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THE RESEARCH ON THE IMPACT ASSESSMENT OF VISUAL LANDSCAPE OF COUNTRY PARKS IN BEIJING

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Abstract. The attribute of a country park and its visual environment are not only influenced by the distance from the park to the downtown area, but also the degree of urbanization. Based on the landscape geography, landscape ecology, landscape aesthetics theories and the Guideline for Technical Review of Environmental Impact Assessment of Construction Projects (HJ 616-2011) and aiming to evaluate the visual quality of the country parks, we put forward three first-grade indicators (visual sensitive capacity, visual space capacity and visual absorption capacity) and seven second grade indicators (sighting distance, visual disturbance frequency, green looking ratio, inter-visibility, openness, relative angle and the relative area of artificial matrix) in our research. By virtue of the established entropy weight method model, combined with field data, the quantitative research of the visual environment of landscape in country parks was carried out so that the visual quality of the park can be improved. At same time, this can also provide a scientific basis for spatial planning of urban fringe area and repositioning of the park attribute.

Keywords: country park, urban-rural area, visual landscape, visual environment quality, impact assessment, entropy weight method.

Introduction

With the acceleration of urbanization, urban fringe areas where originally belong to green space have been replaced by many high-rise buildings, which seriously interferes with the edge of the city green-land. This especially affects the visual environment of the country park and destroys the integrity, openness and continuity of urban green space, resulting in lacking of green landscape preservation in the urban-rural area. In 2011, Ministry of Environmental Protection of the People's Republic of China promulgated the Guideline for Technical Review of Environmental Impact Assessment of Construction Projects (HJ 616-2011), which was mainly aimed at roads, railways, mines, quarries, scenic areas, water conservancy and hydropower projects, and large construction projects in urban areas, in particular, reckoning in the impact assessment of landscape aesthetics (Ministry of Environmental... 2011). Country park as a typical representative of green space in the urban-rural area, its impact assessment of visual landscape is imperative. Based on previous studies, using a new method of the impact assessment of visual environment evaluates the quality of country parks. As a result, the visual environment of urban-rural green space can be quantified, which provides a scientific basis for spatial planning of urban fringe area and repositions the park attribute.

Visual landscape, in short, is a visual resource. For the concept of the visual landscape, scholars have not reached on consensus and each sticks to his argument. When researching on the visual landscape quality, Daniel and Vining (1983) summed up the evaluation models, and those were ecological model, formal aesthetic model, psychophysical model, psychological and phenomenogical model. Through the analysis of landscape structure and image, Krause (2001) wanted to protect and develop high-quality natural and cultural beauty. Dramstad *et al.* (2006) studied the visual landscape preference of the different groups for different landscape structures. For the problems of accessing data of traditional landscape perception and preference in the visual landscape assessment, Roth (2006) used the network to obtain data in order to solve the above problems. Roads dominated our daily surroundings and were essential conditions of the access to the visual landscape, Garré explored the dual role of road in the

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visual landscape (Garré *et al.* 2009). Along with the pace of urbanization, the countryside transformed itself from a rural area to an urban nation. In reaction to this phenomenon, Spanish scholars studied the rural landscape changed by human, which corresponded to the changes of visual perception (Cloquell-Ballester *et al.* 2012). In order to better understand the future landscape as the aesthetic subject, Nohl (2001) established a conceptual framework. Unlike other visual landscape research, Kaplan *et al.* (2006) studied the visual landscape preference of the urban-rural fringe. Nakamae *et al.* (2001) applied the rendering technology generated by computer graphics and video sequences to evaluate the quality of visual landscape. Researches on the visual impact of other countries involved in the wind power plants, greenhouse parks, mines and other aspects. Spanish researchers had developed a predictive model which could be used to predict the visual impact of the wind plant and as a query tool to analyze and evaluate the proposed wind plant project (Hurtado *et al.* 2004; Molina-Ruiz *et al.* 2011). Along with the advance of modern geographic research techniques, GIS and 3D simulation technology had been widely used in the impact assessment of visual landscape (Ayad 2005). Rogge *et al.* (2008) utilized the GIS to quantify and value the visual impact brought by the development of greenhouse cluster, putting forward the measures to reduce the visual impact of greenhouse park. During the process of mining and restoration, Menegaki *et al.* (2012) took LETOPID (Landscape Evaluation Tool for Open Pit Mine Design) method to reduce the visual impact. The impact assessment of visual landscape, often involving in the occlusion and avoidance, usually used GIS to establish the 3D visual model, then made sight and viewshed analysis (Hernández *et al.* 2004a, 2004b). Through the questionnaire survey, Hernández *et al.* (2004b) determined the influence of building on the surrounding landscape in order to verify the effectiveness of the GIS for site selection.

