Analysis of Health Landscape Performance of Urban Parks in Severe Cold Regions Based on Citizen Satisfaction

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Abstract—Urban Park is an important part of a healthy city. It is important to find out the satisfaction of the landscape health of urban parks in severe cold areas as a way to improve them and to enhance the vitality of urban parks and create a healthy and comfortable living environment. This study takes the health landscape of urban parks in severe cold regions as the starting point, and uses exploratory factor analysis method to screen out the factors affecting the health performance of urban parks in severe cold regions based on the questionnaire survey of the citizens. Besides, the importance-performance analysis (IPA) method is adopted to establish the satisfaction-importance model of urban parks. This research shows that the most satisfying park factor for citizens is the reflection of local characteristics; The fac-tor that citizens feel satisfied but less important is the health assistance of the park; The factor that citizens feel dissatisfied but important is the land-scape design of the park; And the park factor that citizens feel dissatisfied and not important is the size and number of distribution of the park. Based on the above research results, this study puts forward the improvement strategies suitable for the design and improvement of urban parks in severe cold regions, to create a healthy and comfortable park environment for citizens.

Index Terms—Severe cold regions, Health landscape, Citizen satisfaction, Important-performance analysis

I. INTRODUCTION

In the current situation of the widespread of the COVID-19 in the world, urban citizens are facing a huge health crisis in dense and fast-paced cities where the outbreak is spreading faster and people are exercising less outdoors[1]. In this situation, urban citizens urgently need a healthier environment, and the question of how to build a healthier city has become a pressing concern. In 1986, the World Health Organization first proposed the concept of "Healthy Cities", advocating that health is not only reflected in physical and mental health, but also in moral health and the ability to adapt well to society [2]. Many countries have developed their own healthy city pro-jects according to their national conditions [3]. China released

the "Healthy China" in 2019, which provides a series of safeguards for the physical and mental health of residents. China's urbanization process continues to accelerate [4]. The accelerated urbanization process has created economic value, but also produces many adverse effects. Relevant research shows that the huge intensity of urban work, many citizens are in sub-healthy state [5]. The negative health effects of living in cities are gradually emerging due to the huge intensity of urban work and sedentary residents. Studies have shown that more exposure to the natural environment can be effective in improving many of the health problems that occur in urban citizens. Green spaces play a positive role in meeting the basic attributes of human proximity to nature [6]. However, green spaces in cities are usually small in volume and scarcely have effect on health improvement. Urban parks have moderate volume, rich landscape, and diverse types of crowd activities. However, urban green areas often have insufficient volume, single landscape structure, and insufficient space for crowd activities, so urban parks become the best choice for citizens to get close to nature and promote health [7]. Therefore, under the current circumstances of multiple outbreaks of COVID-9 in multiple locations, which restrict people from traveling long distances, urban parks have become a healing and restorative place in urban life by meeting the needs of citizens to be close to nature and travel more conveniently. Current urban parks should no longer focus solely on landscape, but should be a comprehensive study of ecology, architecture, and human subjective feelings. Although health landscape is a new term, it is not a new concept, as it can be traced back to the Healing Garden in medieval Europe [8], and subsequently evolved into horticultural therapy and other related concepts. The Landscape Architecture Foundation (LAF) introduced the term "landscape performance" in the Landscape Performance Series (LPS), which means "measuring the effectiveness of landscape [9]. The theoretical framework is divided into three dimensions: environmental, social, and economic benefits, and is an evaluation tool that interacts with various disciplines [10], but there are no relevant studies on land-scape health performance of urban parks in severe cold regions, where residents' lack

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of outdoor activities during the long winter can worsen health problems. As an important place for residents to go out, the landscape design of urban parks is important, so it is important to conduct a study on the satisfaction of urban parks for residents in severe cold regions. To explore the satisfaction and the importance of the factors in health landscape performance of urban parks in severe cold regions, the main questions studied in this paper are as follows: How do citizens in severe cold regions feel about the landscape elements in completed parks? What should be done to improve the health and landscape performance of urban parks in severe cold regions?

