



Aesthetics-based development of green open space using the SBE–AHP approach to support user experience and social interaction

Rian Palimirmo Adi¹, Mahawan Karuniasa^{1,*}, Rudy Parluhutan Tambunan¹

¹ Department of Environmental, Graduate School of Sustainable Development, Universitas Indonesia, Central Jakarta, Special Capital Region of Jakarta 10440, Indonesia.

*Correspondence: mahawan.karuniasa11@ui.ac.id

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ABSTRACT

Background: Over the past two decades, Jakarta's built-up area has expanded by approximately 19%, increasing environmental pressures on urban green spaces. The North Kembangan Urban Forest is a green open space intended to support environmental improvement in urban planning. However, its management and aesthetic value remain suboptimal. Enhancing esthetic value aligns with an emerging placemaking perspective that emphasizes user experience and place quality and offers a viable solution to improve green open space (GOS) quality by integrating public perception and expert assessment. **Methods:** This study used a photo-based questionnaire was administered to 110 respondents and analyzed using Scenic Beauty Estimation (SBE), while development priorities were evaluated through the Analytical Hierarchy Process (AHP) involving nine experts. **Findings:** The results indicated that photos 5, 7, and 10 showed relatively high aesthetic preferences, with SBE scores of 28.34, 54.09, and 84.28, respectively, although all remained within the moderate aesthetic category. Color, vegetation, neatness, and comfort were significantly associated with aesthetic value, with neatness and comfort showing the strongest correlations ($r = 0.97$, $p < 0.001$). The High-Canopy Tropical GOS was being the preferred development alternative, with a priority weight of 0.41. **Conclusion:** These findings highlight the importance of integrating ecological, economic, social aspects, and aesthetic value in GOS planning, particularly in the North Kembangan Urban Forest, to inform more user-oriented and place-sensitive planning of urban green spaces. **Novelty/Originality of this article:** The study extends the application of the SBE–AHP framework to tropical urban-forest planning by integrating photo-based public aesthetic preferences with expert development priorities in the context of Jakarta. This synthesis results in an aesthetic-driven GOS model underpinned by an environmental science perspective, and contributes to the development of user-centered and place-oriented urban GOS planning.

KEYWORDS: analytical hierarchy process; placemaking; scenic beauty estimation.

1. Introduction

Urbanization in Indonesia continues to drive rapid land-use change. The Java-Bali region is predicted to experience an increase in built-up areas from 13% in 2019 to 22% in 2032 (Pravitasari et al., 2024). Jakarta has experienced the fastest growth in built-up area in Indonesia, increasing by 19% from 483 km² in 2000 to 574 km² in 2020 (Sarker et al., 2024). This massive expansion has resulted in severe environmental degradation, including elevated temperatures and urban climate change (Das et al., 2024). Consequently, modern urban planning must prioritize urban resilience, which is the ability of urban areas to

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withstand and recover from environmental and socio-economic pressures (Meerow et al., 2016). Therefore, urban planning that prioritizes the environment is urgently required, including the use of green open spaces (GOS).

GOS play a critical role in urban resilience by providing essential ecosystem services to reduce heat and regulate humidity in urban areas, improve urban air quality, maintain water resource sustainability, provide habitats for urban plant and animal biodiversity, and add to the aesthetic value of cities (Bao et al., 2022; Cardinali et al., 2024; Mbarep et al., 2021; Mundher et al., 2022). Furthermore, GOS provide benefits for human social life and health, thereby improving the welfare of urban communities. GOS that focus on providing these amenities, such as creating meaningful, inclusive, and engaging public spaces that strengthen the well-being of the urban community, use a placemaking approach. Placemaking is defined as an activity that integrates diverse perspectives and uses by people to transform the urban environment in terms of its spatial aspects and the social processes that shape that space (Akbar & Edelenbos, 2021). Studies have shown that visiting GOS facilitates psychological recovery, reduces stress levels, and improves concentration (Arnberger et al., 2024; Asahiro et al., 2023), while providing space for urban socialization (Costa et al., 2024; Jabbar et al., 2022). In addition, green space development can boost economic growth through spatial spillover effects (Zhou et al., 2022).

The economic impacts of GOS are well-documented. For instance, Setiowati et al. (2024) applied the Hedonic Price Method (HPM) analysis on GOS located in Jakarta, Indonesia, and found that the proximity to urban parks and forests increased surrounding land prices by 17% and 19%, respectively, within a 500–2,000 m² radius. From a cost-benefit perspective, Horváthová et al. (2021) compared natural shading from urban trees with parasols or large tents. Their market approach revealed that while tree planting and ongoing maintenance incur higher initial costs, it yields significantly greater cumulative benefits than temporary artificial structures once the tree life cycle exceeds 40 years.

Recognizing these multi-dimensional benefits, the Provincial Government of DKI Jakarta has adopted several policies to improve the quality and adopt innovative methods for producing a sustainable GOS throughout Jakarta. These are stipulated in Law Number 26 of 2007 concerning Spatial Planning, Jakarta Provincial Regulation Number 7 of 2024 concerning the 2024-2044 Spatial Plan, and DKI Jakarta Governor Regulation Number 31 of 2022 concerning the Detailed Spatial Plan. The North Kembangan Urban Forest is a designated GOS in West Jakarta. However, these broader regulations provide limited site-specific guidance for aesthetic and user-oriented planning of the North Kembangan Urban Forest. Preliminary observations conducted in February 2025 revealed that while the North Kembangan Urban Forest possesses strong ecological potential, its visual quality has never been systematically evaluated. Consequently, which zones yield high or low esthetic values based on visitor perceptions remains unknown. Due to a lack of targeted maintenance, certain areas feel isolated and uninviting despite the forest's close proximity to residential zones. These conditions form the basis for the necessity of this study. Therefore, to maximize the potential of urban trees, urban forest management requires an interdisciplinary approach, involving all levels of government and diverse perspectives (O'Brien et al., 2022). Growing urban forests is a long-term endeavour that requires ongoing commitment and community support (Sousa-Silva et al., 2023).

Integrating esthetic value offers a highly innovative solution to optimize this space. Landscape aesthetics is an important consideration in urban forest planning because the quality of urban green spaces is determined not only by their ecological and physical characteristics but also by how these environments are perceived and experienced by the public. Landscape aesthetic quality therefore emerges from the interaction between environmental characteristics and human perception (Mundher et al., 2022). Landscape aesthetics is a basic result of the interaction between humans and the landscape (Skřivanová & Kalivoda, 2010). Therefore, understanding public perception of landscape aesthetics can provide valuable information for identifying landscape attributes that should be considered in urban forest planning and management (Ma et al., 2021). However, the relationship between measurable landscape characteristics and public aesthetic perception

remains insufficiently understood in North Kembangan Urban Forest, highlighting the need for further investigation.

