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Evaluation of Road Landscapes in Tibet Cultural Tourism and Creative Park Based on POE and AHP

JIANG Pengcheng[1], AI Qiao[1], LI Guoqing[2]
(1. School of Architecture and Urban Planning, Chongqing Jiaotong University, Chongqing 400074, China; 2. Chongqing College of Humanities, Science & Technology, Chongqing 401524, China)

Abstract The internal road landscapes of Tibet Cultural Tourism and Creative Park at an altitude of 3,650 m were taken as the research object, and focusing on the restrictive effect of the high-altitude extreme environment on the road landscapes, data were collected through data crawling and survey questionnaires. Post occupancy evaluation (POE) was used to establish an evaluation system containing five dimensions and 24 indicators (including five high-altitude specific indicators), and statistical analysis was conducted by using multiple methods such as the analytic hierarchy process (AHP), SD semantic difference method, and IPA image analysis method. The results show that the respondents are generally satisfied with the overall evaluation of road landscapes in Tibet Cultural Tourism and Creative Park. However, the performance of high-altitude associated indicators is worrying. That is, anti-glare safety requirements are not met, and the survival rate of plateau plants is lower than the requirements of landscape effect; the integration of cultural landscapes fails to reflect regional culture. Based on this, high-altitude adaptive design strategies of three-dimensional synergy of "culture, ecology and security" were proposed to provide a certain paradigm reference for the evaluation and design of road landscapes in high-altitude areas.

Keywords High altitude, Road landscape, Landscape assessment, POE, AHP
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Road landscape, an important public space in a city, integrates multiple values of production, life and ecology, and plays a key role in improving urban environment, enhancing travel experience and enriching urban landscape[1]. The post occupancy evaluation (POE) method spans multiple fields, providing strong support for the development of road and landscape design theories[2]. Liao Rui[3], Yu Bing et al.[4] and Zhao Yipeng[5] adopted the analytic hierarchy process (AHP) to establish the evaluation system of functions of green space landscape along urban roads and roads in a scenic area, and put forward suggestions for diversity optimization. Yang Lijia[6] and Xin Lei et al.[7] used the SD (semantic differential) method to analyze and evaluate the current situation of road traffic and urban road greening, and put forward corresponding suggestions for road landscape. Chai Mingyang[8] conducted a difference analysis on the satisfaction and importance of farmland landscapes using the importance-performance analysis (IPA) method.

Existing research indicates that the diversity, complexity and regional differences of road landscapes have led to the fact that no unified consensus has been reached on evaluation criteria and paradigms. Current studies mostly focus on the low-altitude areas in the central and eastern regions. There is still a gap in the evaluation system for the special environments at high altitudes (such as low temperature and low oxygen, strong ultraviolet rays, and ecological fragility) and unique cultures. In this study, taking Tibet Cultural Tourism and Creative Park as an example, the "high-altitude adaptability evaluation framework" was innovatively proposed, and the risk of ultraviolet glare, the integration degree of cultural landscapes in Tibet, and the growth survival rate of high-altitude plants were incorporated into the quantitative system for the first time to fill the methodological gap in this field.

1 Study area and current situation

Tibet Cultural Tourism and Creative Industry Park (built in 2012) is located in the southeast of Lhasa, facing the Potala Palace across the river. It is a representative of high-altitude cultural and creative industrial parks in China. The park covers an area of 8.14 km^2, and the total length of roads is 10.75 km. Due to the high-altitude special environment, the road landscapes are significantly different from that in the inland areas.

In this study, 18 typical road sections (including main and secondary roads and sidewalks) within the park were selected, and an evaluation system was constructed; the design rules of road landscapes at high altitudes were explored to provide support for the planning, maintenance and cultural inheritance of the park.

2 Data sources and research methods

2.1 Data sources

18 sections within the park were selected for on-site exploration and questionnaire distribution in August 2023 and February 2024. Data was crawled using the Scrapy framework, and text sentiment analysis was conducted using TextBlob (Fig.1).