In China, Kongjian Yu as one of the researchers who studied the visual landscape, proposed the concept of landscape threshold (Kongjian 1991). Binyi Liu introduced American visual resources management into China, and deepened its development (Binyi 1990). However, the visual landscape impact research started relatively late in the last century, some scholars researched on the concept, evaluation process, content and methods of visual impact of landscape, and conducted a quantitative evaluation (Renhai 1999; Yang, Xiaolin 1999). In the 21st century, this field really began to be concerned about, but only made some theoretical researches initially (Tan *et al.* 2000; Yuhu 2001). With the maturity of some theories and methods, visual landscape impact research had gradually applied to different evaluation objects. On the basis of literature review research, Tong *et al.* (2013) emphasized that visual landscape should give the viewer a strong visual perception and impression in a particular area. However, most of Chinese researchers were limited to the internal area for visual landscape environment impact, lacking in the research on the negative impact arising from the external disturbances (Chuanfa, Jianhua 2009; Youbo, Yue 2007; Hui *et al.* 2009; Xüling *et al.* 2012; Jianhua 2008).

Whether it is the natural landscape or cultural landscape, environmental problems lead to specific requirements needed in various sectors for visual impact assessment. But, evaluation factors involved are too subjective, and less factors that can be objective and quantitative, which makes the impact assessment of visual landscape is too subjective (Mortberg *et al.* 2007). In this article, objective quantitative evaluation of interference factors (especially the artificial building) outside the park has an effect on the visual environment, which is a good reference for solving the above problems.

1. Materials and methods

1.1. Study area

In this article, 14 parks are selected in Beijing (12 country parks, two city parks) to carry on the case study. 12 country parks selected are very representative (there are three in the west and the east, two in the south and four in the north), and the two city parks are the typical parks which are used to compare with the country parks (Fig. 1). By conducting field data collected, combined with the indoor processing, the evaluation indicators of the initial data are obtained.

1.2. The index system of the impact assessment of visual landscape

There is a close relationship among the interference of high-rise buildings in the urban-rural area and their spatial position, physical attribute. Korean scholar put forward the visual threshold carrying capacity (VTCC) in the study of city landscape management. Kyushik (1998) considered that the influence of external disturbance factors on the visual landscape was a cumulative effect, and not a single effect. The study of visual environment should examine its internal constitution and surroundings, including some sensitive landscapes, spatial attribute and the coordination between different landscapes. We find many problems in Beijing Limited Construction Area Planning (BLCAP): the construction limited area is not clear. The boundaries between construction areas and green space are uncertain, and construction guidelines only make demands on building height (Ying *et al.* 2012). There are also other problems, such as lacking in the consideration of architectural appearance, visual control, visual corridor, coordination and other aspects. Based on these, three first-grade indicators are proposed for the impact assessment of visual landscape: visual sensitive capacity (VSEC),

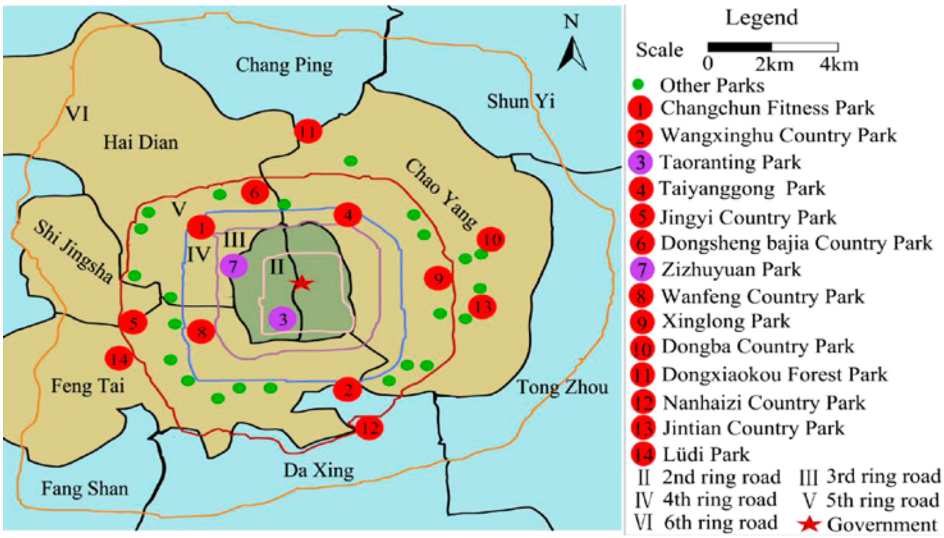

Fig. 1. The location map of the 14 sample parks

visual space capacity (VSPC), visual absorption capacity (VABC).

