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Determining Cooling Green Space Planning Criteria for Mitigating the Urban Heat Island Effect Using the Delphi Technique

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Abstract
The urban heat island (UHI) effect is a major environmental challenge associated with rapid urbanization, increasing impervious surfaces, and the loss of natural areas, leading to elevated temperatures in urban environments. Planning cooling green spaces is considered one of the most effective nature-based solutions for mitigating the UHI effect. However, existing studies have primarily focused on directly applying evaluation criteria to cooling green space planning, while the systematic identification of these criteria through expert consensus has received limited attention to date. Therefore, this study aimed to identify the evaluation criteria for cooling green space planning for urban heat island mitigation using the Delphi technique. The study was conducted using a three-round Delphi process involving 14 experts from different disciplines. In the first round, expert opinions collected through open-ended questions were analyzed using content analysis to develop an initial set of evaluation criteria for the Delphi survey. In the second and third rounds, the importance of each criterion was assessed using a seven-point Likert scale. Consensus was evaluated using the median, quartiles (Q1–Q3), Decreasing Average Factor (DAF), and frequency distributions. Of the 19 criteria evaluated in the second round, consensus was achieved for 15, while the remaining four were re-evaluated in the third round. Following the third round, two additional criteria reached a consensus and were included in the final framework, whereas the remaining two criteria were excluded. Consequently, a scientifically validated final set of evaluation criteria, comprising five main criteria and 17 sub-criteria, was established based on expert consensus. The proposed framework is expected to provide a methodological foundation for future GIS-based spatial suitability analyses, multi-criteria decision-making applications, and urban planning studies aimed at climate-change adaptation.

Keywords: Urban heat island, cooling green space planning, Delphi technique, evaluation criteria

1. Introduction

Rapid urbanization, the replacement of natural and permeable surfaces with asphalt, concrete, and other impervious materials, increasing building density, and rising anthropogenic heat emissions have significantly intensified the Urban Heat Island (UHI) effect, resulting in higher temperatures in urban areas than in their surrounding rural environments. The urban heat island effect is one of the most pronounced microclimatic changes associated with urbanization and has significant adverse impacts on human health, energy consumption, air quality, and thermal comfort, particularly by exacerbating the effects of heat waves (Oke, 1982; Santamouris, 2015). Given the increasing frequency and intensity of extreme heat events driven

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by global climate change, mitigating the urban heat island effect has become a key priority in sustainable urban planning as part of climate change adaptation strategies (Akbari and Kolokotsa, 2016; Wong et al., 2021).

Among the strategies developed to mitigate the urban heat island effect, green infrastructure has been widely recognized as one of the most effective, nature-based solutions. Parks, urban forests, green corridors, street trees, and other urban green spaces contribute to improving the urban microclimate by reducing surface and air temperatures through shading and evapotranspiration (Aram et al., 2019). Systematic review studies have demonstrated that well-planned green spaces can reduce land surface temperatures by several degrees Celsius, with the magnitude of this cooling effect depending on factors such as green space size, vegetation characteristics, tree canopy cover, spatial configuration, and density of surrounding built-up areas (Bowler et al., 2010; Wong et al., 2021). Furthermore, green spaces integrated with blue infrastructure have been reported to provide greater improvements in thermal comfort while simultaneously delivering multiple synergistic and ecosystem benefits (Gunawardena et al., 2017).

Recent studies have shown that simply increasing the amount of urban green space is insufficient to mitigate the urban heat island effect. However, the cooling performance of green spaces is strongly influenced by their spatial configuration, degree of fragmentation, connectivity, and vegetation composition. In particular, areas with dense tree canopy cover and green infrastructure systems that maintain a balanced distribution with surrounding impervious surfaces have been shown to provide stronger cooling effects (Ziter et al., 2019). Furthermore, strategically distributed green spaces across urban areas may generate a broader cooling effect than single large urban parks (Norton et al., 2015). Similarly, the relationship between vegetation and both land surface and air temperatures varies according to urban morphological characteristics, highlighting the need for local planning decisions to be supported by scientific evidence (Shiflett et al., 2017).

