Visual Environment Evaluation Mechanism of Tropical Coastal Public Space Based on Landscape Elements Quantification

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Abstract. This study employed audio-visual experiments to examine the influence of landscape elements in tropical island city coastal public spaces on respondents' overall satisfaction, comfort, and aesthetic perception. The findings indicate that landscape elements below eye level are less likely to be perceived by respondents. Additionally, beaches, paths, activity sites, and sculptures significantly impact environmental evaluation and aesthetic appreciation. Regarding demographic differences, the landscape elements have a more pronounced effect on male respondents, while younger individuals exhibit greater sensitivity to landscape elements compared to older adults. Natural landscape elements notably affect the environmental evaluation among older adults. These research outcomes provide valuable insights for targeted visual environment design in tropical island city coastal public spaces, particularly concerning plant selection and artificial environment configuration.

Keywords: Tropical Island; Coastal Public Space; Visual Environment; Landscape Elements; Environmental Evaluation

1 Introduction

Coastal cities, with their attractive coastal landscapes, are popular tourist destinations and provide recreational spaces for residents [1, 2]. Coastal public spaces serve as "restorative environments," effectively improving mood and reducing negative emotions. Many studies have examined how external urban factors like traffic accessibility, population density, and internal design elements such as service facilities and landscape design influence satisfaction, aesthetic evaluation, and attractiveness of these areas.

Numerous factors influence the visitor experiences and satisfaction of coastal public spaces, such as the accessibility of transport from the outside and the services provided from the inside [3]. As the main way for individuals to obtain external information, the existing visual environment evaluation has been fully studied. Previous studies have identified individuals' preferences for specific types of vegetation in urban open spaces, and underscored the importance of maintaining an optimal proportion of plant coverage

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[3, 4]. In addition, landscape quality, landscape type, variability among respondents, idealized mental image of respondents, and so on [5, 6].

Regarding research methodologies, the subjective evaluation of landscape elements through psychophysical approaches has been extensively utilized and acknowledged [7, 8]. Many researchers who focus on assessment of aesthetic preferences believe that it is the physical characteristics of the landscape versus the psychological response of the person viewing it [9-12]. Therefore, aesthetic preference assessment is the process of perception of landscape attributes by respondents, and a perception-based assessment paradigm was constructed [8].

In the field of perceptive evaluation of visual environmental stimuli, the discussion of landscape visual elements mostly focuses on visual element classification, combination of different elements and so on. The research objects are mainly concentrated in rural areas, greenways, and urban parks. This study concentrated on the coastal public spaces of tropical island cities and employed a subjective evaluation method grounded in psychological paradigms to investigate the compositional principles of visual elements and their influence on subjective assessments.

2 Methodology

A psychophysical method was used to play a designed audio-visual scene in a qualified audio-visual laboratory. The respondents were invited to answer a questionnaire after receiving audio-visual stimuli to investigate their satisfaction and comfort with the environment, as well as their perception of visual environment aesthetics and landscape elements.

2.1 Collection of Environmental Information

Based on preliminary research into the spatial typology clustering analysis of coastal public spaces in Hainan's coastal cities that satisfy specific criteria [13], and taking into account the actual distribution ratios of each spatial type, we determined the sources of spatial types for the experimental visual scenes.

A large number of pictures and sound recordings were collected from coastal public spaces within the corresponding spatial types. Photos were taken with a Nikon COOLPIX P7000 camera and selected based on factors like field of view, height, depth of field, and visual element proportions. Environmental sounds were recorded for at least 2 minutes at each site using a Philips VTR7800 sound collector, avoiding large crowds of people, obvious traffic noise and social noise.

2.2 Environmental Information Processing

To analyze the impact of visual elements on visual environment assessment, it is necessary to first digitize landscape element information by classifying and quantifying these elements. The elements that can be identified without careful discrimination in all

the selected visual images are counted, and the 8 landscape elements are finally divided into two groups: artificial landscape and natural landscape, as shown in Table 1.

