Neutrosophic Sets and Systems, Vol. 83, 2025

University of New Mexico

Using the TreeSoft Set and AROMAN Approach for Evaluating Environmental Design Quality in Urban Parks: An Integrated Methodology

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Abstract: Urban parks play a crucial role in enhancing the quality of life in cities by providing green spaces for recreation, social interaction, and environmental sustainability. However, evaluating the environmental design quality of these parks requires a structured and multi-criteria approach that considers aesthetic appeal, ecological balance, accessibility, safety, and user satisfaction. This study explores a comprehensive framework for assessing urban park design quality by incorporating environmental, functional, and social dimensions. By applying a Multi-Criteria Decision-Making (MCDM) approach, the research identifies key factors that influence park usability and sustainability. We use the TreeSoft Set to show the relationship between the criteria and sub-criteria. We have six main criteria and 30 sub-criteria. We use the MEREC method to compute the criteria weights and the AROMAN method to rank the alternatives.

Keywords: TreeSoft Set; Multi-criteria Decision-Making Approach; Environmental Design; Urban Parks.

1. Introduction

Urban parks have become essential components of modern cities, serving as green lungs that counteract the negative effects of urbanization. As cities expand and populations grow, the need for well-designed, functional, and sustainable parks has become increasingly evident. Urban parks not only provide a space for leisure and recreation but also contribute to environmental conservation and social well-being. The assessment of their design quality, therefore, requires a holistic evaluation framework that accounts for various environmental, functional, and user-centric criteria[1], [2]. The environmental quality of urban parks is influenced by multiple factors, including landscape aesthetics, ecological sustainability, and the integration of green infrastructure. Parks with diverse vegetation, water features, and sustainable landscaping contribute significantly to biodiversity, air purification, and temperature regulation. However, poor planning or maintenance can diminish their ecological benefits, leading to urban heat islands and reduced usability. Evaluating these aspects is crucial for ensuring that parks contribute positively to the urban ecosystem[3], [4]. Accessibility and inclusivity are also key considerations in park design. A well-planned park should cater to people of all ages and abilities, ensuring barrier-free access and facilities that accommodate diverse needs. Parks that incorporate universal design principles foster greater community engagement and social interaction. On the other hand, parks that lack proper pathways, seating, or safety measures may deter visitors and fail to serve their intended purpose. Therefore, accessibility assessments play a vital role in the overall evaluation of park quality.

The functionality and recreational value of parks depend on the availability of well-maintained facilities, such as playgrounds, fitness areas, walking trails, and gathering spaces. A park that offers a variety of recreational activities can attract a broader user base, encouraging physical activity and mental well-being. However, inadequate maintenance, poor facility placement, or lack of security can negatively impact user experience. Thus, understanding the balance between infrastructure and natural landscapes is critical in park design evaluation[5], [6]. Safety and security are essential elements that determine park usability. Effective lighting, surveillance, and emergency response measures can significantly enhance the perception of safety among park visitors. Conversely, poorly lit areas, lack of visibility, and insufficient security measures can lead to safety concerns, discouraging people from using the park, especially during evening hours. Evaluating safety protocols is, therefore, an integral part of assessing overall park quality[7]. Public perception and user satisfaction provide valuable insights into the success of urban park design. Conducting surveys, gathering visitor feedback, and analyzing user behavior help assess how well a park meets the needs of its community. A park that aligns with public preferences and encourages frequent visits is more likely to be considered successful. Therefore, integrating community feedback into evaluation methodologies can enhance the effectiveness of urban park design assessments[8], [9]. As cities continue to expand, the demand for high-quality, sustainable, and well-designed urban parks will only grow. This study emphasizes the need for a structured evaluation framework that combines environmental, social, and functional dimensions to assess urban park quality. By adopting an MCDM approach, decision-makers can identify strengths and weaknesses in park designs, leading to informed improvements that enhance both environmental sustainability and user experience[10], [11].

2. Literature Review

The evaluation of urban parks' design quality has become increasingly critical due to their multifaceted contributions to urban life, encompassing ecological, social, aesthetic, and recreational dimensions. A significant body of research has addressed these dimensions, yet often individually rather than holistically. For instance, Cohen et al. [6] developed a methodological framework that primarily emphasizes ecological sustainability, focusing on measurable ecological parameters such as biodiversity and vegetation diversity. However, their approach largely overlooked essential social dimensions, including accessibility, inclusivity, and overall user satisfaction.

Similarly, Jabben et al. [7] proposed a systematic framework for rating the environmental value of urban parks, highlighting ecological criteria such as air purification, temperature regulation, and habitat creation. While these aspects are crucial for assessing environmental quality, their model did not integrate user-centric considerations such as recreational facilities, safety, and community engagement. This limitation can lead to incomplete assessments, potentially neglecting critical areas of improvement that directly impact park users' daily experiences.

On the other hand, Gungor and Polat [3] investigated the relationship between landscape visual quality and environmental features, focusing predominantly on aesthetic aspects. Despite the valuable contributions made, their research did not sufficiently consider functional and social perspectives, such as user preferences, safety perceptions, and practical accessibility features, all essential factors influencing urban park usability.

Recent contributions by Halecki et al. [4] reviewed various methodologies employed in green space planning and emphasized integrating diverse evaluation criteria. However, their study lacked a structured methodological framework capable of comprehensively combining and comparing these criteria across various contexts. Such limitations indicate a significant research gap in existing literature.

Thus, this research aims to bridge these gaps by proposing an integrated and comprehensive evaluation framework employing the TreeSoft Set, MEREC, and AROMAN methods, which collectively address ecological, social, functional, and aesthetic criteria simultaneously. This integrated methodology ensures a holistic understanding of urban park quality, fostering more informed planning and management decisions.

3. Proposed Model

Let U as a universal set and $P(U)$ is a power set of U. Let a set of criteria such as $R_1, R_2, \dots R_n and\ n \geq 1\ for\ the\ first\ level$ and intersection of these criteria are non-empty set. Every criterion $A_i, 1 \leq 1 \leq n$, is formed by sub criteria:

$$\begin{gathered} R_1 = \{R_{11}, R_{12}, R_{13}, R_{14}, R_{15}\} \\ \vdots \\ R_n = \{R_{n1}, R_{n2}, R_{n3}, R_{n4}, R_{n5}\} \end{gathered} \tag{1}$$

Where R_{ij} are sub criteria and these criteria are formed as level in tree[12], [13]. The TSS can be formed as:

$$F: P\big(Tree(A)\big) \rightarrow P(H) \tag{2}$$

Then we applied the steps of the MEREC method to compute the criteria weights.

Build the decision matrix.

Normalize the decision matrix

$$y_{ij} = \frac{\min_i x_{ij}}{x_{ij}} \tag{2}$$

$$y_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \tag{3}$$

Obtain the overall performance.

$$P_i = \ln\left(1 + \left(\frac{1}{m}\sum_i \left|\ln\left(y_{ij}\right)\right|\right)\right) \tag{4}$$

Obtain the overall performance by removing each criterion

$$P_{ij}^{/} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} \left|\ln\left(P_{ij}\right)\right|\right)\right) \tag{5}$$

Obtain the removal effect of the criterion

$$H_i = \sum_i \left|P_{ij}^{/} - P_i\right| \tag{6}$$

Obtain the criteria weights

$$w_j = \frac{H_i}{\sum_i H_i} \tag{7}$$

Apply the steps of the AROMAN method to rank the alternatives.

