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Research on the Evaluation Methodology of Expressway Service Area from Multi-Perspective

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Abstract. In order to evaluate the service quality of the expressway service area scientifically, the comprehensive evaluation indexes of the service area are constructed from the three aspects of facility layout, user perception and green ecology. The calculation and classification methods of the index layer in each evaluation system are put forward, and the adaptability of each evaluation method is discussed. The results show that the evaluation system of service areas from different perspectives is different. The evaluation indicators based on facility layout can be quantitatively calculated, and the weight analysis is carried out by the entropy method; The evaluation indicators based on user perception are subjective and more suitable to use the analytic hierarchy process. The evaluation index of the service area based on green ecology can use the coordinated development index to reflect the coordination of the service area in the regional environment.

1. Introduction

As a basic part of expressway, service area plays an irreplaceable role in traffic safety of vehicles and rest of drivers[1]. With the rapid development of economy, when people enjoy more efficient, convenient and distinctive service areas, they also put forward higher requirements for their overall development. Excellent evaluation method can not only accurately measure the comprehensive service level of service area, but also ultimately improve the sustainable development ability of service area on expressway network[2]. Similarly, the sustainable development ability of service areas and the frequent flow of production factors will also react on the evaluation system. In a word, a reasonable evaluation system plays a positive role in guiding the investment and construction capacity of the service area. Also, good service area construction will certainly promote the reconstruction of the overall evaluation system[3]. Based on the above background, this paper studies the evaluation system and methods of expressway service area in order to promote the managers to obtain high-efficiency benefits and the surrounding economy to accelerate development.

2. Evaluation method based on facility layout

2.1 Comprehensive evaluation index

The facility layout of service area is an important reflection of its comprehensive service level. It has a remarkable systematicness that the overall layout and facility level under the basic and expanding functions are taken as objects in the evaluation system. Based on the evaluation system of facility layout,

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its criterion layer includes overall layout and infrastructure[4]. According to the analysis angle of the criterion layer, the index layer with multi-level criteria is divided, and finally a complete service area evaluation system is constructed. The specific book sword is shown in Table 1.

Table 1. Comprehensive evaluation index based on facility layout

Target layer	First level	Second level
Service area evaluation system	Overall layout	Scientificality of layout rationality of scale
	Infrastructure	Facility utilization Facility integrity

The index level of overall layout includes scale rationality and layout rationality. Rationality of scale mainly refers to the overall scale of service area, including the area of service facilities and the proportion of different functions of each facility.

2.2 Estimation and classification of evaluation indicators

2.2.1 Scientificity of layout. Scientificity of layout tends to evaluate the demand of people and vehicles, which is mainly expressed by the travel time of customers between different facilities in the service area. Therefore, it can reflect the effectiveness of service area on the distribution of traffic and traffic flow. Specific algorithms for scientific layout indicators are as follows:

$$\mathrm{S1} = \max\ \mathrm{K}ij/K'$$

In the formula, $\mathrm{S1}$ is the scientificity of layout, $\mathrm{K}ij$ is the time required for customers to walk from facility i to facility j, and K' is the maximum walking time accepted by customers.

2.2.2 Rationality of scale. The rationality of service area scale mainly evaluates the responsiveness of overall scale to service level by measuring its area and capacity of service facilities. The specific algorithm is as follows:

$$\mathrm{S2} = \left|\sum Hi - \sum H'i\right|$$

In the formula, $S2$ is the rationality of scale, Hi is the actual building area of i facility, $H'i$ is the theoretical building area of facility.

2.2.3 Rationality of scale. Infrastructure indicators are usually evaluated by scoring. Among them, facility utilization rate refers to the ratio of actual use time to planned use time of facilities in service area, which can be quantified accurately. Facility integrity tends to be described qualitatively. It can be judged by the inspector's score on the defect of basic equipment in the service area. Every missing item is deducted by 10 points and up to 100 points. Specific classification criteria are shown in Table 2.

Table 2. Facility usage and integrity classification table.