Early qualitative approaches to quantify the abstract concept of scenic beauty have transitioned into robust quantitative models. Research on aesthetic value has been conducted in several countries, including Scenic Beauty Estimation (SBE) modelling, Landscape Visual Quality, and Perceived Sensory Dimensions (Ma et al., 2020; Stoltz & Grahn, 2021; Wang et al., 2020b). The SBE method objectively measures public forest landscapes by establishing a stimulus-response model using photographic representations evaluated through human psychological behaviors and signal detection theories (Daniel & Boster, 1976). To complement these user-centric data with expert planning priorities, the Analytic Hierarchy Process (AHP) provides a reliable Multi-Criteria Decision-Making (MCDM) framework (Pant et al., 2022; Saaty, 1980). The AHP method has been employed in several studies on GOS to determine policy priorities for GOS development in Jakarta to meet the availability requirement of 30% of the administrative area's total land area. Min & Pan (2022) also used AHP to evaluate the landscape conditions of national forest parks. Six parameters were used for AHP analysis: carbon sequestration, dust retention, humidification, benefits from plant aesthetics, benefits from ornamental plants, and integration of roadside landscapes. Previous studies suggest that landscape aesthetic preference is shaped by the interaction of vegetation structure, color diversity, visibility, perceived naturalness, and landscape neatness (Aspe et al., 2018; Hao et al., 2024; Mundher et al., 2023; Tyrväinen et al., 2003). Therefore, to evaluate the Kembangan Utara Urban Forest, this study focuses on three main variables: (1) Vegetation Structure, (2) Aesthetic Quality, and (3) Social Interaction Facility, which are assessed using the Analytic Hierarchy Process (AHP) and Scenic Beauty Estimation (SBE).

A placemaking perspective, user perception and spatial experience are the most important factors in shaping social interactions within a GOS (Ma et al., 2021; Zhao et al., 2022). However, structural deficiencies often hinder these outcomes. For example, a study in Derby, England, revealed that certain GOSs fell short of public expectations in terms of aesthetics, quietness, and naturalness (Creed & Carvalho, 2024), while 72% of surveyed visitors at Kalijodo GOS, Jakarta, reported thermal discomfort (Mbarep et al., 2021). Furthermore, Hegetschweiler et al. (2022) indicated that user demographics introduce varying spatial needs, where adolescents seek active socialization while adults prioritize reflective experiences, both anchored by deep emotional bonds with the urban trees, where trees serve as a source of comfort, support, and even "friends" for many people, evoking feelings such as joy, loneliness, love, and sadness (Straughan et al., 2023). Civil society actors are essential for inclusive, participatory, and knowledge-based environmental management (Slobodníková & Tóth, 2025). Based on these collective insights, evaluating color, vegetation, neatness, and comfort is essential for understanding the aesthetic-experiential dimensions of GOS development.

GOS development focuses not only on aesthetic value but also on the quality of the space and user experience. The placemaking approach is particularly relevant in this context because it emphasizes the importance of interactions among people, spaces, and local values in creating meaningful public open spaces. From a placemaking perspective, landscape aesthetics contributes to the quality of urban public spaces by shaping how users perceive, experience, and interact with their surroundings. Visual attributes such as color, vegetation, and neatness may influence the perceived attractiveness and character of a place, while comfort can affect users' willingness to stay and engage with the space (Kim & Li, 2024; Zeng & Wang, 2025b). Together, these attributes contribute to spatial experience, sense of place, and the creation of meaningful and user-centered public environments. Therefore, evaluating these landscape characteristics can provide useful insights for understanding how urban forests are perceived and how their design and management can better respond to user needs. An attractive vegetation composition, visual coherence, neatness of the landscape, and environmental comfort may help create conditions that encourage social interaction. Thus, aesthetic assessment moves beyond superficial

concerns and promotes the establishment of meaningful, engaging, and user-centered public spaces.

While traditional urban forest management focuses predominantly on ecological metrics, modern urban planning demands a shift toward user-oriented frameworks by integrating landscape aesthetics and placemaking theory (Gobster et al., 2007; Matsuoka & Kaplan, 2008). Although previous studies have combined SBE and AHP, limited attention has been given to integrating public evaluations of specific landscape attributes—such as color, vegetation, neatness, and comfort—with expert-based planning priorities in the context of urban forest management. Particularly in developing nations such as Indonesia, user-centered aesthetic evaluation and multi-criteria decision-making for urban forest planning remain largely unintegrated in the existing literature. This gap is significant because the ultimate success of urban GOS depends not only on ecological performance but also on how users perceive and experience the space. Accordingly, this study applies SBE and AHP as complementary approaches to connect users' aesthetic evaluations with expert-based prioritization of landscape attributes, thus providing a more context-specific basis to address this gap for urban forest planning.

While this integrated concept is valuable, systematically unifying public and expert considerations still faces empirical challenges. Huang et al. (2023) combined the SBE method with AHP to analyze the validity and reliability of parks in Hangzhou, China, revealing the potential integration of these approaches to support landscape aesthetic value. Compared with Huang et al. (2023), who focused on proving the validity of a methodology in urban parks, this study applies the SBE-AHP approach to sustainable urban forest management in Jakarta, emphasizing community-based user experiences and environmental science perspectives in aesthetic-based GOS planning. Studies on the combined use of SBE and AHP in urban forest management are still limited, especially in relation to GOS in developing countries. This application is highly critical for the North Kembangan Urban Forest. Further research is needed to understand the community's perspectives and experiences regarding aesthetic value to optimize sustainable urban forest and GOS management. Therefore, this study was conducted to determine the SBE and AHP in the North Kembangan Urban Forest and the relationship between public perception and aesthetic value to develop and enhance aesthetic GOS. The study's findings are interpreted within a broader planning framework that considers ecological, economic, and social dimensions to enhance Jakarta's broader urban resilience.