Obtain linear normalization

$$L_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{8}$$

Obtain vector normalization

$$V_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{9}$$

Obtain normalization matrix

$$Z_{ij} = \frac{\beta L_{ij} + (1-\beta) V_{ij}}{2} \tag{10}$$

The score of β among 0 and 1.

Obtain the weighted normalized decision matrix.

$$D_{ij} = W_j Z_{ij} \tag{11}$$

Obtain increased positive criteria and decreased cost criteria.

$$Q_i = \sum_{j=1}^{n} \left(D_{ij}\right)^{max} \tag{12}$$

$$S_i = \sum_{j=1}^{n} \left(D_{ij}\right)^{min} \tag{13}$$

Obtain the R values of this method

$$G_i = Q_i^{\varphi} + S_i^{(1-\varphi)} \tag{14}$$

The value of φ among 0 and 1

Rank the alternatives

3.1 Data Collection and Expert Selection

The credibility and accuracy of our results rely significantly on the meticulous data collection process and careful selection of experts. Three distinguished urban planning and environmental design experts participated in this study, each with extensive experience (exceeding ten years) in fields such as urban sustainability, landscape architecture, and urban environmental assessments.

These experts independently assessed ten urban parks against six main criteria (each containing five sub-criteria, totaling 30 sub-criteria), using a structured and standardized rating scale from 0 (indicating poor performance) to 0.9 (indicating excellent performance). Their evaluations were rigorously reviewed, compiled, and averaged to establish an aggregate decision matrix.

Experts were selected based on their proven expertise, professional background, and extensive practical knowledge in urban environmental management. Their diverse yet complementary expertise ensured a balanced, thorough, and representative evaluation of the parks. Data consistency was thoroughly verified, thus significantly contributing to the reliability and robustness of subsequent analysis.

4. Results and Discussion

This section shows the results of the proposed approach to compute the criteria weights and ranking the alternatives. We use the TreeSoft Set to show the relationships between the criteria and sub criteria. This study uses six criteria with five sub-criteria in each main criterion. We divided criteria as a tree to obtain the criteria weights. We obtain the weights of the criteria in the main criteria and in the sub-criteria.

A. Aesthetic and Landscape Quality
    a. Exceptional
    b. Well-designed
    c. Moderately appealing
    d. Basic
    e. Poor
B. Ecological Sustainability
    a. Highly sustainable (native vegetation, water conservation, low carbon footprint)
    b. Sustainable (balanced ecosystem, limited resource consumption)
    c. Moderately sustainable (some green initiatives, moderate energy use)
    d. Low sustainability (few green elements, higher energy/resource use)

e. Unsustainable (high pollution, lack of green initiatives)

C. Accessibility and Inclusivity
   a. Highly accessible (universal design, barrier-free, diverse user-friendly)
   b. Accessible (most areas accessible, some specialized features)
   c. Moderately accessible (partial compliance with accessibility standards)
   d. Low accessibility (limited inclusivity features)
   e. Inaccessible (barriers prevent usage for many)
D. Recreational and Functional Facilities
   a. Excellent (diverse, high-quality facilities for all age groups)
   b. Well-equipped (variety of good quality facilities)
   c. Moderate (essential facilities, but limited diversity)
   d. Basic (minimal facilities, not well-maintained)
   e. Poor (lack of functional spaces and amenities)
E. Safety and Security Measures
   a. Highly safe (well-lit, monitored, secure, emergency measures in place)
   b. Safe (good lighting, some security measures)
   c. Moderately safe (few security features, some safety concerns)
   d. Low safety (poor lighting, limited monitoring)
   e. Unsafe (lack of security, high risks)
F. User Satisfaction and Community Engagement
   a. Very high (actively used, highly rated by visitors, well-integrated with community events)
   b. High (frequent usage, positive feedback)
   c. Moderate (average usage, mixed reviews)
   d. Low (infrequent visits, common complaints)
   e. Very low (unused, strongly negative feedback)

The alternatives are:

A. Central Greenway Park
B. Harmony Eco-Park
C. Sunrise Recreational Park
D. Urban Oasis Park
E. Lakeside Community Park
F. Eco-Heritage Park
G. Metropolitan Nature Reserve
H. Skyline Riverfront Park
I. Sustainable Innovation Park
J. Cultural Harmony Garden

We apply the MEREC method to the main criteria through the following steps: First, a decision matrix is constructed based on evaluations provided by three experts, who assigned scores ranging between 0 and 0.9. These evaluations are then combined into a unified decision matrix. Subsequently, we normalize the decision matrix using Equations (2) and (3), with the results presented in Table 1. Next, the overall performance is calculated according to Equation (4), as shown in Table 2. We then compute the overall performance after sequentially removing each criterion using Equation (5), illustrated in Table 3. Following this, the removal effect for each criterion is determined using Equation (6). Finally, the criteria weights are derived using Equation (7), and the results are displayed in Figure 1.

Table 1. The normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	72.55	16.07143	1	1	150.2222	39.78571
A_2	83.7	24.2619	185.3333	16.07143	1	1
A_3	61.5	24	1	1	173.6667	24
A_4	1.55	31.83333	51.55556	39.78571	136.4444	31.90476
A_5	1	37.2381	3.444444	24.2619	125.4444	34.52381
A_6	33.75	13.97619	62.66667	26.54762	87.44444	13.64286
A_7	83.7	5.5	125.1111	18.71429	50.33333	5.761905
A_8	67.05	10.78571	136.6667	13.71429	64	5.5
A_9	83.4	26.88095	124.2222	26.88095	4.666667	13.90476
A_{10}	83.7	1	2.222222	16.07143	185.6667	47.78571

Table 2. Overall performance.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	4.284276	2.777043	0	0	5.012116	3.683508
A_2	4.427239	3.188907	5.222156	2.777043	0	0
A_3	4.119037	3.178054	0	0	5.157138	3.178054
A_4	0.438255	3.460514	3.94266	3.683508	4.915918	3.462755
A_5	0	3.617332	1.236763	3.188907	4.831863	3.541649
A_6	3.51898	2.637355	4.13783	3.27894	4.471004	2.613216
A_7	4.427239	1.704748	4.829202	2.929287	3.918668	1.751268
A_8	4.205439	2.378223	4.917545	2.618438	4.158883	1.704748
A_9	4.423648	3.291418	4.822072	3.291418	1.540445	2.632231
A_{10}	4.427239	0	0.798508	2.777043	5.223953	3.866727

Table 3. the overall performance by removing each criterion.

