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Research on the Site Selection and Transfer Path Optimization of Garbage Transfer Station in East Lake Scenic Area Based on Analytic Hierarchy Process

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Abstract:
With the development of social economy, people's living standards have been significantly improved, the output of garbage in daily life has also increased greatly, and the effect of garbage disposal has a great impact on the environment and society. The scenic area is a densely populated area, and its garbage production is also very high. In order to reduce the workload of garbage transportation, reduce labor costs, shorten the total transportation distance and reduce transportation costs, the research object of this paper is the East Lake Ecological Scenic Area in Wuhan, and the garbage transfer station in the scenic area is mainly selected and the garbage transfer route is planned. In this paper, the analytic hierarchy process is used to select the location of the garbage transfer station, Get optimal route planning. The research ideas and methods in this paper have certain reference significance for the site selection and transfer path planning of other waste transfer stations.

Keywords: site selection; analytic hierarchy process; path optimization; East Lake Ecological Scenic Area; garbage transfer station

INTRODUCTION

The analytic hierarchy process (AHP method) was proposed by the American operations researcher Professor Satie of the University of Pittsburgh in the 70s of the twentieth century, and is a practical analysis method that can effectively deal with the comparison of multiple schemes, which is characterized by the combination of qualitative and quantitative to solve complex problems systematically and hierarchically[1-3]. The existing research on waste transfer stations is usually one of the types of waste transfer stations and waste transfer routes. Before the 90s of the last century, China's living standards were low, and the daily garbage production was also at a low level, so there was not much pressure on the garbage disposal system, and there was less research on the garbage transfer station. At the beginning of the 21st century, China's economic level developed rapidly, and the output of domestic waste increased rapidly, and at the same time, the research on garbage transfer stations was intensified. On the one hand, the optimization of the location of the garbage transfer station can reduce the sum of the distance between the garbage produced by each garbage producing area and the transfer station, reduce the consumption of workers' working time, reduce work fatigue, and then reduce the cost of garbage transportation and labor costs. On the other hand, the location of a suitable garbage transfer station is convenient for the daily activities and health level of tourists in the scenic spot, and promotes the construction of an ecological scenic spot. The garbage transportation route planning not only reduces the sum of transportation distances to a certain extent, reduces transportation costs and labor costs, but also greatly reduces the impact of garbage transportation on the daily activities of tourists in scenic spots. In this paper, the analytic hierarchy process is used to select the location of the waste transfer station. Through the redivision of the garbage generation area and the investigation of the amount of garbage generated in each period, the analytic hierarchy process was used to plan the garbage transfer route to obtain the optimal transfer route[4-7].

SITE SELECTION OF GARBAGE TRANSFER STATION

Establish an Analytic Hierarchy Model

The location of the garbage transfer station needs to be measured and evaluated by some specific indicators, combined with the current situation of garbage transportation, the planning policy of the East Lake Scenic Area, and the comprehensive consideration of cost factors, scenic image factors, influencing factors for tourists, and traffic factors. Among them, the cost factor refers to the material cost and labor cost of developing the site and building the transfer station, the image factor of the scenic spot refers to the degree of influence of the location of the construction transfer station on the image of the scenic spot, the influencing factor of tourists refers to the influence of the garbage transfer station on tourists due to noise, smell and other factors, and the traffic factor refers to the convenience of traffic when transporting garbage[8-11]. Therefore, according to the principle of the most beautiful appearance, the principle of convenient transportation, the principle of minimum flow of people and the principle of minimum cost, the index system is proposed to be constructed as shown in Figure 1.