2. Methods

2.1 Study area

The North Kembangan Urban Forest is located in West Jakarta and covers 2.61 hectares. The North Kembangan Urban Forest is located on the border of the villages of North Kedoya and North Kembangan, in the, Kembangan sub-district, West Jakarta Administrative City. The North Kembangan Urban Forest is part of the management area of the Jakarta Urban Forestry and Parks Agency, managed by the West Jakarta Urban Forestry and Parks Sub-agency manages. This urban forest is located at an average elevation of 7 meters above sea level, with an area of 2.6 hectares, at coordinates 6°10'10" south latitude and 106°45'04" east longitude. According to BPS data in 2024, the total rainfall in West Jakarta Administrative City was 188.27 mm/year, with the highest rainfall in February at 500.50 mm/year. The average temperature in West Jakarta Administrative City is 28.97°C, with the highest at 36.60°C in May 2024 and the lowest at 23.60°C in July and September 2024. The average humidity in 2024 is 76.19%, with the highest humidity at 100% in January and February 2024 and the lowest humidity at 77.50% in August 2024. The North Kembangan Urban Forest area is dominated by residential areas, but it also includes open spaces and green areas. There is an open space on the north side of the North Kembangan Urban Forest, namely the Kampung Baru Child-Friendly Integrated Public Space, and the Green Garden Park on the south side. The Cengkareng Drain is on the west side, the

Pesanggrahan River is on the south side, and the Pesing River is on the north side. The research location map is showed in Figure 1.

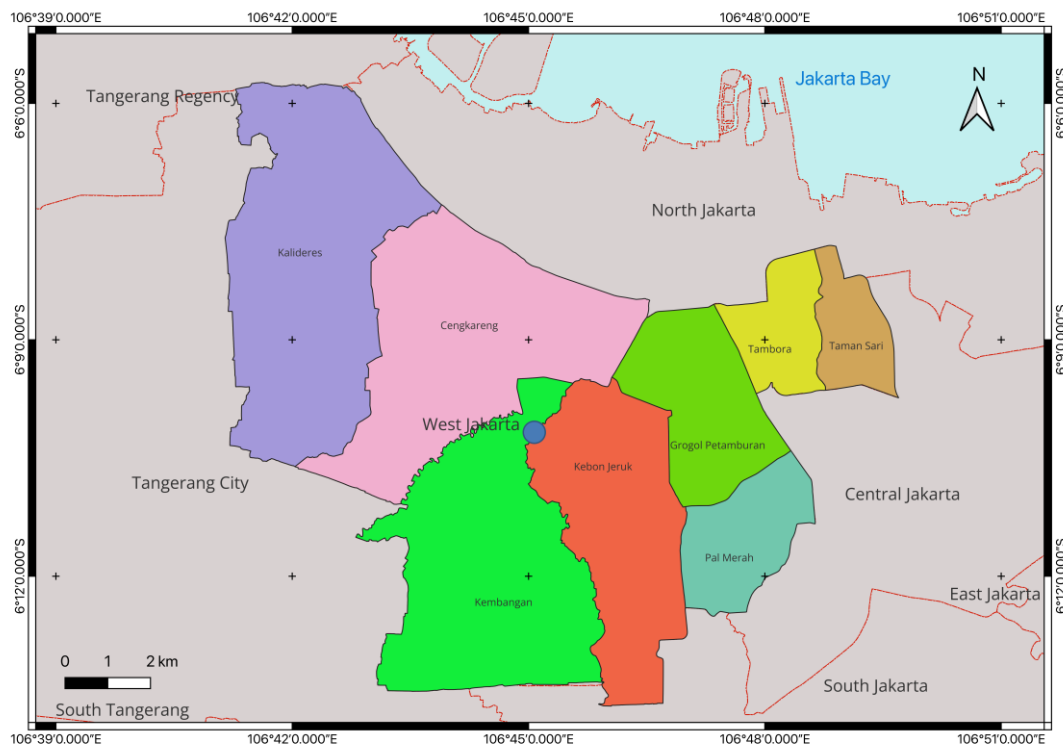


Fig. 1. Map of research locations

The Kembangan subdistrict, which is the administrative area of the North Kembangan Urban Forest, has an area of 24.16 km² and a population of 311,262 people, with a population density of 12.883 people/km². Looking at the location of the North Kembangan Urban Forest, which is in the North Kembangan Village, the population in 2024 will reach 69,824 people in 2024. In 1995, the North Kembangan Urban Forest was designated and used as part of the GOS in 1995. The densely populated Kampung Baru neighborhood and the Green Garden complex surround the North Kembangan Urban Forest. The area around the North Kembangan Urban Forest is dominated by communities, with residents using the roads around the urban forest for their daily activities. Its proximity to residential areas allows the North Kembangan Urban Forest to serve as a GOS, providing ecosystem services to living creatures in the urban ecosystem.

2.2 Respondents or participants

This study combines SBE and AHP to identify aesthetic perception and develop an aesthetic-based GOS plan to support community experiences and social interactions. Respondents for the SBE assessment were selected from people who had never visited the North Kembangan Urban Forest, using snowball sampling through an online questionnaire. This method was chosen for its ease of use, practicality, and accessibility in assessing the aesthetic value of GOS. This approach was applied to respondents who were familiar with and interested in GOS and were able to provide a visual assessment of the aesthetics of the research site. The selection criteria for respondents took into account demographic diversity, such as age and gender. This category of respondents was selected to maintain objectivity in the assessment process and reduce the potential for experiential bias. The number of respondents in this study was 110. While snowball sampling is a non-probability method, this sample size is justified based on the requirements of visual preference analysis. Referring to visual studies, the number of respondents was >100 (Hao et al., 2024; Spano et

al., 2023; Wang et al., 2020a), providing sufficient observations for the visual preference analysis. Furthermore, this approach is highly compatible with the AHP, which prioritizes respondent consistency and specific contextual understanding over population-level statistical representativeness."

A sample of 9 experts was selected for the AHP method through purposive sampling at least 5 years of experience, based on their academic qualifications and professional experience in academia, the government, and the private sector. The selection of experts was based on the areas covered by the research variables, namely, vegetation structure, vegetation composition, air temperature, relative humidity, thermal comfort, aesthetic value, and public perception. The population from which data were collected consisted of researchers or professional experts; each informant was required to possess knowledge and experience related to landscapes, urban forest management, and plant species in urban forests. The respondents were as follows, (1) one expert or researcher in biology or vegetation-related fields; (2) one agricultural expert or researcher; (3) one forestry expert or researcher; (4) one climate expert or researcher; (5) one expert or researcher in horticulture or landscape architecture; (6) one urban planning expert or researcher; (7) one environmental expert or researcher; (8) one sociologist; and (9) one management expert in project development and financing.

2.3 Questionnaire for scenic beauty estimation

The questionnaire was created by and assigning scores to photos taken with a camera. The assessment covered aspects such as the likability, color, vegetation, neatness, and comfort of the image. Each photograph was assessed using a 10-point rating scale, where 1 represented the lowest perceived quality and 10 represented the highest perceived quality for each attribute. The questionnaire was designed using a Google Form and distributed online. A pilot survey involving 30 respondents was conducted to evaluate the clarity and comprehensibility of the questionnaire before its implementation.