In recent years, studies on cooling green space planning have increased considerably, with most focusing on identifying suitable locations through the integration of Geographic Information Systems (GIS), remote sensing, multi-criteria decision-making (MCDM) methods, and spatial optimization approaches. Within these models, land surface temperature (LST), vegetation density (NDVI), land use/land cover (LULC), proportion of impervious surfaces, building density, building height, size and spatial configuration of existing green spaces, population density, and environmental and climatic variables are among the most frequently used evaluation criteria (Wang et al., 2022; Zhang et al., 2022; Li et al., 2023).

Although numerous spatial planning studies have been conducted to identify suitable locations for cooling green spaces, the type, number, and relative importance of the evaluation criteria employed have varied considerably across studies. Although some evaluation criteria are widely adopted, there is no universally accepted approach for their selection and prioritization. Recent systematic reviews have highlighted substantial variations in the evaluation criteria, data sources, and methodological approaches used in previous studies, making it difficult to achieve methodological consistency and comparability across studies (Galalizadeh et al., 2024; Li et al., 2023). Furthermore, recent review studies have demonstrated that the planning and design variables influencing the cooling performance of green spaces vary

according to local climatic conditions, urban morphology, and green space characteristics, emphasizing the need for a common and systematic evaluation framework that can be applied across different study areas (Li et al., 2023; Norouzi et al., 2024).

Although numerous spatial suitability analyses and spatial modeling studies have been conducted to identify suitable locations for cooling green spaces, studies that systematically address the question of which evaluation criteria should be employed in cooling green space planning based on expert opinion remain limited. Existing research has largely focused on planning outcomes, while relatively little attention has been paid to the development and validation of the evaluation criteria that underpin these outcomes. Therefore, this study aims to address this research gap by identifying the evaluation criteria that should be considered in cooling green space planning for urban heat island mitigation through the Delphi technique based on expert consensus. Furthermore, it seeks to provide a scientifically validated evaluation framework that can serve as a foundation for future GIS-based suitability analyses, multi-criteria decision-making (MCDM) applications, and other spatial planning studies.

2. Materials and Methods

2.1. Research design

In this study, the Delphi technique was employed to identify the evaluation criteria to be considered in cooling green space planning for mitigating the urban heat island effect. The research process consisted of three main stages. In the first stage, the disciplinary fields relevant to the research topic were identified, and the selection criteria for experts to be included in the Delphi panel were established. Subsequently, a Delphi expert panel was formed by recruiting experts who met predefined selection criteria. Particular attention was paid to ensuring that the panel members possessed relevant academic expertise and professional experience related to the topic. The second stage comprised the first round of the Delphi process. An open-ended questionnaire was designed to enable experts to express their opinions freely, and it was distributed via e-mail. The qualitative data obtained from the first round were analyzed using content analysis, through which similar responses were grouped and synthesized to establish the main and sub-criteria. Based on these findings, a second-round questionnaire employing a seven-point Likert scale was developed. In the third stage, the second round of the Delphi process was conducted. The responses obtained from the experts were analyzed by calculating the median, first quartile (Q1), third quartile (Q3), Decreasing Average Factor (DAF), and frequency distributions. These descriptive statistics were used to evaluate the level of consensus for each evaluation criterion. Criteria that satisfied the predefined consensus criteria were incorporated into the final evaluation framework, whereas those that failed to reach a consensus were forwarded to the third Delphi round for re-evaluation.

Only the criteria that failed to reach a consensus in the second round were re-evaluated in the third round. Accordingly, a revised questionnaire including these criteria was redistributed to the experts, and the responses were analyzed by recalculating the median, Q1, Q3, DAF, and frequency distributions to reassess the level of consensus. Criteria that met the predefined consensus were incorporated into the final set of evaluation criteria, thereby completing the Delphi process. Conversely, criteria that failed to satisfy any of the predefined consensus criteria after the third round were excluded from the study, and only those for which a consensus

was achieved were retained in the final evaluation framework. The overall workflow of this study is shown in Figure 1.