	C_1	C_2	C_3	C_4	C_5	C_6
A_1	1.192265	1.279817	1.742931	1.423443	1.147074	1.228086
A_2	1.174839	1.248551	0.785357	1.27191	1.416598	1.416598
A_3	1.194725	1.250144	1.6649	1.417419	1.129797	1.250144
A_4	1.58782	1.455965	1.312514	1.445511	1.385679	1.45586

A_5	1.454724	1.269715	1.202257	1.293499	1.19904	1.273958
A_6	1.487873	1.526924	1.592624	1.498658	1.443918	1.527972
A_7	1.392931	1.519761	1.44955	1.464695	1.417878	1.517724
A_8	1.424449	1.508736	1.450431	1.498052	1.426687	1.538093
A_9	1.414764	1.468327	1.600088	1.468327	1.545893	1.498238
A_{10}	1.262217	1.485844	1.795749	1.351518	1.21607	1.293452

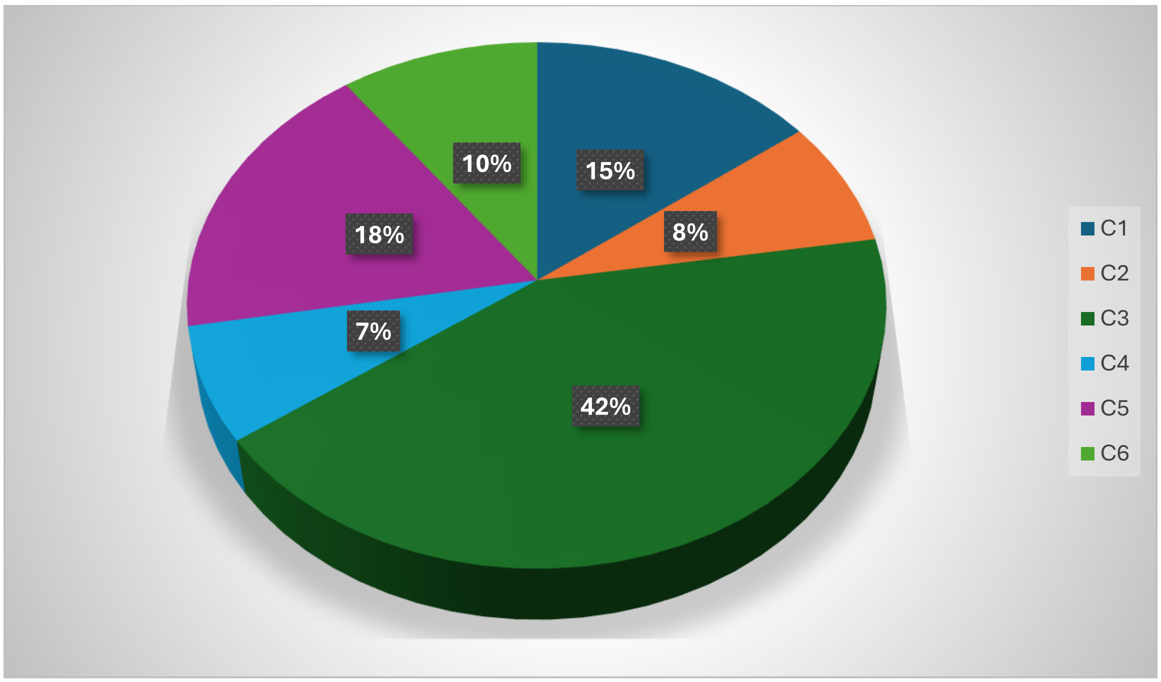

Figure 1. The weights of the main criteria.

The wights of first sub-criteria.

The decision matrix is normalized using Equations (2) and (3), with the resulting values presented in Table 4. Next, the overall performance is calculated using Equation (4), as displayed in Table 5. Subsequently, we determine the overall performance after individually removing each criterion by applying Equation (5), as illustrated in Table 6. The removal effect for each criterion is then calculated using Equation (6). Finally, criteria weights are obtained using Equation (7), and these weights are shown in Figure 2.

Table 4. The normalized decision matrix.

	$C_{1\text{-}1}$	$C_{1\text{-}2}$	$C_{1\text{-}3}$	$C_{\text{-}1\text{-}4}$	$C_{1\text{-}5}$
A_1	223	16.07143	1	1.354839	150.2222
A_2	1	39.85714	197.8889	36.09677	1
A_3	223	16.07143	75	1	173.6667
A_4	112	31.92857	149	61.09677	136.4444
A_5	186.3333	31.92857	112	32.51613	125.4444
A_6	75	34.61905	173.7778	57.54839	87.44444

A_7	186	18.7381	161.2222	28.93548	50.33333
A_8	149	10.78571	161.4444	36.51613	64
A_9	185.3333	26.88095	124.2222	36.41935	4.666667
A_{10}	186	1	2.222222	21.77419	185.6667

Table 5. Overall performance.

	C_{1-1}	C_{1-2}	C_{1-3}	C_{-1-4}	C_{1-5}
A_1	5.407172	2.777043	0	0.303682	5.012116
A_2	0	3.685302	5.287706	3.586204	0
A_3	5.407172	2.777043	4.317488	0	5.157138
A_4	4.718499	3.463501	5.003946	4.112459	4.915918
A_5	5.227537	3.463501	4.718499	3.481736	4.831863
A_6	4.317488	3.544404	5.157777	4.052626	4.471004
A_7	5.225747	2.930559	5.082784	3.365069	3.918668
A_8	5.003946	2.378223	5.084161	3.597754	4.158883
A_9	5.222156	3.291418	4.822072	3.5951	1.540445
A_{10}	5.225747	0	0.798508	3.080725	5.223953

Table 6. the overall performance by removing each criterion.

	C_{1-1}	C_{1-2}	C_{1-3}	C_{-1-4}	C_{1-5}
A_1	1.106319	2.060674	1.475907	1.458402	1.138466
A_2	1.420648	1.168908	1.035984	1.176576	1.420648
A_3	1.401901	2.202848	1.4668	1.689119	1.417169
A_4	1.681564	2.205858	1.668196	1.709368	1.672338
A_5	1.633916	2.236952	1.658449	1.715661	1.653037
A_6	1.668924	2.095374	1.628531	1.681325	1.661665
A_7	1.573659	2.107963	1.581041	1.665712	1.639199
A_8	1.569606	2.125034	1.565424	1.64022	1.612637
A_9	1.461462	1.632256	1.484392	1.551602	1.654925
A_{10}	1.186561	2.174135	1.477644	1.338168	1.186698