2.4 Scenic beauty estimation analysis

Sampling of aesthetic value with SBE was conducted by photographing several locations in the North Kembangan Urban Forest area that exhibit characteristics. These locations were selected using random sampling. The photos were reviewed to ensure the clarity, relevance, and consistency of the evaluation criteria. The photos were then compiled into a questionnaire. SBE photography is defined by Dewi & Sarilestari (2018). The first step in evaluating the SBE value is selecting vantage points and determining which landscape photos to use. Observation and determination of photo objects are adjusted to represent the characteristics of each block in the North Kembangan Urban Forest. Photos of the North Kembangan Urban Forest landscape will be taken, and a 1-10 scale questionnaire will be distributed to respondents. Respondents were instructed to observe each photograph for approximately 10 seconds before providing their ratings. There are advantages to the SBE method, (1) it takes preferences and responses from the perceptions felt by the public and assesses different landscapes; (2) in terms of validity testing, SBE provides similar and consistent results for photos taken randomly from subjects evaluated directly at the same location but at different times, thereby saving human resources and time; (3) can be applied to various landscapes; and (4) minimizes evaluation errors caused by differences in individual aesthetic concepts. However, there are also weaknesses in the SBE method, (1) the selection of landscape samples to represent general landscape groups is debatable; (2) photographic techniques and angles affect the assessment results; (3) it is not easy to see the evaluated area precisely and specific areas of the photo; (4) it cannot distinguish whether the evaluator's preferences are based on perception or cognition of the landscape; and (5) the coefficients calculated in the analysis do not have a definite explanation, may vary between individuals, and are relatively subjective.

Photography with SBE was conducted strictly in accordance with the principles outlined in the study (Jia et al., 2022), with modifications to reflect the true beauty of urban forest vegetation: (1) photos were taken in clear weather with high visibility between 8:00 a.m. and 10:00 a.m. and 3:00 p.m. and 5:00 p.m.; (2) photography was carried out by the same person, with the same camera and the same parameters to ensure consistency between photos. To ensure stable photos, the camera was mounted on a support at a height of approximately 1.6 m. The camera used was a Fujifilm X-T3 with an F6.3 aperture, auto-focus mode, and no flash; and (3) the influence of factors not present in the GOS area was avoided. The photos were then sorted according to the following criteria: (1) The photos provide a representation and reflect the characteristics of a particular type of vegetation; and (2) The photos are of high quality and do not have backlighting. The questionnaire data were statistically processed to obtain the SBE value for each landscape. The SBE value was calculated using the average Z value from the data processing. The Z-value formula is as follows:

$$Z_{ij} = \frac{(R_{ij} - R_j)}{S_j} \quad (\text{Eq. 1})$$

Where Z_{ij} represents the Z-score for the i-th photo rating by the j-th respondent, R_{ij} denotes the rating given to the i-th photo by the j-th respondent, R_j refers to the average of all ratings provided by the j-th respondent, and S_j represents the standard deviation of all ratings provided by the j-th respondent. Z-values were calculated for all landscape metrics from photographs taken in the North Kembangan Urban Forest. The total Z value was obtained by accumulating the Z values from these photographs. The calculated total Z value was then used as the standard for assessing beauty, using the SBE formula. The SBE formula developed by Zhou et al. (2022) is as follows:

$$SBE_x = [Z_{yx} - Z_{y0}] \times 100 \quad (\text{Eq. 2})$$

Where SBE_x represents the estimated aesthetic value of the landscape x, Z_{yx} denotes the average Z-value of landscape x, and Z_{y0} refers to average Z-value of a specific landscape that is close to 0 and is considered the standard. The assessment of beauty using SBE is then categorized into the following intervals: (1) poor category: SBE value less than 0; (2) moderate category: SBE value between 0 and 90; and (3) Good category: SBE value greater than 90. The results of the analysis of aesthetic value are presented using descriptive statistics. Pearson correlation analysis was used to examine the associations between SBE scores and mean scores for color, vegetation, neatness, and comfort. Statistical significance was assessed at $p < 0.05$. Statistical analyzes were performed using Microsoft Excel.

2.5 Analytical hierarchy process

The AHP (Analytical Hierarchy Process) was conducted in cooperation with nine experts, comprising four academic researchers in urban planning, landscape architecture, biology, or vegetation-related fields, a sociologist, one representative from the Jakarta Environmental Agency, one representative from Indonesia's Meteorology, Climatology, and Geophysics, one representative from the Indonesian Landscape Architects Association, and two representatives from the private sector. The opinions of the experts were obtained through pairwise comparison questionnaires to assess the relative importance of the evaluation criteria and development alternatives. Data were collected through structured, one-on-one pairwise comparison interviews conducted either in person or via digital communication platforms. The extent to which the expert responses were consistent was evaluated using the Consistency Ratio (CR), ensuring the reliability of the decision-making process. AHP generates several alternatives that can be used to model GOS based on aesthetic value. The following steps are required to use AHP: 1) decomposition; 2)

comparative evaluation; 3) priority synthesis; and 4) logical consistency (Saaty & Vargas, 2012).

2.5.1 Decomposition and comparative assessment

Decomposition is the process of analysing the variables of a problem and organizing them into an interconnected hierarchical structure, from the top level down to the base level (Saaty & Vargas, 2012). Following the decomposition process, researchers evaluate all decision-making factors for each variable at every level of the hierarchy through comparative assessment. The values are weighted using a scale of 1–9, as shown in Table 1.

Table 1. AHP rating scale

Value	Description	Explanation
1	Equally important	Both elements contribute equally to a trait
3	Slightly more important	Experience and consideration slightly favor one element over the other
5	More important	Experience and consideration strongly favor one element over the other
7	Much more important	One element is supported and the other is dominated, as evidenced in practice
9	Absolutely more important	The evidence supporting one element over the other has the highest possible certainty level
2, 4, 6, 8	A value of importance reflecting a compromise	A compromise between the two considerations is necessary

(Source: Saaty & Vargas, 2012)

A panel of nine designated experts conducted the evaluation. Individual expert judgments for each pairwise comparison were aggregated using the geometric mean to construct the group comparison matrix (Saaty & Vargas, 2012):

$$\bar{a} = \sqrt[n]{a_1 \times a_2 \times a_3 \times \dots \times a_n} \quad (\text{Eq. 3})$$

Where $\bar{a}$ represents Average comparison score for variables X and Y, n denotes the number of evaluators, and a_n refers to the comparison score for variables X and Y from the n-th evaluator.

2.5.2 Priority synthesis

Priority synthesis is a process used to determine the relative importance or weight of each alternative based on predetermined criteria. This process combines the results of pairwise comparisons conducted by the decision-maker to produce a priority ranking that reflects the relative importance of each element in the decision hierarchy.

