location of Emergency RESOURCES Distribution Center									
Second layer B		Social factor		Economic factor		Safety factor			Technique factor		
Third layer C	Evaluation factor	Infrastructure	Coordination with other resources	Loss estimated	Running expenses	Weather condition	Geology condition	Hydrology condition	Loading measures	Degree of the transportation covering	Transport delay
Fourth layer D	1	7	8	5	6	7	6	5	8	7	6
	2	5	8	7	5	6	7	6	7	8	7
	3	8	6	7	6	6	7	8	6	7	6
	4	7	8	7	7	6	6	7	7	5	6

Tab. 3 A-B superiority relation matrix

Index A	B1	B2	B3	B4
B1	0.5	0.6	0.7	0.4
B2	0.4	0.5	0.4	0.3
B3	0.3	0.6	0.5	0.6
B4	0.6	0.7	0.4	0.5

Tab. 4 B-C superiority relation matrix（to B1）

Index B1	C1	C2
C1	0.5	0.6
C2	0.4	0.5

Tab. 5 B-C superiority relation matrix（to B2）

Index B2	C3	C4
C3	0.5	0.7
C4	0.3	0.5

Tab. 6 B-C superiority relation matrix（to B3）

Index B3	C5	C6	C7
C5	0.5	0.3	0.4
C6	0.7	0.5	0.6
C7	0.6	0.4	0.5

Tab. 7 B-C superiority relation matrix（to B4）

Index B4	C8	C9	C10
C8	0.5	0.4	0.4
C9	0.6	0.5	0.6
C10	0.6	0.4	0.5

Tab. 8 A-B fuzzy relation matrix

Index A	B1	B2	B3	B4
B1	0.5	0.575	0.525	0.5
B2	0.425	0.5	0.45	0.425
B3	0.475	0.55	0.5	0.475
B4	0.5	0.575	0.525	0.5

Tab. 9 B-C fuzzy consistent judgment matrix（to B1）

Index B1	C1	C2
C1	0.5	0.55
C2	0.45	0.5

Tab. 10 B-C fuzzy consistent judgment matrix（to B2）

Index B2	C3	C4
C3	0.5	0.6
C4	0.4	0.5

Tab. 11 B-C fuzzy consistent judgment matrix（to B3）

Index B3	C5	C6	C7
C5	0.5	0.4	0.45
C6	0.6	0.5	0.55
C7	0.55	0.45	0.5

Tab. 12 B-C fuzzy consistent judgment matrix（to B4）

Index B4	C8	C9	C10
C8	0.5	0.433	0.467
C9	0.567	0.5	0.533
C10	0.533	0.467	0.5

Fourthly, work out the value of each element in the goal and $\alpha = \frac{n-1}{2}$, then get the value which each layer compare with the up layer:

Value B to A:

$$w_0 = (0.267, 0.2167, 0.250, 0.2667)^T \tag{2}$$

Value C to B:

$$w_1 = (0.550, 0.450)^T \tag{3}$$

$$w_2 = (0.600, 0.400)^T \tag{4}$$

$$w_3 = (0.283, 0.383, 0.333)^T \tag{5}$$

$$w_4 = (0.300, 0.367, 0.333)^T \tag{6}$$

Fifthly, evaluate each location project. Work out the evaluation point of each project's main target and sub-target (tab.2 had given out). Then work out the importance of each project to the main target D_{is}: $D_{is} = (X_{s1}, \cdots, X_{sn}) \cdot w_i$, X_{ij} is the experts' grade, such as $D_{11} = (X_{11}, X_{12}) w_1$. In the similar way we can get $D_{12}, D_{13}, \cdots D_{44}$, as follows:

$$D_1 = (7.450, 5.400, 5.944, 6.967) \tag{7}$$

$$D_2 = (6.350, 6.200, 6.377, 7.367) \tag{8}$$

$$D_3 = (7.100, 6.600, 7.043, 6.367) \tag{9}$$

$$D_4 = (7.450, 7.000, 6.327, 5.933) \tag{10}$$

The comprehensive grade point of each project is: $E_s = D_s \bullet w_0 \ (s = 1, 2, 3, 4)$

$E_1 = 6.500$, $E_2 = 6.594$, $E_3 = 6.780$, $E_4 = 6.665$,

Through comparing the grade point of each emergency resources distribution center project, we can know that the third project is the best.

4. Conclusions

The location of emergency resources influences the following rescue activity. This paper builds up the index system of the location according character of the emergency resources supply, and makes use of FAHP to solve the solid example. The possibility, usefulness has proved that the method has certain reference value.

5. References

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