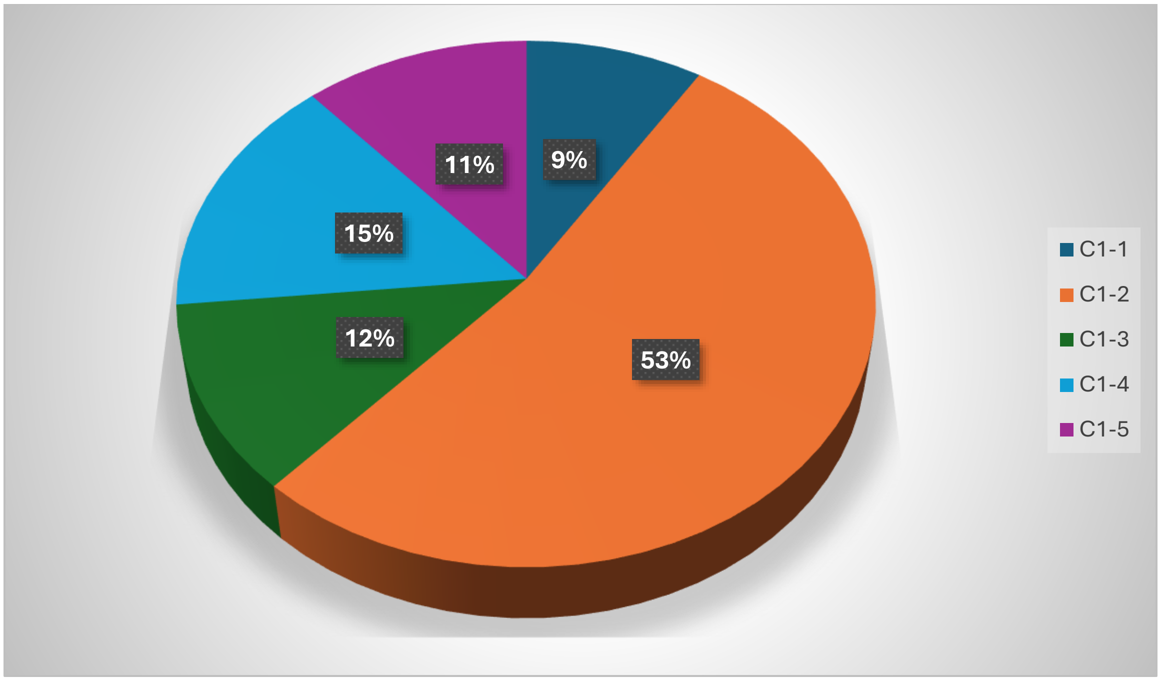

Figure 2. The weights first sub-criteria.

The wights of second sub-criteria.

The decision matrix is then normalized using Equations (2) and (3), with the results shown in Table 7. Subsequently, the overall performance is calculated using Equation (4), as presented in Table 8. The overall performance after individually removing each criterion is also computed using Equation (5), with the results provided in Table 9. Next, the removal effect for each criterion is determined by applying Equation (6). Finally, the criteria weights are obtained using Equation (7), and the outcomes are depicted in Figure 3.

Table 7. The normalized decision matrix.

	C_{2-1}	C_{2-2}	C_{2-3}	C_{2-4}	C_{2-5}
A_1	1.438735	16.07143	1	1	16.59524
A_2	1.833992	1	125.1111	11.04762	5.761905
A_3	1	16.07143	28.11111	6.02381	6.02381
A_4	4.450593	1	51.55556	18.92857	18.92857
A_5	7.486166	39.71429	64.88889	29.5	29.5
A_6	4.422925	47.78571	197.8889	42.40476	34.52381
A_7	6.616601	5.5	210.4444	29.28571	21.35714
A_8	5.300395	10.78571	136.6667	13.71429	13.71429
A_9	6.592885	26.88095	124.2222	26.88095	1
A_{10}	6.616601	1	2.222222	16.07143	39.78571

Table 8. Overall performance.

	C_{2-1}	C_{2-2}	C_{2-3}	C_{2-4}	C_{2-5}
A_1	0.363764	2.777043	0	0	2.809116
A_2	0.606495	0	4.829202	2.402215	1.751268
A_3	0	2.777043	3.336165	1.79572	1.79572
A_4	1.493037	0	3.94266	2.940672	2.940672
A_5	2.013057	3.681711	4.172676	3.38439	3.38439
A_6	1.486801	3.866727	5.287706	3.747261	3.541649
A_7	1.889582	1.704748	5.349222	3.3771	3.061386
A_8	1.667781	2.378223	4.917545	2.618438	2.618438
A_9	1.885991	3.291418	4.822072	3.291418	0
A_{10}	1.889582	0	0.798508	2.777043	3.683508

Table 9. the overall performance by removing each criterion.

	C_{2-1}	C_{2-2}	C_{2-3}	C_{2-4}	C_{2-5}
A_1	0.874026	0.227505	0.91127	0.91127	0.579531
A_2	1.177322	1.122781	0.783899	1.028455	1.085013
A_3	1.231441	0.825478	0.952476	1.090994	1.090994
A_4	1.240112	1.339849	1.045069	1.129495	1.129495
A_5	1.538112	1.524427	1.414854	1.461624	1.461624
A_6	1.631363	1.520645	1.425662	1.514186	1.525431
A_7	1.475475	1.532074	1.255104	1.386603	1.406137
A_8	1.419042	1.380211	1.200182	1.359821	1.359821
A_9	1.348392	1.108025	1.136937	1.252726	1.463886
A_{10}	1.034879	1.290323	1.127372	0.952777	0.86132

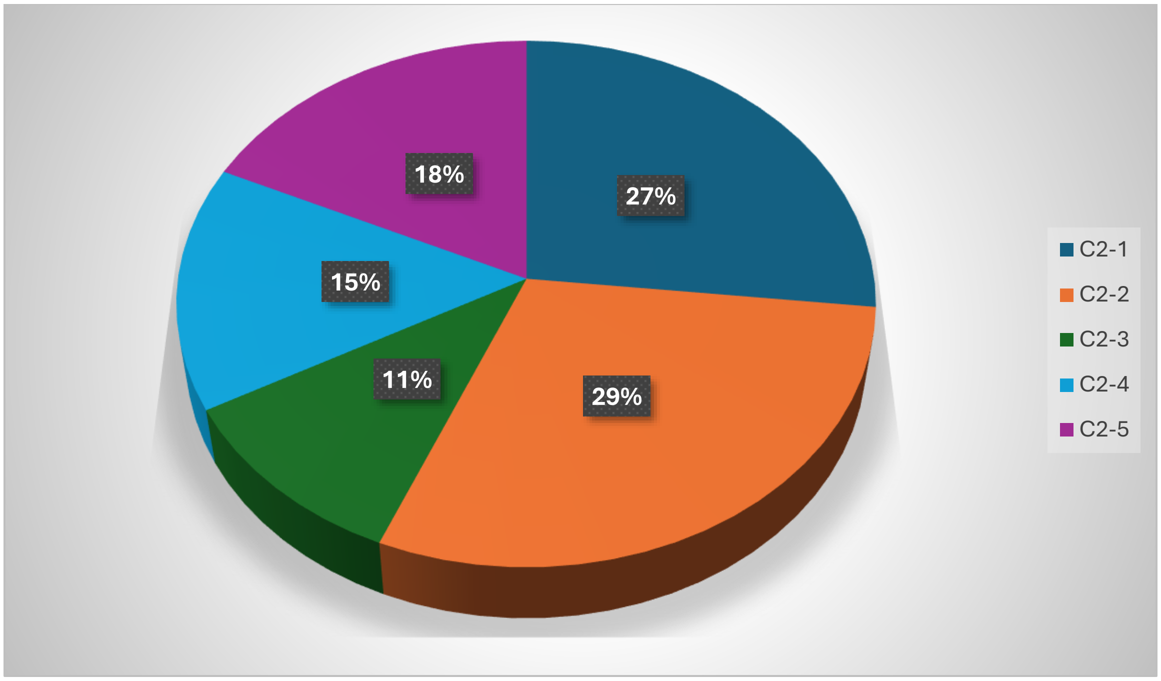

Figure 3. The weights second sub-criteria.

The wights of third sub-criteria.

The decision matrix is normalized using Equations (2) and (3), and the results are presented in Table 10. Subsequently, the overall performance is calculated using Equation (4), as displayed in Table 11. Following this, the overall performance after individually removing each criterion is computed using Equation (5), with the outcomes illustrated in Table 12. Next, the removal effect for each criterion is determined by employing Equation (6). Finally, criteria weights are derived using Equation (7), as depicted in Figure 4.