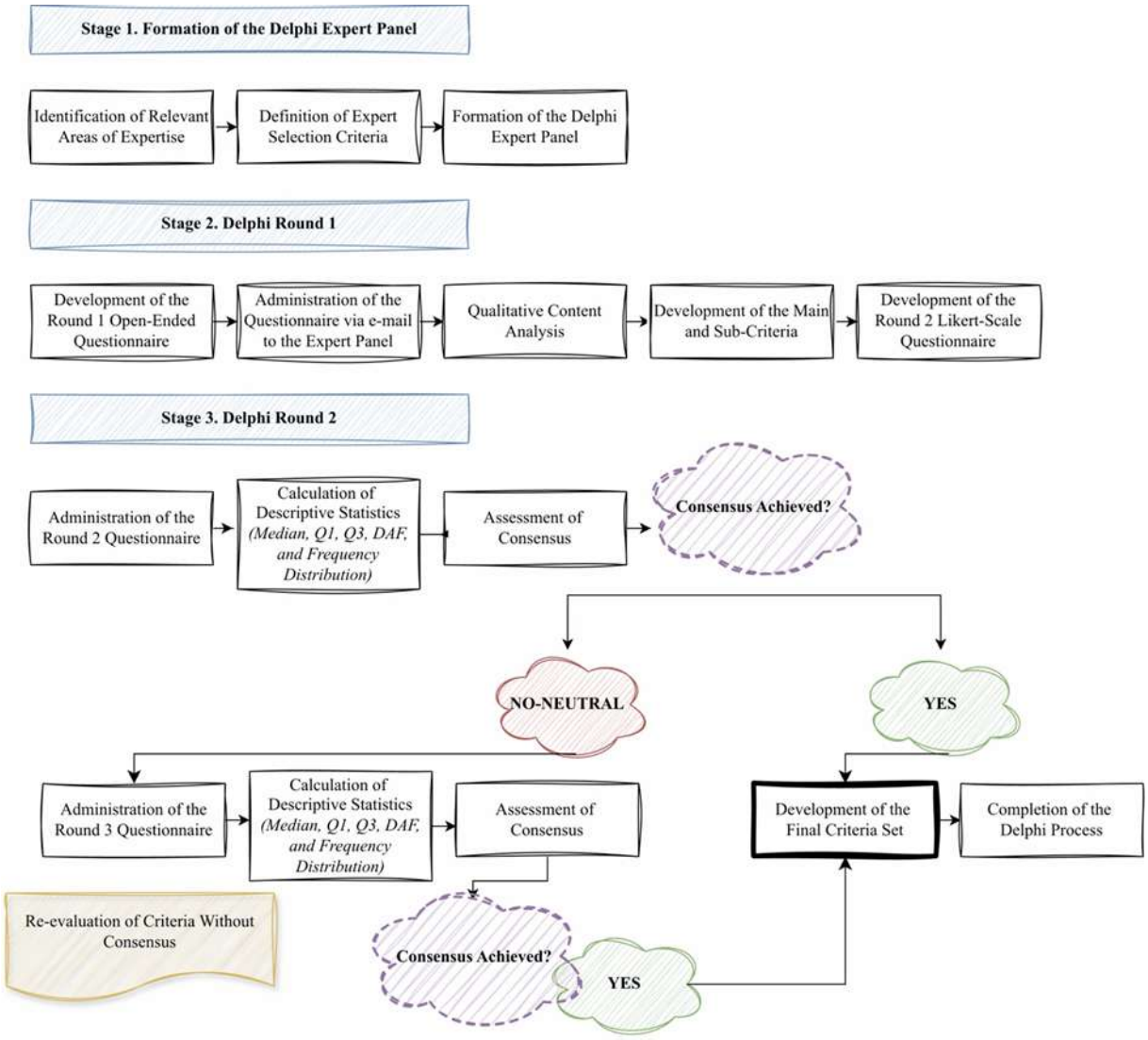


Figure 1. Workflow of the Delphi-based research design

2.2. Delphi process

The Delphi technique is an iterative research method used to systematically collect, organize, and synthesize expert opinions into a group consensus on complex or uncertain issues (Linstone, 1975). The method is particularly appropriate in situations where directly measurable data are limited, expertise from different disciplines is required, and the decision problem is multidimensional (Hsu and Sandford, 2007).