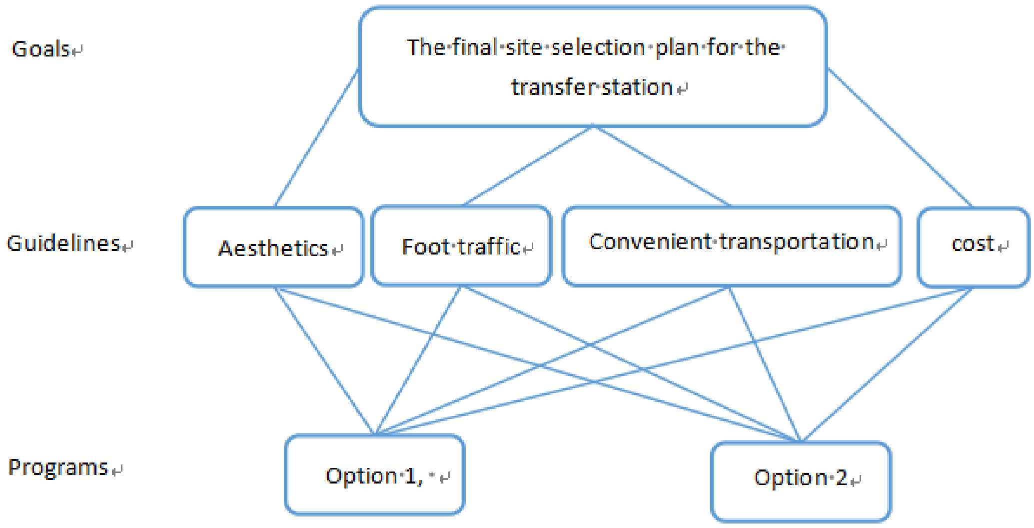

Figure 1. Evaluation index system

Construct Pairwise Judgment Matrix and Weight Calculation

In this study, the importance of the four influencing factors of the transfer station was compared and evaluated and scored, and then the evaluation results were converted into the corresponding judgment matrix, and the weights of each factor were calculated and the consistency test was carried out, and the specific results are shown in the table below. From the results, it can be seen that the CR<0.1 indicates that the weight value obtained by the matrix is very reasonable. Similarly, the same method is used to find the weight values of the two schemes in the criterion layer, and the advantages and disadvantages of each scheme are evaluated, and the specific results are shown in Table 1~Table 5.

Table 1. Judgment matrices of the target layer and the criterion layer

	C_1	C_2	C_3	C_4	Wi	Wi_0	Consistency checks
C_1	1	1/3	1/5	1/7	0.31	0.06	
C_2	3	1	1/2	1/4	0.78	0.15	$\lambda_{max}\approx4.03$
C_3	5	2	1	1/2	1.50	0.28	CR=0.01<0.1
C_4	7	4	2	1	2.74	0.51	

As shown in Table 1, the judgment matrix passed the consistency test, and the weights of C1, C2, C3, and C4 were 0.06, 0.15, 0.28, and 0.51, respectively.

Table 2. Judgment matrices of layers C1 and P

C_1	P_1	P_2	Wi	Wi_0	Consistency checks
P_1	1	6	2.45	0.86	$\lambda_{max}=2$
P_2	1/6	1	0.41	0.14	$CR_1=0<0.1$

As shown in Table 2, the judgment matrix passes the consistency test, and the weight of P1 scheme is 0.86 and that of P2 is 0.14 on the C1 factor.

Table 3. Judgment matrices of C2 and P layers

C_2	P1	P2	Wi	Wi0	Consistency checks
P1	1	7	2.65	0.875	λmax=2
P2	1/7	1	0.38	0.125	CR2=0<0.1

As shown in Table 3, the judgment matrix passes the consistency test, and the weight of P1 scheme is 0.875 and that of P2 is 0.125 in terms of C2 factor.

Table 4. Judgment matrices of C3 and P layers

C_3	P_1	P_2	Wi	Wi_0	Consistency checks
P_1	1	1/3	0.58	0.25	$\lambda_{max}=2$
P_2	3	1	1.73	0.75	$CR_3=0<0.1$

As shown in Table 4, the judgment matrix passed the consistency test, and the weight of P1 scheme was 0.25 and that of P2 was 0.75 in the C3 factor.

Table 5. Judgment matrices of C4 and P layers

C_4	P_1	P_2	Wi	Wi_0	Consistency checks
P_1	1	2	1.41	0.67	$\lambda_{max}=2$
P_2	1/2	1	0.71	0.33	$CR_4=0<0.1$

As shown in Table 5, the judgment matrix passed the consistency test, and the weight of P1 scheme was 0.67 and the weight of P2 was 0.33 on the C4 factor.

The Total Ranking of the Program Layer

Table 6 shows the weight values of the total ranking of candidate schemes. The random consistency ratio of the total ranking of the scheme layer CR=0<0.1 indicates that the total ranking results of the scheme layer have a satisfactory consistency.