1.2.1. *Visual sensitive capacity*

"Sensitive" comes from the psychology, referring to responding to the external things quickly. Kongjian Yu put forward the "landscape sensitivity" in the study of conservation planning of South Taihang Mountain Canyon landscape, introducing the term "sensitive" to landscape geography. He deemed that the landscape sensitivity was a measure of the degree of landscape to be noticed, the comprehensive reflection of relative slope, the distance between landscape and the observer, the probability of landscape appearance in the field of vision and striking degree of landscape (Kongjian 1991). This was the evaluation of the natural heritage landscape, meanwhile, it also had a reference for city landscape evaluation. Aoki Yoji in 1987 presented the notion of "Green Looking Ratio", defining it as the share within the vision of green plants (Xiaojun, Honggang 2002). Visual sensitive capacity is mainly in the light of the impact assessment of physical properties of artificial architecture and the natural landscape, including sighting distance, visual disturbance frequency and green looking ratio.

Sighting distance (D): From the point of view to outside the building is D, can be measured by a laser range finder, if no building outside the area, then D = 0.

Visual disturbance frequency (V): According to the green space size, at 100 m (small scale) or 200 m (large scale) interval separately setting a viewpoint, between adjacent viewpoints, the visible distance of outside the building is L. Then V = L/100 or V = L/200, if never see outside structure between adjacent viewpoints, then V = 0; if the building has always been seen outside the region between adjacent viewpoints, then V = 1.

Green looking ratio (G): The share within the vision of green plants, importing photos to Photoshop software, calculating the area of green vegetation in the photograph and photo area, then obtains green looking ratio (green vegetation area/photo area).

1.2.2. *Visual space capacity*

Space not only belongs to the geography, but also the aesthetic category. It could be divided into three-dimensional physical space – objective space, psychological space – subjective space, behavior space – social space and symbolic space. Space discussed in this article only refers to physical space which is composed of the base surface and the three-dimensional boundary. When it comes to visual space, we should consider the openness of viewshed (the horizontal direction) and the continuity of the line of sight (the vertical direction). Visual space capacity mainly focus on visual control range and visual corridor of the human eye, referring to the degree of vision openness, spatial category and characteristics of the horizon constitution, which depends on the scale of landscape element and visual space openness surrounded by the skyline. To evaluate the visual space capacity, two second grade indicators are proposed in this article: inter-visibility and openness.

Inter-visibility (I): By investigating the continuity of the line of sight, we use a laser range finder to measure the distance between observer and the object that blocks line of sight.

Openness (O): To examine the extent of open of viewshed, photographs are imported into Photoshop software for processing and computed the skyline share in the field of vision (the length of skyline in the photograph/the width of photograph).

1.2.3. Visual absorption capacity

In 1960s–1970s, due to the improvement of public's concernment for the visual environment quality, as well as the introduction of legal documents relating to the environment, America's environmental impact assessment emphasized on the visual and aesthetic resource value. In the United States, there were three important scenic resources management systems: Visual Management System (VMS), Visual Resources Management (VRM) and Landscape Resources Management (LRM) (Xiaojun 1993). Scenic resources management system was mainly used in landscape evaluation, and it was based on landscape quality assessment and visual impact assessment to divide different level of regions. Visual absorption capacit (VABC) evaluation was put forward in VRM assessment. VABC had the ability to assimilate outside environment or visual impact, maintaining the inherent characteristics of the landscape (Anderson 1979). In landscape Ecology, landscape structure is divided into patch (punctiform), corridor (threadiness) and matrix (planar). This is a large-scale landscape structure, zooming to the city landscape, artificial construction can be regarded as a kind of matrix. The height and distance of artificial construction outside the park determine the observer's angle, which will affect the coordination of the entire park and its ability to assimilate visual environment. Therefore, the visual absorption capacity evaluates the coordination between artificial architecture outside and the natural landscape, including the relative angle and the relative area of artificial matrix.

Relative angle (A): Measure the angle of elevation of sight between artificial architecture of outside and viewer through a laser range finder. The angle of elevation of observing landscape is α, its sine value is relative angle. $A = \sin \alpha$ ($0^o \le \alpha < 90^o$). When $\alpha = 0$, $A = 0$.

Relative area of artificial matrix (C): We import photographs into Photoshop software to calculate the area of artificial construction and photo area, and calculate the visual share of artificial construction (artificial construction area/photo area).

2. The process of the impact assessment of visual landscape

The impact assessment of visual landscape covers three first-grade indicators and seven second grade indicators. This article intends to build a mathematical model of the impact assessment of visual landscape by entropy weight method to achieve quantitative evaluation of the visual quality.

