

POST-USE EVALUATION OF BEIJING'S SECOND GREEN BELT COUNTRY PARKS BASED ON LSTM MODEL ANALYSIS

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Highlights:

- comprehensive analysis of visitor expectations: We systematically analyze visitor comments from online reviews, capturing a diverse range of perspectives on country parks' location layout, landscape environment, functional services, and physical and mental perceptions;
- seasonal variations in visitor sentiment: Our analysis reveals significant seasonal variations in visitor sentiment, with spring and autumn having higher emotional scores than summer and winter. This finding provides valuable insights into the impact of seasonal changes on visitor experiences;
- identification of key issues: We identify management services and supporting facilities as areas with low-level emotional value, indicating a need for improvement in these aspects to enhance visitor satisfaction;
- natural landscape and aesthetic perceptions as key drivers of visitor sentiment: Our study underscores the crucial role of natural landscape and aesthetic perceptions in determining visitor sentiment, highlighting the importance of preserving and enhancing these natural features.

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Abstract. The country parks in Beijing's Second Green Belt are important to urban green space expansion and recreation. Therefore, exploring park visitors' real needs and expectations has practical significance. Online review data and the LSTM model were used to analyze and systematically study four aspects of the country park – location layout, landscape environment, functional service, and physical and mental perception. The results showed that 1) The overall emotional scores of visitors' comments on the country parks were high and varied by season. Spring and autumn were the peak comment periods and had high emotional values, in contrast to summer and winter. 2) Management service and supporting facilities had the lowest emotional value; negative comments indicated a lack of park facilities and rich landscapes affected the recreation experience. 3) Natural landscape and aesthetic perception determined that emotional attitudes affected overall visitor evaluations and were positively correlated with overall emotional values.

Keywords: Second Green Belt of Beijing, country park, LSTM model, post-use evaluation, online comment, landscape management.

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1. Introduction

According to the Urban Green Space Classification Standard (CJJ/T 85-2017) (Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2017) in China, country parks are defined as green spaces located on the outskirts of urban areas, characterized by rural landscapes, essential facilities, and functions such as nature access, recreation, and science education. At the beginning of 2007, constructing a "country park ring" in Beijing was proposed to improve the landscape and quality of the urban fringe area (Lin et al., 2018a). In 2015, the construction of country parks in the First Green Belt of Beijing achieved remarkable results, forming the first ecological barrier between Beijing's Fourth and Fifth Ring Roads, which integrates environmental and recreational functions while serving the needs of residents (Ge, 2020). The Beijing

Urban Master Plan (2016–2035) proposed building a green space structure of "one screen, three rings, five rivers, and nine wedges" within the city area, and the Second Green Belt area has officially become a new key area for country park ring construction, aiming to strengthen the ecological security pattern and promote urban-rural integration through the creation of ecological buffer zones, urban leisure belts, and suburban development circles (F. Li et al., 2021). In the future, the number of country parks in Beijing will continue to increase, and the quality needs to be improved. Therefore, an in-depth study of country parks is particularly important. Studies on country parks have focused mainly on the planning and design (Suo, 2018; Lin, 2019), layout and site selection (Zhao, 2020; Wang, 2019; Wang et al., 2021), management (Ma, 2020; Delang, 2010; Ly & Zhang, 2019) and ecological conservation (Cheung & Wong, 2022; Li et al., 2023a; Sun & Liu, 2020) of coun-

try parks. However, because visitors are the main users and direct users of country parks, understanding their real needs and requirements can provide a strong foundation and scientific basis for further improvements in quality and efficiency. Furthermore, the real needs of visitors can be obtained through post-use evaluations of country parks.

Currently, questionnaire surveys, interviews, and field observation methods are mostly used for post-use evaluations of country parks (Hong et al., 2022; Shen, 2012). The sample size of these methods is limited; although they are representative, they cannot fully reflect users' wishes. With the progress of science and technology and the development of big data, the richness of data resources and the immediacy of network media provide a new perspective and tool for the post-use evaluation of green space. On the one hand, the use of massive data provided by network comments is free from regional and time restrictions, and addresses issues related to single-source information, insufficient data, and other problems; on the other hand, deep learning technology has become an important application in the field of Natural Language Processing (NLP) (Liu, 2021). The judgment of text sentiment tendencies based on deep learning algorithms provides a new solution for the quantitative analysis of online comment data, overcomes the limitations of traditional questionnaire surveys and expert scoring methods (Chen, 2019), and realizes the effective processing of large amounts of data in a short time. In park evaluation model research, open-source platforms like Baidu EasyDL are employed (Liu et al., 2024). A customized Long Short-Term Memory (LSTM) model, a recurrent neural network, allows for targeted design and parameter tuning, potentially enhancing model performance and accuracy based on specific needs and data characteristics.

Therefore, the country parks within the Second Green Belt of Beijing were chosen as the research object, and big data-based network information and deep learning technology, network text data, and a deep learning method based on the LSTM network model were used to construct a post-use evaluation index of the country parks. Then, the actual use of the parks was systematically evaluated. In this paper, the valuable feedback and post-use comments in the online text were analyzed, and the needs and expectations of tourists for country parks were explored to provide a basis for the construction and quality optimization of Beijing Country parks in the future.

2. Materials and methods

2.1. Study objects

According to the latest Beijing Parks List revised by the Office of the Capital Greening Commission of the Beijing Municipal Bureau of Landscape and Afforestation in April 2023 (Beijing Parks list [first batch], 2023), and based on the green space structure proposed in The Beijing Urban Master Plan (2016–2035) (Beijing Municipal Commission of Planning and Natural Resources, 2017; Figure 1), the Second Green Belt of Beijing includes 39 parks. Based on

preliminary investigation and big data analysis, 33 country parks with over 50 online comments each were selected to ensure sufficient data for this study (Table 1 and Figure 2). These parks include 15 in Chaoyang District, 4 in Haidian District, 10 in Fengtai District, 2 in Daxing District, and 2 in Changping District.