Following the principle that the ratio of the object to sample size is 1∶5, a questionnaire containing 21 indicators was designed and distributed to three groups: tourists, personnel

Fig.1 Emotional analysis of road landscapes in Tibet Cultural Tourism and Creative Park

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from greening departments, and local drivers. A total of 147 valid questionnaires were collected (with an effective rate of 98%). The reliability of the questionnaires was analyzed by SPSS (Cronbach's Alpha=0.92), indicating that the design was reasonable and reliable[9].

2.2 Research methods

2.2.1 Establishing an evaluation system based on POE. This POE evaluation aims to systematically collect feedback on the use of road landscapes in the park, assess its effectiveness, and provide data support for optimization[10-14]. The evaluation adheres to the principles of science, comprehensiveness, operability and user orientation.

In view of the significant differences in production, life and ecology between Lhasa area and inland low-altitude areas (Table 1), the evaluation indicator system has been adaptively adjusted. Five indicators in the criteria layer and 24 indicators in the indicator layer were finally determined (Table 2), including multiple high-altitude characteristic indicators such as anti-glare, regional characteristic display, and plant growth status.

2.2.2 Determine the weight of AHP indicators. Based on the evaluation indicator system, a

Table 1 Differences between Lhasa area and inland low-altitude areas

Type	Regional difference	Lhasa area	Inland low-altitude area
Production	Transportation mode	Highways	Highways, railways, waterways, etc.
	House construction	Most of them are thick-walled and low-rise buildings	Well-ventilated high-rise buildings
	Road traffic volume	The land is vast and sparsely populated, with a low density	High urbanization and high density
	Seasonal flow	Fluctuating with the peak tourist season	Relatively stable
	Road landscape material	Cold-resistant and sun-resistant special material	Diverse materials
	Energy	Photovoltaic, wind power, hydropower, etc.	Fossil energy
Life	Use of road space	It is relatively limited and is mostly used for gathering and distributing, providing shade, etc.	It is relatively extensive and is mainly used for chatting, enjoying the cool, square dancing, etc.
	Driving habit	Road conditions are complex, so drivers should be more cautious	Drivers are relatively relaxed because road conditions are usually good
	Pedestrian traffic awareness	Rather weak	Rather profound
	Road traffic volume	The land is vast and sparsely populated, with a low density	High urbanization and high density
	Pace of life	Slower	Faster
	Diversity of road users	Agricultural vehicles, livestock crossing streets, etc.	Motor vehicles
	Exercise habit	Oxygen is thin and the intensity of exercise is low	Sufficient oxygen and high intensity of exercise
	Time of outdoor activities	Relatively less	Relatively more
	Landscape style	Nature, and culture	Diversification
	Road anti-glare	Daytime	Night car lights
Ecology	Road scenery	Natural scenery	Urban scenery
	Ecological sensitivity	Higher	Lower
	Plant varieties selected	Plateau characteristic plant	More
	Plant growth condition	Poor	Better
	Plant characteristic	Cold-resistant and sun-resistant	Diversity
	Plant shading	Relatively low shading rate	Relatively high shading rate

Table 2 Road landscape indicator system and their weight in Tibet Cultural Tourism and Creative Park