2.1. Division of factor subset

The entire visual environment quality (Z) is divided into three subsets: visual sensitive capacity (Y_1), visual space capacity (Y_2) and visual absorption capacity (Y_3). Then $Z = \{Y_1, Y_2, Y_3\}$, three subsets are: $Y_1 = \{X_1, X_2, X_3\}$, $Y_2 = \{X_4, X_5\}$, $Y_3 = \{X_6, X_7\}$. X_i represents the seven second grade indicators.

2.2. Quantitative classification indicators

Sighting distance: visual effects observed from the object is closely related to sighting distance. Distance is 300 m, which can be observed the form and details of the single structure; from 300 m to 1500 m, building groups can be observed; from 1500 m to 3000 m, only can see the outline of building groups. This principle is related to the division of close view, medium view and distant view, and also affects the scope of each landscape control point. Based on this, the sighting distance is divided into four grades: 0 m, more than 1000 m, (300 m, 1000 m], (0 m, 300 m].

Visual disturbance frequency: If the landscape can been seen between two points, then $l = L$, and sensitivity is the highest; $l = L/2$, medium sensitivity; $l = L/7$, the lowest sensitivity. Visual disturbance frequency is divided into four grades: 0, (0, 15%], (15%, 50%], (50%, 100%].

Green looking ratio: When the green looking ratio is less than 15%, the artificial traces are increased. The green looking ratio is more than 15%, and natural feeling will increase. When the green looking ratio reaches 25%, people will feel most comfortable, and it's beneficial to human health. Chunfa and Jianhua (2009) evaluated the visual environment of Yuntai mountain, dividing the herb coverage into four grades which based on the three thresholds: 70%, 80% and 90%. Reference to the above research results, this article will divide green looking ratio into four grades: [90%, 100%], [70%, 90%), (25%, 70%), [0, 25%].

Inter-visibility: Road traffic had strict requirements for the inter-visibility, in general, the visual distance of road's longitudinal slope design must reach 400–600 m (Jishuang, Yong 2001). According to the degree of occlusion, this article will divide inter-visibility into four grades: 600 m, [400 m, 600 m], [200 m, 400 m), (0 m, 200 m).

Openness: "Golden section" has a close inner link mechanism with human vision. Based on this, openness is divided into the following four grades: 100%, (61.8%, 100%), (0, 61.8%], 0.

Relative angle: Based on the 50 m contour interval, Kongjian Yu (1991) calculated the sensitivity of relative slope during the evaluation of canyon landscape of Wangxiangyan. The relative angle is divided into the following four grades: 1, [1/2, 1), [1/4, 1/2), [0, 1/4).

Relative area of artificial matrix: Based on the share of artificial landscape outside the park, we divide the relative area of artificial matrix into four grades in this paper (Guxin, Feng 2009): [0, 4%], (4%, 10%], (10%, 20%], (20%, 100%].

Table 1. The indicators classification of the impact evaluation of visual landscape

Assignment Indicators	7 points	5 points	3 points	1 points
Sighting distance (m)	0	D > 1000	300 < D ≤ 1000	0 < D ≤ 300
Visual disturbance frequency (%)	0	0 < V ≤ 15	15 < V ≤ 50	50 < V ≤ 100
Green looking ratio (%)	90 ≤ G ≤ 100	70 ≤ G < 90	25 < G < 70	0 ≤ G ≤ 25
Inter-visibility (m)	Unobstructed or I > 600	400 ≤ I ≤ 600	200 ≤ I < 400	0 < I < 200
Openness (%)	1	0.618 < O < 1	0 < O ≤ 0.618	0
Relative angle	0	0 < A ≤ 1/4	1/4 < A ≤ 1/2	1/2 < A ≤ 1
Relative area of artificial matrix (%)	0 ≤ C ≤ 4	4 < C ≤ 10	10 < C ≤ 20	20 < C ≤ 100

2.3. Entropy empowerment

In order to overcome the subjectivity of the traditional methods of empowerment, we use entropy weight method to determine the weight of each indicator factor (Wanhua 2010). The weight depends on the information loaded by each indicator, and the information content can be represented by entropy, that is the entropy of information (Yu, Zongfang 2006). The reduction of entropy means the increase of the information content. According to the view of information theory, indicator variation is usually used to examine the role of each indicator in the evaluation model. The change of indicator is larger, and the information content is greater, then the indicator of "recognition" is stronger (Meihong, Aihua 2006). In short, if the change of a certain indicator X in different evaluations is large, then it has an important role on differentiating the subject of evaluation and should be given greater weight. Entropy model includes many formulas and calculation process. The formula of W_i and H_i are used to respectively calculate the values of weight and the entropy of each indicator. f_{ij} is the proportion of each indicator in standardization value, and k is the correction coefficient.