This study takes the landscape health of urban parks in severe cold regions as an entry point, enumerates the influencing factors proposed in previous studies, conducts a questionnaire survey of the residents in severe cold regions, and adopts exploratory factor analysis to screen out the factors affecting the health performance of parks in severe cold regions, and then uses the IPA model to establish a satisfaction-importance model for urban parks in severe cold regions to point out the direction of the subsequent design and renovation.

II. OVERVIEW OF THE RESEARCH OBJECT

A. Definition of Study Area

Severe cold area refers to the coldest monthly average temperature ≤ -10 °C or daily average temperature \leq 5 °C days ≥ 145 days in China, which includes Heilongjiang, Jilin, Liaoning and the northeastern part of Inner Mongolia Autonomous Region. Cold cities have long and cold winters, and every year from November to April, the cities face severe cold, snow and cold wind, and the impact of regional climate characteristics on the construction of urban habitat attractiveness cannot be underestimated [11]. As defined in "Code for the design of public park", the park is a public green space that provides people with rest, sightseeing, sightseeing, physical exercise, scientific and cultural activities, and has a green environment and various facilities [12].

In this paper, Harbin, a typical city in the severe cold region, was selected for the survey. Online questionnaires were distributed to Harbin citizens to investigate the overall recollection of parks that citizens had visited rather than for a single specific park, in order to draw conclusions with a high degree of generalizability.

B. Extraction of Evaluation Elements

The LAF in the landscape performance project LPS has a practical case study and discussion for urban parks, the evaluation system is mainly divided into three dimensions: environmental regulation, social service, and economic development [13], Chinese researchers introduce and use landscape performance approach, according to local conditions to put forward for their own research objects. Chinese researchers have applied the landscape performance approach to local studies, using field research and expert review to make some adjustments to the framework of landscape performance adding these dimensions for community parks: the

landscape enjoyment and the open space. The health benefit has been added to studies specifically on the health land-scape performance of parks [14], and studies on urban parks in severe cold regions have classified their main functions into landscape enjoyment [15], microclimate regulation [16], social activity, and health promotion [17].Therefore, this paper summarizes four dimensions: landscape enjoyment, environmental regulation, social service, and health benefit, which are subdivided into 9 indicators and 32 details, as shown in Table I and Fig. 1.



Figure 1. Summary of urban park dimensions in severe cold regions

Layer A	Layer B	Layer C					
Landscape Enjoyment Dimension A1	Green Landscape B1	Green Plant Species C11 Seasonal Change of Green					
		Plant C12 Green Plant Layout C13					
	Water Landscape B2	Water Seasonal Changes C21 Waterfront Trail Distance from Water C22					
		Water Quality C23					
	Landscape Elements B3	The Landscape Elements Fit the Theme of the Park C31					
		Sense of Belonging C32					
Environmental	Microclimate	Regulating the Temperature in the Park C41					
Regulation Dimension A2	Regulation B4	Regulating Humidity in the Park C42					
		Regulating Wind Speed in the Park C43					
		Regulation of Solar Radiation in the Park C44					
	Landscaping regulation B5	Improve Urban Landscape C51					

Group Sports

Activities B6

Event Venue Scale C61

Event Venue Seasonal

Walking Trail Scale C63

Scale of Sports Equipment

Seasonal Adaptation of Sports

Walking Trail Seasonal

Equipment Area C66

Adaptability C62

Adaptability C64

Area C65

TABLE I. LANDSCAPE HEALTH IMPACT FACTORS IN URBAN PARKS IN SEVERE COLD REGIONS

Social Service

Dimension A3

	Interaction Activities B7	Number of Seating Gazebo C71 Seating Gazebo Open Degree C72 Seating Gazebo Seasonal
Health Benefit Dimension A4	Physiological Health B8	Adaptability C73 Improvement of Three High Chronic Diseases C81 Improvement of Sudden Discomfort such as Headache C82 Improvements to Daily Sleep C83 Relief of Fatigue in Daily Life C84
	Mental Health B9	Relief of Anxiety in Daily Life C91 Stress Relief in Daily Life C92 Feel More Relaxed C93 Feel More Energetic C94 Feel More Energetic C95 Have More Social Activities C96 Feel Healthier C97

C. Research Method

1) Factor analysis method

The importance influence factor data from the questionnaire were imported into spss23.0 software and factor analysis were performed using principal component analysis, and the rotation method was the Kaiser normalized OBL method. Factor loadings ranged from 0-1, and factors with factor loadings higher than 0.5 were considered suitable for factor analysis, and factors that were not suitable were excluded.