Table 1. Basic information sheet of 33 country parks within the Second Green Belt in Beijing

Administrative region	Park name	Construction/Opening Year	Area/Hectare
Chaoyang District	White Deer Country Park	2008	28.6
	Baihua Country Park	2009	21.53
	Dongba Country Park	2007	234.2
	Haitang Country Park	2009	33.1
	Hongbo Country Park	2008	71.8
	Huangcaowan Country Park	2009	39
	Kam Tin Country Park	2008	147.8
	Beijing Huaiyuan Country Park	2008	73.2
	Beijing Liyuan Country Park	2007	62.6
	Beijing Forest Country Park	2011	43.33
	Beijing Sports Country Park	2011	37.49
	Laojun Tang Country Park	2007	48.33
	Qinghe Camp Country Park	2009	58
	Warrior Camp Country Park	2011	20.4
	Zhenhai Temple Country Park	2009	33.55
Haidian District	Dan Tsing Po Country Park	2007	36.89
	Dongsheng Bajia Country Park	2008	81.96
	Pingzhuang Country Park	2009	23.78
	Shucun Country Park	2009	48.85
Fengtai District	North Paradise Country Park	2020	45.58
	Dawayao Country Park	2020	17.04
	Gaoxin Country Park	2008	28.54
	Huai Xin Country Park	2009	90
	Kandan Country Park	2009	48.18
	Green Embankment Country Park	2009	105.82
	Taoyuan Country Park	2009	21.53
	Tianyuan Country Park	2008	21.82
	Wanfeng Country Park	2007	28
Daxing District	Yukang Country Park	2009	36.09
	Wangxing Lake Country Park	2008	22.38
Changping District	Wangxing Lake Country Park North District	2009	90.8
	Banta Country Park	2011	28.66
	Taiping Country Park	2009	72.33

Based on natural landscapes and cultural resources, the primary functions were extracted to categorize the 33 countryside parks into four types: leisure and outdoor recreation, ecological conservation forests, thematic botanical gardens, and cultural and historical parks (Table 2).

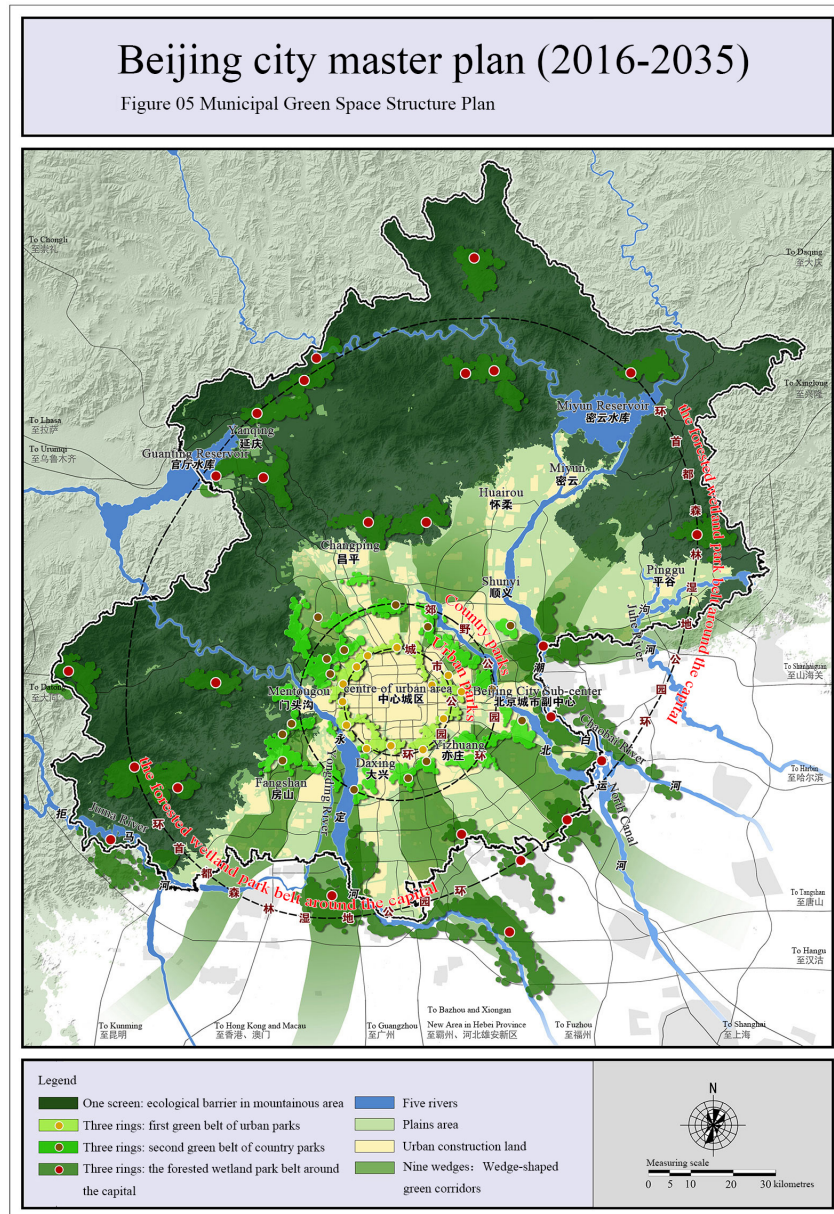


Figure 1. Beijing Urban Green Space Structure Plan from The Beijing Urban Master Plan (2016–2035)

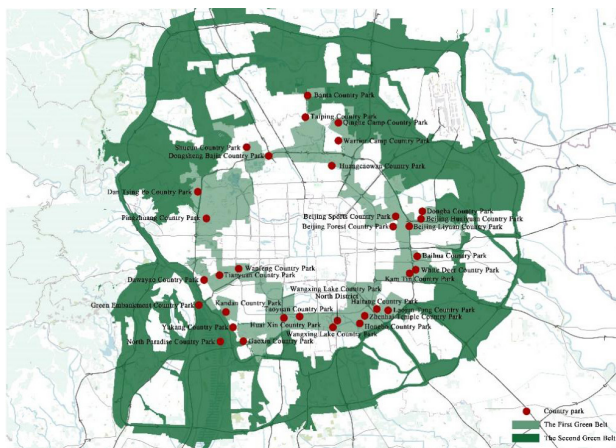


Figure 2. Distribution map of 33 country parks within the Second Green Belt of Beijing

2.2. Research methodology

2.2.1. Data collection and preprocessing of country park online comments

Data collection. Based on a comprehensive consideration of factors such as the number of users, the amount of data, and the popularity of the website, the popular Dianping website (Dianping, 2024) and Ctrip website (Ctrip, 2024) were chosen to obtain comment data, and an octopus collector (BaZhuayu Collector, 2023) was utilized to construct a data crawling framework. The final collection included the park name, comment text, comment time, and user ID name.