The fundamental characteristics of the Delphi technique include the establishment of an expert panel, independent and anonymous expression of expert opinions, implementation of multiple rounds of evaluation, provision of controlled feedback after each round, and statistical assessment of group consensus (Hasson et al., 2000). Anonymity minimizes the influence of dominant individuals on the group and reduces the conformity pressure that may arise from face-to-face interactions, whereas the iterative nature of the Delphi process enables experts to reconsider their previous judgments in light of the overall group responses (Rowe and Wright,

1999). In the present study, participant anonymity was strictly maintained throughout the Delphi process. The identities of the experts and their individual responses and ratings were not disclosed to other participants. Instead, only anonymized and aggregated statistical summaries of group responses were provided as feedback after each round. This approach prevented participants from being influenced by the opinions of specific panel members while allowing them to independently revise their judgments based on the overall group tendency.

The objective of Delphi applications is not to achieve complete agreement among all experts but to determine the degree of convergence and stability of expert opinions based on predefined consensus criteria. Therefore, the definition of consensus, statistical measures to be employed, acceptance and exclusion thresholds, and criteria for terminating the Delphi process should be clearly established before data collection begins. Evaluating consensus using predefined criteria is essential for ensuring methodological transparency and reproducibility of Delphi studies (Diamond et al., 2014).

The primary reason for employing the Delphi technique in this study was that identifying the evaluation criteria for cooling green space planning requires integrating knowledge and experience from experts representing different disciplines. Accordingly, rather than developing a list of evaluation criteria based solely on the literature or the researcher's judgment, this study aimed to develop a scientifically justified set of evaluation criteria by systematically evaluating interdisciplinary expert opinions through a structured consensus process.

2.3. Expert panel

The reliability and validity of the results obtained through the Delphi technique largely depend on the quality of the expert panel (Powell, 2003). Therefore, the selection of experts was based on the principle of including participants with disciplinary expertise directly relevant to the research topic, as well as substantial academic knowledge and professional experience in their field.

In this study, an expert panel was established by considering the interdisciplinary nature of cooling green space planning for mitigating the urban heat island effect. Accordingly, a Delphi expert panel comprising 14 experts from the disciplines of landscape architecture (n = 8), architecture (n = 3), urban and regional planning (n = 2), and geomatics engineering (n = 1) was formed. Thirteen experts were academics. By including experts from different disciplines, this study aimed to integrate expertise in ecology, spatial planning, urban design, and Geographic Information Systems (GIS). Although there is no universally accepted standard regarding the number of experts required for Delphi studies, the appropriate panel size is considered to depend on the scope of the study, accessibility of experts, and diversity of expertise relevant to the research topic. In particular, panels consisting of 10–15 participants are generally considered sufficient for homogeneous groups, whereas 10–30 participants are recommended for heterogeneous groups to obtain reliable results (Okoli and Pawlowski, 2004). Based on these considerations, the expert panel was considered to provide an adequate level of disciplinary diversity and expertise to achieve the objectives of this study. The disciplinary composition of the expert panel is shown in Table 1.

Thirteen experts participated in the first round. Fourteen experts participated in the second-round survey, which was developed based on the evaluation criteria identified in the first round. The same group of experts also participated in the third round. One of the experts

invited to participate in the first round was unable to provide feedback during the data collection period and therefore did not participate in the initial round but was included in the second and third rounds. Maintaining a high participation rate throughout the Delphi process is essential for ensuring the stability of expert opinions and enhancing the reliability of the consensus achieved (Diamond et al., 2014).