Grading standard	Facility utilization	Facility integrity
A	80%—100%	80%—100%
B	70%—80%	70%—80%
C	50%—70%	50%—70%
D	30%—50%	30%—50%
E	0%—30%	0%—30%

2.3 Determination of index weight

When using the established evaluation system for field research, the most critical step is to give reasonable weight to different indicators, so that the evaluation is more comprehensive and scientific. Entropy method can be used to analyze the overall impact factors of different index values on the system, so as to obtain the reasonable weight of each index and ensure the scientificity of the comprehensive evaluation system. In information theory, entropy represents the degree of disorder of a system, and information is the opposite concept of entropy, which measures the degree of orderliness of a system.

Entropy and information are equal in size, but opposite in direction. That is, the absolute values are equal and the symbols are opposite. For example, the original data matrix of the evaluation system is $X=(X_{ij})_{AxB}$, where A represents the number of evaluation objectives and B is the number of evaluation indicators. For a certain index X_j in the system, the greater the difference between X_{ij} and X_j, the greater the impact of the index on the overall evaluation; if the index values are close to each other or all equal, the lower the reference value of the index in the overall evaluation. The weight algorithm of each index in the evaluation system based on facility layout is as follows:

$$A_j = -\frac{1}{lnn}\sum_{i=1}^{n} y_{ij}\ln(X_{ij})$$

$$a_j = 1 - A_j$$

$$F_j = a_j / \sum_{j=1}^{n} a_i$$

In the formula: A_j is the entropy of J index, a_j is the j index, F_j is the weight of j index, n is the index number, X_{ij} is the specific value of index.

3. Evaluation method based on user perception

When evaluating the service level of service area comprehensively, we should not only ensure the rationality of infrastructure and scale layout, but also improve its social welfare and self-improvement based on users'needs.

3.1 Construction process

The construction of evaluation system based on user perception has great bidirectional subjectivity, mainly because the dimensions of perceived service quality studied by different builders are quite different. At the same time, customer experience of service level is divergent[5]. Therefore, the evaluation index should be formulated according to the main function and objective operation characteristics of the service area, and the specific process is shown in Figure 1:

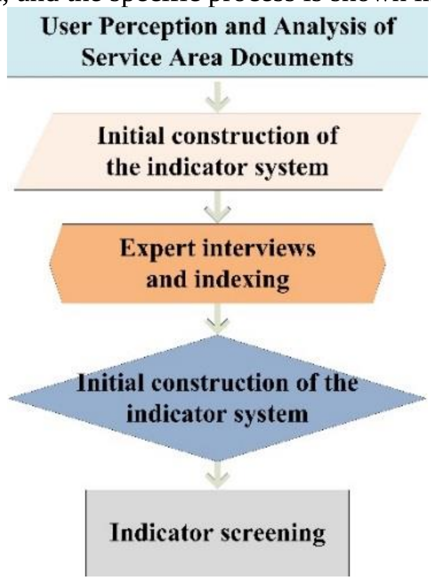

Figure 1. Construction process of evaluation system

3.2 Grading of evaluation indicators

The first level index of the evaluation system based on user perception mainly describes the objective nature of the service area, including security, tangibility, reliability and comfort. Within the scope of the first-level indicators, according to the characteristics of customers, the second-level indicators of the evaluation system are constructed by merging the indicators with high correlation. Specific indicators are shown in table 3.

Table 3. Evaluation indicators based on user perception

Target layer	First level	Second level
User perception	Safety	Fire emergency facilities
		Public order situations
		Medical care
	Tangibility	Restaurant, resting place
		Scale and layout of parking area
		Facilities in other public service areas
	Reliability	Attitudes of service personnel
		Fees, pricing standards
		Service efficiency
	Comfort.	Greening layout
		Overall cleanliness of facilities
		Seasonal services

3.3 Determination of index weight

Because different groups of users have different judgments on Evaluation indicators, it is more suitable to adopt subjective comprehensive evaluation methods, such as analytic hierarchy process (AHP). The main purpose of analytic hierarchy process (AHP) is to rank and calculate the elements of each layer, including factors, objectives, indicators and their upper elements. Thus, the problem is divided into hierarchical models with multi-layers. The specific calculation is as follows:

$$w_i = \lambda_i / m$$

In the formula: λ_i is the eigenvalue of each index， m is the number of index variables.