Target layer	Criterion layer	Weight	Indicator layer	Weight	CR
	Safety characteristic (B1)	0.275 51	Visual obstruction (C1)	0.394 86	0.040 00
			Anti-glare (C2)	0.177 03	
			Plant color (C3)	0.141 04	
			Intersection flow rate (C4)	0.072 96	
			Lighting (C5)	0.214 12	
	Cultural characteristic (B2)	0.258 84	Display of regional characteristics (C6)	0.311 90	0.052 00
			Degree of integration between landscape and culture (C7)	0.490 48	
			Utilization of native plants (C8)	0.197 62	
Evaluation of the municipal road landscapes in Tibet Cultural Tourism and Creative Park (A)	Landscape visual haracteristic (B3)	0.137 75	Harmony of roadside plants (C9)	0.350 71	0.004 00
			Landscape space (C10)	0.109 33	
			Viewing duration and seasonal changes (C11)	0.189 25	
			Aesthetic sense (C12)	0.350 71	
	Ecological characteristic (B4)	0.242 17	Plant growth condition (C13)	0.257 38	0.034 00
			Vegetation coverage and diversity (C14)	0.248 47	
			Sustainable design (C15)	0.153 57	
			Plant shading (C16)	0.101 25	
			Microclimate regulation (C17)	0.123 59	
			Air purification (C18)	0.104 69	
			Soil and water conservation (C19)	0.080 07	
	Service characteristic (B5)	0.085 72	Lighting facility (C20)	0.426 13	0.004 00
			Sanitation facility (C21)	0.101 67	
			Identification system (C22)	0.274 25	
			Transportation facility (C23)	0.162 06	
			Road space (C24)	0.244 24	

model was constructed by using the analytic hierarchy process (AHP)[15-18], and road landscapes in the park (A) were quantitatively analyzed by using the 1 – 9 scale, covering five core elements. The consistency index (CI) and consistency ratio (CR) of the constructed judgment matrix are both less than 0.1, meeting the consistency inspection standards.

Experts in the fields of urban planning, landscaping and road landscape design were invited to score and evaluate the indicators, and the weight of each indicator was obtained through a judgment matrix. In view of the regional characteristics of sparse permanent residents and fluctuating tourism in Tibet, the weight of safety in the evaluation system was appropriately reduced, and the weight of ecology and culture was increased.

2.3 SD semantic and IPA quadrant analysis

In this study, the SD method was adopted to quantify public landscape perception to objectively reflect the actual quality of the landscapes[19-22].

Based on the results of quantitative analysis, the advantages and disadvantages of the road landscapes were identified, and then targeted optimization suggestions were put forward. 24 pairs of semantically opposite adjectives were set, and 147 respondents scored 24 indicators of road landscapes of the park. The scoring criteria are based on the degree of consistency between the evaluation content and the on-site landscapes (Table 3), and a 5-level scale was used (−2 – 2 points). Among them, an average score of 0 – 2 means a positive factor, and an average score from −2 to 0 stands for a negative factor. Satisfaction can be classified into four levels according to the score.

In addition, the IPA quadrant analysis method was used to identify the "high importance–low performance" elements and optimize the allocation of resources for improvement[23].

3 Results and analysis

3.1 Weight of AHP indicators

Through the weight analysis of the indicator system, it is found that the weight ranking of the criterion layer is: B1 > B2 > B4 > B3 > B5. The top three indicators in terms of weight ranking are C1, C7 and C9, reflecting the differences in the importance of various indicators in the landscape evaluation system.

3.2 Results of SD semantic and IPA quadrant analysis

The results of SD semantic evaluation (Table 4) show that the criterion layer contains 1 negative factor and 4 positive factors, while the indicator layer includes 9 negative factors and 15 positive factors. In the satisfaction evaluation, there are 5 "very satisfied" items, 10 "relatively satisfied" items, and 9 negative factors.

Based on the results of SD semantic analysis (Fig.2 and Fig.3), the IPA four-quadrant analysis method was further adopted to determine the improvement priority. The results reveal that in the criterion layer, B2 and B4 are restoration areas, and B1 is an advantage zone, while B3 and B5 are maintenance areas. In the indicator layer, 4 items such as C7 are restoration areas, and four items such as C2 are opportunity areas; 9 items including C23 are maintenance areas), and 4 items including C12 are advantageous areas.

3.3 Analysis of evaluation results

Based on the above research methods, the analysis of the evaluation results covers the following five aspects.

(1) The expression of regional culture is insufficient. The cultural features of some sections have a low degree of integration with road landscapes. High-altitude culture relies more on architectural carriers, which is significantly different from low-altitude culture.