Data preprocessing. Text de-emphasis processing and manual auditing of data cleaning were used to obtain 13622 valid comments. Then, the Jieba library in Python was used for word division processing, and the Harbin Institute of Technology deactivation word list was adopted

Table 2. Classification of 33 country parks by land use and primary functions

Classification	Park name	Classification	Park name
Cultural and his- torical parks	Dawayao Country Park	Leisure and outdoor recreation	Beijing Forest Country Park
	Dongba Country Park		Beijing Sports Country Park
	North Paradise Country Park		Huai Xin Country Park
	Pingzhuang Country Park		Huangcaowan Country Park
	Shucun Country Park		Taiping Country Park
	White Deer Country Park		Tianyuan Country Park
	Yukang Country Park		Wanfeng Country Park
	Zhenhai Temple Country Park		Warrior Camp Country Park
Ecological conser- vation forests	Banta Country Park	Thematic botanical gardens	Baihua Country Park
	Dan Tsing Po Country Park		Beijing Huaiyuan Country Park
	Dongsheng Bajia Country Park		Beijing Liyuan Country Park
	Green Embankment Country Park		Gaoxin Country Park
	Hongbo Country Park		Haitang Country Park
	Kam Tin Country Park		Kandan Country Park
	Laojun Tang Country Park		Taoyuan Country Park
	Qinghe Camp Country Park		
	Wangxing Lake Country Park		
	Wangxing Lake Country Park North District		

to remove deactivated words and form a source of data for the subsequent study.

2.2.2. Construction of the post-use evaluation elements for country parks

Python was used to determine the frequency of words, and the top 300 high-frequency words were extracted from the element thesaurus. Based on the analysis of the element thesaurus, related literature on post-use park evaluations (Luo et al., 2021; Wang, 2023), and principles of environmental psychology theory (Kaplan & Kaplan, 1989), a post-use evaluation system was constructed, categorizing evaluation elements into material and nonmaterial elements according to visitors' environmental cognition. Material elements, including park layout, supporting facilities, activity space, plant landscape, etc., directly affect the material perceptions of visitors, and nonmaterial factors focus on visitors' behavioral activities, psychological experiences, and overall mental and emotional perceptions. In summary, nine detailed evaluation elements (Table 3) were identified and categorized into four categories: location layout, landscape environment, functional service, and physical and mental perception.

2.2.3. Country park sentiment analysis

Sentiment analysis is a core task in the field of natural language processing. At present, there are three main methods for sentiment analysis: one is the sentiment dictionary method, in which a sentiment dictionary is constructed to judge the sentiment tendency of the text; however, this method is unsupervised learning and limited by the degree of lexicon coverage (Li, 2022). The second method is the machine learning method, in which the corresponding statistical probabilistic algorithms are used to carry out feature learning on the labeled or unlabeled corpus

dataset, and a classifier that uses machine training to determine the sentiment tendency is built; however, this method needs to set the corresponding parameters manually, and the degree of adaptation must be increased (Zhong, 2023). The third is the deep learning method, in which the text is analyzed by constructing a network model to simulate the neural system of the human brain, such as the classical Recurrent Neural Network (RNN) model (Zhang, 2022), which can effectively utilize the temporal data, extract text features through multiple neural network layers, and carry out the task of sentiment categorization and prediction; however, the RNN has limited memory capacity. To solve the long-term dependency problem of recurrent neural networks (Yechuri & Ramadass, 2021), Hochreiter and Schmidhuber proposed the Long Short-term Memory (LSTM) network in 1997, which is a specialized type of RNN, enhancing memory capacity by introducing gating mechanisms and cell states and thus can better address long sequential data (Hochreiter & Schmidhuber, 1997). In this paper, we train an LSTM-based model for country park network comment data based on sentiment analysis (Figure 3).

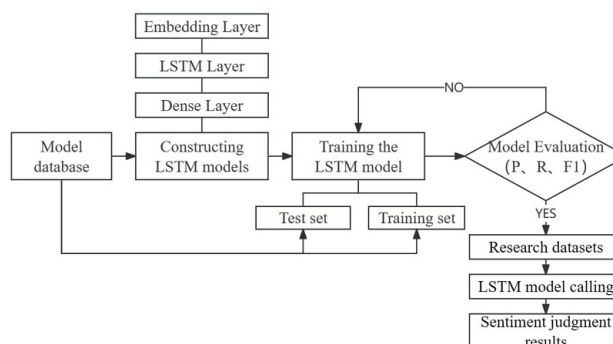
**Figure 3.** Emotional analysis process of the LSTM model

Table 3. Elements of post-use evaluation of Beijing's country parks

Element categories	Evaluation elements	Element description	Element thesaurus	Total word frequency
Location layout	External condition	Factors related to external conditions such as accessibility and surrounding facilities	Door, surrounding, next to, etc.	22 964 (7.70%)
	Internal condition	Internal elements related to spatial scale, pedestrian flow scale, etc.	Crowd, quiet, lively, etc.	14 349 (4.81%)
Landscape environment	Natural landscape	Natural or artificial elements related to nature, such as plants and water bodies	Ginkgo biloba, water bodies, trees, etc.	68 044 (22.82%)
	Humanistic landscape	Ancient buildings, sculptures, and other landscape elements composed of cultural and historical characteristics	Culture, New Fourth Army, History, etc.	1996 (0.67%)
Functional service	Supporting facility	Related supporting facilities such as signage and amusement	Parking lot, basketball court, square, etc.	45 173 (15.15%)
	Management service	Elements related to park hygiene, safety, maintenance, etc.	Free, management, maintenance, etc.	37 535 (12.59%)
Physical and mental perception	Recreational experience	Rest and stay, sightseeing and leisure, entertainment activities, sports and fitness, and other recreational experience elements	Strolling, walking, picnicking, etc.	70 871 (23.76%)
	Physical and mental restoration	The restoration of the park's physiological and psychological perceptual elements	Comfortable, cozy, relaxing, etc.	12 589 (4.22%)
	Aesthetic perception	Perceptual elements of park aesthetic features	Photography, scenery, landscape, etc.	24 696 (8.28%)