Table 6. Weights of each scheme relative to the target layer

	C_1	C_2	C_3	C_4	The weight of the target layer P	Consistency checks
	0.06	0.15	0.28	0.51		
P_1	0.86	0.875	0.25	0.67	0.59	$CR=CR_1+CR_2+CR_3+CR_4=0<0.1$
P_2	0.14	0.125	0.75	0.33	0.41	

The Final Location of the Garbage Transfer Station

The total ranking weight of the two schemes at the scheme layer is calculated, the total importance of scheme 1 is 0.59, the total importance of scheme 2 is 0.41, and the total importance of scheme 1 is greater than that of scheme 2, so scheme 1 is better than scheme 2 when considering the four factors. Therefore, in the site selection plan of the garbage transfer station in the East Lake Scenic Area, the first option should be built near the Liyuan Scenic Area.

GARBAGE TRANSFER PATH PLANNING

Once the site of the new waste transfer station has been determined, the waste transfer is planned. The original garbage transportation mode of the scenic spot is to consign the garbage bin that has been filled, and replace it with an empty garbage bin, the number of garbage transportation in a day is very large, and at the same time, when the garbage is consigned due to the fixed time of the garbage, the garbage bin is not full, resulting in transportation waste, so based on the new garbage transfer station, the garbage transportation mode and method are rearranged[12-15].

Regional Division

Table 7. Partitioning of regions

Area 1	Luoyan Scenic Area, Wetland Park
Area 2	East Lake Listening to the Waves Scenic Area, East Lake Ocean Park
Area 3	East Lake Beach Scenic Area, OCT Ecological Wetland Park
Area 4	Happy Valley White Horse Station Scenic Area
Area 5	East Lake Piper Scenic Area, Forest Park East Lake
Area 6	Yingpan Mountain Scenic Area
Area 7	East Lake Plum Garden, Moshan Scenic Area
Area 8	Fengdu Mountain Scenic Area

The garbage production of different time periods in the scenic spot is investigated, and because the scenic spot is connected by a number of scenic spots, the scenic spot is now divided into eight areas, and the division is shown in Table 7. Figure 2 shows the regional distribution[16-18].

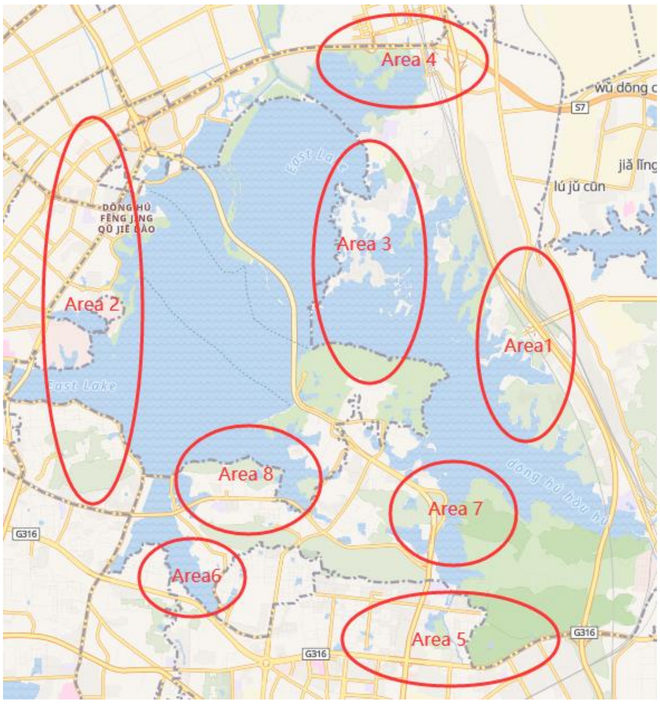

Figure 2. Location map of scenic spots

Survey of Garbage Generation in Each Region

Now the garbage production of each area in different time periods is investigated, the investigation time period is 7:00-10:00, 10:00-13:00, 13:00-17:00, 17:00-20:00, with the scenic garbage bin as a unit, the garbage output is investigated, and it is found in the investigation process that because the area 1-3 is a popular scenic spot area, the amount of garbage generated in each time period is very large, and the kitchen waste of each restaurant will be treated separately as a raw material for feed, and is not counted in the results. The results of the survey are shown in Table 8.

