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Study on the Improvement of the Green Looking Ratio of Built Micro Green Space in High-Density Cities

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Abstract:

In high-density urban landscapes, it is difficult to achieve a larger area of green space. It is necessary to explore whether there is still the possibility of greening improvement in existing areas, especially the possibility of increasing the total green looking ratio. Green looking ratio plays a certain role in improving the urban microclimate, enhancing people's psychological and physical comfort, relieving pressure, creating a humanized urban environment, and exerting the ecological benefits of plants. Through the three selected research plots, the structured observation method, the green looking ratio statistics method, and the Likert scale analysis, the methods to improve urban greening from the perspective of increasing the green looking ratio are summarized. Three ecological factors: a. Create a scale by increasing the number of micro-green spaces. b. Make more room for people and increase participation. c. Create an eco-city or improve the overall green volume of the environment.

1. Introduction

1.1. High-Density Urban Micro-Green Space and Green Looking Ratio Background

Due to the development of urbanization, high-density cities have become the characteristics of developed cities in China [1], and will show a continuous growth trend in the future. The high density of people and buildings makes the allocation of green space unbalanced [2], resulting in high social and spatial density. This creates a crowded and anxious psychological environment [3].The high-density urban environment has the characteristics of "hybrid, symbiotic public space and vertical urbanism" [4]. The city needs to develop, and the land is constrained, forcing us to explore a land development model suitable for high-density cities [5]. In order to alleviate this phenomenon, micro-green space has gradually been applied and developed in high-density cities. It has public attributes, is open and small in scale,

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and is a green open space with functions such as recreation, entertainment, and education [6]. The world's first real micro-green space, Perey Park (pocket park), marks the official birth of the micro-green space type [7]. In recent years, the research on the green-looking ratio of green space has also attracted more and more attention, which explains the importance of micro-green space for high-density urban populations. The green-looking ratio is the green that can be seen everywhere visually and psychologically, which is in line with the current development trend of humanism in urban open spaces [8]. The Japanese scholar Yoji Aoki proposed that the proportion of green vegetation in the field of vision of the human eye can be used as a measure of human perception of the green environment, which is defined as the "green looking ratio" [9]. As a physical quantity reflecting the proportion of green vegetation in the urban landscape in the residents' vision [10], the green-to-green ratio is closely related to the level of urban greening, the image of the city, and the physical and mental health of residents.

1.2. Overview of the Status Quo of Micro-Green Space and Green Looking Ratio in High-Density Cities

The population density of high-density cities, as determined by the international academic community, ranges between 25,000 and 30,000 people per square kilometer [11]. More than 50% of my country's population is concentrated in cities that account for only about 4% of the country's land area. The environmental renovation and renewal of urban central areas have become a hot issue in green space design [12]. The land in most high-density cities is almost saturated, and it is difficult to increase the amount of environmental green in a large area. It is necessary to explore whether the existing areas have the possibility of developing green again. The amount of environmental green can affect people's psychological feelings, produce positive stimulation for people's nervous systems, and help people relieve tension and depression [13]. The three research sites selected in this study are of the same size and can represent the typical characteristics of the high-density urban micro-green space in Guangzhou, and explore how the micro-green space under the concept of green looking ratio can better provide people with recreational functions, improve public communication, and beautify the environment. green space with a good ecological effect [14].

2. Research Site and Research Method

2.1. Research Site Overview

Research site 1: Guigang Road Pocket Park. Located near the Podong Commercial Center in Yuexiu District, with a green landscape at the turning point of the crossroads, it is a cultural park with a long history. Play the role of environmental improvement, filter dust and noise. (Figure 1)

Figure 1. Guigang Avenue Pocket Park Figure.

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Research Site 2: Dongshan Master South Plaza, Yuexiu District Dongshan Young Master South Plaza is the intersection of business and residents' lives, as well as the starting point and ending point of bus stops. It is convenient for local residents to rest and it attempts to attract more foreign tourists to learn about Dongshan's regional culture. Its biggest feature is that people can carry out a variety of activities under the lush vegetation. (Figure 2)

Figure 2. Dongshan Master South Plaza.