(2) Greening structure is monotonous. In some sections, plant layers are monotonous, and the application of native species is insufficient. High-altitude environments restrict the variety and growth of plants, exacerbating the limitations.

(3) There are safety performance hazards. Some plants along the main roads have no anti-glare function, and their colors are monotonous. The strong sunlight in Lhasa leads to severe light pollution (such as dizziness caused by building

Table 3 SD semantic evaluation of road landscapes in Tibet Cultural Tourism and Creative Park

Criterion layer	Indicator layer	Content	SD semantic evaluation
Safety characteristic (B1)	Visual obstruction (C1)	Degree of visual obstruction	Strong – weak
	Anti-glare (C2)	Anti-glare degree	Strong – weak
	Plant color (C3)	Influence of plant color	Strong – weak
	Intersection flow rate (C4)	Degree of intersection flow	High – low
	Lighting (C5)	Impact of lighting on safety	Strong – weak
Cultural characteristic (B2)	Display of regional characteristics (C6)	Display degree of regional characteristics	Rich – single
	Degree of integration between landscape and culture (C7)	Degree of integration between landscape and culture	Harmonious – general
	Utilization of native plants (C8)	Number of native plants	More – less
Landscape visual characteristic (B3)	Harmony of roadside plants (C9)	Harmony between roadside plants and the environment	Harmonious – general
	Landscape space (C10)	Aesthetic appeal of landscape space	Aesthetically pleasing – average
	Viewing duration and seasonal changes (C11)	Viewing duration and richness of seasonal changes	Rich – single
	Aesthetic sense (C12)	Overall aesthetic sense	Aesthetically pleasing – average
Ecological characteristic (B4)	Plant growth condition (C13)	Degree of plant growth condition	Good – average
	Vegetation coverage and diversity (C14)	Degree of vegetation coverage and diversity	Rich – single
	Sustainable design (C15)	Effect of sustainable design	Good – average
	Plant shading (C16)	Plant shading rate	High – low
	Microclimate regulation (C17)	Microclimate regulation capacity	Strong – weak
	Air purification (C18)	Air purification capacity	Strong – weak
	Soil and water conservation (C19)	Soil and water conservation capacity	Strong – weak
Service characteristic (B5)	Lighting facility (C20)	Whether lighting facilities are complete	Complete – missing
	Sanitation facility (C21)	Whether sanitation facilities are complete	Complete – missing
	Identification system (C22)	Whether identification system is complete	Complete – missing
	Transportation facility (C23)	Whether transportation facilities are complete	Complete – missing
	Road space (C24)	Degree of utilization of road space	More – less

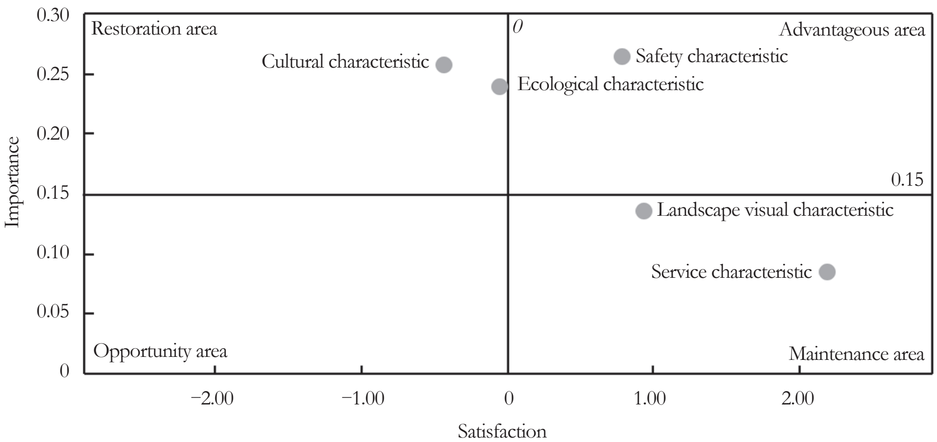

Fig.2 IPA quadrant chart of satisfaction and importance of the criterion layer for road landscapes in Tibet Cultural Tourism and Creative Park