The LSTM model database is constructed. According to the nine specific elements of tourists' post-use evaluations of the Beijing Country Parks, the Spacy library in Python was used to traverse all the comment texts and establish the correspondence between the elements and sentences. Finally, 96,860 research datasets were obtained after sentence division. Afterward, more than 10% of the data were randomly selected, and 11,200 data points were manually annotated in the form of biclassification, where 1 indicates positive emotions and 0 indicates negative emotions. A model database was constructed, and this database was divided into a training set and a test set at a ratio of 9:1. The training set was used to train the Long Short-Term Memory (LSTM) model, and the test set was used to evaluate the classification effect of the model.

The LSTM model for emotional tendency judgment training is constructed. A digital mapping of vocabulary lists and labels is created, an embedding matrix is constructed to map discrete words to a continuous vector space, the sequence data is processed through an LSTM layer, and a dense layer is added. The activation function is set to "softmax" to output the probability distribution of each category.

The LSTM model is evaluated. To ensure the model training accuracy, the precision rate P and the recall rates R and F1 are used as the evaluation indices (Kumar et al., 2023), and the "precision_score", "recall_score" and "f1_score" functions are used to verify the accuracy of the model. The model precision rate P is 0.913, the recall rate R is 0.917, and the F1 value is 0.915, indicating a more accurate batch judgment of country park reviews with universal applicability.

The LSTM model is called for sentiment judgment. The LSTM model judgment is positive probability and negative

probability, taking the value range (0,1), and the total probability is summed to 1. The judgment result is written into a .csv file, and for the convenience of the research, the value of the positive probability is used as the sentiment score for the comment.

3. Results and analysis

3.1. Overall emotional attitudes of visitors according to the evaluations of country parks

The analysis of the results of the overall affective score indicated that visitors' overall affective attitude score to the 33 country parks ranged from 0.63 to 0.87 (Figure 4). The mean value is 0.76, greater than 0.50, and the variance is 0.004, indicating that the overall evaluation of the visitors' emotional attitudes toward the country parks is positive. There are 10,799 positive comments, accounting for 79.28%, and 2,823 negative comments, accounting for 20.72%.

According to the emotional attitude score band, there are 2 parks with an emotional attitude of 0.85 or above, which are Beijing Liyuan Country Park and Tianyuan Country Park; 11 parks with 0.8–0.85 (excluding 0.85); 12 parks with 0.7–0.8 (excluding 0.8); and 8 parks with 0.6–0.7 (excluding 0.7). The table reveals variability in visitor evaluations of country parks, with few parks receiving high scores, while the majority attain medium or low ratings, highlighting potential areas for improvement.

3.2. Temporal differences in visitors' affective attitudes toward country park reviews

The greatest number of comments occurred in April, followed by May and November, and the lowest occurred in January and February (Figure 5a). Comprehensive analysis