Table 1. Classification of landscape elements in visual scenes.

Categories	Items	Description
Artificial landscape	Pedestrian or biking paths	A readily accessible and navigable route for pedestrians and cyclists.
	Activity site	A designated area for specific sports or activities, such as a basketball court or a plaza where people can linger for extended periods.
	Sculptures	Landscape elements that serve an ornamental function, such as sculptural rest seats with strong aesthetic appeal.
Natural landscape	Sky	A background sky that is immediately recognizable without the need for careful identification.
	Sea	A background sea that is immediately recognizable without the need for careful identification.
	Beach	A sandy beach serves as a clearly distinguishable transitional zone between the sea and public space without the need for careful identification.
	Tall plants	Plants taller than 1.50 meters, such as coconut trees and tall shrubs, obstruct the view.
	Low plants	Plants lower than 1.50 meters, serving both to define spatial boundaries and enhance visual appeal without obstructing the line of sight.

Subsequently, the proportion of pixels for each landscape element is calculated individually. Using Adobe Photoshop software, the selection tool is employed to isolate each landscape element, tally the selected pixel count, and determine its percentage relative to the entire image [14], as detailed in Table 2.

2.3 Visual Perception Experiment

Nine experimental scenes were designed, with the number of space types in each scene determined according to proportions observed in actual coastal public spaces. Each scene included ambient environmental sounds characteristic of coastal areas, such as ocean waves, wind, bird or insect calls, rustling leaves, and background sounds of vehicles and human conversations (without discernible semantic content). These sounds did not incorporate any experimental independent variables; rather, they were designed to provide an authentic representation of a coastal public space.

The questionnaire consists of 5 pages and is structured into two sections. Section one collects basic demographic information such as age, gender, education level, and occupation, enabling precise sample differentiation. Section two assesses perceptions and

evaluations of nine specific scenes, focusing on overall environment and visual aesthetics. This section utilizes a 7-point Likert scale and a 7-point semantic differential scale for measurement [15].

Table 2. Proportion of Pixels Representing Landscape Elements in Visual Scenes.

	Original images/ color blocks	Landscape element proportion		Original images/ color blocks	Landscape element proportion
1		1-42.40% 6-0.32% 2-0.00% 7-16.50% 3-3.65% 8-3.42% 4-4.91% 9-7.53% 5-21.26%	2		1-32.75% 6-0.00% 2-1.43% 7-16.05% 3-9.48% 8-1.80% 4-26.19% 9-2.33% 5-9.97%
3		1-47.18% 6-1.00% 2-0.00% 7-6.84% 3-0.00% 8-0.97% 4-20.72% 9-0.21% 5-13.10%	4		1-22.29% 6-0.00% 2-0.67% 7-2.68% 3-2.44% 8-1.94% 4-12.25% 9-3.79% 5-13.95%
5		1-22.28% 6-1.66% 2-0.00% 7-34.35% 3-2.55% 8-4.44% 4-8.19% 9-1.43% 5-25.11%	6		1-38.01% 6-0.00% 2-0.00% 7-26.55% 3-1.67% 8-1.51% 4-24.43% 9-0.23% 5-7.59%
7		1-24.47% 6-4.04% 2-0.00% 7-28.01% 3-0.00% 8-2.45% 4-19.93% 9-0.48% 5-20.62%	8		1-24.06% 6-1.30% 2-11.94% 7-38.35% 3-0.19% 8-2.04% 4-8.89% 9-0.66% 5-12.57%

	Original images/ color blocks	Landscape element proportion		Original images/ color blocks	Landscape element proportion
9		1-11.47% 6-0.00% 2-0.00% 7-55.06% 3-0.44% 8-0.71% 4-25.63% 9-0.23% 5-6.46%	Legend	1-Tall plants 2-Activity site 3-Sculptures 4-Low plants 5-Pedestrian or biking paths	6-Beach 7-Sky 8-Sea 9-Others

A total of 45 participants were recruited for this experiment, comprising both university affiliates—undergraduate students and faculty—and employees from a corporate entity. The demographic details of the participants are summarized in Table 3. All participants reported normal hearing and either uncorrected or corrected-to-normal visual acuity, and provided informed consent to participate in the study.