Entropy model:

$$W_i = \frac{1-H_i}{m-\sum_{i=1}^{m} H_i}, \quad H_i = -k\sum_{j=1}^{n} f_{ij} \ln f_{ij}, \quad f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}},$$

$$k = \frac{1}{\ln n}.$$

Where, W is the weight value for each single indicator. H is entropy, m is the number of indicator, k is the correction coefficient, n is the number of evaluation subject, f is normalized indicator matrix, r is the normalized value of indicator.

Before analyzing the data, we usually need to standardize the data. After standardization, the original data will be converted into dimensionless indicator value and the value of each indicator will be in the same level, which could be used to make a comprehensive evaluation analysis. The role of formula r_{ij} is to standardize the data.

Standardized formula:

$$r_{ij} = \frac{r_{ij}' - \min\left\{r_{ij}'\right\}}{\max\left\{r_{ij}'\right\} - \min\left\{r_{ij}'\right\}},$$

r_{ij} is the normalized value of indicator, r_{ij}' is the original value.

2.4. The mathematical model of the impact assessment of visual landscape

On the basis of the weight value of each indicator calculated by entropy weight method and the field investigation data, making the visual environment quality (*VEQ*) of country park as the dependent variable and each evaluation indicator as independent variable, to establish the mathematical model of the impact assessment of visual landscape according to the function relationship between the evaluation indicators and the visual environment quality. In this model, *VEQ* is to calculate the value of visual quality, and the influence of each indicator on the visual environment quality is independent.

$$VEQ = m^{-1}\sum_{i=1}^{n}\sum_{j=1}^{m} w_i x_{ij}.$$

Where, VEQ represents the value of visual quality, x_{ij} is the quantity value of indicator i of point j. w_i is the weight of indicator i. n is the number of indicator, m is the number of viewpoint.

2.5. The model of the impact assessment of visual landscape of country park

The mathematical formula *VEQ* is a multivariate first-order equation of linear regression established by the weight value of each indicator. Through regression analysis, we summarize the degree of significant differences and the collinearity, finding out the main factors which impact the visual landscape environment of country park. In this formula, X_i is the weight value of indicator.

$$VEQ = 0.154\,X_1 + 0.378\,X_2 + 0.026\,X_3 + 0.276\,X_4 + 0.115\,X_5 + 0.027\,X_6 + 0.024\,X_7.$$

2.6. Model validation and sample evaluation

For the Beijing urban green space system, the country park is an important part (Beijing Municipal... 2009). The "country park ring" plan has been launched since 2007 in Beijing, and the main function is to prevent the central area of the city and peripheral groups forming into one, controlling urban disordered extension, improving the efficiency of urban land use, avoiding the development of city "pie" type. As a significant greenbelt, country parks play important roles in the capital's economic and social development, urban ecological pattern, and the living quality of residents. At the same time, this also improves the city's sense of identity and belonging, and changes leisure pattern of Beijing city. Considering the difference of types and distributions, 12 representative country parks are selected among the 81 country parks, and the two typical city parks which are used to compare with the country parks.

Table 2. The weight of each indicator of the impact assessment of visual landscape

The first grade indicators (Y)	The second grade indicators (X)	Weight
Visual sensitive capacity (Y_1)	Sighting distance (X_1)	0.154
	Visual disturbance frequency (X_2)	0.378
	Green looking ratio (X_3)	0.026
Visual space capacity (Y_2)	Inter-visibility (X_4)	0.276
	Openness (X_5)	0.115
Visual absorption capacity (Y_3)	Relative angle (X_6)	0.027
	Relative area of artificial matrix (X_7)	0.024

Table 3. Regression analysis

Models	Factors	P	Tolerance
1	(Constant)	.510	
	Sighting distance	.030	.011
	Visual disturbance frequency	.000	.343
	Green looking ratio	.217	.626
	Inter-visibility	.006	.033
	Openness	.010	.087
	Relative angle	.320	.028
	Relative area of artificial matrix	.437	.043
2	(Constant)	.212	
	Sighting distance	.004	.017
	Visual disturbance frequency	.000	.345
	Green looking ratio	.133	.675
	Inter-visibility	.002	.049
	Openness	.000	.229
	Relative angle	.282	.028
3	(Constant)	.480	
	Sighting distance	.000	.251
	Visual disturbance frequency	.000	.373
	Green looking ratio	.155	.680
	Inter-visibility	.000	.210
	Openness	.000	.368
4	(Constant)	.007	
	Sighting distance	.000	.255
	Visual disturbance frequency	.000	.374
	Inter-visibility	.000	.230
	Openness	.000	.389