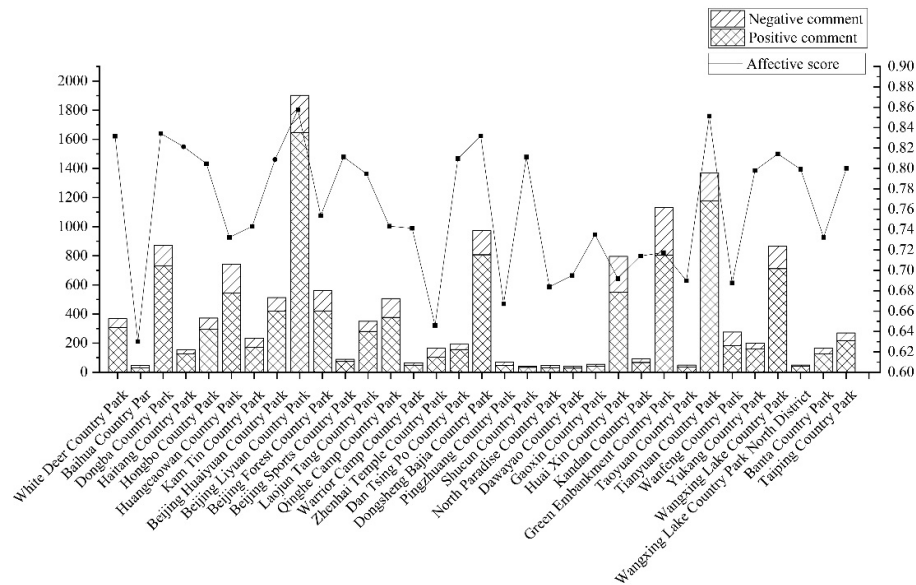


Figure 4. Comments and emotional scores of 33 country parks

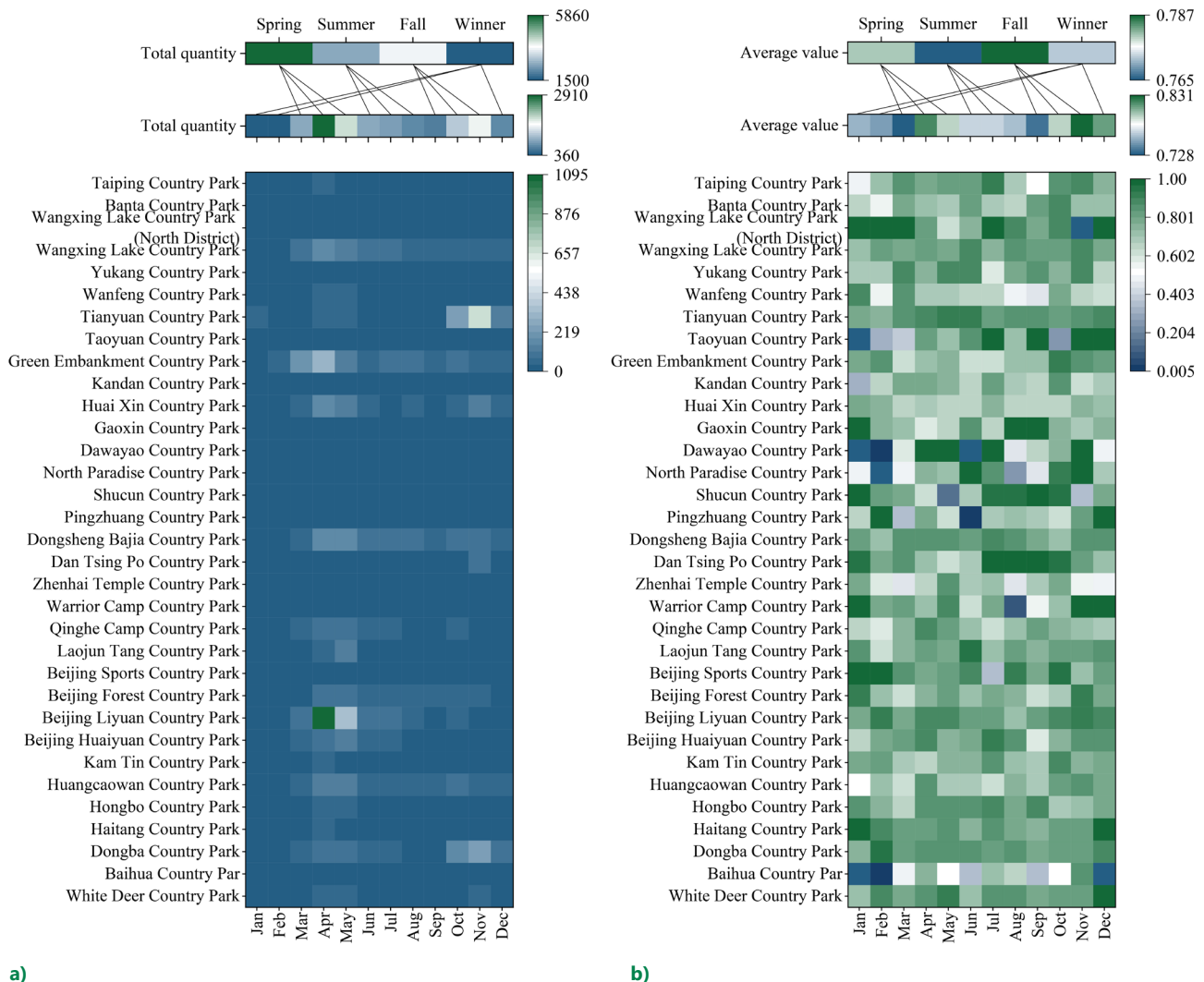


Figure 5. Heatmaps for: a) the number of comments; b) emotional attitudes

shows that country park reviews have obvious seasonal differences, with spring and fall being the peaks of the reviews and winter and summer being the troughs, suggesting that Beijing's cold winters and hot summers affect the number of visitors. To some extent, the seasonal difference in the number of comments characterizes the seasonal fluctuation of visitor arrivals. In April, the peak number of comments occurred in Beijing Liyuan Country Park; an analysis of the comments showed that the characteristic rapeseed flowers in the park attracted many visitors. In November, Tianyuan Country Park had a significant peak in the number of comments, and the ginkgo forest landscape in the park was frequently mentioned; it was the main reason for park visits. The fluctuation in the number of comments reflects that seasonal activities or landscape attractions characterize some country parks.

There is some variability in affective attitudes among different months, with a fluctuation range of [0.728, 0.831] (Figure 5b). The overall trend of autumn (0.787) > spring (0.780) > winter (0.773) > summer (0.765) shows that in autumn, country parks have the highest mean value of sentiment. According to the analysis of word frequency in different months, the high-frequency words in the months with higher sentiment values mainly described natural landscapes and aesthetic perceptions, for example, "ginkgo" (957), "taking pictures" (507), and "beautiful" (271) in November and "rapeflower" (1584), "February orchid" (843), and "flower" (556) in April. The high-frequency words in the months with lower affective means included words that responded to landscape effects and management services, such as "bare" (32), "mosquitoes" (18), and "too cold" (15), suggesting that the lack of planted landscapes in winter, climatic conditions, and the presence of mosquitoes in the park in summer affect visitors' emotional responses to the park environment.

3.3. Analysis of visitors' evaluation of each environmental element in country parks

We used the number of comments and emotional scores of each element to analyze the visitors' emotional attitudes,

retrospectively reviewed the positive and negative comment data of the visitors on each environmental element, analyzed the problems related to the environmental elements, and studied in depth the visitors' satisfaction and specific needs for each element of the country parks in Beijing.

3.3.1. Analysis of the number of comments on each environmental element

According to the analysis of the results of the affective tendency of each environmental element (Figure 6), in terms of quantity, the comments describing the natural landscape were the most frequent, accounting for 19.80%, followed by recreational experience (18.34%) and supporting facilities (14.13%). The descriptions of the humanistic landscape and physical and mental restoration were relatively less frequent, accounting for 1.01% and 3.35%, respectively. The distribution of environmental elements in visitors' comments reflects their focus on playing in country parks. The natural landscape received the most attention, indicating that visitors value the natural environment of country parks. Comments on recreational experiences and supporting facilities were the second most popular, indicating that visitors have certain expectations and needs for recreational and leisure facilities provided by country parks; in contrast, there were fewer comments on humanistic landscapes and physical and mental restoration, which to some extent may be attributed to the complexity of appreciating humanistic landscapes and the subtlety of experiencing mental and physical restoration.