The experiment took place in a quiet room at the R&D Center of Hainan University with background noise controlled at 25 dB(A). A 27-inch DELL U2723QX LED display presented the visual stimuli, and Sennheiser HD620S headphones delivered the ambient sound. Only essential equipment was used to minimize interference [16]. Each audio-visual scene lasted 20 seconds [15,17], and scenes were randomly arranged using Excel's RAND function. Each group had 5 participants.

Table 3. Overview of the participants in the visual perception experiment.

Gender		Age		Educational		Occupation	
Male	28	18-27	17	High school	1	Student	10
Female	17	28-44	25	Undergraduate	32	Teacher	8
		45-60	3	Master's degree	4	Staff	22
				Ph.D.	8	Manager	2
						Other	3
Total							45

3 Results

3.1 Reliability and Validity Test

After processing the questionnaire data, we tested its reliability and validity. The Cronbach's alpha coefficients ranged from 0.897 to 0.954, indicating high reliability. For validity, exploratory factor analysis on Likert scale questions yielded KMO values from 0.651 to 0.757 and significant Bartlett's tests at the 0.05 level, confirming model adaptability. The cumulative contribution rates of extracted principal components exceeded 83%, meeting validity requirements.

3.2 Distribution Characteristics of Landscape Elements

The distribution characteristics of landscape elements in visual scenes are illustrated in Figure 1. Artificial landscapes make up only 18.34% on average (ranging from 6.90% to 24.91%) and are sparsely distributed. Natural landscapes, however, cover nearly 80% on average, showing a more balanced distribution. This indicates that the urban coastal public spaces are predominantly characterized by natural landscapes, complemented by artificial elements.

In artificial landscapes, accessible paths form a major part and serve as primary spaces for walking or cycling. Activity sites act as gathering points, while sculptures occupy minimal space due to their small size. In natural landscapes, the sky and sea (33.55%) along with green plants (46.23%) dominate the view, with tall plants (29.44%) comprising a notably larger share compared to low plants (16.79%).

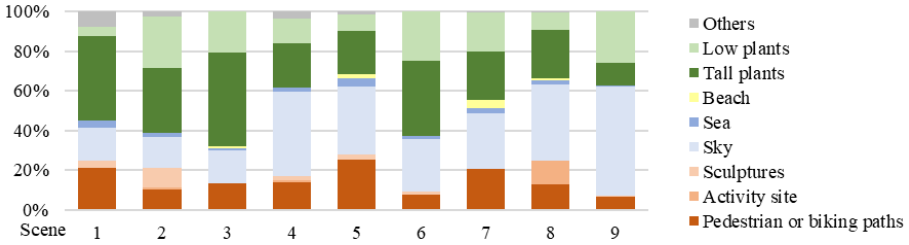


Fig. 1. Distribution of all visual scene landscape elements.

3.3 Perception and Evaluation of Landscape Elements

Researchers collected responses to the question: "Which of the following visual elements do you notice without looking at the scene again? (multiple choices)"in the questionnaire. Answers were compared to the actual presence or absence of elements in the visual images used. Correctly perceived elements were marked as "correct perception", elements present but not noticed as "no perception", and elements absent but perceived as "wrong perception". Perception results for each element are shown in Figure 2.

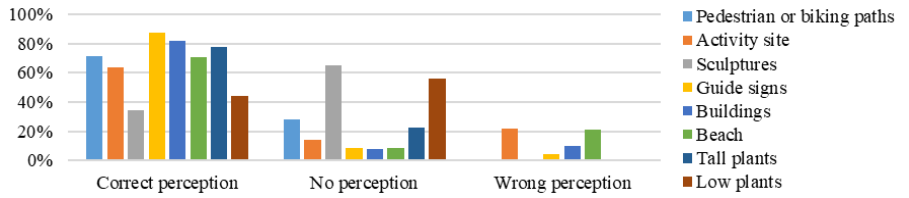


Fig. 2. Perception of visual elements in coastal public space of tropical island city.