In order to verify the validity of the initial model, we use step-by-step backward regression analysis to analyze the significance of difference degree and colinearity of each factor (Table 3). The result shows, P value of relative area of artificial matrix (model 1), relative angle (model 2) and green looking ratio (model 4) are all greater than 0.05. This illustrates significant difference is in low degree, in other words, the degree of recognition of factor is low, and the effect for evaluation is very small. Therefore, excluding the above three factors, and the four factors: sighting distance, visual disturbance frequency, inter-visibility and openness are preserved. Tolerance values are all greater than 0.1 (model 4), meeting the conditions of the collinearity, and the model evaluation by four factors are effective. Then the four factors were assigned weight by the standard deviation method. The final evaluation model is established: $VEQ = 0.272D+0.3V+0.231I+0.197O$.

Urban-rural area, except for urban construction land, is a large area of natural or near-natural state which belongs to urban green space. Along with the spread of urban expansion, the contradiction of the land use of urban-rural fringe is increasing. In 2007, the Beijing municipal government launched the construction of the first green isolating areas into "country park ring". The purpose was to form the space layout of "a ring, six districts, one hundred parks" which was around the center of the city, and to build a "chain cluster" structure of "the whole into a ring, the segmentation into pieces". It becomes a landscape green belt and ecological protection zone, meanwhile, a place for public recreation and exercise.

So far, 81 country parks have been built in Beijing. However, according to our initial investigation, we find the following problems in Beijing country parks: (1) The space layout of country park is not balanced. Large numbers are in the east and south, only a few portions distribute in the north and west. (2) Obvious traces of artificial landscape are seen in somewhere. Golf courses, business club and other illegal constructions occur frequently in the country park. This seriously interferes with the natural landscape. (3) The design of country parks is not a big difference compared with city parks, which lacks in the property of wildness. (4) The boundary is disturbed by high-rise buildings. The features of visual landscape are inconsistent with the attribute of country park.

We calculate the value of visual environment quality of each country park by using the impact assessment of visual landscape model, and visual environment quality of each country park is graded.

3. Discussion

The level of the visual environment quality of the country park reflects the visual impact of peripheral artificial construction on the park and the urbanization level in a certain area. Theoretically, with the increasing of distance from the park to downtown area, the level of urbanization is gradually decreasing, and the visual environment quality of the country park should gradually increase and the park's overall visual environment should gradually improve. However, through our research, we found the visual environment quality of the selected 14 sample parks did not completely comply with the above hypothesis. The main reason is that the direction of urbanization development in Beijing mainly towards the north and west areas, which results in the visual environment quality sharply reducing in Changchun Fitness Park (between west 3rd ring road and west 4th ring road) and Dongsheng bajia Country Park (Between north 4th ring road and north 5th ring road) (Fig. 2). With regards to this, the Beijing City Master Plan (2004–2020) posed that the urban space resources should be rationally utilized and controlled the large-scale population and industrial agglomeration in western and northern mountainous areas of Beijing, and the development direction of city should towards the eastern and southern plain regions (Beijing Municipal People's Government 2005). The results of this research confirm the thought of the Beijing City Master Plan (2004–2020).

The development of Beijing urbanization is not balanced, and in the west and north part areas are significantly higher than other urban areas, which leads to the so-called country park wearing "country park" hat, but dressing in "city park" coat. It is difficult to make distinguish from the attribute of country park. In this article, by calculating the visual environment quality of the country parks, we find that the score of visual environment quality should reach at least 4.2 which could meet the basic requirements of a country park. Besides, according to Beijing Green Space System Planning (BGSSP), country

Table 4. The grade of comprehensive evaluation of the visual environment quality

Visual environment quality	1 ≤ VEQ < 2.8	2.8 ≤ VEQ < 4.2	4.2 ≤ VEQ < 5.6	5.6 ≤ VEQ ≤ 7
Centesimal system	14 < VEQ < 40	40 ≤ VEQ < 60	60 ≤ VEQ < 80	80 ≤ VEQ ≤ 100
Grade	iv	iii	ii	i
Outcome	Lower visual environment quality	Low visual environment quality	High visual environment quality	Higher visual environment quality