Research Site 3: Huapu Green Island, Tianhe District The site is located at a crossroads. The concentric circles form a relatively quiet green island in the city. There are tall Terminalia serrata from the inside to the outside, and a spacious platform and benches on the outside, providing a good resting space for people. (Figure 3, Figure 4)
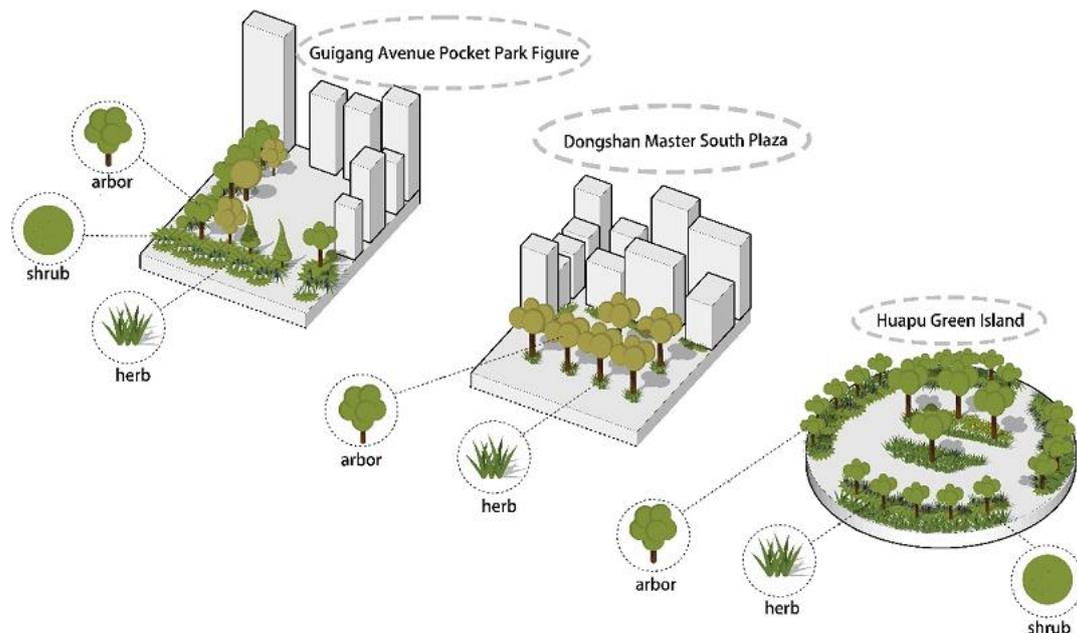

Figure 3. Huapu Green Island.

Figure 4. Research site plant configuration pattern.

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2.2.Research Methods

2.2.1. Structured Observation Method: Observation of Crowd Behavior Patterns

The structured observation method was proposed by Dr. Visas Mehta [15]. Through the structured observation method, object sampling and time sampling are carried out on the elements of space and human behaviors. This structured observation method is mainly based on the observation of crowd behavior patterns. Observing the habitual behaviors of people in pocket parks will help to improve the functional attributes of the microgreen space. Select representative behaviors that are directly related to the purpose of the study from the various behaviors of the observed for observation.

2.2.2. Green Looking Ratio Statistics

Use the image processing software Photoshop to process and analyze the obtained pictures, identify and extract the green part, and finally calculate the green looking ratio according to the green looking ratio calculation formula. A pixel is the most basic and indivisible unit of an image. An image is composed of pixels of different colors and shades, and a collection of many pixels forms an image. The calculation formula for the green-looking ratio can be expressed as follows: green looking ratio = green part pixels * 100%/total pixels of the photo.