Table 1. Disciplinary composition of the expert panel

Area of Expertise	Academic Rank	Number of Experts (n)
Landscape Architecture	3 Professor, 1 Associate Professor, 2 Assistant Professor, 1 Research Assistant, 1 PhD	8
Architecture	Assistant Professor	3
Urban and Regional Planning	1 Assistant Professor, 1 PhDResearch Assistant	2
Geomatics Engineering	Assistant Professor	1
TOTAL		**14**

2.4. Data analysis and consensus criteria

In the first round of the Delphi process, the experts were asked to freely identify the evaluation criteria that should be considered in cooling green space planning to mitigate the urban heat island effect. The open-ended responses were treated as qualitative data and analyzed using content analysis software. During the analysis, statements with similar meanings were grouped, repetitive responses were merged, and the main and sub-evaluation criteria were established based on content similarities (Elo and Kyngäs, 2008). Content analysis is one of the most widely used and reliable methods for systematically classifying expert opinions and organizing them into meaningful themes in open-ended Delphi studies. The data obtained from the second and third rounds were statistically analyzed. As expert opinions were collected using a seven-point Likert scale, the ordinal nature of the data was considered, and the median was used as the measure of central tendency instead of the arithmetic mean. In Delphi studies, the median is regarded as one of the most widely used statistical measures because it is less affected by extreme values and provides a more accurate representation of the central tendency of expert opinions (Hasson et al., 2000).

To evaluate the level of consensus among the expert opinions, the median, Q1, Q3, standard deviation (SD), DAF, and frequency distributions were calculated for each evaluation criterion. The median was used to represent the central tendency of expert opinions, whereas Q1 and Q3 described the distribution of ratings. The standard deviation (SD) was calculated as a complementary measure of variability in expert opinions. The DAF was used to assess the dispersion of expert opinions and the level of consensus among them. In addition, frequency distributions were analyzed to determine the concentration of expert ratings within specific score ranges (von der Gracht, 2012).

In this study, the level of consensus was determined using predefined consensus criteria based on a combined evaluation of the median, DAF, and frequency distributions. Evaluation criteria with a median ≥ 5 and DAF ≤ 1.5 were considered to have achieved consensus. When the DAF ranged between 1.5 and 2.5, a criterion was considered to have reached consensus only if at least 70% of the expert ratings fell within the 5–7 score range. Similarly, evaluation criteria with a median of ≤ 3 and DAF of ≤ 1.5 were considered to not have achieved consensus. When the DAF was 2.5 or lower, at least 70% of the expert ratings were required to fall within the 1–3 score range for the criterion to be classified as lacking a consensus. Evaluation criteria with a median of 4 and DAF ≤ 2.5 were classified as neutral (Şahin, 2009). Following the third

Delphi round, evaluation criteria that did not satisfy any of the predefined consensus criteria were excluded. The consensus criteria adopted in this study are listed in Table 2.

Table 2. Compromise criteria

Compromise	Compromise Indicator
There is a compromise	If median ≥ 5 and DAF ≤ 1.5 If median ≥ 5 and DAF ≤ 2.5 and 5-7 frequency ≥ 70%
No compromise	If median ≤ 3 and DAF ≤ 1.5 If median ≤ 3 and DAF ≤ 2.5 and 1-3 frequency ≥ 70%
Neutral	If median = 4 and DAF ≤ 2.5

3. Results

3.1. Evaluation criteria identified in the first Delphi round

In the first round of the Delphi process, the experts were asked to answer the following question: *"Which evaluation criteria should be considered in cooling green space planning for mitigating the urban heat island effect?"* They were also invited to propose any evaluation criteria they considered relevant. Expert opinions obtained through open-ended questions were analyzed using content analysis. During the analysis, statements with similar meanings were merged, repetitive suggestions were eliminated, and the responses were classified into common themes.

Based on the content analysis, five main criteria and 19 sub-criteria were identified from the expert opinions. These evaluation criteria were grouped into five categories: *urban structure characteristics, green and blue infrastructure characteristics, natural and climatic characteristics, socio-demographic characteristics, and planning and accessibility characteristics of the area.* The resulting set of evaluation criteria served as the basis for developing the second-round Delphi questionnaire.

3.2. Consensus results of the second Delphi round

In the second Delphi round, the 19 evaluation criteria identified in the first round were evaluated by experts using a seven-point Likert scale. Expert ratings were analyzed according to predefined consensus criteria based on the median, Q1, Q3, DAF, and frequency distributions (Table 3).

