Application of Fuzzy Cluster Analysis in the Location of Building Waste Recycling Center

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Abstract. Building waste is a kind of recyclable resources, how to carry on the recovery and treatment of the building waste has become an important problem in the management of the city. Many enterprises have set up the recycling center, but the effect is poor, the reason is that the layout and location of waste recycling center affects the overall efficiency of recycling. In this paper, through the analysis of factors affecting the layout of the building waste recycling center, list some evaluation index about address feature, such as economic benefit, social benefit, environmental benefit and management level, apply fuzzy cluster analysis to the location decision of recycling center, and finally carry on the cluster analysis to verify the practical examples by SPSS software.

1. Introduction

Building waste refers to waste generated due to man-made or natural and other reasons in the project, including the waste residue, waste soiland, clay residue and waste material, is a kind of can be recycled resources. Establish the site appropriate recycling center is an important part of the recycling network, not only can effectively improve the recovery efficiency, but can bring higher recovery benefit. The usual solution to the location problem is the center-of-gravity method and mixed integer programming model method, but the two either only consider geographical factors without considering other effects, either The amount of calculation increases with increasing problem size [1,2]. This paper puts forward the fuzzy cluster analysis method used to solve the location problem of recycling center, and an example using SPSS software to verify the feasibility and effectiveness of the method.

2. Fuzzy cluster analysis

Fuzzy cluster analysis is according to certain requirements and rules to deal with fuzzy problems. According to the property of object to construct fuzzy matrix, on the basis of this, with the degree of membership to determine the cluster relationship, that is by the method of fuzzy mathematics to determine the fuzzy quantitative relationship between samples, and then cluster, make the between class data differences as large as possible, within class data differences as small as possible.Fuzzy cluster analysis steps [3,4]:

Step1: (Establishment of the evaluation index system) The site selection and layout of building waste recycling center, mainly by the following factors: economic benefit, social benefit and environmental benefit and management level [1,5,6], the specific evaluation index system. As shown in Fig. 1.

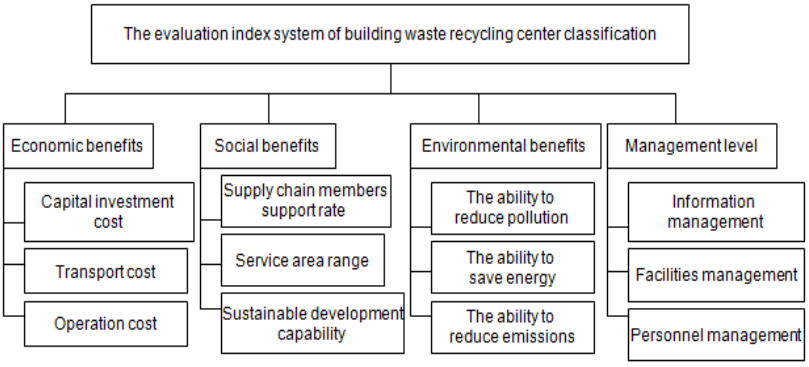

Fig. 1: The classification system of evaluation index of building waste recycling center

Step2: (Sample data standardization) Assuming X= {X1, X2,...,Xn} as classified objects, each object is composed of M indexes represents the characteristics: xi= {xi1, xi2,..... xim}, i=1,2,..... n. So, get the original data matrix $\begin{bmatrix} x_{11}x_{12}...x_{1m} \\ x_{21}x_{22}...x_{2m} \\ ..... \\ x_{n1}x_{n2}...x_{nm} \end{bmatrix}$. Because the dimension and quantity of M indexes are different, so can not directly use the original data to calculate, the raw data must be standardized. Methods the sample data standardization processing commonly used are: Translation-standard deviation transform and shift-range transformation. Translation - standard deviation transform model is:

$$x_{ij}' = \frac{x_{ij} - \bar{x}_j}{s_j}(i = 1,2,...n; j = 1,2,...m) \quad , \quad \bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij}, s_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_{ij} - \bar{x}_j)^2} \quad ,$$

shift-range transformation model is: $x_{ij}' = \frac{x_{ij} - \min\{x_{ij} \mid 1 \le i \le n\}}{\max\{x_{ij} \mid 1 \le i \le n\} - \min\{x_{ij} \mid 1 \le i \le n\}}$.

Step3: (Establishment of fuzzy similarity matrix) The methods about establishment of fuzzy similarity matrix, commonly used are: the correlation coefficient method and distance method. The mathematical model of correlation coefficient method is:

$$rij = \frac{\sum_{k=1}^{m} |x_{ik} - \bar{x}_i||x_{jk} - \bar{x}_j|}{\sqrt{\sum_{k=1}^{m}(x_{ik} - \bar{x}_i)^2}\sqrt{\sum_{k=1}^{m}(x_{jk} - \bar{x}_j)^2}} \quad , \quad \bar{x}_i = \frac{1}{m}\sum_{k=1}^{m} x_{ik}, \bar{x}_j = \frac{1}{m}\sum_{k=1}^{m} x_{jk} \quad .$$

The mathematical model for distance method is: $r_{ij} = 1 - cd(x_i, x_j)$, c is the appropriate selected parameter, makes $0 \le r_{ij} \le 1$.