3.3.2. Emotional attitude analysis of the evaluation of each environmental element

Regarding emotional tendency (Figure 5), the emotional attitude of physical and mental restoration had the highest score of 0.836. Positive comments describe mainly the physiological and psychological impacts of the park's environment, such as "Breathing fresh air and enjoying the natural oxygen bar", "Walking along the park's boulevard, I feel relaxed and happy, and I can relax and release work pressure"; a few negative comments express that the park

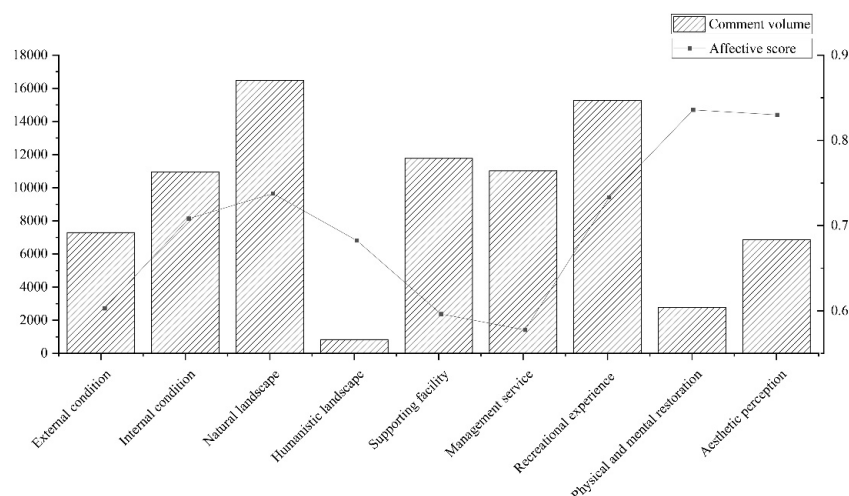


Figure 6. The number of comments and emotional scores of each environmental element

is “dry” and “hot”. Moreover, being “deserted” or “feeling scared” affected the visitors’ mood experience. Second, the sentiments of aesthetic perception (0.830) and natural landscape (0.738) are also high, with mostly positive comments on the park’s greening, animals, water, and aesthetics. Some of the comments also noted the lack of richness in the park’s landscape, such as “few landscapes to be viewed”, “mainly trees, few other landscapes”, and “lack of water system, no aura”. Meanwhile, some comments also raised the issue that the recreational experience in the park is relatively homogenous, such as “tents and hammocks are not allowed in the park” and “it is only suitable for strolling after meals or running during leisure time”.

Management services (0.578) have the lowest sentiment value, followed by supporting facilities (0.596) and external conditions (0.603). Negative comments indicate the maintenance of the park and the attitude of the management staff, such as “the ground is not very smooth and there is a risk of falling” and “the branches are withered and yellow, and the vitality of the park is not vigorous”. “Security guards scold and verbally attack innocent visitors”, etc. Some comments expressed negative sentiments toward maintaining the park’s environmental comfort, such as “mosquitoes are so many, and I got bitten” and “garbage everywhere”. Second, many comments indicate a lack of supporting facilities in the park; unevenly distributed negative attitudes include “there are many forks on the road, the signs are not well thought out”, “only a toilet by the lake, inconvenient!” etc.

3.3.3. Emotional attitudes toward environmental elements in different types of country parks

According to the analysis of emotional attitudes toward environmental elements across different types of country parks (Figure 7), in terms of common features, all park categories excelled in physical and mental restoration and aesthetic perception, receiving high scores. Conversely, external conditions, supporting facilities, and management services generally received lower scores below 0.651, similar to the overall trend.

Regarding differences, cultural and historical parks scored relatively high in internal condition (0.762) and natural landscape (0.783), indicating these parks effectively maintain their internal environments and present natural landscapes, providing visitors with a comfortable and historically enriched experience. However, leisure and outdoor recreation parks scored significantly lower in humanistic landscape (0.653), indicating a potential for improvement in cultural landscape design to enhance their overall appeal.

3.4. Correlation analysis of comment volume and affective attitude toward each environmental element

The Pearson correlation coefficients of the comment volume and emotional scores of each environmental element were correlated with the overall affective attitude, and the correlation characteristics of each environmental element in Beijing Country parks were explored. The number of comments is an important indicator of visitors’ attention and interest in these aspects. The analysis of the correlations between the comment volumes of each environmental element and their correlations with the emotional score of the overall park (Figure 8a), including the natural landscape ($r = 0.503$, $p < 0.01$), aesthetic perception ($r = 0.511$, $p < 0.01$), physical and mental restoration ($r = 0.424$, $p < 0.05$), and recreational experience ($r = 0.373$, $p < 0.05$) with the overall park, revealed a significant positive correlation between the number of comments and overall emotion, indicating that positive comments and concerns in these areas play an important role in enhancing the overall emotional experience and attractiveness of the park.

According to the analysis of the correlation between the emotional scores of each environmental element and the overall park (Figure 8b), there is a significant correlation between the emotional tendencies of different environmental elements ($p < 0.01$), in which the correlation coefficient of external condition and management service is 0.995, which indicates that the better the location conditions are, the greater the score of the emotional attitude of its management services. A correlation analysis of the

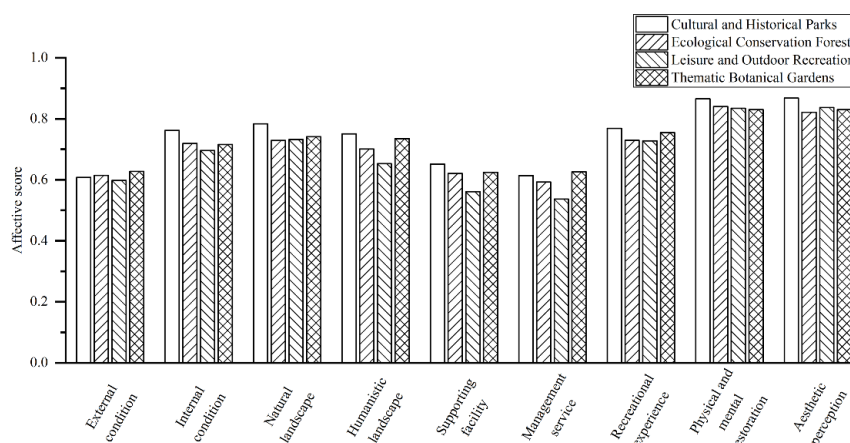


Figure 7. The emotional scores of environmental elements in different types of country parks