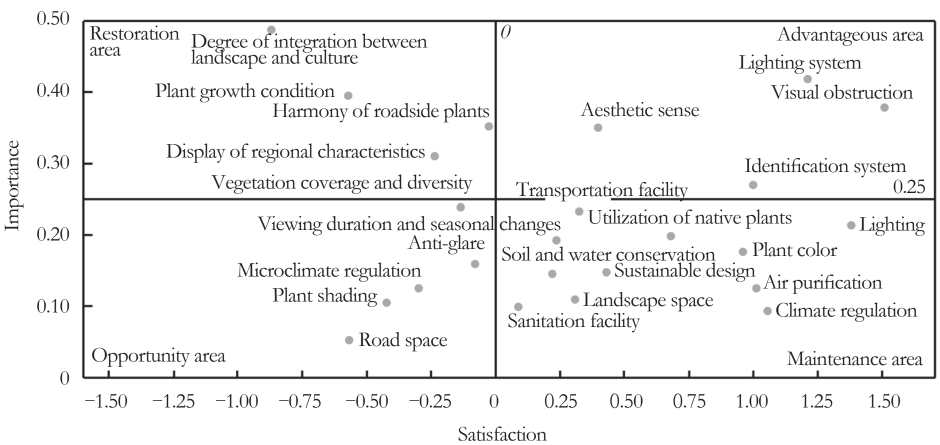

Fig.3 IPA quadrant chart of satisfaction and importance of the indicator layer for road landscapes in Tibet Cultural Tourism and Creative Park

Fig.4 Effects before and after the creation of three-dimensional landscapes

reflection glare), and the demand for anti-glare is higher than that in inland areas.

(4) There is a lack of ecological adaptability. The absence of design specifically for the ecological sensitivity, resource scarcity and long daylight hours at high altitudes leads to inefficient water resource utilization and microclimate imbalance (such as sudden midday heating).

(5) The functions of road space are mismatched. The demand for crowd gathering and dispersion in road space is high (characteristic of "sunshine cities"), and landscape guidance and barrier-free facilities are insufficient.

4 Plans and strategies

Based on the existing problems, optimization paths are proposed.

(1) Weather resistance design of cultural carriers: anti-ultraviolet aging Tibet-style sculptures, cultural walls and other symbols are implanted on the main and secondary roads, and cold-resistant native plants such as Salix zangica N. Chao are configured to form cultural identification corridors, with a survival rate of over 90%.

(2) Creation of three-dimensional landscapes: a four-level structure of "trees-sub-trees-shrubs-ground cover" (such as *Prunus sibirica* L., *Prunus persica* 'Duplex', *Salix alba* 'Tristis', *Juniperus procumbens* Sargent, etc.) is constructed to enhance the layers (Fig.4).

(3) Coordination of safety functions: substandard seedlings are replaced, and their regular maintenance is carried out. The vegetation along the glare sections is replaced with dark-leaf evergreen shrubs, with a leaf surface reflectivity of no more than 15%. A seasonal pruning system is established to ensure that the anti-glare height is 1.8–2.2 m. Plants with rich leaf colors are selected to enhance the anti-fatigue function.

(4) Enhancement of ecological resilience: native plants are utilized, and 11 sponge facilities are set up to achieve water circulation and microclimate regulation, an annual water collection volume of ⩾ 800 m^3, and a decrease of 6 °C in surface temperature (at noon).

(5) Integration of humanized service functions: trees with wide crowns are selected to enhance shading rate, and solar self-luminous guiding signs and barrier-free facilities on gentle slopes are added.

5 Conclusions

Road landscapes, as the spatial carriers of urban green space systems, possess multi-dimensional values in shaping urban images, enhancing perceptual experiences, inheriting regional cultures, and building collective memories. In this study, based on the high-altitude regional characteristics of Lhasa, the main conclusions are as follows.