2.5.3 Logical consistency

The final step in using the AHP method is to ensure logical consistency. This step assesses the consistency of the decision-maker's judgment. An evaluation is considered consistent if the weighting scale for each pair of alternatives does not differ from the weighting scales of other alternatives (Thakkar, 2021). Logical consistency is measured using the Consistency Ratio (CR), which is obtained by comparing the Consistency Index (CI) and the average Random Index (Saaty, 1991) using the following formula:

$$CR = \frac{CI}{\text{Average RI}} \quad (\text{Eq. 4})$$

$$CI = \frac{\lambda_{max} - n}{(n-1)} \quad (\text{Eq. 5})$$

Where CI represents the consistency index which indicates the deviation from consistency, λ_{max} denotes the maximum eigenvalue, n refers to the matrix dimension, and RI represents the random index, which is the consistency index of the reciprocal matrix. Saaty & Vargas (2012) stated that a calculation using the CR formula is considered valid if the CR value is 0.10. However, if the resulting value exceeds 0.10, further evaluation is needed to identify the cause of the discrepancy, which can then be corrected based on expert input or mathematical intervention. Based on that study, the reliability of the experts' assessments was evaluated using the CR value below 0.10, which was considered acceptable. The Consistency Ratio (CR) was evaluated for the aggregated group pairwise comparison matrix, constructed using the geometric mean. A threshold of $CR \leq 0.10$ was strictly applied and considered as an acceptable level of consistency for the overall group judgments.

AHP is used to determine preference weights and an evaluation framework for aesthetic value considered important by experts, while SBE was used to quantitatively assess landscape aesthetic preferences based on respondents' evaluations of photographic stimuli, whereas AHP was used to derive expert-based preference weights and development priorities.

3. Results and Discussion

3.1 Results

Ten photos are displayed in the questionnaire. The Google Forms-created questionnaire, was distributed online to people who had never visited the urban forest. The respondent profile was predominantly female, with 87 out of 110 (79%) being women and 23 (21%) being men. Furthermore, the questionnaire results indicate that young adults aged 20–29 years (100 respondents, 90.91%) made up the majority of the sample, while the teenager (13–19 years old) and adult (30–59 years old) age groups each accounted for only 4.55%. This distribution indicates that the SBE questionnaire responses were largely represented by young adult participants, with higher proportion of female respondents.

Canopy cover, vegetation condition, and color contrast are indicators that can be used to observe GOS characteristics. There are ten photos that describe the condition of the North Kembangan Urban Forest. The first photo describes the entrance to the North Kembangan Urban Forest with densely growing trees on both sides and minimal sunlight. The second photo shows a mixture of ornamental plants and trees at the entrance of the urban forest. The third to sixth photos describe the conditions inside the North Kembangan Urban Forest, with high tree density, a natural footpath, a mixture of plants and trees, and a small pond. The seventh photo features *Eucalyptus deglupta* with its colorful bark and a mixture of crops. The eighth and ninth photos show leaves covering the ground and a stream that flows through several trees, respectively. The last photo shows a path with a lower tree density that allows more sunlight to enter the urban forest. Table 2 shows the esthetic value results for the SBE, color, vegetation, neatness, and comfort scores.

Table 2 presents the calculated distribution of the standardized Scenic Beauty Estimation (SBE) scores across the evaluated photostimuli. In these results, photo number 2 received the closest score to 0, making it the SBE calculation benchmark. Based on the established classification thresholds, the ten photographic stimuli were classified into two categories: moderate and poor aesthetic quality. No photograph reached the good aesthetic category. Photo 10 recorded the highest SBE score (84.28), followed by Photo 7 (54.09), Photo 5 (28.34), and Photo 2 (3.42). Six photographs were classified as having poor aesthetic quality based on SBE scores

below zero. A more in-depth examination of the scores for individual perception criteria reveals the specific visual factors that underlie these public preferences. Photo 7 received the highest mean ratings for color (7.25) and vegetation (7.05), while Photo 10 received the highest ratings for neatness (7.47) and comfort (7.44). Among the lower-rated stimuli, Photo 9 recorded the lowest scores for color (5.27), neatness (4.76), and comfort (4.73), while Photo 8 received the lowest vegetation score (5.27).

Table 2. The SBE questionnaire of the North Kembangan Urban Forest

Photo	Color score	Vegetation Score	Neatness Score	Comfort Score	SBE	Category
	5.41	5.85	5.45	5.30	-28.36	Poor
	6.51	6.82	5.56	5.79	3.42	Moderate
	5.62	5.82	5.74	5.56	-4.45	Poor
	5.70	5.46	5.46	5.78	-14.72	Poor
	6.77	6.46	6.79	6.64	28.34	Moderate
	5.72	5.68	5.27	5.70	-21.92	Poor
	7.25	7.05	7.20	7.15	54.09	Moderate
	5.73	5.27	5.41	5.58	-36.66	Poor
	5.27	5.47	4.76	4.73	-64.03	Poor
	7.18	6.82	7.47	7.44	84.28	Moderate

Public perception is examined in relation to elements that influence aesthetic value. Ecological knowledge directs people to consider different elements when evaluating landscapes (Liang et al., 2023). The results of the influence are shown in

the relationships of color scores, vegetation scores, neatness scores, comfort scores, and aesthetic value.

Color score was strongly and positively correlated with SBE-based aesthetic value ($r = 0.93$, $p < 0.001$). The corresponding R^2 value was 0.87, indicating a close linear association between photo-level color scores and SBE values. The strong correlation suggests that perceived color characteristics may play an important role in shaping aesthetic preference. The correlation results for vegetation scores also show a strong, significant relationship with aesthetic value, with $r = 0.85$ and $p = 0.002$. The R^2 value of 0.72 on the scatter plot indicates that vegetation scores explain 72% of the variation in aesthetic value.