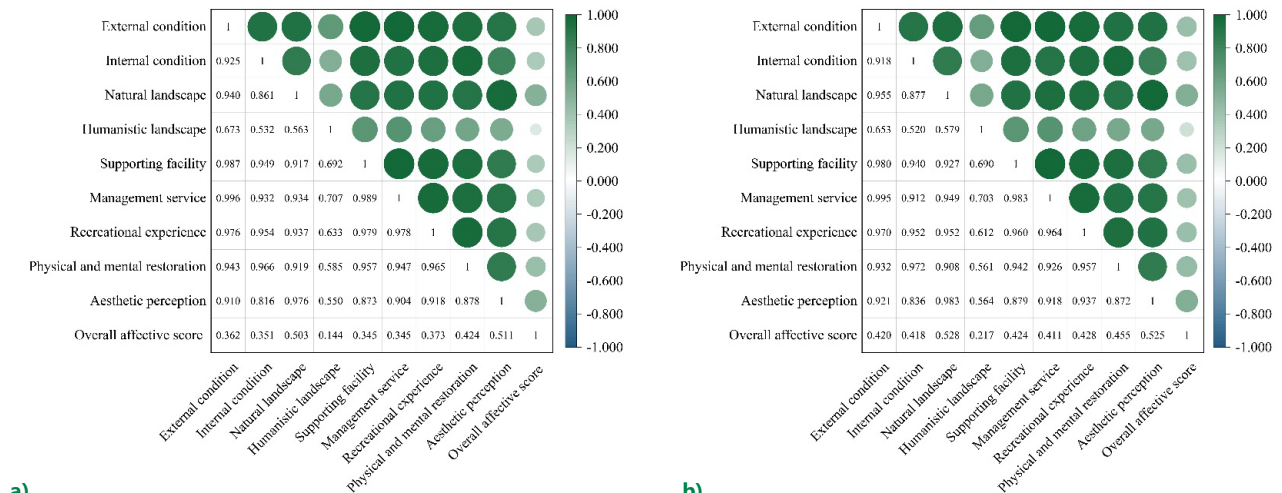


Figure 8. Correlation analysis between environmental elements and overall park sentiment: a) Pearson's correlation between the comment volumes of each environmental element and their correlations with the emotional score of the overall park; b) Pearson's correlation between the emotional scores of each environmental element and the overall park

emotional tendency of each environmental element with the park was performed. Regarding these correlations with the overall emotional attitude of the park, both natural landscape ($r = 0.528$) and aesthetic perception ($r = 0.525$) showed a significant positive correlation with overall emotion at the 0.01 level; humanistic landscape ($r = 0.217$, $p < 0.05$) did not have a significant correlation; and external condition ($r = 0.420$, $p < 0.05$), internal condition ($r = 0.418$, $p < 0.05$), supporting facility ($r = 0.424$, $p < 0.05$), management service ($r = 0.411$, $p < 0.05$), recreational experience ($r = 0.428$, $p < 0.05$), and physical and mental restoration ($r = 0.455$, $p < 0.05$) were positively correlated with overall affective attitudes, which indicated that the positive affect of each environmental element had a positive influence on the overall evaluation of the park, with natural landscape and aesthetic perception being the key factors influencing the overall emotional experience.

3.5. Analysis of key environmental improvement elements

To further clarify the post-use situation of Beijing Country parks and to grasp the direction of key enhancement of country parks, the importance-satisfaction model, i.e., IPA analysis, was introduced for further analysis. The importance of environmental elements I , that is, the user's attention to the degree of elements, is calculated; the greater the value is, the greater the degree of importance, generally with the frequency of elements mentioned in the elements of high and low attention to the elements of high and low (Ye et al., 2022). The satisfaction index P for tourists on the various environmental elements based on the sentiment of the average score is calculated as follows:

$$I = n \div N, \quad (1)$$

I is the importance of the environmental element; n is the word frequency of each environmental element; and N is

the sum of the word frequencies of all environmental elements.

$$P = M \div m, \quad (2)$$

P is the environmental element's satisfaction; M represents each environmental element's total sentiment score, and m represents the number of comments corresponding to each environmental element.

Taking the importance of visitors' evaluations of environmental elements as the horizontal axis and satisfaction as the vertical axis and taking the mean value of importance and satisfaction as the division point of the X-axis (0.11) and the Y-axis (0.70), the space is divided into four quadrants (Figure 9). Quadrants I and II are high satisfaction areas, indicating that visitors' expectations of the park match their actual perceptions, including the natural landscape, recreational experience, aesthetic perception, physical and mental restoration, and internal conditions, and the current level can be maintained. Quadrant III is a low-importance, low-satisfaction area that includes external conditions and a humanistic landscape and can be a low priority for development. Quadrant IV is a low-satisfaction area of high importance that includes supporting facilities and management services; it is the weak point of the current construction of the country parks in Beijing and needs to be prioritized to improve visitors' experience in future construction.

4. Discussion

4.1. The overall sentiment score of visitors' comments on Beijing's country parks is high and shows seasonal differences

The mean overall sentiment score of tourists is 0.76, greater than 0.50, indicating that the overall attitude is positive. The sentiment values of Beijing Liyuan Country Park and