Table 10. The normalized decision matrix.

	C_{3-1}	C_{3-2}	C_{3-3}	C_{3-4}	C_{3-5}
A_1	2.317037	75	1	1	223
A_2	1.986667	223	185.3333	16.07143	1
A_3	1	1	223	16.59524	223
A_4	2.48	223	1	31.92857	149
A_5	1.823704	112	223	16.07143	124.5556
A_6	2.484444	186.3333	112	39.85714	198.5556
A_7	2.484444	186.3333	186.3333	29.30952	87.33333
A_8	1.986667	50.33333	186.3333	39.92857	124.5556
A_9	2.471111	125.4444	124.2222	39.85714	65.22222
A_{10}	2.48	4.666667	2.222222	16.07143	185.6667

Table 11. Overall performance.

	C_{3-1}	C_{3-2}	C_{3-3}	C_{3-4}	C_{3-5}
A_1	0.840289	4.317488	0	0	5.407172
A_2	0.686458	5.407172	5.222156	2.777043	0
A_3	0	0	5.407172	2.809116	5.407172
A_4	0.908259	5.407172	0	3.463501	5.003946
A_5	0.600869	4.718499	5.407172	2.777043	4.824752
A_6	0.910049	5.227537	4.718499	3.685302	5.291069
A_7	0.910049	5.227537	5.227537	3.377913	4.469732
A_8	0.686458	3.918668	5.227537	3.687092	4.824752
A_9	0.904668	4.831863	4.822072	3.685302	4.1778
A_{10}	0.908259	1.540445	0.798508	2.777043	5.223953

Table 12. the overall performance by removing each criterion.

	C_{3-1}	C_{3-2}	C_{3-3}	C_{3-4}	C_{3-5}
A_1	1.2329	0.758887	1.292324	1.292324	0.828309
A_2	1.470542	1.098546	1.168657	1.34259	1.509221
A_3	1.482937	1.116476	1.116476	1.309302	1.116476
A_4	1.497087	1.09931	1.546651	1.342824	1.236846
A_5	1.692283	1.327291	1.442271	1.586747	1.476111
A_6	1.745821	1.459715	1.564124	1.616769	1.533711
A_7	1.718414	1.427504	1.503257	1.601146	1.544528
A_8	1.689083	1.400359	1.453776	1.539949	1.477035
A_9	1.682551	1.404066	1.481584	1.544174	1.517537
A_{10}	1.276755	1.12495	1.284379	1.137125	0.918713

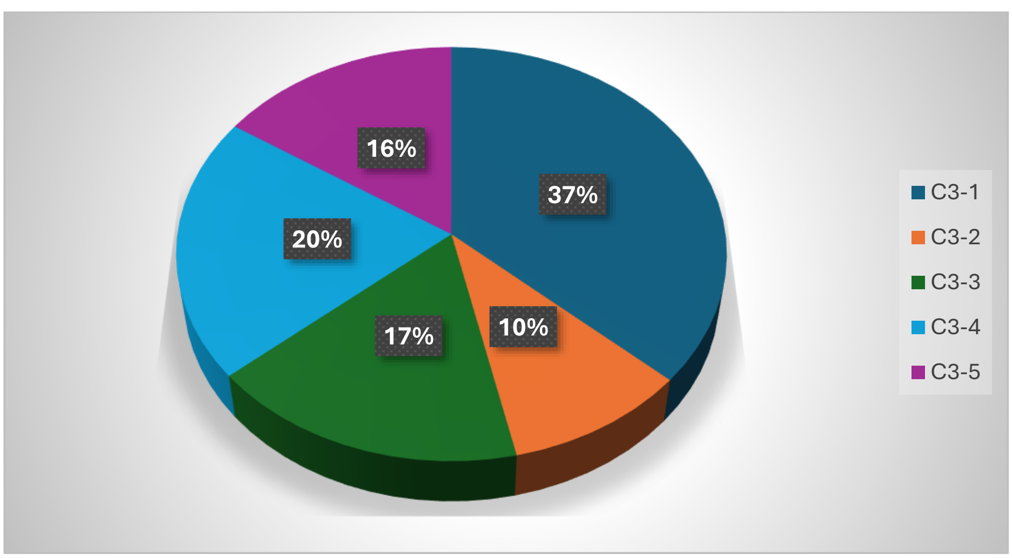

Figure 4. The weights of third sub-criteria.

The wights of fourth sub-criteria.

The decision matrix is normalized using Equations (2) and (3), with the resulting values presented in Table 13. Subsequently, the overall performance is calculated using Equation (4), as illustrated in Table 14. The overall performance after removing each criterion individually is then computed using Equation (5), with the results displayed in Table 15. Following this, the removal effect for each criterion is determined using Equation (6). Finally, the criteria weights are obtained using Equation (7), as shown in Figure 5.

Table 13. The normalized decision matrix.

	C_{4-1}	C_{4-2}	C_{4-3}	C_{4-4}	C_{4-5}
A_1	72.55	16.07143	1	1	150.2222
A_2	83.7	24.2619	185.3333	16.07143	1
A_3	61.5	24	1	1	173.6667
A_4	1.55	31.83333	51.55556	39.78571	136.4444
A_5	1	37.2381	3.444444	24.2619	125.4444
A_6	33.75	13.97619	62.66667	26.54762	87.44444
A_7	83.7	5.5	125.1111	18.71429	50.33333
A_8	67.05	10.78571	136.6667	13.71429	64
A_9	83.4	26.88095	124.2222	26.88095	4.666667
A_{10}	83.7	1	2.222222	16.07143	185.6667

Table 14. Overall performance.

	C_{4-1}	C_{4-2}	C_{4-3}	C_{4-4}	C_{4-5}
A_1	4.284276	2.777043	0	0	5.012116
A_2	4.427239	3.188907	5.222156	2.777043	0
A_3	4.119037	3.178054	0	0	5.157138
A_4	0.438255	3.460514	3.94266	3.683508	4.915918
A_5	0	3.617332	1.236763	3.188907	4.831863
A_6	3.51898	2.637355	4.13783	3.27894	4.471004
A_7	4.427239	1.704748	4.829202	2.929287	3.918668
A_8	4.205439	2.378223	4.917545	2.618438	4.158883
A_9	4.423648	3.291418	4.822072	3.291418	1.540445
A_{10}	4.427239	0	0.798508	2.777043	5.223953

Table 15. the overall performance by removing each criterion.