2) Important-performance analysis method

The importance and satisfaction impact factor data from the questionnaire were im-ported into SPSS 23.0 software and fell into the four quadrants of the IPA grid division for analysis, with the mean importance values of the indicators listed as the y-axis and the mean satisfaction values listed as the x-axis. This is shown in Fig. 2.



Figure 2. Important-performance analysis model picture

III. DATA COLLECTION AND ANALYSIS

A. Questionnaire Design and Data Collection

The study is based on an online questionnaire survey. supplemented by on-site interviews. The questionnaire setup consists of two parts: the basic information questionnaire and the scale questionnaire refers to the respondents' assessment of each evaluation factor in terms of the importance and performance level of the health landscape in the park. Two scale questions were used to vote on the satisfaction and importance of the 32 evaluation items, respectively. The questionnaires were placed online from 2021.7 to 2022.4, and citizens' responses were screened according to the set questions to meet the requirements. 1,430 online questionnaires were collected, and finally 1,285 valid questionnaires met the requirements and had credibility, which rate of 89.86%. Supporting interviews conducted during the questionnaire administration ensures that respondents can understand the questions in the questionnaire.

B. Reliability and Validity Analysis of the Questionnaire

In order to verify the validity of the questionnaire data, this paper uses SPSS 23.0 to conduct reliability and validity tests. Cronbach's reliability coefficient test was conducted on a total of 69 variables within the questionnaires, and the α value was 0.976, which was higher than 0.8, indicating the great reliability of the questionnaire; the KMO value was 0.936, which was higher than 0.8, the P value is 0.001, indicating the good validity of the questionnaire and the suitability of the interpretation extracted from the information.

C. Analysis of Statistical Characteristics of the Sample

In the 1285 valid samples surveyed, the gender composition is close to that of men and women, with 685 men (53.31%) and 600 women (46.69%). In China, the proportion of males was 51.24% and the proportion of females was 48.76%, which was similar in this study. The population age ratio of the study sample was 10.23% for minors, 32.25% for 18-60 years old, and 57.52% for older adults above 60 years old. In terms of the frequency of going to the park, the largest percentage is 45.16% for those who go every day. See Fig. 3 for detail.



Figure 3. Distribution of the frequency of people going to parks in severe cold areas

D. Citizen Importance and Satisfaction

As shown in Fig. 4, the most important dimension in the public's perception of the importance of parks is the Landscape Enjoyment Dimension A1, with a mean importance of 1.99, in which the green plants and the water landscape are very important to the public, but the other dimensions are not very different.

As shown in Fig. 4, in the satisfaction evaluation of the public for the park, the most satisfied factor is also the Landscape Enjoyment Dimension A1, whose mean satisfaction is 3.54, in which the water quality and landscape vignette design have the highest scores, while the other dimensions do not differ much.

Based on the above analysis, among the various functions of urban residents in cold regions for parks, landscape appreciation is the most concerned part of the public in terms of satisfaction and importance. The dimensions of landscape appreciation belong to the additional items of public experience beyond landscape appreciation. These four dimensions cannot be viewed in isolation, and they are mutually influential and complementary.



Figure 4. Importance factor evaluation and Satisfaction factor evaluation

IV. IPA MATRIX ANALYSIS AND IMPROVEMENT STRATEGY

A. IPA Matrix Analysis

The statistical analysis of the importance of the questionnaire against each factor allows the importance of each factor to be derived, as shown in Table II. The factor loading coefficients are all less than 0.5, when sig is less than 0.05, T can be considered significant. There were no factors that needed to be excluded in this experiment, which laterally proves that all the influencing are very important.