Table 8. Waste production by region and time period

	7:00-10:00	10:00-13:00	13:00-17:00	17:00-20:00
Area 1	16	13.25	16	13.5
Area 2	12	8	12	8.25
Area 3	10	7.5	10	7.5
Area 4	4	2.5	4	2.5
Area 5	0.5	0.5	0.5	0.5
Area 6	0.5	0.5	0.5	0.5
Area 7	0.5	0.5	0.5	0.25
Area 8	1	0.5	0.5	0.5

According to the garbage production of different time periods, draw up a new garbage transportation scheme: adopt medium-sized garbage trucks for garbage shipment and transportation, design out the designated route to ship the garbage at various points, medium-sized garbage trucks have two models, the capacity is 12 square meters and 10 square meters respectively, from the data in the above table, it can be seen that the garbage output of area 1-3 in each time period is very large, so it needs to be transported separately, after carrying out a separate transportation in these areas, the remaining garbage can be consigned in the same batch with the garbage in other areas, The amount of waste remaining in each area after a separate transport in zones 1-3 is shown in Table 9.

Table 9. Residual garbage production by region

	7:00-10:00	10:00-13:00	13:00-17:00	17:00-20:00
Area 1	4	1.25	4	1.5
Area 2	0	0	0	0
Area 3	0	0	0	0
Area 4	4	2.5	4	2.5
Area 5	0.5	0.5	0.5	0.5
Area 6	0.5	0.5	0.5	0.5
Area 7	0.5	0.5	0.5	0.25
Area 8	1	0.5	0.5	0.5

Transshipment Path Planning

As can be seen from the above table, the garbage in area 2-3 can be checked separately by medium-sized garbage trucks, and the garbage in other areas in various time periods can be collected and transported according to a certain route. The garbage transportation routes in areas 1 and 4-8 are planned, and the distances between the areas are shown in Table 10.

Table 10. Distances between regions

	Area1	Area4	Area5	Area6	Area7	Area8
Area1	0	23.71	20	21.63	13.42	18.11
Area 4	23.71	0	37.55	34.44	27.57	24.82
Area 5	20	37.55	0	7.21	10	15.23
Area 6	21.63	34.44	7.21	0	8.49	10
Area 7	13.42	27.57	10	8.49	0	7.21
Area 8	18.11	24.82	15.23	10	7.21	0

Table 11 shows the distance between each area and the garbage transfer station.

Table 11. Distances between each region and the transfer station

	Area1	Area4	Area5	Area6	Area7	Area8
Distances	21.65	16.57	25.57	20.38	16.37	10.48

The design of the garbage transfer route in the East Lake Scenic Area is a traditional VRP problem, for which the relevant symbols and variables are defined as follows:

Cij: Cijcorresponds to each arc (i, j) and represents the cost of transportation from customer i to customer j, and its meaning can be distance, expense, time, etc.

Dij: the distance of the empty point of the Dij node

A: A={(i, j| i, j∈ V, i≠ j} is the set of arcs

V: node set, V= {0.1, 2, ..., n}, where 0 represents the waste transfer center

V': customer point set V'= {1, 2, ..., n} This should be the place where each garbage point in the school is generated

N: The point where the garbage is generated

q: The maximum loading capacity of the vehicle

Gi: The output of the garbage generation point i

m: Number of service vehicles, in a general vehicle routing problem, the number of service vehicles assumes that all vehicles are of the same type, i.e., the same maximum loading capacity and maximum vehicle distance constraints.

R: vehicle set, R= {1, 2, ..., m}

Ri: vehicle route, R={(0, i, …, in, 0)|i1,…,in ∈V`, i∈ R}

$xijk=\begin{cases}1, & \text{vehicle k from i to j}\\ 0, & \text{otherwise}\end{cases}$, $yik=\begin{cases}1, & \text{The point of demand i is served by vehicle k}\\ 0, & \text{otherwise}\end{cases}$

Then the mathematical model of vehicle transportation planning is obtained as follows:

$$Min=\sum_{i=0}^{n}\sum_{j=0}^{n}\sum_{k=1}^{n} Cij\ xijk \tag{1}$$

$$\sum_{i=1}^{n} giyik \leq q \qquad \forall k \in R \tag{2}$$

$$\sum_{k=1}^{m} yik=1 \qquad \forall i \in V` \tag{3}$$

$$\sum_{i=0}^{n} xijk= yik \qquad \forall j \in V`, \forall k \in R, \tag{4}$$

$$\sum_{j=0}^{n} xijk= yik \qquad \forall i \in V`, \forall k \in R, \tag{5}$$

$$\sum_{j=0}^{n} xijk= yik \qquad \forall i, j \in V`, \forall k \in R, \tag{6}$$

In this model, Eq. 1 is the objective function, i.e., the minimum transportation cost; Eq.2 defines the vehicle capacity constraint; Equation 3 ensures that only one vehicle is used to transport garbage to each garbage generating point; Equations 4 and 5 restrict the arrival and departure of a waste generating point to one and only one vehicle[19,20].