2.2.3. Likert Scale Research Method

This satisfaction research method adopts the Likert scale method, which consists of a set of statements. For each statement, participants can choose one option from the five statements of "strongly agree," "agree," "average," "disagree," "strongly disagree." Set five different scores according to the five answers. Make a horizontal comparison based on the final score and the green looking ratio data. The satisfaction evaluation method in this study adopts a combination of dynamic evaluation and static evaluation. The dynamic satisfaction evaluation is the real-time evaluation of the visual perception of the screen by the respondents on the spot. It is set as D (dynamic satisfaction evaluation, D), and the static satisfaction evaluation The evaluation is carried out in the form of an online questionnaire, set as S (static satisfaction evaluation, S).

3. Results and Discussion

3.1. Structured Observations

3.1.1. Observation of Crowd Behavior Patterns

The spatial forms of the micro-green spaces selected for this study are micro-green spaces facing the streets, square-affiliated micro-green spaces, and micro-green spaces in traffic roundabouts. The structured observation method was used to analyze the crowd behavior at the three survey sites, and the specific conclusions were as follows (Table 1, Table 2):

Table 1. *Structured observation behavior summary table of the observation point of Guigang Avenue Pocket Park.*

Observation Time	Space Type	Climate of the Day
10.00am-10.30am	Street green space	cloudy, breezy、 19℃-24℃
Pavement composition		
sesame gray, frosted aluminum plate, black pebbles		

space description	It is located in the old residential area of Yuexiu District, at the corner of the street. The space is a block space, which belongs to the open community green space. Its functions are mainly for passage, rest, and public activities.
Spatial elements	Seating, lighting equipment, signage systems, trash cans, gazebos, flower beds, landscape installations, sculptures, buildings
Surroundings	Shopping malls, residential areas, markets, greenways, subway stations, restaurants
Activities	Chatting, passing, looking at mobile phones, eating, taking pictures, playing poker, smoking
use crowd	elderly, middle-aged

Table 2. *Structured observation behavior summary table of the observation point of Dongshan Young Master South Square.*

Observation Time	Space Type	Climate of the Day
12.00am-12.30am	Traffic island green space	Cloudy, Breezy, 19°C-24°C
Pavement composition sesame grey, black pebbles		
space description	It is located near Huapu Plaza in Tianhe District, in the traffic circle. The space belongs to the open green space, the space is an arc space, and the functions are mainly traffic island, rest, and public activities, and the scale is small.	
Spatial elements	Seats, lighting equipment, substations	
Surroundings	Office buildings, shopping malls, residential areas	
Activities	Chat, pass, look at mobile phone, rest, take pictures, read	
use crowd	middle-aged, young	

3.2. Summary of the Green Looking Ratio of the Built Micro-Green Space and Its Population Satisfaction

3.2.1. Green Looking Ratio Comparison

On-site sampling was carried out for the three survey sites based on the calculation method of the green looking ratio statistical method. The observation points were mainly selected for their locations with large crowd flows, easy access, frequent stops of tourists, and many locations with representative landscapes. The results of the green looking ratio and citizen satisfaction were compared horizontally, and the conclusions were drawn based on the data. For the convenience and efficiency of the experimental process, the 80°–160° horizontal field of view of the human eye can be simulated more accurately, and the distance of the photos taken is as close as possible to the field of view when the human eye is actually observed [16]. The subjects held the device horizontally at the observation point, and the horizontal line of sight at a distance of about 1.5 m from the ground was taken as the shooting height. (Figure 4, Figure 5)
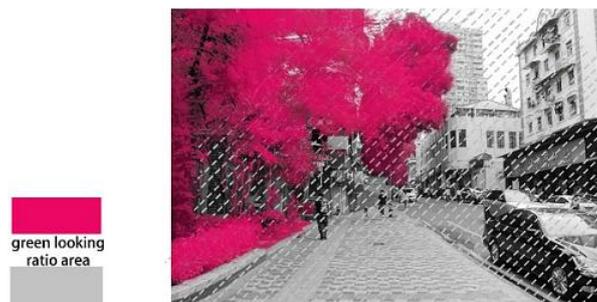