As shown in the figure, the perception accuracy for most visual elements exceeds 60%, except for sculptures and low plants, which have wrong perception rates of 65.26% and 55.83%, respectively. These elements are typically below eye level and occupy only 2.27% of image pixels on average, making them less noticeable. Low

plants, often blending with taller vegetation, may be misidentified as background landscape rather than foreground.

In the wrong perception, activity sites (22.08%), beaches (21.09%), and buildings (10.17%) were incorrectly identified as present despite not appearing in the scenes. This indicates that respondents relied on "imagination" during their perception process. For example, some may have mistaken pedestrian or cycling paths for activity sites, or assumed based on prior experiences that coastal public spaces should include areas for activities. For beaches and buildings, given that the experiment focused on the coastal public space of a tropical city, respondents made reasonable associations between "city-building" and "coast-beach", leading them to identify beaches and buildings in the experiment.

The overall environmental satisfaction is 5.20, comfort is 5.21, and visual aesthetics is 5.17, all highly exceeding the neutral score of 4.00. Respondents agree strongly on natural landscapes, likely because humans evolved in such environments, influencing shared perceptions, and natural elements such as plants and water bodies have a significant impact on aesthetic judgments [18].

3.4 The Impact of Landscape Elements on Environmental Assessment

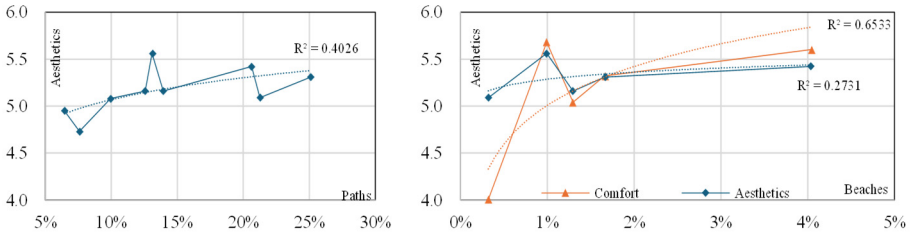
In the visual environment perception experiment, the questionnaire assessed respondents' satisfaction, comfort, and visual aesthetics. Table 4 shows that comfort and visual aesthetics are significantly positively correlated with the proportion of paths in artificial landscapes and beaches in natural landscapes.

Table 4. Correlation analysis landscape elements and environmental evaluation.

Items	Tall plants	Activity site	Sculptures	Low plants	Pedestrian/or biking paths	Beach	Sky	Sea	Natural elements	Artificial elements
Comfort	0.014	-0.053	-0.052	0.047	0.068	**.144****	-0.042	-0.017	0.054	0.010
Vision aesthetic	0.030	-0.005	-0.048	-0.047	**.111***	**.124***	-0.050	0.040	0.009	0.076
**. Significant association at 0.01 level (two-tailed). *. Significant association at 0.05 level (two-tailed).										

The relationship between the proportion of pedestrian/cycling paths and beaches and their impact on visual aesthetics and comfort is illustrated in Figure 3. Figure 3 (a) illustrates the correlation between path proportion and visual aesthetics. As the path proportion increases, visual aesthetics scores show a consistent upward trend. This suggests that a higher proportion of paths within a landscape correlates with enhanced evaluations of its visual beauty. This relationship may be attributed to the design and layout of the paths, which not only serve a functional purpose for walking but also significantly contribute to the overall aesthetic appeal through elements such as shape, material, and color. Moreover, the meandering nature of the paths can add intrigue and depth to the landscape, drawing attention and further elevating its visual appeal. Figure 3 (b) shows the correlation between beach proportions and both comfort and visual