TABLE II. IPA MATRIX

Factor	Load factor	P-I	Т	Signific	Sig
Green Plant Species	0.647	1.06	12.528	0.001**	0.01
Seasonal Change of Green Plant	0.613	1.00	10.865	0.003**	0.01
Green Plant Layout	0.597	1.03	11.967	0.000**	0.01
Water Seasonal Changes	0.608	1.06	11.524	0.001**	0.01
Waterfront Trail Distance from Water	0.649	1.23	10.715	0.001**	0.02
Water Quality	0.733	1.58	14.485	0.000**	0.01
The Landscape Elements Fit the Theme of the Park	0.592	1.23	11.168	0.000**	0.01
Landscape Elements Evoke a Sense of Belonging	0.558	1.27	12.4	0.001**	0.01
Regulating the Temperature in the Park	0.750	1.19	14.153	0.000**	0.02
Regulating Humidity in the Park	0.738	0.96	10.402	0.001**	0.01
Regulating Wind Speed in the Park	0.676	1.11	12.129	0.000**	0.01
Regulation of Solar Radiation in the Park	0.743	1.18	12.547	0.000**	0.01
Improve Urban	0.712	1.04	9.525	0.001**	0.01
Event Venue Scale	0.707	1.18	11.998	0.000**	0.01
Event Venue Seasonal Adaptability	0.638	1.17	12.027	0.000**	0.01
Walking Trail Scale	0.678	1.11	11.734	0.000**	0.01
Walking Trail Seasonal Adaptability	0.710	1.08	11.358	0.000**	0.01
Scale of Sports Equipment Area	0.721	1.13	12.366	0.000**	0.01
Seasonal Adaptation of Sports Equipment Area	0.718	1.28	13.022	0.000**	0.01
Number of Seating Gazebo	0.646	1.28	12.631	0.000**	0.01
Seating Gazebo Open Degree	0.665	1.05	10.152	0.016*	0.05
Seating Gazebo Seasonal Adaptability	0.720	1.21	12.076	0.000**	0.01
Improvement of Three High Chronic	0.597	1.07	10.613	0.000**	0.01
Improvement of Sudden Discomfort Such as Headache	0.597	1.12	11.477	0.011**	0.02
Improvements to Daily Sleep	0.695	1.14	11.623	0.000**	0.01
Relief of Fatigue in	0.707	1.10	11.721	0.000**	0.01
Relief of Anxiety in Daily Life	0.691	1.19	12.818	0.001**	0.01
Stress Relief in Daily Life	0.760	1.11	11.168	0.003**	0.02
Feel More Relaxed	0.613	1.07	11.184	0.000**	0.01
Feel More Energetic	0.729	1.04	11.088	0.005**	0.01
Feel More Energetic	0.692	1.11	12.031	0.000**	0.01
Have More Social Activities	0.685	1.01	9.851	0.005**	0.01
Feel Healthier	0.771	1.09	11.125	0.000**	0.01

According to the scores, the 32 factors were represented in the IPA system (Fig. 5).



Figure 5. IPA quadrant chart

B. IPA Quadrant Analysis

1) Quadrant 1 - Keep Up Good Work Analysis

The results show that eight variables are located in this area, namely: Green Plant Species C11, the Landscape Elements Fit the Theme of the Park C31, Landscape Elements Evoke A Sense of Belonging C32, Regulating the Temperature in the Park C41, Regulating Wind Speed in the Park C43, Seating Gazebo Seasonal Adaptability C73, Improvement of Three High Chronic Diseases C81, Improvement of Sudden Discomfort such as Headache C82, indicating that in these items citizens consider important and very satisfactory. For parks, the diversity of greenery is an important marker to distinguish them from green areas in front of houses; Harbin has distinctive urban features, and the design of landscape features can evoke a sense of identity among citizens; the greenery, water bodies, and activity sites in parks will improve the microclimate in parks [18]. Through offline practical research, it is found that there are active outdoor gathering activities in all seasons, and the seasonal adaptability of seating gazebos is more important and satisfactory than that of other activity facilities. The reason why seasonal adaptation of seating gazebos is more important and satisfactory than seasonal adaptation of other activity facilities is that seasonal adaptation of activity venues is more difficult to achieve, while seating gazebos can be achieved by simple structural measures such as adding a roof; People's perception of park exercise activities is generally considered to be a relief measure for existing physical discomfort rather than a way of life.