The consensus analysis showed that 15 of the 19 evaluation criteria satisfied the predefined consensus criteria and were therefore considered to have achieved a consensus. In contrast, the four evaluation criteria coded C10, C11, C14, and C19 failed to satisfy the predefined consensus criteria based on the combined evaluation of the median, DAF, and frequency distributions. Accordingly, these criteria were identified as not having achieved consensus at the end of the second Delphi round. Consistent with the iterative nature of the Delphi technique, these criteria were subsequently re-evaluated by the expert panel in the third Delphi round.

Among the evaluation criteria that achieved consensus, the median values ranged from 5.0 to 6.5, and the expert ratings were predominantly concentrated within the 5–7 range. In particular, K3 and K13 received high-importance ratings from all experts (100%), indicating a strong consensus for these evaluation criteria. Similarly, for the remaining evaluation criteria

that achieved consensus, the proportion of ratings within the 5–7 score range varied between 71.43% and 92.86%, demonstrating a high degree of agreement among experts. In contrast, the evaluation criteria that failed to achieve consensus exhibited a broader distribution of ratings, with responses primarily concentrated in the 4 and 5–7 ranges. These findings indicate that expert ratings for these evaluation criteria had not yet converged sufficiently, necessitating their re-evaluation in the third Delphi round.

Table 3. Consensus analysis results for the evaluation criteria in the second Delphi round

Criteria	Q1	Median	Q3	DAF	1-3 (%)	4 (%)	5-7 (%)	Consensus
C1	6	6.5	7	1	0.00	7.14	92.86	**YES**
C2	5	5	6	1	7.14	14.29	78.57	**YES**
C3	6	6	7	1	0.00	0.00	100.00	**YES**
C4	5	6	7	2	0.00	14.29	85.71	**YES**
C5	5	6	6.75	1.75	0.00	14.29	85.71	**YES**
C6	6	6	7	1	7.14	7.14	85.71	**YES**
C7	5	6	6.75	1.75	7.14	0.00	92.86	**YES**
C8	5	6.5	7	2	0.00	14.29	85.71	**YES**
C9	5	6	7	2	7.14	7.14	85.71	**YES**
C10	4	4.5	6	2	14.29	35.71	50.00	**--**
C11	4	5	5.75	1.75	14.29	21.43	64.29	**--**
C12	6	6.5	7	1	14.29	7.14	78.57	**YES**
C13	5	6	6	1	0.00	0.00	100.00	**YES**
C14	4	4.5	5.75	1.75	21.43	21.43	57.14	**--**
C15	5	6	7	2	0.00	21.43	78.57	**YES**
C16	4.25	6	6.75	2.5	14.29	14.29	71.43	**YES**
C17	4.25	5	6	1.75	21.43	7.14	71.43	**YES**
C18	5	5.5	7	2	7.14	7.14	85.71	**YES**
C19	4	5.5	6	2	0.00	35.71	64.29	**--**

*(C1 Building Density, C2 Building Height, C3 Impervious Surface Ratio, C4 Land Use/Land Cover (LULC), C5 Albedo (Surface Reflectance), C6 Existing Green Space Size, C7 Green Space Connectivity, C8 Tree Canopy Cover, C9 Vegetation Quality / Evapotranspiration Capacity, C10 Proximity to water bodies, C11 Green Roof and Green Wall Potential, C12 Land Surface Temperature (LST), C13 Wind Potential / Ventilation Corridors, C14 Topography (slope, aspect, and elevation), C15 Population Density, C16 Sensitive Population Density, C17 Accessibility to Green Spaces, C18 Urban Vacant Land and Redevelopment Potential, C19 Maintenance and Sustainability Potential)

3.3. Consensus results of the third Delphi round

The four evaluation criteria coded as C10, C11, C14, and C19, which failed to satisfy the predefined consensus criteria in the second Delphi round, were re-evaluated in the third Delphi round after the corresponding questionnaire items were revised based on expert feedback. The expert ratings obtained in the third Delphi round were analyzed using the same approach adopted in the second round, based on the median, Q1, Q3, DAF, and frequency distributions (Table 4).