aesthetics. As depicted in the figure, an increase in beach proportion significantly influences comfort and visual aesthetics. Regarding comfort, the beach offers expansive open spaces and abundant natural elements that allow individuals to move freely, bask in the sunlight, and enjoy the seascape. This immersive experience of being close to nature markedly enhances personal comfort. In terms of visual aesthetics, the broad expanse of the beach and its distinctive natural features, such as waves and sand textures, contribute a unique beauty to the landscape. The golden sand creates a striking color contrast with the surrounding greenery and sea and sky, while activities on the beach, including recreational pursuits like playing and swimming, infuse vitality and interest into the scenery, thereby enhancing visual appeal.



a) Impact of the proportion of paths on visual aesthetic b) Impact of the proportion of beach on comfort level and visual aesthetic

Fig. 3. Influence of proportion of paths and beach on evaluation in coastal public space.

3.5 Population Differences

The correlation analysis between landscape elements and evaluations/aesthetics for different genders is shown in Table 5. Males were more sensitive to visual elements like paths and beach areas, especially the proportion of beach, which significantly influenced their perception of environmental comfort and visual aesthetics. In contrast, females showed less sensitivity to these visual elements.

Table 5. Effects of landscape elements on males' evaluation and aesthetic appreciation.

Items	Tall plants	Activity site	Sculptures	Low plants	Pedestrian or biking paths	Beach	Sky	Sea	Natural elements	Artificial elements
Comfort	-0.015	-0.119	-0.068	0.08	0.089	**.183****	-0.023	-0.019	0.054	-0.013
Vision aesthetic	0.049	-0.035	-0.051	-0.043	**.142***	**.159***	-0.077	0.053	0.03	0.087
**. Significant association at 0.01 level (two-tailed). *. Significant association at 0.05 level (two-tailed).										

As illustrated in Table 6, correlation analysis across three age groups shows that younger individuals are more sensitive to artificial visual elements, impacting their environmental satisfaction. Older adults, however, are more influenced by the overall natural elements like sea, sky, and plants, affecting their comfort evaluation. Artificial elements mainly influence overall satisfaction, while natural elements affect comfort and aesthetics.

Table 6. Age differences in the impact of landscape elements on evaluation and aesthetics.

Age groups	Young group			Middle-aged group	Older group
Correlation coefficient	Satisfaction	Comfort	Vision aesthetic	Vision aesthetic	Comfort
Tall plants	-0.032	-0.037	-0.014	0.034	0.282
Activity site	-0.091	**-.198***	-0.13	0.106	-0.305
Sculptures	**.190***	0.102	0.068	**-.133***	-0.194
Low plants	0.006	0.099	0.044	-0.122	0.277
Pedestrian or biking paths	**.162***	0.121	0.142	0.102	0.055
Beach	0.14	0.159	**.180***	0.112	0.277
Sky	-0.105	-0.069	-0.082	-0.012	-0.279
Sea	0.113	0.035	0.055	0.047	-0.178
Natural elements	-0.009	0.045	0.032	-0.035	**.418***
Artificial elements	**.175***	0.043	0.086	0.092	-0.208
**. Significant association at 0.01 level (two-tailed). *. Significant association at 0.05 level (two-tailed).					

4 Analysis and Discussion

In tropical island coastal public spaces, natural landscapes, primarily comprising the sky, sea, and vegetation, constitute nearly 80% of the scenery. This predominance is attributed to the tropical climate, tourism emphasis, and abundant natural resources. Although the sky and sea offer limited design flexibility, the arrangement of greenery and color coordination play a pivotal role in the overall design. Artificial elements such as pedestrian and cycling paths, activity sites, and artificial grounds significantly impact user experience through their shape, form, and color. Small structures like sculptures serve as striking focal points against the expansive natural surroundings, thereby enhancing aesthetic appeal. In conclusion, in the coastal public spaces of tropical island cities, the integration of natural greenery (tall and low plants), artificial elements (activity sites and pedestrian/cycling paths), and artificial structure elements holds significant design value.