2) Quadrant 2 - Major Improvement Area Analysis

The results show that ten variables are located in this area, namely: Seasonal Change of Green Plant C12, Green Plant Layout C13, Water Seasonal Changes C21, Regulating Humidity in the Park C42, Walking Trail Scale C63, Walking Trail Seasonal Adaptability C64, Scale of Sports Equipment Area C65, Seating Gazebo Open Degree C72, Improvements to Daily Sleep C83, Have More Social Activities C96 The public is not satisfied with the current situation, but they think it is important. Severe cold regions have limitations for the growth of many plants, and green plants can rarely be seen in winter, which limits both visual and climate improvement, so the selection and arrangement of plants in parks is important [19]; Citizens in severe cold cities have a preference for ice sports, the water bodies in parks are natural ice rinks that should be managed and utilized appropriately; Both plants and water bodies in parks can improve the microclimate in parks including temperature, humidity, and wind speed [16], but humidity and solar radiation are less detectable: There are four social service dimensions in this quadrant, indicating that these activity venues and facilities need further optimization, both in terms of scale and seasonal adaptation; Some studies have shown that light exercise can improve sleep [20], and fresh air as well as plants can significantly improve sleep depth and duration; Parks are important places where many group activities take place, and group activities can effectively promote human interactivity, which is valuable for communication and interaction in the city.

3) Quadrant 3 - Low Priority Area Analysis

The results show that twelve variables are located in this area, which are Waterfront Trail Distance from Water C22, Regulation of Solar Radiation in the Park C44, Improve Urban Landscape C51, Event Venue Scale C61, Event Venue Seasonal Adaptability C62, Relief of Fatigue in Daily Life C84, Relief of Anxiety in Daily Life C91, Stress Relief in Daily Life C92, Feel More Relaxed C93, Feel More Energetic C94, Feel More Energetic C95, Feel Healthier C97, indicating that in these items, the public finds it satisfactory but not very important. Firstly, during the field research on Harbin city parks, it was found that almost every park creates waterfront trails around water bodies, but combined with interviews with citizens and research results, the quality of water bodies is more concerned than waterfront trails; The physical sensation of solar radiation is not obvious, so people are not urgent about its improvement; the enrichment of urban landscape belongs to the urban design dimension, and citizens have no personal feeling about this; The next seven items are all health benefits dimensions and include all items of mental health, reflecting that urban parks do provide health benefits, especially on the psychological level, in addition to the very significant positive effects of urban parks on socialization and health promotion [21].

4) Quadrant 4 – Possible Overkilled Area Analysis

The results show that three variables are located in this area, namely Water Quality C23, Seasonal Adaptation of Sports Equipment Area C66, Number of Seating Gazebo C71, indicating that in these items, the public does not think it is important or necessary to pay attention to change. This research found that most parks will landscape water bodies, and park managers to ensure the quality of water bodies and spend a lot of energy to maintain, but the public does not care much; Sports equipment area is generally more moderate stretching nature of sports facilities, not affected by seasonal changes, even in the cold winter. People can also adapt by adjusting their own clothing; Park renovation in recent years and the transformation of green space in front of the house will leave sufficient seats gazebo for people to exchange rest. But for the cold areas in the cold winter outdoors, if there are no active movements to keep the

body hot, sitting will quickly make people feel cold, so the practicality of the seats is low.

V. CONCLUSION

In this paper, through the research of health landscape, landscape performance and literature related to outdoor activities in severe cold regions, the factors affecting citizens' activities in parks are summarized. The factor analysis method was used to screen out the influencing factors that are really applicable to severe cold regions, including landscape ornamental dimension, environmental regulation dimension, social service dimension and health benefit dimension, which are subdivided into 9 indicators and 32 details. By using IPA analysis method, the 32 factors are divided into four areas according to the importance and satisfaction level reflected by the citizen's questionnaires, and are classified and transformed to make suggestions for the subsequent gradual optimization of the park. By combining the climate characteristics of severe cold regions and people's evaluation of the importance and satisfaction of healthy landscape elements in parks, the priorities for improvement in healthy landscape elements are analyzed, in order to provide a reference and basis for the next step of developing a healthy landscape performance evaluation that meets the characteristics of urban parks in severe cold regions.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

Yue Zhu conducts experiments under supervision and writes this paper.