Consensus analysis showed that C11 and C19 satisfied the predefined consensus criteria in the third Delphi round. For C11, the median was 5.0, the DAF was 0.75, and 85.71% of the expert ratings were within the 5–7 score range, indicating a strong consensus among the experts. Similarly, C19 achieved a median of 5.5, a DAF of 1.75, and 71.43% of expert ratings within the 5–7 score range, thereby satisfying the predefined consensus criteria. In contrast, C10 and C14 did not satisfy the predefined consensus criteria after the third Delphi round. For both evaluation criteria, the expert ratings were distributed across a wider range of scores, with a concentration in the low and moderate score ranges, indicating that sufficient convergence had

not been achieved. Consequently, these criteria were excluded from the final set of evaluation criteria.

Table 4. Consensus analysis results for the evaluation criteria in the third Delphi round

Criteria	Q1	Median	Q3	DAF	1-3 (%)	4 (%)	5-7 (%)	Consensus
C10	3	4.5	6	3	35.71	14.29	50.00	--
C11	5	5	5.75	0.75	14.29	0.00	85.71	**YES**
C14	3	5	5.75	2.75	35.71	7.14	57.14	--
C19	4.25	5.5	6	1.75	0.00	28.57	71.43	**YES**

*(C10 Proximity to water bodies, C11 Green Roof and Green Wall Potential, C14 Topography (slope, aspect, and elevation), C19 Maintenance and Sustainability Potential)

Following the third Delphi round, consensus was achieved for two of the four evaluation criteria that had been re-evaluated, whereas the remaining two failed to satisfy the predefined consensus criteria. Accordingly, based on the results obtained from the second and third Delphi rounds, the final set of evaluation criteria, validated by expert consensus, was established.

3.4. Final set of evaluation criteria

Following the completion of the Delphi process, the evaluation criteria that satisfied the predefined consensus criteria in the second and third rounds were incorporated into the final set of evaluation criteria. Consequently, a scientifically validated and consensus-based final set of evaluation criteria was established through expert consensus.

The final set of evaluation criteria consisted of five main criteria and 17 subcriteria. The evaluation criteria were classified into five categories: urban structure characteristics, green and blue infrastructure characteristics, natural and climatic characteristics, socio-demographic characteristics, and planning and accessibility characteristics. Collectively, these represent the key evaluation criteria that should be considered in cooling green space planning for mitigating the UHI effect. The final set of evaluation criteria is listed in Table 5.

Table 5. Final set of evaluation criteria established through the Delphi process

Main Criteria	Final Sub-Criteria
Urban Structure Characteristics	Building Density (C1)
	Building Height (C2)
	Impervious Surface Ratio (C3)
	Land Use/Land Cover (LULC) (C4)
	Albedo (Surface Reflectance) (C5)
Green and Blue Infrastructure Characteristics	Existing Green Space Size (C6)
	Green Space Connectivity (C7)
	Tree Canopy Cover (C8)
	Vegetation Quality / Evapotranspiration Capacity (C9)
	Green Roof and Green Wall Potential (C11)
Natural and Climatic Characteristics	Land Surface Temperature (LST) (C12)
	Wind Potential / Ventilation Corridors (C13)
Socio-Demographic Characteristics	Population Density (C15)
	Sensitive Population Density (C16)
Planning and Accessibility Characteristics	Accessibility to Green Spaces (C17)
	Urban Vacant Land and Redevelopment Potential (C18)
	Maintenance and Sustainability Potential (C19)

The final set of evaluation criteria developed in this study provides a scientifically validated, consensus-based, and comprehensive set of evaluation criteria for cooling green space planning to mitigate the UHI effect. This final set of evaluation criteria is expected to serve as a valuable reference for future GIS-based spatial suitability analyses, multi-criteria decision-making (MCDM) applications, and urban planning studies focusing on climate change adaptation.