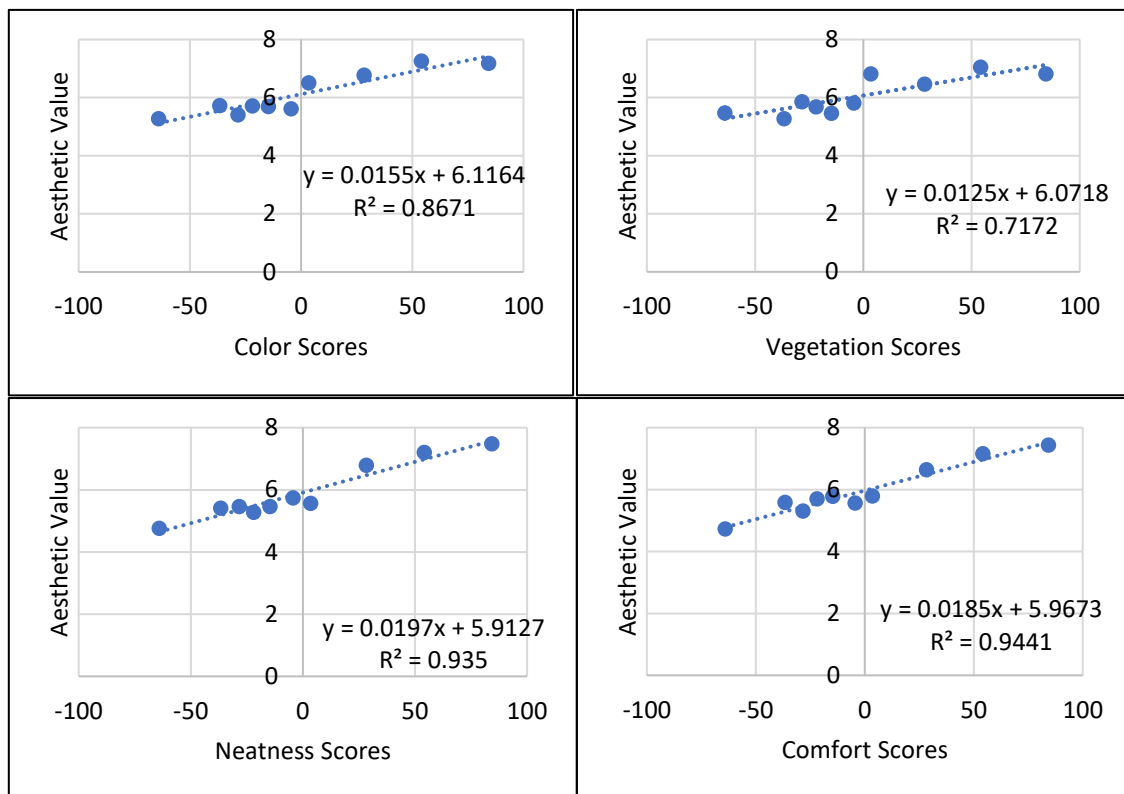


Fig. 2. The relationship between Color Scores, Vegetation Scores, Neatness Scores, Comfort Scores, and aesthetic value in photos of the North Kembangan Urban Forest.

The correlation results indicate a very strong, significant relationship between neatness scores and aesthetic value, with $r = 0.97$ and $p < 0.001$. The R^2 value of 0.94 on the scatter plot indicates that the level of neatness accounts for 94% of the aesthetic value of a GOS. This shows that neatness is one of the determining factors of the beauty and aesthetics provided by urban forests. The comfort score shows a very strong, significant correlation with aesthetic value, with $r = 0.97$ and $p < 0.001$. The R^2 value is 0.94 based on the scatter plot. Comfort contributes 94% to the aesthetic value of the scatter plot. The strong association between comfort and aesthetic ratings suggests that visually preferred settings may also be perceived as more comfortable for respondents. The results are shown in Fig. 2.

The questionnaire results were collected and processed using Microsoft Excel. The calculation results indicate that each criterion and alternative are consistent. These results are presented in Table 3. The AHP analysis systematically divides the decision-making hierarchy into local and global priority weights to ensure a thorough assessment of GOS development. As shown in Table 3, the experts assigned the highest global weight to Vegetation (0.36 or 36%), followed by Thermal Comfort (0.31 or 31%), while Cost was considered the least critical factor (0.07 or 7%). From the experts' perspective, ecological

and experiential dimensions (vegetation quality and microclimate regulation) are roughly five times more important than financial constraints in driving esthetics-based development. After the weighting of the criteria, the experts were presented with alternative options regarding the types of GOS suitable for enhancing aesthetic value.

Table 3. Selection criteria for the development of GOS based on aesthetic value

Criteria	Weight	Criteria	Weight	Consistency Ratio (CR)*
Vegetation	0.36	High-Canopy Tropical GOS	0.42	0.02
		Thematic GOS (City Landmark)	0.18	
		Flower Garden GOS	0.13	
		Agroforestry GOS	0.27	
Thermal Comfort	0.31	High-Canopy Tropical GOS	0.61	0.02
		Thematic GOS (City Landmark)	0.12	
		Flower Garden GOS	0.10	
		Agroforestry GOS	0.17	
Aesthetic Value	0.11	High-Canopy Tropical GOS	0.18	0.04
		Thematic GOS (City Landmark)	0.43	
		Flower Garden GOS	0.26	
		Agroforestry GOS	0.13	
Cost	0.07	High-Canopy Tropical GOS	0.46	0.004
		Thematic GOS (City Landmark)	0.16	
		Flower Garden GOS	0.19	
		Agroforestry GOS	0.19	
Public Perception	0.15	High-Canopy Tropical GOS	0.10	0.02
		Thematic GOS (City Landmark)	0.41	
		Flower Garden GOS	0.26	
		Agroforestry GOS	0.22	

*The overall CR is below 0.10, which is accepted.

The High-Canopy Tropical GOS emerged as the dominant model for both vegetation (42%) and thermal comfort (61%) when evaluating alternatives based on specific criteria. This high priority reflects the biological realities of Jakarta's tropical climate, where a dense, multi-layered canopy is crucial for mitigating the urban heat island effect, thereby directly influencing landscape quality perceptions. Conversely, the Flower Garden GOS received the lowest scores based on these criteria (13% for Vegetation; 10% for Thermal Comfort), most likely due to its high maintenance requirements and lower capacity to cool the microclimate.

Interestingly, there was a divergence of opinion regarding the criteria of Aesthetic Value and Public Perception. For Aesthetic Value, experts preferred the Thematic GOS (City Icon) at 43% (while the Agroforestry GOS received the lowest score at 13%). Similarly, under the Public Perception criterion, Thematic GOS received the highest weight at 41%, while High-Canopy Tropical GOS received the lowest score at 10%. Within the expert-based AHP assessment, Thematic GOS received the highest priority when alternatives were evaluated specifically against aesthetic value and perceived public preference. However, when synthesizing the entire global matrix while considering all trade-offs across all criteria, the High-Canopy Tropical GOS ultimately received the highest overall priority score of 0.41 (41%), while the Flower Garden GOS remained at the lowest position with 0.16 (16%). This synthesis demonstrates that while iconic thematic spaces are visually appealing, integrated GOS planning must prioritize a dense tropical canopy because it provides users with the ecological and thermal benefits and long-term user experience. Furthermore, the overall Consistency Ratio (CR) for these matrices is 0.02, which is well

below the Saaty threshold of 0.10, confirming the mathematical reliability of the experts' assessments. The results of our research are presented in Table 4.