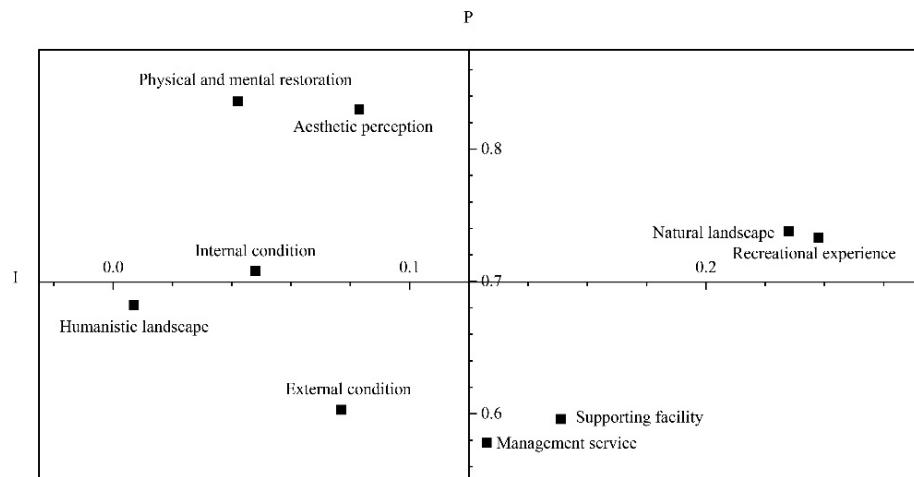


Figure 9. The IPA quadrant of environmental elements

Tianyuan Country Park are greater than 0.85. According to the statistics of the comment volume in each season, spring and fall are the peak periods of comments, while winter and summer are the trough periods; moreover, the analysis of high-frequency words indicates that the seasonal difference has something to do with the characteristic landscapes and activities of the parks, such as the spring February orchid sea in White Deer Country Park and the autumn ginkgo forests in Huai Xin Country Park. Similarly, Zhang et al. (2023) analyzed the online comments of Goose Ridge Park in Chongqing and found that tourists' visits showed more obvious seasonal characteristics and focused on spring and autumn. Yao (2023) analyzed the comments of Hangzhou Comprehensive Park and found that the plant viewing period and various kinds of festivals and activities had a greater impact on the number of comments. Liu et al. (2023) found that tourists prefer and spend more time in plant landscapes with red and yellow or red-yellow combinations, which are warm-toned and typical of autumn. Moreover, the study revealed relatively low sentiment values in the summer and winter seasons, and an analysis of the original comments suggested that the lack of landscape in winter and climatic conditions in summer are the main reasons for negative sentiments. Climate factors significantly affect tourists' travel intentions and perceptions (McKercher et al., 2024; Huai & Van de Voorde, 2021). In summer, a lack of shade and cool areas causes discomfort, reducing satisfaction and positive emotions. In winter, cold, dry conditions and limited winter plant displays or indoor heating lead to a monotonous visitor experience. In the future construction of country parks, while continuing to strengthen the autumn and spring landscape, we should focus on landscape and activity planning in summer and winter, instituting anti-mosquito efforts and sunscreen provisions in summer and cold facilities in winter, to enhance the attractiveness of the park throughout the whole cycle.

4.2. The management service and supporting facility have the lowest emotional value, affecting visitors' recreational experience, and are prioritized elements for enhancement

Management services (0.578) and supporting facilities (0.596) have the lowest affective value. A lack of management and supporting facilities affects visitors' affective attitudes; furthermore, negative comments on recreational experiences indicate that park facilities and landscapes lack richness and are also associated with negative attitudes among visitors. According to the IPA quadrant analysis, management services and support facilities are located in the fourth quadrant, which indicates that they are the key factors for enhancing country parks. Studies have shown that park features such as rest and activity facilities, signage systems, sanitation facilities, and recreational facilities had a significant impact on recreationist satisfaction (Wang & Hu, 2024; Zou, 2022), similar to the results of this study. Country parks have the dual functions of ecological protection and recreational services (Lin et al., 2018b), and in the future construction of country parks, the recreational function of parks should be strengthened under the premise of protecting the green substrate and ecological environment. A sound management system can be developed at the management service level through clear functional zoning, such as the locations of hiking trails, companion learning trails, and camping areas, and improved supporting facilities that provide diversified recreational activities. The current management of country parks is weak, with no one in charge of some parks; thus, maintenance and management personnel should be strengthened in the future. Furthermore, the management of country parks should prioritize safety, comfort, and the integration of cultural and natural elements, rather than focusing solely on isolated park attributes, to enhance visitor satisfaction and overall visitor experiences (Liu et al., 2023).

4.3. The natural landscape and aesthetic perception are key factors in determining affective attitudes and influencing the overall evaluation of tourists

Natural landscape ($r = 0.528$) and aesthetic perception ($r = 0.525$) were significantly correlated with overall emotion at the 0.01 level and were the key factors influencing overall emotional attitude. Among the environmental elements, the natural landscape had the highest number of comments, indicating that visitors valued and expected the natural landscape of country parks, and physical and mental restoration had the highest scores of affective attitudes, suggesting that visitors were able to obtain positive impacts at the physiological and psychological levels in the country park environment. Li et al. (2023b) showed that landscape features such as vegetation and water systems positively impacted people's access to positive perceptual aspects such as feelings of pleasure. Li (2021) reported that green spaces in Shanghai City were positively correlated with aesthetic appreciation and emotional attitudes toward green spaces. These findings are similar to the results of this study. Furthermore, Bi et al. (2024) explored how natural elements significantly influenced residents' perceptions of aesthetics, which is consistent with the findings of this study, demonstrating a significant correlation between natural landscapes and aesthetic perception ($r = 0.983$). Therefore, enhancing natural landscapes, such as increasing vegetation and optimizing water layouts, should be prioritized to improve aesthetic perception and restorative experiences, making them essential for attracting visitors and fostering positive emotions.

5. Conclusions

To summarize, the LSTM model applicable to the sentiment analysis of country park reviews is trained from four evaluation levels, namely, location layout, landscape environment, functional service, and physical and mental perception. It utilizes nine elements of post-use evaluation indices, namely, external condition, internal condition, natural landscape, humanistic landscape, supporting facility, management service, recreational experience, physical and mental restoration, and physical and mental restoration, to learn the semantic information and sentiment tendencies in the online reviews. The results of emotional tendency judgments provide valuable feedback and opinions for designers and managers and can help decision-makers grasp the needs and expectations of visitors to a large extent; subsequently, the quality of country parks can be optimized more accurately to improve visitors' experience. Because social media comments are collected from internet platforms, the user groups on these platforms may not fully represent all park visitors, particularly those who are less likely to access the internet, such as elderly individuals and children. Word frequency analysis and label classification

effectively identify users' main concerns but may overlook less-discussed yet important aspects. Future research could complement these methods with qualitative analysis or surveys to capture a wider range of visitor feedback for a more comprehensive evaluation. However, overall, the final model has an accuracy of 0.913, a recall of 0.917, and an F1 value of 0.915 and thus can be used for effective analysis of the comment text.

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Conflicts of interest

The authors declare no conflict of interest.

Data availability statement

All data generated or analyzed during this study are included in this article.

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