	C_{4-1}	C_{4-2}	C_{4-3}	C_{4-4}	C_{4-5}
A_1	1.080886	1.851336	1.390874	1.390874	1.01716
A_2	1.334218	1.098546	1.280461	1.437362	1.590018
A_3	1.126162	1.842232	1.414288	1.414288	1.038251
A_4	1.609568	1.236967	1.416957	1.432542	1.356153
A_5	1.439531	0.744989	1.363416	1.230076	1.102189

A_6	1.532834	1.915088	1.498857	1.545708	1.480075
A_7	1.469135	1.984697	1.445738	1.551801	1.497974
A_8	1.50813	1.981895	1.467931	1.592296	1.510702
A_9	1.443699	1.554341	1.419906	1.508378	1.600829
A_{10}	1.163112	2.038074	1.412707	1.284379	1.098845

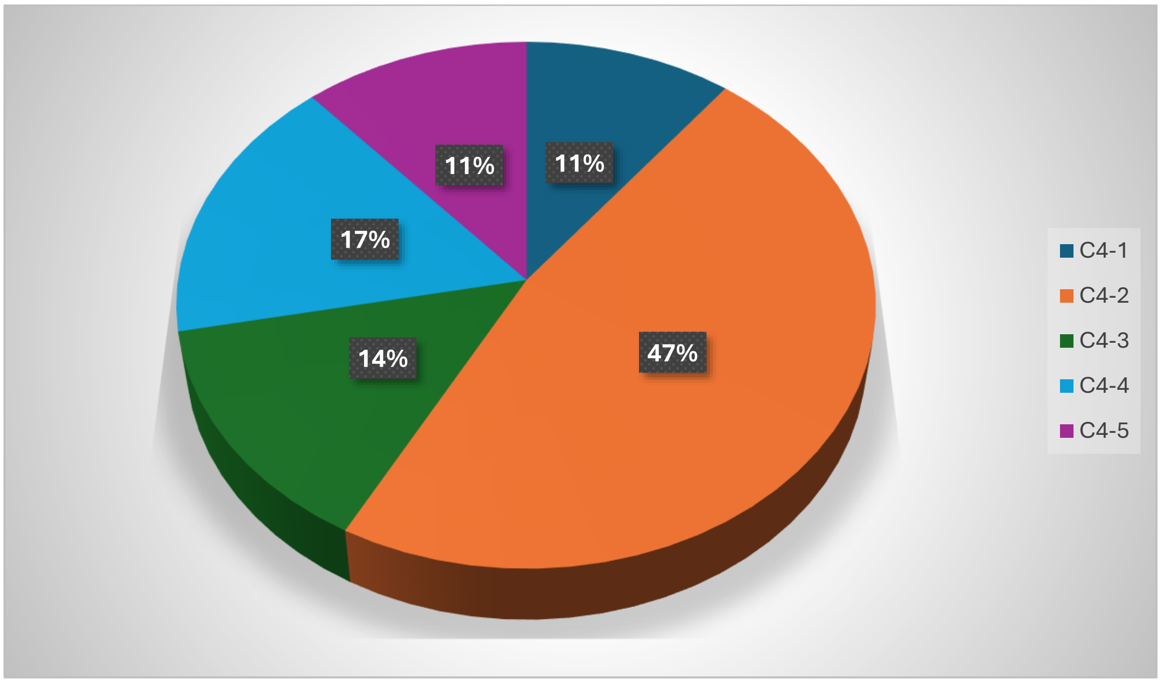

Figure 5. The weights of fourth sub-criteria.

The wights of fifth sub-criteria.

The decision matrix is normalized using Equations (2) and (3), with the outcomes presented in Table 16. Subsequently, the overall performance is calculated using Equation (4), as shown in Table 17. Then, the overall performance after individually removing each criterion is computed by applying Equation (5), with the results provided in Table 18. Next, the removal effect for each criterion is calculated using Equation (6). Finally, the weights of the criteria are determined using Equation (7), as illustrated in Figure 6.

Table 16. The normalized decision matrix.

	C_{5-1}	C_{5-2}	C_{5-3}	C_{5-4}	C_{5-5}
A_1	1	16.07143	1	1	67.6
A_2	4.582418	16.59524	125.1111	23.95238	1
A_3	4.293956	26.80952	64.88889	16.59524	39.75
A_4	3.093407	45.09524	197.8889	26.80952	89.05
A_5	3.373626	42.40476	210.4444	37.16667	61.95
A_6	3.074176	29.2381	160.8889	42.40476	72.4

A_7	4.590659	8.142857	136.4444	26.59524	50.4
A_8	3.684066	10.78571	136.6667	8.404762	28.65
A_9	4.582418	26.88095	124.2222	26.88095	18.2
A_{10}	4.598901	1	2.222222	16.07143	83.55

Table 17. Overall performance.

	C_{5-1}	C_{5-2}	C_{5-3}	C_{5-4}	C_{5-5}
A_1	0	2.777043	0	0	4.213608
A_2	1.522227	2.809116	4.829202	3.176068	0
A_3	1.457208	3.288757	4.172676	2.809116	3.68261
A_4	1.129273	3.808777	5.287706	3.288757	4.489198
A_5	1.215988	3.747261	5.349222	3.615412	4.126328
A_6	1.123037	3.375472	5.080714	3.747261	4.282206
A_7	1.524024	2.097141	4.915918	3.280732	3.919991
A_8	1.304017	2.378223	4.917545	2.128798	3.355153
A_9	1.522227	3.291418	4.822072	3.291418	2.901422
A_{10}	1.525817	0	0.798508	2.777043	4.425445

Table 18. the overall performance by removing each criterion.

	C_{5-1}	C_{5-2}	C_{5-3}	C_{5-4}	C_{5-5}
A_1	1.010751	0	1.010751	1.010751	0.527247
A_2	1.309304	1.099051	1.056697	1.190929	1.407114
A_3	1.501472	1.407819	1.337478	1.423184	1.369133
A_4	1.652231	1.484214	1.430072	1.543028	1.476735
A_5	1.650495	1.503088	1.429413	1.528163	1.500063
A_6	1.63343	1.483707	1.41876	1.496349	1.465942
A_7	1.515884	1.513522	1.309811	1.414461	1.374842
A_8	1.433877	1.34947	1.191358	1.383474	1.303496
A_9	1.520953	1.418889	1.322188	1.419314	1.442624
A_{10}	1.098695	1.275919	1.157534	0.98859	0.82213