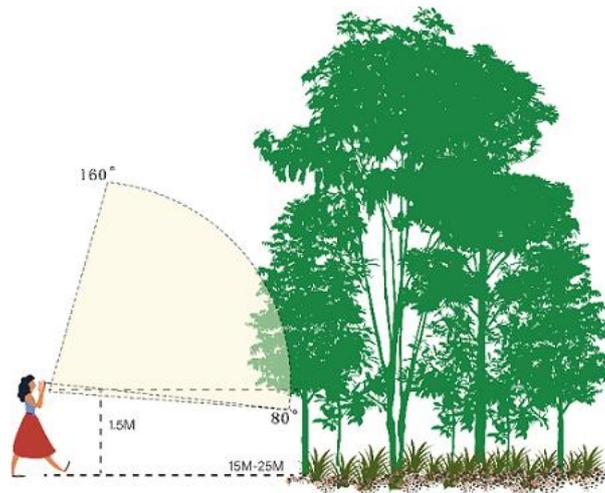**Figure 4.** *green looking ratio Area Chart.*

Figure 5. Take a field of view.

3.2.2. Green Looking Ratio Analysis of Maple Green Island

Taking observation point 1 as an example, the green looking ratio of the front, rear, left, and right points in the visible line of sight is 12.24%, 10.13%, 23.34%, and 10.99%, respectively, and the average value of this observation point is 14.18%. (Figure 6, Figure 7).

Figure 6. Image example of green looking ratio observation point 1 in Guigang Avenue Greenland Park.
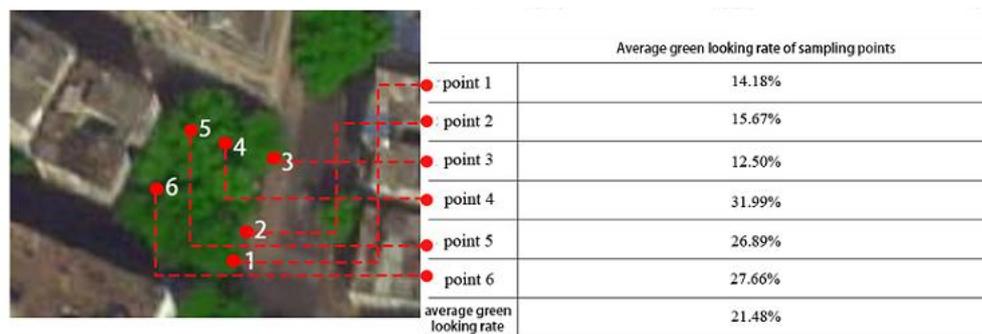

	Average green looking rate of sampling points
point 1	14.18%
point 2	15.67%
point 3	12.50%
point 4	31.99%
point 5	26.89%
point 6	27.66%
average green looking rate	21.48%

Figure 7. Summary of green viewing rate of micro-green space observation points on Guigang Avenue.

3.2.3. Analysis of Green Looking Ratio in Dongshan Young Master South Plaza

Taking observation point 1 as an example, the green looking ratio of the front, rear, left, and right points in the visible line of sight are 15.65%, 11.75%, 12.39%, and 31.77%, respectively, and the average value of this observation point is 17.89%. (Figure 8, Figure 9).

Figure 8. *Image example of green looking ratio observation point 1 in Dongshan Master South Plaza.*

Figure 9. *Summary of green visual rate of the micro-green observation point of The Young Master of Dongshan South Square.*

3.2.4. Analysis of Green Looking Ratio of Guigang Avenue Greenland Park

Taking observation point 5 as an example, the green looking ratio of the front, rear, left, and right points in the visible line of sight are 40.1%, 44.5%, 34.1%, and 40.4%, respectively, and the average value of this observation point is 39.88%. The survey sites were Guigang Avenue Greenland Park, Huapu Green Island, and Dongshan Young Master South Plaza, and the average green looking ratio values were 21.48%, 19.42%, and 34.14%, respectively. (Figure 9, Figure 10).