Table 5. Visual environment quality and grade of the 14 sample parks

Sample parks	Location	Distance to the city center (Tiananmen Square) (km)	Visual environment quality/ Centesimal system (%)	Grade
Changchun Fitness Park	Between north 3rd ring road and north 4th ring road	10.8	1.14/16.3	iv
Wangxing Lake Country Park	Between south 4th ring road and south 5th ring road	10.9	2.7/38.6	iv
Taoranting Park	Within south 2nd ring road	3.9	2.79/39.9	iv
Taiyanggong Park	Between north 3rd ring road and north 4th ring road	8.6	3/42.9	iii
Jingyi Country Park	Between west 4th ring road and west 5th ring road	15.1	3.08/44	iii
Dongsheng bajia Country Park	Between north 4th ring road and north 5th ring road	13.4	3.11/44.4	iii
Zizhuyuan Park	Between west 2nd ring road and west 3rd ring road	7.5	3.24/46.3	iii
Wanfeng Country Park	Between west 3rd ring road and west 4th ring road	9.2	3.34/47.7	iii
Xinglong Park	Between east 4th ring road and east 5th ring road	11.4	3.44/49	iii
Dongba Country Park	Between east 5th ring road and east 6th ring road	14.6	4.09/58.4	iii
Dongxiaokou Forest Park	Between north 5th ring road and north 6th ring road	14.4	4.14/59	iii
Nanhaizi Country Park	Between south 5th ring road and south 6th ring road	15.5	5.3/75.7	ii
Jintian Country Park	Between east 5th ring road and east 6th ring road	14.4	5.42/77.4	ii
Lüdi Park	Between west 5th ring road and west 6th ring road	16.3	5.65/80.7	i

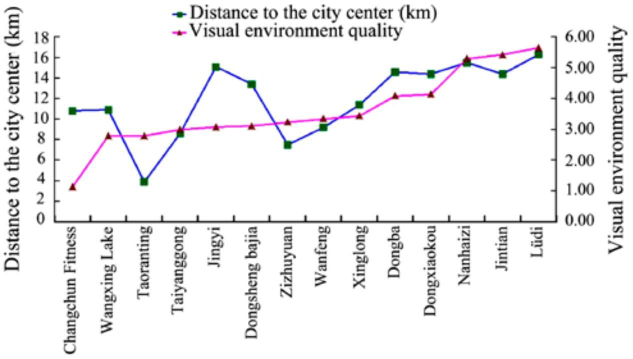

Fig. 2. The line graph of visual environment quality and distance to the city center

parks are mainly situated in the first green isolating areas, and the location of green isolating areas are mainly outside the 4th Ring Road in Beijing (the distance to the city center ≥8km). The park's attribute classification is too administrative, lacking in scientific basis, then we present two important bases to redefine the attribute of country park: (1) The visual environment quality of the country park reaches more than 4.2; (2) To have a certain distance to the city center, and the distance depends on different cities, being proportional to the city scale. For example, the country park to downtown area should be more than 8 km in Beijing. In accordance with the above two rules, among the 12 country parks selected, only the Lüdi, Jintian and Nanhaizi belong to the country park (Fig. 2).

Collecting and processing the field data of a park's visual environment to calculate the visual environment quality of each viewpoint. Through analysis and research, the factors which affect the visual environment quality of each viewpoint can be drawn. Then, the targeted improvement measures are proposed, so as to enhance the overall visual quality of the park. Taking Jingyi Country Park as an example, the viewpoints that impact on the overall visual quality of the park are: point 1, point 2, point 3 and point 8 (Fig. 3). The most obvious interference factors for the four points are outside of high-rise buildings. The high-rise buildings are not only close to the park, but their large body, as well as the impact of high-voltage tower. It can be covered by planting tall trees, and as much as possible to reduce the disturbances occurred in the vertical line of sight of visitors. Another way, micro-terrain design around the park boundary, to some degree, it may reduce the range of inter-visibility and visual disturbances, the interference of high-voltage tower and high-rise buildings, but it also can arise the green looking rate. So, the visual environment quality of park can be greatly improved, and the standard of country park can be reached.

The influence of building facilities on the visual environment, the sighting distance, visual disturbance frequency, inter-visibility and openness are especially evident. The denser of artificial buildings are, the higher of visual share and the degree of landscape feature alienation will be. Materials, volume, color, style and other aspects of the artificial buildings do not coordinate with the park natural rustic charm. At the same time, there are also other artificial facilities, such as billboards and pipelines, which bring negative influence on the visual environment quality of country park. During the field study, we found that most of the country parks have been built in the area of

Fig. 3. The four viewpoints of Jingyi Country Park
Point 1 (upper left), Point 2 (upper right), Point 3 (lower left), Point 8 (lower right).

high-voltage corridor. Because it locates in the park area, and the landscape striking degree is high, which brings serious visual pollution to the country park. The layout of vegetation within the park primarily affects inter-visibility and openness. The construction of country park was based on the first green isolating areas, and the main function of the original vegetation is the ecological protection, and lacks some considerations of landscape visual effect. The vegetation of some areas where adjacent to the main tour roads are too dense, blocking the line of sight, compressing the visual space, without concerning about the psychological perception of tourists, which gives a feeling of oppression to viewers.