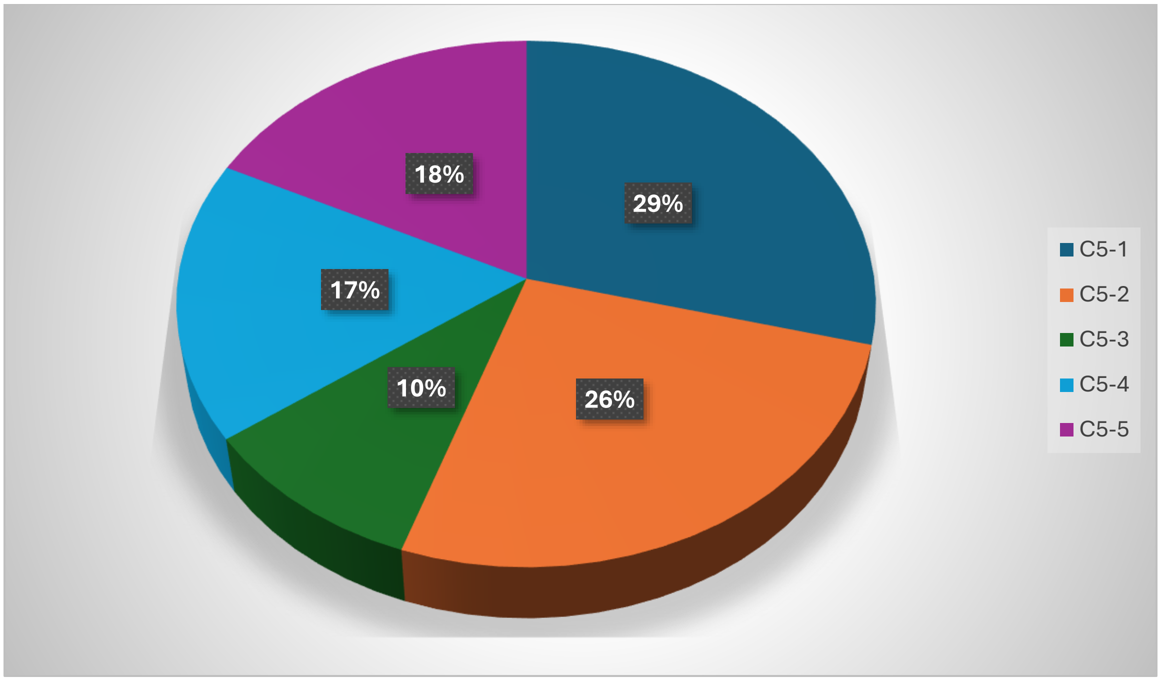

Figure 6. The weights of the fifth sub-criteria.

The wights of sixth sub-criteria.

The decision matrix is normalized using Equations (2) and (3), with the resulting values presented in Table 19. Next, the overall performance is computed using Equation (4), as illustrated in Table 20. Subsequently, the overall performance after individually removing each criterion is calculated using Equation (5), with results provided in Table 21. Following this, the removal effect of each criterion is determined using Equation (6). Finally, the criteria weights are obtained using Equation (7), as depicted in Figure 7.

Table 19. The normalized decision matrix.

	C_{6-1}	C_{6-2}	C_{6-3}	C_{6-4}	C_{6-5}
A_1	1.442346	16.07143	1	1	11.04762
A_2	1	24.2619	148.5556	16.07143	31.92857
A_3	1.553678	29.28571	99.66667	21.61905	37.21429
A_4	1.99503	34.52381	173.6667	37.21429	31.83333
A_5	1.770378	47.78571	210.4444	45.09524	47.78571
A_6	1.882704	42.47619	210.4444	45.09524	34.59524
A_7	1.77336	34.52381	197.8889	37.16667	18.66667
A_8	1.333002	21.35714	186	29.57143	16.33333
A_9	1.658052	26.88095	124.2222	26.88095	1
A_{10}	1.664016	1	2.222222	16.07143	39.78571

Table 20. Overall performance.

	C_{6-1}	C_{6-2}	C_{6-3}	C_{6-4}	C_{6-5}
A_1	0.366271	2.777043	0	0	2.402215
A_2	0	3.188907	5.000959	2.777043	3.463501
A_3	0.440625	3.3771	4.601831	3.073575	3.616693
A_4	0.690659	3.541649	5.157138	3.616693	3.460514
A_5	0.571193	3.866727	5.349222	3.808777	3.866727
A_6	0.632709	3.748944	5.349222	3.808777	3.543716
A_7	0.572876	3.541649	5.287706	3.615412	2.926739
A_8	0.287434	3.061386	5.225747	3.386809	2.793208
A_9	0.505643	3.291418	4.822072	3.291418	0
A_{10}	0.509234	0	0.798508	2.777043	3.683508

Table 21. the overall performance by removing each criterion.

	C_{6-1}	C_{6-2}	C_{6-3}	C_{6-4}	C_{6-5}
A_1	0.830652	0.198822	0.869779	0.869779	0.579882
A_2	1.527708	1.079939	1.211156	1.364392	1.319547
A_3	1.540581	1.199137	1.288405	1.388557	1.354102
A_4	1.598174	1.332621	1.34218	1.438054	1.44728
A_5	1.653046	1.345905	1.393358	1.484661	1.481373
A_6	1.631721	1.348082	1.369539	1.462942	1.47817
A_7	1.577509	1.293341	1.298602	1.406646	1.447956
A_8	1.529699	1.21011	1.218529	1.345978	1.383877
A_9	1.348392	1.108025	1.019612	1.14892	1.380688
A_{10}	1.034879	0.85986	1.00885	0.809957	0.703689

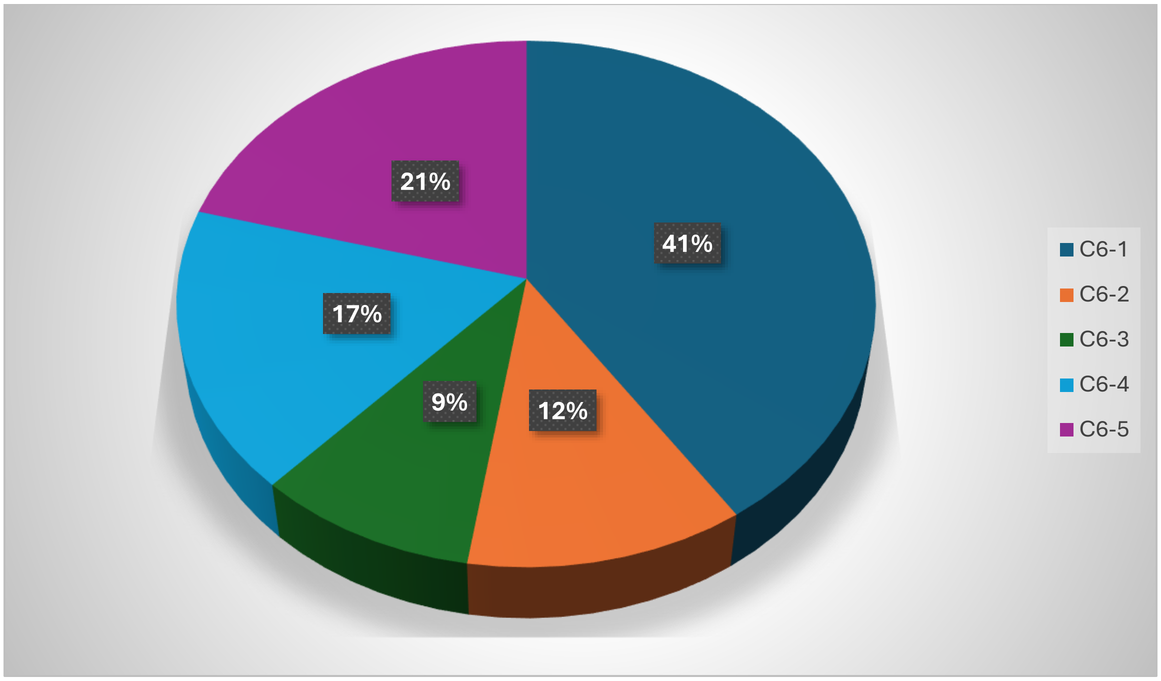

Figure 7. The weights sixth sub-criteria.

We then apply the AROMAN approach to the identified sub-criteria, which consists of 30 sub-criteria across seven alternatives. First, linear normalization is calculated using Equation (8), with results presented in Table 22. Next, vector normalization is computed using Equation (9), as shown in Table 23. Following this, we determine the normalization matrix by applying Equation (10), the results of which are provided in Table 24. Subsequently, we calculate the weighted normalized decision matrix using Equation (11). Afterward, the positive (benefit) criteria and negative (cost) criteria are determined using Equations (12) and (13), respectively. Finally, the R values for the method are computed using Equation (14), and the alternatives are ranked accordingly, as illustrated in Figure 8.