According to the garbage production of each location, the optimal route sequence is shown in Figure 3.

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X_Best =

     4     6     5     3     1     2

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Figure 3. Optimal route sequence

Therefore, the route of transporting garbage is area 6 - area 8 - area 7 - area 5 - area 1 - area 4, as shown in Figure 4, the blue circle is the location of the garbage transfer station, the garbage transport vehicle starts from here, first arrives at area 6, processes the garbage of Luoyan Scenic Area and wetland park, then goes to area 8 to deal with the garbage of Fengdu Mountain Scenic Area, then arrives at area 7, treats the garbage of the East Lake Plum Garden and Moshan Scenic Area, and then arrives at area 5 to deal with the garbage of the East Lake Piper Scenic Area and the East Lake of the Forest Park, After that, go to Area 4 to deal with the garbage in the White Horse Station Scenic Area of North Happy Valley, and finally return to the garbage transfer station to complete the transportation of garbage in the scenic spot.

To sum up, the final transportation plan can be obtained: each day will be divided into four time periods, namely 7:00-10:00, 10:00-13:00, 13:00-17:00, 17:00-20:00, area 1-3 is a popular attraction area, which needs to be transported separately in each time period, the garbage in area 2 and area 3 can be transported at one time, and the remaining garbage in area 1 and the garbage in area 4, area 5, area 6, area 7, area 8 are transported in the same vehicle, and according to the route" Zone 6 - Zone 8 - Zone 7 - Zone 5 - Zone 1 - Zone 4".This is shown in Figure 4.

Figure 4. Transportation route map

ANALYSIS OF RESULTS

As obtained from Table 10, when the garbage is transferred according to the original transfer scheme, the daily garbage transport number is 156.75 times, and the total transfer distance is 2464.29. Based on the ratio of the actual distance to the length of the coordinates, the following results are:

The actual total distance of transshipment = 2464.29 * 25 = 61607.25 meters ≈ 61.6 kilometers

Check the information to get the vehicle fuel cost of 0.5658 yuan / km, you can get:

Daily garbage vehicle fuel consumption cost = 0.5658 * 61.6≈34.85 yuan

The waste transfer workers work eight hours a day, during which they can transport 24 garbage trucks, and each waste transfer requires two people, so it can be calculated that about 12 waste transfer workers are needed.

Based on the location of the new garbage transfer station and the garbage transfer route, and according to the survey data, the daily garbage transport number is 16 times, and the total transfer distance is 518, which is converted according to the ratio of the actual distance to the coordinate length:

The actual distance of transshipment = 518 * 25 = 12950 meters = 12.95 kilometers

Daily vehicle fuel consumption = 0.5685 * 12.95 = 7.36 yuan

There are 4 trains that need to be transported in each time period, and two groups of workers can be carried out at the same time, and each group has three people, so that about 6 workers are needed.

Comparing the old transfer plan with the new transfer plan, the daily vehicle fuel consumption was reduced from 34.85 yuan to 7.36 yuan, and the number of workers required was reduced from 12 to 6. It can be seen that the site selection of garbage transfer stations and the re-planning of transfer routes have greatly reduced the total cost of garbage transportation.

SUMMARY AND OUTLOOK

By residing the garbage transfer station and planning the garbage transfer route, the vehicle fuel consumption cost is reduced, the number of workers required is reduced, and the total waste transportation cost is greatly reduced. Although the location of the transportation route and transfer station calculated in this paper has significantly reduced the cost of garbage transportation and labor cost, there are still some shortcomings

1. Mix all types of garbage transportation, but now many cities are advocating garbage classification, the garbage in the school does not consider the classification of garbage, and the process of garbage loading will increase the link of processing recyclable garbage, which increases labor costs to a certain extent.

2. There is a certain error in the data of the survey, such as the garbage output and location coordinates, the garbage output is in the box, and the garbage output of each scenic spot is converted, and there will be a certain error. The coordinates of each scenic spot are measured on a map at scale, and the actual distance between places is not measured, so there will be a small amount of error.

3. The garbage output of the survey is a fixed value by default, and the garbage output may fluctuate to a certain extent without taking into account, and the output of the survey is the data of working days, and the garbage output on rest days is not considered.

Therefore, there is still a lot of work to be done for the location of garbage transfer stations and the route planning of recycling, and the research on site selection and route planning needs to be further improved in the future.

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