(1) An evaluation system for road landscapes in Tibet Cultural Tourism and Creative Park covering 5 dimensions and 24 indicators was constructed. The index system was built based on the post occupancy evaluation (POE), and the weight was determined with the help of analytic hierarchy process (AHP); the SD semantic difference method was coupled with the IPA analysis method to form guiding conclusions.

(2) High-altitude specific indicators such as anti-glare, plant growth/shading, microclimate regulation, and road space are innovatively introduced to form an altitude adaptive landscape evaluation paradigm.

(3) The research has filled the theoretical gap in the evaluation method system of high-altitude road landscapes, and proposed a collaborative

Table 4 SD Semantic Evaluation Results of Road Landscapes in Tibet Cultural Tourism and Creative Park

Criterion layer (score)	Indicator layer	Number of evaluated subjects						Total score	Average score
		Very consistent	Consistent	General	Not consistent	Very inconsistent	Order		
Safety characteristic	Visual obstruction	112	24	8	3	0	1	45	1.666 66
(0.846 24)	Anti-glare	19	32	42	28	26	17	−10	−0.068 02
	Plant color	51	55	32	3	6	6	142	0.965 98
	Intersection flow rate	34	22	56	22	13	11	42	0.285 71
	Lighting	86	41	12	6	2	3	203	1.380 95
Cultural characteristic	Display of regional characteristics	13	26	36	57	15	19	−35	−0.238 09
(-0.428 57)	Degree of integration between landscape and culture	8	16	37	12	74	24	−128	−0.870 74
	Utilization of native plants	63	16	29	36	3	7	100	0.680 27
Landscape visual characteristic	Harmony of roadside plants	17	36	21	57	16	16	−3	−0.020 40
(0.925 17)	Landscape space	26	28	63	25	5	10	45	0.306 12
	Viewing duration and seasonal changes	33	28	48	17	21	12	35	0.238 09
	Aesthetic sense	34	21	70	13	10	8	59	0.401 36
Ecological characteristic	Plant growth condition	23	16	22	25	61	22	−85	−0.578 23
(-0.013 48)	Vegetation coverage and diversity	13	29	46	43	16	18	−20	−0.136 05
	Sustainable design	26	43	12	43	14	14	25	0.130 06
	Plant shading	17	28	14	48	40	21	−66	−0.448 97
	Microclimate regulation	20	27	25	39	36	20	−44	−0.299 31
	Air purification	76	23	27	16	5	4	149	1.013 60
	Soil and water conservation	26	43	42	10	26	13	33	0.224 48
Service characteristic	Lighting facility	87	46	9	5	0	2	215	1.465 58
(2.183 23)	Sanitation facility	32	23	34	42	16	15	13	0.088 43
	Identification system	59	47	29	7	5	5	148	1.006 80
	Transportation facility	57	43	24	16	7	9	47	0.319 72
	Road space	12	11	29	68	27	23	−87	−0.591 83

design strategy of "safety-ecological-culture". The results have been applied to the practice of park renovation.

(4) The limited number and scope of the research samples may affect the comprehensiveness of the evaluation. In the follow-up research, it is suggested to expand comparative studies on different altitude gradients, expand the construction of high-altitude landscape ecological models, and develop a multi-source data fusion analysis platform to enhance the reliability and spatial applicability of research results.

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(To be continued in P22)

facility density. Secondly, it achieves a 3-layered optimization of "ecology - function - perception" by linking green patches through non-motorized transportation system and integrating aromatic gardens. Thirdly, it introduces a point-based incentive system to encourage resident participation in plant maintenance, which helps to address the traditional governance dilemma of "government-led initiatives with resident disengagement".

The Green-Healthy City concept is not only a new direction for urban development, but also a new goal for community construction. This study contribute empirical evidence to promote community habitat improvement, so as to accelerate the adoption of this paradigm, thereby contributing to the realization of harmonious coexistence between cities and nature.

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