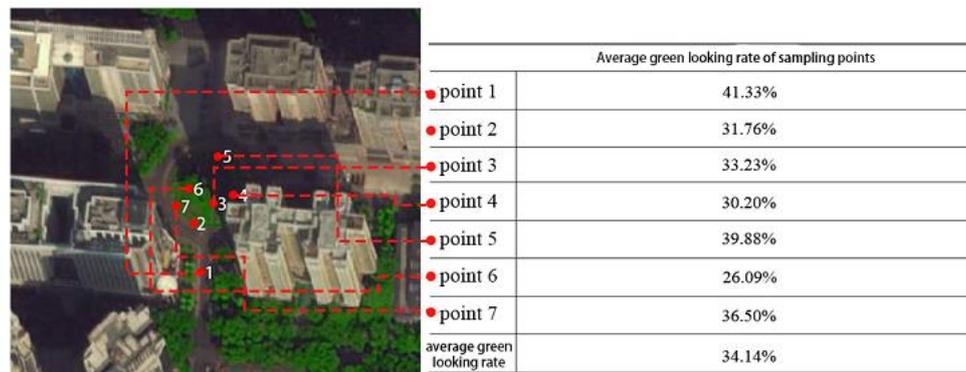**Figure 10.** *An example of an image of the green looking ratio observation point 8.*

Figure 11. *Sumnary of green visuality at huapu green island micro -green area observation points.*

3.2.5. Crowd Satisfaction Based on Green Looking Ratio

According to the static satisfaction collection, there are 51 valid samples for static satisfaction, 21 valid samples for dynamic satisfaction, 51 valid samples for static

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satisfaction at Guigang Avenue Pocket Park, 23 valid samples for dynamic satisfaction, and 23 valid samples for dynamic satisfaction. Green Island has 51 valid samples of static satisfaction and 15 valid samples of dynamic satisfaction. The specific summary data is as follows (Table 3, Table 4):

Table 3. *Green Vision Static S Satisfaction Summary.*

Average Satisfaction with Green Vision Rate	
Guigang Avenue Pocket Park	1.865
Dongshan Master South Plaza	1.44
Huapu Green Island	2.185

Table 4. *Green Vision Dynamic D Satisfaction Summary.*

Average Satisfaction with Green Looking Ratio	
Guigang Avenue Pocket Park	2.151
Dongshan Master South Plaza	1.98
Huapu Green Island	2.62

4. Conclusions

4.1. Summary of Data Summary

When the green looking ratio is lower than 20%, people's satisfaction with the green looking ratio is in the general range. When the green looking ratio is above 20%, people's observations in both static and dynamic conditions are in the satisfactory range. When the green looking ratio reaches more than 30%, people's satisfaction with greenery is close to very satisfied. According to relevant research and practice, when the green looking ratio is higher than 25%, it will produce a better psychological feeling of green, and when the green looking ratio is more than 50%, people can perceive more green and produce a comfortable psychological feeling. The most famous longevity area in the world has an average green looking ratio of more than 15% [17], and increasing the green looking ratio can improve space satisfaction and increase physical benefits [18]. The following picture shows the comparison table of green looking ratio and satisfaction and the factors affecting the green looking ratio obtained after analyzing the three sites (Figure 12, Table 5):
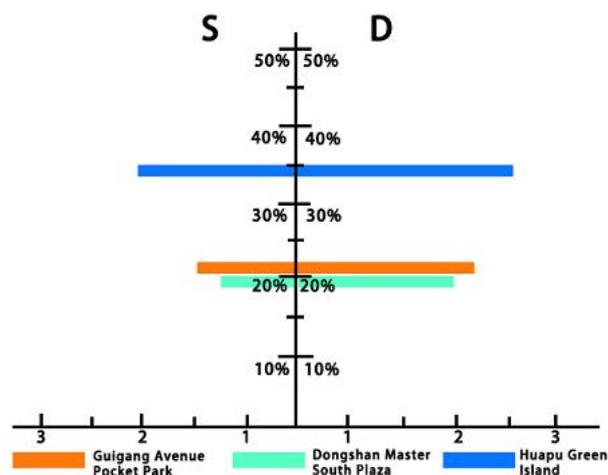