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REFERENCES

- [1] T. W. Xu, "New crown pneumonia outbreak: Reshaping global public health security," *The Journal of International Studies*, vol. 41, no. 3, pp. 230-256, June 2020.
- [2] World Health Organization, "Ottawa charter for health promotion," World Health Organization. Regional Office for Europe, Ottawa, 1986.
- World Health Organization, *Tracking Universal Health Coverage:* 2017 Global Monitoring Report, World Health Organization, 2017, pp. 7-9.
- [4] National Bureau of Statistics of the People's Republic of China, *China Statistical Yearbook China Statistics Press*, China Statistics Press, pp. 30-34, 2021.
- [5] J. Zhang and J. Chaaban, "The economic cost of physical inactivity in China," *Preventive Medicine*, vol. 56, pp. 75-78, Jan. 2013.
- [6] S. H. Tan, C. Yang, L. L. Feng, and L. Zang, "Environment influences on health restoration review," *Chinese Landscape Architecture*, vol. 36, pp.53-58, Jan. 2020.
- [7] H. Nordh, C. Alalouch, T. Hartig, "Assessing restorative components of small urban parks using conjoint methodology,"

Urban Forestry & Urban Greening, vol. 10, pp. 95-103, Feb. 2011.

- [8] S. L. Bell, et al, "From therapeutic landscapes to healthy spaces, places and practices: A scoping review," *Social Science & Medicine*, vol. 196, pp. 123-130, Jan. 2018.
- [9] Landscape Architecture Foundation. About Landscape Performance [EB/OL] Available: https://www. landscapeperformance.org/about-landscape-performance
- [10] T. Noszczyk, et al, "The impact of the COVID-19 pandemic on the importance of urban green spaces to the public," *Land Use Policy*, vol. 113, Feb. 2022.
- [11] H. Leng, Q. Yuan, and E. Guo, "Study on the design strategy of "Winter-Friendly" amenity city in cold region," *Architecture Journal*, vol. 9, pp. 18-22, 2007.
- [12] Ministry of Housing and Urban-Rural Development, Code for the design of public park, *China Architecture & Building Press*, China Statistics Press, 2017, pp. 4-16.
- [13] The National Study of Neighborhood Parks. Active Parks, Healthy Cities. pp. 4-18. [Online]. Available: https://cityparksalliance.org/wp-content/uploads/2019/06/activeparks-healthy-cities.pdf?pdf=report
- [14] B. Yu, C. Xie, and S. Yang, "Correspondence analysis on residents' perceived recreation satisfaction and importance in shanghai urban community park," *Chinese Landscape Architecture*, vol. 30, pp. 75-78, Sep 2007.
- [15] X. Han, T. Sun, and T. Cao, "Study on landscape quality assessment of urban forest parks: take Nanjing Zijin Shan National Forest Park as an example," *Ecological Indicators*, vol. 120, Jan 2021.
- [16] X. Geng, Z. Yu, D. Zhang, C. Li, Y. Yuan, and X. Wang, "The influence of local background climate on the dominant factors and threshold-size of the cooling effect of urban parks," *Science of The Total Environment*, vol. 823, June 2022.
- [17] B. D. Blasio, "Healthier neighborhoods through healthier parks," *Lancet (London, England)*, vol. 388, pp. 2850-2851, Sept. 2016.
- [18] H. Jin, H. Lv, and Y. Lin, "Influence of vegetation structures on winter and summer microclimates of urban residential areas in severe cold regions," *Landscape Architecture*, vol. 25, pp. 12-15, 2018.
- [19] H. Yan, F. Wu, and L. Dong, "Influence of a large urban park on the local urban thermal environment," *Science of the Total Environmen*, vol. 622, pp. 882-891, May 2018.
- [20] R. Miyazaki, M. Ayabe, H. Kumahara, et al, "Effects of light-tomoderate intensity aerobic exercise on objectively measured sleep parameters among community-dwelling older people," *Archives of Gerontology and Geriatrics*, vol. 94, May-June 2021.
- [21] S. Liu and X. Wang, "Reexamine the value of urban pocket parks under the impact of the COVID-19," *Urban Forestry & Urban Greening*, vol. 64, Sep 2021.

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