In addition, the weight usually takes the form of relative calibration, which has a certain degree of subjectivity. At the same time, the evaluation system requires that the groups involved in the calibration should have good professional literacy and clear discrimination ability, so the final judgment of the calibration is more suitable to use the quantitative form, such as the construction of the judgment matrix. According to the eigenvectors and eigenvalues of the judgment matrix, the research is carried out. The eigenvectors are used to calculate the weights of each layer relative to the previous one, and the eigenvalues are usually used to check the consistency, and then complete the hierarchical single ranking of the whole model. After obtaining the ranking weights of each layer element relative to the previous one, the weights of each layer are calculated comprehensively to obtain the final ranking of each layer, and the consistency test is carried out. Common test methods include KMO test and BARLETT test.

4. Evaluation method based on green ecology

Due to its special geographical location, the waste in service area is more difficult to deal with than similar buildings, which has a serious impact on the natural environment and economic and social. Therefore, the construction of service area evaluation system based on green ecology is particularly important.

4.1 Basic evaluation index

The construction process of green ecological evaluation system is to quantify the information of green technology factors in service areas, thus reflecting the coordination between service areas and regional environment. Therefore, the evaluation indicators include: ecosystem and environmental protection, resource consumption and conservation, building environment and quality, and energy consumption. Secondary indicators can be subdivided according to the first-level indicators, combined with the operational characteristics of services and their own positioning. Specific indicators are shown in table 4.

Table 4. Evaluation system of service areas based on green ecology

Target layer	Level I indicator layer	Secondary index layer
Green ecological evaluation system of service area	Ecosystem and environmental protection	Eco-environmental protection
		land resource
		Humanistic environmental protection
	Resource consumption and saving	Solid waste management
		Water resources management
		Utilization of recycled materials
	Architectural environment and quality	The surrounding environment of the building
		Disaster prevention and mitigation
		Construction infrastructure
	Energy consumption	Building energy
		Energy-saving technology and equipment
		Renewable energy

The indicators of green ecological evaluation system should be diversified, systematic and targeted. According to relevant statistical data and standard specifications, constructors can select quantitative indicators with high relevance to the building environment as far as possible.

4.2 Coordination development index

Because of the particularity of the environmental system and the large number of secondary indicators, the weight difference is small. When the traditional weight assignment model is used for analysis, the final results are less relevant to the actual operation status. Therefore, when analyzing the evaluation system based on green ecology, it is more suitable to use the coordinated development index to reflect the coordination of service areas in the regional environment[6]. Firstly, assuming that the weights of each index are consistent, the expert scoring method is used to determine the score of each index. The average score of the first index is m, and the second index is n. Then the coordinated development index of each index relative to the whole is calculated according to the following formula. The larger the result, the better the coordination of the environment in the service area.

$$\mathrm{I} = \frac{1}{1 + e^{-mn}}$$

In the formula, m is the average score of the first index, n is the average score of the second index.

5. Conclusion

Scientific service area evaluation method is an important prerequisite to ensure the planning, layout and operation of service area, and plays a positive role in guiding the sustainable development ability of service area. The specific conclusions of this paper are as follows:

(1) Based on the evaluation method of facility layout, its evaluation index includes scientific layout, rationality of scale, facility utilization rate and facility integrity. Because of the objectivity of the index, more accurate quantitative calculation can be carried out, and the weight analysis can be carried out by using the entropy method.

(2) The evaluation method based on user perception is more suitable for analytic hierarchy process (AHP) because the construction and calculation of evaluation indicators are subjective.

(3) Because of the particularity of the environmental system, the number of secondary indicators in the evaluation system is large and the weight difference is small. It is more scientific and reasonable to use the coordinated development index to reflect the coordination of the service area in the regional environment.

Acknowledgments

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