Figure 12. *Greenview satisfaction versus greenview.*

Table 5. *Factors influencing green vision.*

Objective Factors	
Spatial layout	1. The nature of green space (traffic island type, critical green

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	space type, square green space, etc.) 2. Green area concentration
Morphology	1. Plant configuration 2. Tree height, plant crown 3. Seasonal climate
Surroundings	1. Building height and density 2. Accessibility 3. Road form 4. Crowd base
Subjective Factors	
Observer position and angle	1. Viewer's line of sight 2. The orientation and height of the observer
Observer behavior pattern	1. The observer stands or sits 2. The observer walks or rides a bicycle 3. Observer movement speed

4.2. Conclusions and Design Recommendations

In high-density cities, if there is not enough land to expand green space, it is recommended to increase the green looking ratio and increase the urban green coverage rate to improve and enhance the space quality. The green looking ratio can not only guide the ecological, refined, and humanized urban green space, but it can also realize the psychological perception of the green space and improve the urban ecological benefits. Increasing the number and area of three-dimensional greening, adjusting the number and variety of plant configurations [19], transforming green space, and utilizing corner space can effectively improve the green looking ratio. For improving the green ecological space in the city, forming a green patchy urban park system [20], and improving the use of micro-green space and humanized design more efficiently, there are the following design suggestions (Table 6):

Table 6. Design recommendations.

Lift factor		Design recommendations
Site	Open up space and form scale. Establish a micro-to-macro perspective, connect points with lines, and form planes with lines to form connections between green space patches, and improve the overall level of urban green vision.	1. For the places with "height difference" changes in the complex terrain, greening should be used as much as possible, and green spaces should be selectively developed for the medium such as walls, colonnades, pergolas, hangings, fences, epiphytes, and roofs.
		2. Promote the design and application of new ecological and sustainable green spaces such as rain gardens and healing gardens.
		3. For transitional and ambiguous boundary spaces, as well as leftover or temporary idle spaces in the process of urban development, the green space design is enriched with strip-shaped or point-shaped micro-green spaces to improve the green looking ratio of spaces such as boundaries.
		4. Carry out a reasonable design to improve the green looking ratio for the existing micro-green space.
Crowd	Create a humanize space and increase engagement. Aiming at accessibility and convenience, increasing	1. It provides a more pleasant urban environment for people who go to and from work in the city to relieve psychological pressure; it also provides convenient leisure activities for nearby residents and tourists.
		2. Enriching venue functions and adding or updating public facilities can also improve the living comfort of children and the elderly and attract more people to

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	the quality of public facilities is a must.	participate in outdoor activities.
		3. Create a green space for temporary rest for sanitation workers, takeaway workers and other people who work outdoors for a long time, and also provide temporary shelter for vulnerable groups such as homeless.
Ecology	The climate is the primary factor, and the plant configuration is optimized according to the climate to increase the green coverage and create an ecological city.	1. Improve high-density urban microclimate.
		2. Absorb dust and purify the air
		3. Reduce noise and have a certain isolation effect.
		4. Safety protection, reducing glare and urban light pollution during vehicle driving.
		5. Provide habitat for birds, stray cats, dogs and other animals.
		6. Adjust the plant configuration mode, such as the spacing, quantity, and spatial relationship of trees, shrubs, and grasses for scientific planting.
		7. Green vegetation maintenance and replanting shall be carried out on a regular basis, and greening optimization measures shall be taken in a timely manner to ensure the quality of urban greening.

In the design of micro-green space in high-density cities, site factors, crowd factors, and ecological factors complement each other. It is necessary to organically combine these three factors for design and rationally use existing or potential resources for micro-green space. The transformation and design of the space ensure the use of residents to increase the green viewing rate and environmental green volume in the micro-green space and create a high-density urban environment that is livable and suitable for business, vitality, ecology, and sustainability.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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