4. Discussion

In this study, the evaluation criteria for cooling green space planning aimed at mitigating the UHI effect were identified using the Delphi technique based on an interdisciplinary expert consensus. The final set of evaluation criteria obtained in this study is largely consistent with the key planning variables highlighted in recent systematic review studies. Recent reviews have emphasized the importance of jointly considering land surface temperature, vegetation characteristics, building density, proportion of impervious surfaces, and spatial characteristics of green spaces when evaluating the cooling performance of urban green spaces (Li et al., 2025). However, a substantial proportion of previous studies have incorporated these variables directly into spatial modeling, remote sensing, or statistical analyses while providing limited justification for their selection or explaining whether they were validated through expert consensus. Although there is broad agreement in the literature regarding the importance of these key variables, recent systematic reviews have demonstrated considerable variation in how they are selected, defined, and applied across studies. This suggests that a standardized methodology for establishing evaluation criteria has not yet been developed (Norouzi et al., 2024).

From a methodological perspective, this study differs from existing literature. Rather than developing a spatial suitability model or quantifying the cooling effect of green spaces, the primary objective was to identify the evaluation criteria that should be considered in future spatial planning studies through a systematic process of expert consensus. Consequently, instead of relying solely on researchers' judgment or literature-based selection, the final set of evaluation criteria was established through the collective evaluation of experts from different disciplines. This can be attributed to the ability of the Delphi technique to enhance the methodological rigor of decision-making processes by systematically synthesizing expert knowledge and facilitating the development of consensus-based judgment (Okoli and Pawlowski, 2004; Von der Gracht, 2012).

Although several evaluation criteria achieved consensus in the second Delphi round, others required re-evaluation in the third round. These findings highlight that cooling green space planning is a multidimensional problem that requires the integrated consideration of numerous factors, including climate, urban morphology, land use, and green infrastructure characteristics. Similarly, recent systematic reviews of climate-adaptive blue-green space planning emphasize that the effectiveness of planning interventions depends on the integrated evaluation of multiple environmental, spatial, and urban characteristics rather than a single planning parameter (Han et al., 2025).

5. Conclusion

In this study, the Delphi technique was employed to identify evaluation criteria for cooling green space planning aimed at mitigating the UHI effect. The Delphi process resulted in a final evaluation framework consisting of five main criteria and 17 sub-criteria established through expert consensus, providing a systematic and transparent basis for cooling green space planning. The findings of this study demonstrate that cooling green space planning cannot be based on a single factor; rather, it is a multidimensional planning process that requires the integrated consideration of built environment characteristics, green infrastructure components, climatic and environmental characteristics, and socio-spatial indicators. These findings highlight the importance of interdisciplinary expert consensus in supporting planning decisions aimed at mitigating the UHI effect.

The principal contribution of this study lies in the systematic identification and validation of evaluation criteria through a Delphi process based on expert consensus, rather than relying primarily on researchers' subjective judgments, as is common in the existing literature. The final set of evaluation criteria developed in this study is expected to provide a scientifically grounded basis for GIS-based spatial suitability analyses, multi-criteria decision-making (MCDM) applications, and urban planning studies focusing on climate change adaptation, thereby supporting evidence-based decision-making in the planning of cooling green spaces. Accordingly, the proposed evaluation framework has the potential to support transparent, evidence-based, and reproducible spatial planning and decision-making processes.

A limitation of this study is that the Delphi process was conducted with an expert panel representing specific disciplines. Future research should validate the proposed evaluation criteria using expert panels with broader disciplinary and geographical representations. In addition, the relative importance of the evaluation criteria can be determined using MCDM methods, and the resulting weights can be integrated into GIS-based spatial suitability analyses to support the planning of cooling green spaces. Such applications would further demonstrate the practical applicability of the proposed criteria for spatial decision-making processes.

Ethics Statement

This study was based on the anonymous and voluntary collection of expert opinions using the Delphi technique and did not involve biological samples, clinical interventions, or personal/health-related data. Participation was entirely voluntary, the data were used solely for scientific purposes, and the study was conducted in accordance with the principles of research and publication ethics.

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Author Contributions

This was a single-author study. The author was solely responsible for the conceptualization of the study, methodology, data collection, data analysis, interpretation of the findings and manuscript preparation.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding this study.

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