For the perception of landscape elements, low sculptures and plants generally exhibit lower perception rates. In coastal public spaces, users often look out at the sea, making below-eye-level elements less noticeable. To maximize visibility, designers should strategically position attention-grabbing facilities within the typical line of sight. Low plants are often perceived as background elements, while tall greenery, especially iconic tropical trees like coconut palms, stands out more due to their symbolic value and greater visibility. If iconic plants such as Hainan's bougainvillea are placed among low greenery, tall trees serve as background elements, enhancing the foreground prominence of the bougainvillea. The arrangement of low and tall plants facilitates a shift in the perception between foreground and background elements. Misperceived elements,

like activity sites and beaches, are significant due to higher human activity and engaging behaviors, highlighting users' desire for a balance between artificial and natural environments. Therefore, for coastal public spaces in tropical island cities, landscape design should emphasize consistency between elements and scenic perspectives, clear distinction between foreground and background, and integration of artificial and natural environments.

Thirdly, the analysis of respondents' overall satisfaction reveals a significant correlation between the proportion of pedestrian and cycling paths and beach areas with visual aesthetics. Additionally, beach areas positively influence comfort levels. In tropical island coastal public spaces, natural elements serve as dominant focal points, constituting over 80% of the environment, while artificial elements account for less than 20%. The findings indicate that an appropriate balance of artificial elements enhances user evaluation and aesthetic appreciation, crucial for improving tourist experiences. Well-managed beaches, integrating both natural and artificial elements, significantly contribute to positive evaluations, whereas poorly maintained beaches can leave negative impressions. At the level of visual aesthetics, the design and quality of roads and beaches play a critical role. The ground, tall green vegetation, sea surface, and sky are primary visual elements, with the ground being the most controllable and thus requiring detailed attention to color, texture, and form. Therefore, emphasis should be placed on designing artificial ground features like pedestrian and cycling paths and beach areas, which greatly influence users' overall perception.

Finally, when addressing coastal public spaces with diverse user characteristics, targeted landscape strategies can be implemented. At the gender level, for areas predominantly used by men, the proportion of artificial surfaces and beaches can be increased to enhance visual appeal while maintaining natural-artificial balance. At the age level, for areas frequented by younger individuals, the proportion of artificial elements such as sculptures, signage, and hard-surfaced pathways can be moderately increased to cater to their preferences for dynamic activities. However, it is crucial to manage potential negative impacts, such as crowd attraction and noise, to ensure overall satisfaction. Conversely, in areas utilized by middle-aged individuals, the artificial features should be reduced to preserve aesthetic harmony. For areas serving the elderly people, the whole natural landscape environment, including a variety of plants, scenic views of the sky and sea, should be significantly enhanced to improve comfort and experience.

5 Conclusion

To investigate the impact of visual landscape elements on the evaluation and aesthetics of tropical urban coastal public spaces, we conducted both field investigations and laboratory-based audiovisual perception experiments. The following conclusions were drawn: In real tropical urban coastal public spaces, artificial landscapes constitute a relatively small proportion and are dispersedly distributed, while natural landscapes account for nearly 80% with a more balanced distribution. Regarding the perception of landscape elements, many low-level elements below eye level go unnoticed, whereas background elements (such as beaches and buildings) that define the environment are

prone to misinterpretation. In terms of influence mechanisms, certain artificial landscape elements significantly enhance environmental evaluation and aesthetics; for instance, the volume of beaches, roads, and sculptures is positively correlated with higher evaluations. Additionally, there are demographic differences in these influence mechanisms, with males and younger individuals being more sensitive to landscape elements, while older individuals prefer natural elements.