①Hamming distance: $d(x_i, x_j) = \sum_{k=1}^{m} |x_{ik} - x_{jk}|$

②Euclidean distance: $d(x_i, x_j) = \sqrt{\sum_{k=1}^{m}(x_{ik} - x_{jk})^2}$

③Chebyshev distance: $d(x_i, x_j) = \vee\{|x_{ik} - x_{jk}|, 1 \le k \le m\}$

Step4: (Cluster, Cluster diagram drawn) Starting from fuzzy similar matrix R, solving transitive closure t(R) with square method, sequentially selecting λ-matrix, then divide the sample X. Using the theory method, according to the classification requirements, alternative address can be divided into several categories and levels, and obtain the corresponding definite conclusion. Cluster analysis can be implemented in statistical software SPSS.

3. Application of fuzzy cluster analysis for site selection process to building waste recycling center

One area plans to build three recycling center for disposal building waste. The existing eight alternative address, i.e. X={X1, X2, X3, X4, X5, X6, X7, X8}. According to the relevant statistical data of each address, the comprehensive evaluation score by experts, obtained initial evaluation index value of each alternative address. As shown in Table 1.

Table 1: Initial evaluation index value of alternative address

Address / Index		X1	X2	X3	X4	X5	X6	X7	X8
Economic benefits	Capital investment cost（million）	1470	1260	1070	990	1380	1140	1310	1420
	Transport cost	0.7	0.74	0.83	0.89	0.78	0.81	0.77	0.73
	Operation cost（million）	2.01	1.89	1.74	1.53	1.61	1.72	1.69	1.99
Social benefits	Supply chain members support rate	0.58	0.81	0.67	0.88	0.73	0.79	0.7	0.64
	Service area range(num)	7	5	4	3	6	4	6	7
	Sustainable development capability	0.71	0.77	0.82	0.86	0.75	0.81	0.74	0.73
Environmental benefits	The ability to reduce pollution	0.61	0.73	0.7	0.74	0.71	0.68	0.72	0.62
	The ability to save energy	0.67	0.77	0.8	0.75	0.83	0.72	0.79	0.67
	The ability to reduce emissions	0.87	0.71	0.83	0.76	0.81	0.82	0.73	0.86
Management level	Information management	0.62	0.57	0.77	0.81	0.68	0.75	0.59	0.63
	Facilities manageme	0.58	0.47	0.67	0.7	0.56	0.66	0.5	0.57

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	Personnel management	0.72	0.67	0.75	0.63	0.79	0.65	0.68	0.74

Because there is some correlation between indicators, some indicators may lead to information overlap, reducing the actual operation, so screening initial evaluation index in order to achieve the optimal location. Here, using principal component analysis method to simplify the index [5]. As shown in Table 2.

Table 2: Evaluation index value after screening

Alternative address	Economic benefits	Social benefits	Environmental benefits	Management level
	Transport cost	Service area range(number)	The ability to reduce pollution	Information management
X1	0.7	7	0.61	0.62
X2	0.74	5	0.73	0.57
X3	0.83	4	0.7	0.77
X4	0.89	3	0.74	0.81
X5	0.78	6	0.71	0.68
X6	0.81	4	0.68	0.75
X7	0.77	6	0.72	0.59
X8	0.73	7	0.62	0.63

According to the data in Table 2, establish the data file in SPSS software, considering the various indicators have the dimension difference, so standardize numeric variables, here adopts the standard difference transform, calculate the Z score of each variable. As shown in Table 3.

Table 3: *Z score* of each variable

Alternative address	Z Transport cost	Z Service area range(number)	Z The ability to reduce pollution	Z Information management
X1	-1.33093	1.17604	-1.60331	-.64201
X2	-.67570	-.16801	.83983	-1.20028
X3	.79856	-.84003	.22904	1.03280
X4	1.78140	-1.51205	1.04342	1.47942
X5	-.02048	.50402	.43264	.02791
X6	.47095	-.84003	-.17815	.80949
X7	-.18428	.50402	.63623	-.97697
X8	-.83951	1.17604	-1.39971	-.53036

With SPSS, get the fuzzy cluster results of the problem and validation. As shown in Table 4, Table 5, Fig. 2 and Table 6.