Table 4. Table of alternative green open space scores based on aesthetic value

Alternative	Weight	Rank
High-Canopy Tropical GOS	0.41	1
Thematic GOS (City Landmark)	0.22	2
Flower Garden GOS	0.16	4
Agroforestry GOS	0.21	3

3.2 Discussion

3.2.1 Discussion of the research findings and implications

The snowball sampling approach enabled efficient recruitment but resulted in a demographically imbalanced respondent sample. Although snowball sampling facilitates the recruitment of respondents interested in Green Open Spaces (GOS), it may have introduced self-selection bias. Nevertheless, the inclusion of respondents who have not physically visited the Kembangan Utara Urban Forest is justified. Because the Scenic Beauty Estimation (SBE) method relies on the visual evaluation of standardized landscape photographs, respondents can reliably assess the aesthetic quality of the area regardless of their prior on-site experience. However, the questionnaire results were dominated by young adult female respondents aged 20–29 years. This indicates a potential demographic imbalance. Although this method allows for efficient data collection and broad reach, the questionnaire results may skew aesthetic preference patterns and limit the generalizability of these findings to the broader urban population. Further research using either random or stratified sampling methods and involving visitors at GOS to improve representativeness and generalizability is recommended.

Perceived color showed a particularly strong association with landscape aesthetic value in shaping urban beauty perception. This was also found in a study by Wang et al. (2020a), who found that color is one of the first indicators processed by the human perception system. Rich and contrasting colors are often associated with ecosystem health, which can increase the psychological comfort and aesthetic experience of visitors. Hao et al. (2024) similarly reported that the diversity of vegetation colors has a greater impact than structural diversity and species diversity. This pattern is broadly consistent with the present photo-level correlations, in which color showed a stronger association with SBE ($r = 0.93$) than vegetation ($r = 0.85$). However, the diversity of plant shapes, types, and canopy structures plays an important role in determining the characteristics of GOS. Diverse vegetation provides complex visual layers, enhancing the perception and appeal of naturalness and comfort.

Neatness can be determined from the GOS structure and composition. A neat and natural structure and composition give a positive community perception. However, excessive emphasis on visual neatness may reduce perceived naturalness and potentially conflict with ecological management objectives. Therefore, a balance between natural and artificial neatness is required in GOS. The comfort created by GOS is not only thermal, but also visual. Comfort is also strongly linked to color because it provides balance and a healthy ecosystem. Sunlight exposure can influence both visual perception and thermal sensation, although its effect on comfort depends on local microclimatic conditions (Nitidara et al., 2022). Greenness, sunlight intensity, and connection to nature have different effects on the restorative dimension (Spano et al., 2023). GOS with broad-canopied trees tend to attract people to linger, even without designated seating (Zhang et al., 2022), thereby providing visitors with comfort.

The factors that have the most impact on aesthetic value are comfort and neatness, followed by color value, and finally vegetation. In accordance with the AHP results, the priority criterion is Vegetation, with a weight of 0.36; the priority alternative by value is High-Canopy Tropical GOS, with a value of 0.41. These findings could be used in future planning to differentiate areas requiring aesthetic enhancement from areas where ecological conservation may be prioritized. These findings provide empirical support for applying placemaking principles to aesthetic-oriented urban forest planning. The idea behind placemaking is that transforming physical green “spaces” into socially dynamic and meaningful community “places” requires optimizing comfort, visual appeal, and social friendliness.

Favorable perceptions of color, vegetation, neatness, and comfort may contribute to conditions that support more positive user experiences and potentially encourage social use of public spaces. This result aligns with the concept of placemaking, which emphasizes the quality of place and user experience in public spaces and urban resilience frameworks. Neatness and comfort were strongly associated with aesthetic preference and may also have broader implications for perceived usability and attractiveness of GOS. The alternative results for the High-Canopy Tropical GOS can help achieve placemaking objectives by creating a shaded, esthetically appealing, and thermally comfortable GOS environment. These three factors influence the length of visits and strengthen the sense of attachment of users to GOS. In the context of urban resilience, well-managed urban forests that provide valuable ecosystem services can support cities’ ability to adapt to environmental changes and foster community interaction in areas undergoing rapid urbanization. Integrating aesthetic and ecological considerations is essential for developing resilient and sustainable GOS that positively impact the surrounding communities.

From an ecological perspective, trees can be a source of comfort and support for humans in the urban environment. The comfort provided by trees is generative to conviviality, the ability of humans to live harmoniously alongside other living beings. Maintenance is necessary to preserve the aesthetics of GOS. Maintenance, such as pruning, has no significant impact on the provision of urban forest ecosystem services (Speak & Salbitano, 2023). Esperon-Rodriguez et al. (2025) highlighted the need for high tree species diversity (integrating native and exotic species), incorporating biodiversity, engaging the community, and addressing socio-ecological inequalities. Improving vegetation structure can enhance and positively impact outdoor thermal comfort (Li et al., 2025). Integration of biodiversity can be achieved through the enhancement of urban wildlife.

From an economic perspective, the beauty of GOS can indirectly increase visits and economic benefits to the environment. However, GOS maintenance requirements will be higher. Shah et al. (2024) identified costs associated with green infrastructure, such as construction and maintenance costs, human health and biodiversity damage costs, and ecosystem loss costs. The research explains that cutting frequency and plant diversity have a consistent negative correlation, where reducing cutting intensity tends to support increased biodiversity. Maintenance of urban forests is important to ensure that the benefits provided by trees can be maximized during the young to mature phases (Hauer et al., 2015). Without proper planning, costs can increase. Proper pruning cycles, adequate irrigation during the tree planting phase, and appropriate pest control strategies contribute significantly to the overall feasibility of urban forest maintenance (Hwang et al., 2025). Because urban forests also serve biodiversity-conservation functions, aesthetic management should be balanced with the retention of ecologically important natural features.

From a social perspective, cities are the center of human activity. Understanding how urban areas serve as containers for communities, providing identity and a sense of place that has been passed down from generation to generation (Taylor, 2025), becomes important as a foundation for the formation and determination of GOS. This is also supported by Thompson (2002), assertion that GOS serve as spaces for socializing, enjoying

solitude, and gathering cultural diversity. Community participation may be particularly relevant to the long-term management of the North Kembangan Urban Forest. Campbell et al. (2022) stated that the community needs to see urban forests not only from an aesthetic point of view, but also as a system that supports life and human relations with nature, such as local functions and the preservation of the city's cultural heritage.