Conclusions

1. To provide reference for planning control and land resource management in fringe area of central city. Firstly, "single-storey house be changed to high building" policy should be adjusted and need to be appropriate intensive layout. This policy has resulted in landscape fragmentation, and the continuity of country park ring and the integrity of landscape pattern are destroyed by the current implementation policy that the constructions are built in the original place and dispersed layout. Secondly, on the basis of country park ring that has been built between 4th ring road and 5th ring road, the thickness of the greenbelt should continue to widen between 5th ring road and 6th ring road, and make it a landmark in the urban fringe area. Thirdly, to some extent, the construction of country park limits the development direction of Beijing city fringe area, the distribution of country parks and the landscape pattern. There are mountainous areas in the west of Beijing city center, the historical and cultural protection area in the northwest, which owns a good substrate of greenbelt landscape, and there should be no large-scale construction in this area. The area that in the east and south of Beijing is in the intersection of the region of ecological protection and the urban-rural integration construction. The scale, speed and complexity of landscape change are unprecedented. Fourthly, it should maintain a certain width of green space among city center, fringe groups, and the peripheral of fringe groups. At least 200 meters visual buffer zones should be set up between construction area and landscape protection area.
2. To flexibly apply the following planning methods:
   (1) Protection. Avoiding the landscape which has a negative impact on the visual environment of park. Prohibiting super high-rise buildings so as to protect important skyline and landscape view corridor. Some country parks outside the 5th ring road should be taken protective measures firstly. For instance, Dongxiaokou Forest Park, Olympic Forest Park and Taiping Country Park are in the traditional north-south axis of Beijing city, which is an important visual channel for Beijing, and the inter-visibility of the visual corridor should be protected. Adjacent to the Yongding river, Lüdi Park is an important ecological corridor and a landscape corridor, but also an air duct, which plays a role in improving the air quality in the center city. Lüdi Park is the highest score in the grade of comprehensive evaluation of the visual environment quality among the 14 parks and is a key visual protection area. As the nearest natural wetland to city center, Nanhaizi Country Park keeps the country characteristic that country park should possess. To establish the control zone between the country park and other landscape areas, and avoid building too many artificial constructions around the periphery of the country parks. Then, the visual interference frequency will be reduced, and the continuity and inter-visibility of the green landscape will be protected.
   (2) Restriction. If the negative impact is inevitable, we must control its development and construction. The building that is near the park should strictly limit its number of floors and control its height. It has built some residential area in the north of the Dongba Country Park and the south of Jintian Country Park, like these country parks outside the 5th ring road, which should set up visual buffer zones between different landscape boundaries. By controlling the location, volume, shape, height of artificial construction and the distance to restrict the visual impact of artificial constructions on the country parks.
   (3) Avoidance. In order to enhance the aesthetic perception of tourist, the design for the park tour road should try to avoid the low quality of the visual environment of viewpoint, and makes tourism line through the high visual environment quality of the viewpoint as far as possible. In the important node of tour road of country park, like Jingyi Country Park and Dongshengbajia Country Park, ground cover, herbs, shrubs, trees should be cultivated to shape multi-level landscape to promote the aesthetic value of the country parks. In addition, making necessary adjustment of the direction of some tour roads to avoid interference of visual sensitive points of artificial buildings outside the country parks and improve the inter-visibility and openness of nodes.
   (4) Repair. For the existing visual pollution, we should take measures to repair the visual environment. Due to the continuous expansion of urban development to the periphery, the peripheral of country park has appeared the high-rise buildings and other negative landscape. Faced with such a situation, we take steps such as micro-topography, planting tall trees and other ways to weaken its visual impact. A few

country parks such as Xinglong Country Park and Jingyi Country Park are between 4th ring road and 5th ring road which need to adopt necessary measures for the boundary of parks to cover and conceal the visual contact of peripheral architecture. Taking micro-topography processing or planting some tall crown diameter trees, like poplar and ginkgo, to form the enclosure of internal landscape, at the same time, to improve the green looking ratio. The degree of visual influence of artificial high-rise buildings and high-voltage towers will be cut down.

(5) Reposition the park attribute: By protection, restriction, avoidance, repair and other measures, some country parks such as Wangxing Lake Country Park, Changchun Fitness Park, Taiyanggong Park and Wanfeng Country Park cannot change the visual impact of external artificial construction to the parks. These parks are relatively close to the city center and the surrounding areas have been completely urbanized, and the visual environment quality are under 4.2. Then, we suggest changing the attributes of these parks, and convert them into city parks.

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