Table 4: Proximity matrix

Case	Squared Euclidean Distance							
	1	2	3	4	5	6	7	8
1	.000	8.516	14.762	28.418	6.763	11.449	6.894	.295
2	8.516	.000	7.985	15.066	2.555	6.842	.784	7.298
3	14.762	7.985	.000	2.280	3.529	.323	6.077	11.844
4	28.418	15.066	2.280	.000	9.791	4.110	14.128	24.103
5	6.763	2.555	3.529	9.791	.000	3.032	1.078	4.792
6	11.449	6.842	.323	4.110	3.032	.000	6.090	9.069

7	6.894	.784	6.977	14.128	1.078	6.090	.000	5.225
8	.295	7.298	11.844	24.103	4.792	9.069	5.225	.000

This is a dissimilarity matrix

Table 5: Agglomeration schedule

	Cluster Combined			Stage Cluster First Appears		
Stage	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	Next Stage
1	1	8	.295	0	0	6
2	3	6	.323	0	0	5
3	2	7	.784	0	0	4
4	2	5	1.817	3	0	6
5	3	4	3.195	2	0	7
6	1	2	6.581	1	4	7
7	1	3	11.539	6	5	0

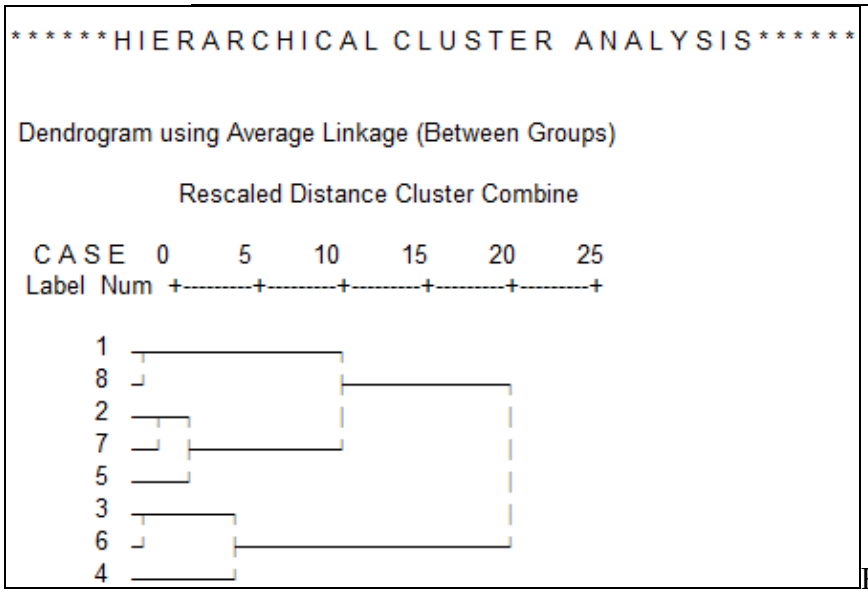

Fig. 2: *Dendrogram* by fuzzy cluster analysis

Table 6: Significance test by one-way *anova*

		Sum of Squares	df	Mean Square	F	Sig.
Transport cost	Between Groups	.021	2	.011	11.135	.014
	Within Groups	.005	5	.001		
	Total	.026	7			
Service area range	Between Groups	14.167	2	7.083	26.563	.002
	Within Groups	1.333	5	.267		
	Total	15.500	7			
The ability to reduce pollution	Between Groups	.015	2	.007	17.446	.006
	Within Groups	.002	5	.000		
	Total	.017	7			

Information management	Between Groups	.047	2	.024	13.482	.010
	Within Groups	.009	5	.002		
	Total	.056	7			

4. Cluster Analysis

From Table 5 and Fig. 2, the alternative address of X1, X8 as a class; X2, X5, X7 as a class; X3, X4, X6 as a class. So, the region can choose a place from the address of X1 and X8 to establish a building waste recycling center, choose a place from X2, X5 and X7 to establish, a place from X3, X4 and X6 to establish a recycling center, in order to realize the recycling of building waste [6].

From Table 6, the value of sig is less than 0.05, imply four observation indexes in cluster analysis have significant differences, and the indexes have played a significant role, and the results of the fuzzy cluster analysis is effective.

5. Conclusion

Recycling of building waste is based on the concept of circular economy to realize the sustainable development of regional economy. Although there are many enterprises have found building waste recycling can reduce the cost of enterprises, realize greens environmental protection and enhance image. But the recycling center location is not scientific causes supply chain members support rate is not high, and the enterprise operating costs increase and ineffective. In this paper, through the analysis of four major factors which influence the location of building waste recycling center, established the corresponding evaluation index system, analyzed recycling center location using fuzzy cluster, and used SPSS software to realize cluster and prove effectiveness.

The location of building waste recycling center is a complex mathematical programming problem, it has many influence factors. Because of the availability of data and computed strength, this paper only analyzed four influencing factors about economic benefit, social benefit, environmental benefit and management level, not including all. The future will continue to strengthen theoretical research and investigation combined with the actual, to make the analysis more comprehensive.

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