The findings of this study may also contribute to broader urban design strategies by emphasizing the importance of integrating aesthetic quality, ecological function, and user experience in GOS planning. Color, vegetation, neatness, and comfort are priorities for creating user-oriented public spaces that enhance the quality of the urban environment, social interaction, and sense of place. Within the context of SDG 11, improving the quality and usability of urban green spaces may support more inclusive and attractive public environments. As noted by Yamasaki & Yamada (2022), the integration of physical, economic, social, and environmental elements is a key objective in building sustainable urban ecosystems and communities. Integrating ecological function with human-centered spatial experiences is important for implementing community-oriented GOS design approaches. Therefore, the esthetic value of the North Kembangan Urban Forest can be enhanced to maximize its functionality and create spaces that align with the needs and preferences of both the community and the government.

Efforts to maximize the functionality, aesthetic value, and community experience of the North Kembangan Urban Forest can be achieved through several planning strategies. To meet the AHP priority of the experts (High Canopy GOS = 0.41) and the SBE preferences of the community for color and comfort, the forest layout must be organized into distinct visual strata. Large-canopied native or site-appropriate tropical tree species (e.g., *Samanea saman* or Trembesi) could be prioritized to enhance shading and canopy structure. Beneath this canopy, architects should introduce a well-organized, colorful, and low-maintenance understory layer of shrubs, which creates visual appeal and unity without obstructing human views or reducing the sense of security in open spaces. A future management strategy could consider differentiating areas intended for more intensive social use from areas prioritized for ecological conservation, for example “Aesthetic-Social Zone” and an “Ecological-Conservation Zone.” The Aesthetic-Social Zone, located near the entrance to the residential area, must prioritize highly weighted parameters such as neatness and comfort. Potential interventions could include clearly defined permeable pathways and shaded seating areas, subject to further site-specific design assessment. Conversely, the Ecology-Conservation Zone should be left in a more natural and wild state to preserve urban biodiversity and protect local ecosystem services, as justified by multi-criteria considerations. To balance the economic costs of maintenance with community engagement, a participatory management involving local residents and relevant municipal agencies could be explored as a complementary long-term governance strategy. (Slobodníková & Tóth, 2025). Public programs in which community volunteers assist with the maintenance of green spaces (e.g., weed removal and planting colorful shrubs) should be launched. Such participation can strengthen the community's sense of ownership and long-term engagement, although the financial implications require a separate evaluation, while directly strengthening the sense of ownership, sense of place, and long-term attachment of the community to the North Kembangan Urban Forest.

3.2.2 Methodological limitations

In interpreting the results of the aesthetic assessments of landscape, a few methodological limitations of this study should also be considered. Among these limitations is the imbalanced demographic characteristics of respondents, with many falling in the young adult age group (female majority). This composition may have influenced the observed aesthetic-preference patterns because visual perceptions can vary across demographic groups.

The dominance of the young adult female group means that the SBE scores obtained in this study tend to represent the aesthetic preferences of that group rather than the general

public's perceptions. Accordingly, the results of the public perception scores from the current study are more consistent with the perceptions of the respondents than with the overall aesthetic preferences of the urban forest user population. Thus, caution should be exercised when generalizing the research findings to the general community or to the users of North Kembangan Urban Forest.

Nevertheless, the study's findings still provide relevant information regarding visual preference trends for landscape characteristics found in the North Kembangan Urban Forest. Future research should include a more diverse and proportionally representative sample of respondents across various age groups, genders, social backgrounds, and levels of green open space usage to enhance the representativeness and external validity of the research findings.

4. Conclusions

Photos 5, 7, and 10 showed relatively high SBE scores of 28.34, 54.09, and 84.28, respectively, while remaining within the moderate aesthetic category. There is a significant relationship between color, vegetation, neatness, and comfort with aesthetic value, with neatness and comfort identified as the primary visual drivers. The AHP synthesis identified High-Canopy Tropical GOS as the highest-priority development alternative, with an overall weight of 0.41. This synthesis of public perceptions and expert assessments directly implements placemaking. These findings suggest that integrating aesthetic quality, vegetation structure, and perceived comfort may help inform more user-oriented and place-sensitive planning for the North Kembangan Urban Forest.

This study provides targeted and multidimensional recommendations for two key stakeholder groups to implement these empirical findings into actionable urban development. For urban planners and landscape architects, spatial interventions must shift from providing standard green spaces to user-centered design programs that optimize the highly prioritized parameters of comfort and aesthetics. When implementing the recommended High-Canopy Tropical model, site-appropriate tropical tree species with broad canopies could be considered to enhance shade and canopy structure. Planners must establish structured visual zones by maintaining clear pedestrian boundaries using permeable paving, clearing overgrown shrubs along main pedestrian paths, and arranging modular seating clusters directly beneath canopy nodes to alleviate safety concerns and encourage social interaction to meet the public's preference for tidiness without sacrificing ecological value. At the same time, Relevant municipal authorities could consider the SBE-AHP framework as a complementary decision-support approach for evaluating aesthetic preferences and development priorities in urban green spaces. The framework may also help identify locations or design priorities that warrant further management attention, although budget-allocation implications would require separate economic evaluation. Under the umbrella of DKI Jakarta Regional Regulation No. 7 of 2024 on Spatial Planning, policymakers can utilize this multi-criteria framework to guide future community-based pocket park renovations, thereby ensuring that public investments simultaneously support urban structural resilience and social sustainability.

Future research is recommended to select respondents using random or stratified sampling methods, involve GOS visitors, combine photo-based evaluation with direct field studies, conduct a long-term evaluation of changes in the public's perception of aesthetic value following landscape interventions, and adopt a participatory approach by involving the local community to validate AHP-based development priorities at GOS.

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Author Contribution

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Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the participants to publish this paper.

Data Availability Statement

Not available.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT to assist in improving explain the sentences, and Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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Biographies of Authors

Rian Palimirmo Adi, Department of Environmental, Graduate School of Sustainable Development, Universitas Indonesia, Central Jakarta, Special Capital Region of Jakarta 10440, Indonesia.

- Email: rian.palimirmo.ac@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Mahawan Karuniasa, Department of Environmental, Graduate School of Sustainable Development, Universitas Indonesia, Central Jakarta, Special Capital Region of Jakarta 10440, Indonesia.

- Email: mahawan.karuniasa11@ui.ac.id
- ORCID: 0000-0001-6444-6560
- Web of Science ResearcherID: N/A
- Scopus Author ID: S-1740-2017
- Homepage: N/A

Rudy Parluhutan Tambunan, Department of Environmental, Graduate School of Sustainable Development, Universitas Indonesia, Central Jakarta, Special Capital Region of Jakarta 10440, Indonesia.

- Email: rudyptamb@gmail.com
- ORCID: 0009-0004-7209-7101
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57216354261
- Homepage: N/A