There are several limitations in this study. Firstly, the sample size is relatively small, and other variables besides gender and age of the sample population have not been analyzed in detail. Secondly, the study employs a laboratory experiment method, which cannot fully replicate real-world conditions such as climate, lighting, and crowd interactions in actual coastal public spaces. For future research, it is recommended to increase the sample size and incorporate a more diverse range of demographic factors, including life experiences and cultural backgrounds, to enhance the inclusivity and appeal of personalized landscape design. Additionally, a combination of field investigations, laboratory studies, and on-site observations should be considered to provide a more comprehensive understanding. Further exploration is needed regarding how landscape elements influence human behavior (e.g., staying, moving, communicating) and how landscape design can foster positive behaviors. Furthermore, long-term follow-up surveys could be employed to study the dynamic changes in coastal public space landscapes and their impact on people.

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References

1. Ewald K C. The neglect of aesthetics in landscape planning in Switzerland[J]. Landscape and Urban Planning. 2001, 54(1-4): 255-266.
2. Li L., Coastal Landscape Planning and Design Based on Regional Landscape Characteristics[D]. 2021, Beijing Forestry University.
3. Ozer B, Baris M E. Landscape Design and Park Users' Preferences[J]. Procedia - Social and Behavioral Sciences. 2013, 82: 604-607.
4. Qiu Y., Luo T., Wang Y., et al. Study on the Perceptual Features of Urban Landscape Elements Based on Visual Attention and Aesthetic Preference [J]. Chinese Landscape Architecture. 2023. 39(6): 82-87.
5. Kalivoda O, Vojar J, Skřivanová Z, et al. Consensus in landscape preference judgments: The effects of landscape visual aesthetic quality and respondents' characteristics[J]. Journal of Environmental Management. 2014, 137: 36-44.
6. Hagerhall C M. Consensus in Landscape Preference Judgements[J]. Journal of Environmental Psychology. 2001, 21(1): 83-92.
7. Lothian A. Landscape and the philosophy of aesthetics: is landscape quality inherent in the landscape or in the eye of the beholder?[J]. Landscape and Urban Planning. 1999, 44(4): 177-198.

8. Fang, Y., et al., Visual aesthetic quality assessment of the streetscape from the perspective of landscape-perception coupling. Environmental Impact Assessment Review, 2024. 106: p. 107535.
9. Tveit M S. Indicators of visual scale as predictors of landscape preference; a comparison between groups[J]. Journal of Environmental Management. 2009, 90(9): 2882-2888.
10. Aboufazeli, S., A. Jahani and M. Farahpour, A method for aesthetic quality modelling of the form of plants and water in the urban parks landscapes: An artificial neural network approach. MethodsX, 2021. 8: p. 101489.
11. Vouligny É, Domon G, Ruiz J. An assessment of ordinary landscapes by an expert and by its residents: Landscape values in areas of intensive agricultural use[J]. Land Use Policy. 2009, 26(4): 890-900.
12. Molnarova K, Sklenicka P, Stiborek J, et al. Visual preferences for wind turbines: Location, numbers and respondent characteristics[J]. Applied Energy. 2012, 92: 269-278.
13. Yi F., Ge J.. Typing study urban of public spaces for improved human settlements - Taking tropical coastal public spaces as an example[J]. Green Building, 2024, 62-66.
14. Kim, B., S. Kim and Y. Joo, Visual impact control of urban waterfront development on the background mountain view: Examining its justifiability through two types of immersive virtual reality experiments. Environmental Impact Assessment Review, 2024. 106: p. 107500.
15. Yi F., Kang J.. Impact of environment color on individual responses in public spaces of shopping malls[J]. Color Research & Application, 2020, 45512-526.
16. Parmar, V. and A. Jana, A review of tools and techniques for audio-visual assessment of urbanscape. Discover Cities, 2024. 1(1).
17. Du, M., et al., Multiple effects of visual-acoustic-thermal perceptions on the overall comfort of elderly adults in residential outdoor environments. Energy and Buildings, 2023. 283: p. 112813.
18. Kaplan R, Kaplan S. The Experience of Nature: A Psychological Perspective[M]. New York: Cambridge University Press, 1989.