Table 22. The linear normalization.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	0.865175	1	0.73156	0.006651	0	0.39601	1	0.79867	0.996372	1
C_2	0.4159	0.641919	0.634691	0.850854	1	0.358081	0.124179	0.270039	0.714192	0
C_3	0	1	0	0.274262	0.013261	0.334539	0.673297	0.735986	0.668475	0.006631
C_4	0	0.388582	0	1	0.599754	0.658686	0.456722	0.327808	0.667281	0.388582
C_5	0.808063	0	0.935018	0.733454	0.673887	0.468111	0.267148	0.341155	0.019856	1
C_6	0.829008	0	0.491603	0.66056	0.716539	0.270229	0.101781	0.096183	0.275827	1
C_7	1	0	1	0.5	0.834835	0.333333	0.833333	0.666667	0.83033	0.833333
C_8	0.387868	1	0.387868	0.795956	0.795956	0.865196	0.456495	0.251838	0.666054	0
C_9	0	1	0.375847	0.751693	0.56377	0.87754	0.81377	0.814898	0.625847	0.006208
C_{10}	0.005904	0.584004	0	1	0.524423	0.940955	0.464842	0.590982	0.589372	0.345679
C_{11}	0.808063	0	0.935018	0.733454	0.673887	0.468111	0.267148	0.341155	0.019856	1
C_{12}	0.067642	0.12858	0	0.531993	1	0.527727	0.865935	0.66301	0.862279	0.865935

C_{13}	0.322137	0	0.322137	0	0.827481	1	0.096183	0.20916	0.553181	0
C_{14}	0	0.592573	0.129443	0.241379	0.30504	0.940053	1	0.647745	0.588329	0.005836
C_{15}	0	0.242668	0.121334	0.433007	0.688327	1	0.683151	0.307073	0.625072	0.364002
C_{16}	0.402087	0.122775	0.129527	0.462247	0.734807	0.864334	0.524862	0.327808	0	1
C_{17}	0.887226	0.664671	0	0.997006	0.55489	1	1	0.664671	0.991018	0.997006
C_{18}	0.333333	1	0	1	0.5	0.834835	0.834835	0.222222	0.560561	0.016517
C_{19}	0	0.83033	1	0	1	0.5	0.834835	0.834835	0.555055	0.005506
C_{20}	0	0.387156	0.400612	0.794495	0.387156	0.998165	0.727217	1	0.998165	0.387156
C_{21}	1	0	1	0.666667	0.556557	0.88989	0.388889	0.556557	0.289289	0.831832
C_{22}	0.865175	1	0.73156	0.006651	0	0.39601	1	0.79867	0.996372	1
C_{23}	0.4159	0.641919	0.634691	0.850854	1	0.358081	0.124179	0.270039	0.714192	0
C_{24}	0	1	0	0.274262	0.013261	0.334539	0.673297	0.735986	0.668475	0.006631
C_{25}	0	0.388582	0	1	0.599754	0.658686	0.456722	0.327808	0.667281	0.388582
C_{26}	0.808063	0	0.935018	0.733454	0.673887	0.468111	0.267148	0.341155	0.019856	1
C_{27}	0	0.99542	0.915267	0.581679	0.659542	0.576336	0.99771	0.745802	0.99542	1
C_{28}	0.341793	0.353672	0.585313	1	0.938985	0.640389	0.161987	0.221922	0.586933	0
C_{29}	0	0.592573	0.30504	0.940053	1	0.763395	0.646684	0.647745	0.588329	0.005836
C_{30}	0	0.554342	0.376653	0.623347	0.873491	1	0.618171	0.178838	0.625072	0.364002

Table 23. The vector normalization.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	0.351273	0.405259	0.297771	0.007505	0.004842	0.163411	0.405259	0.324643	0.403806	0.405259
C_2	0.229862	0.347007	0.343261	0.455298	0.5326	0.199895	0.078664	0.154263	0.384466	0.014303
C_3	0.00332	0.615342	0.00332	0.171174	0.011436	0.208065	0.415392	0.453759	0.412441	0.007378
C_4	0.014656	0.235536	0.014656	0.583083	0.355572	0.389071	0.274269	0.200991	0.393956	0.235536
C_5	0.40757	0.002713	0.471178	0.37019	0.340345	0.237247	0.13656	0.173639	0.012661	0.503735
C_6	0.472299	0.011871	0.284906	0.378744	0.409835	0.161955	0.0684	0.065291	0.165064	0.567268
C_7	0.422875	0.001896	0.422875	0.212386	0.353344	0.142223	0.352712	0.282549	0.351448	0.352712
C_8	0.198829	0.493096	0.198829	0.395007	0.395007	0.428292	0.23182	0.133436	0.33256	0.012372
C_9	0.002375	0.470069	0.178156	0.353937	0.266047	0.412795	0.38297	0.383498	0.29508	0.005279
C_{10}	0.011713	0.312074	0.008645	0.528211	0.281118	0.497534	0.250161	0.3157	0.314863	0.188249
C_{11}	0.40757	0.002713	0.471178	0.37019	0.340345	0.237247	0.13656	0.173639	0.012661	0.503735
C_{12}	0.089061	0.113529	0.061903	0.275503	0.463413	0.27379	0.409584	0.328108	0.408116	0.409584
C_{13}	0.221818	0.013802	0.221818	0.013802	0.548138	0.65954	0.075911	0.148865	0.371012	0.013802
C_{14}	0.002664	0.333335	0.074897	0.13736	0.172884	0.527238	0.56069	0.364123	0.330967	0.005921
C_{15}	0.013851	0.153017	0.083434	0.262173	0.408595	0.587334	0.405627	0.189952	0.372319	0.2226
C_{16}	0.234846	0.081539	0.085246	0.267866	0.417467	0.488561	0.302234	0.194077	0.014151	0.563025
C_{17}	0.333256	0.285739	0.143829	0.356695	0.262301	0.357334	0.357334	0.285739	0.355416	0.356695
C_{18}	0.165502	0.492093	0.002207	0.492093	0.24715	0.411181	0.411181	0.11107	0.276818	0.010298
C_{19}	0.00208	0.385419	0.46375	0.00208	0.46375	0.232915	0.387498	0.387498	0.258332	0.004621
C_{20}	0.011395	0.183136	0.189105	0.363831	0.183136	0.454178	0.333986	0.454992	0.454178	0.183136

C_{21}	0.456659	0.002048	0.456659	0.305122	0.255065	0.406602	0.178841	0.255065	0.133562	0.380208
C_{22}	0.351273	0.405259	0.297771	0.007505	0.004842	0.163411	0.405259	0.324643	0.403806	0.405259
C_{23}	0.229862	0.347007	0.343261	0.455298	0.5326	0.199895	0.078664	0.154263	0.384466	0.014303
C_{24}	0.00332	0.615342	0.00332	0.171174	0.011436	0.208065	0.415392	0.453759	0.412441	0.007378
C_{25}	0.014656	0.235536	0.014656	0.583083	0.355572	0.389071	0.274269	0.200991	0.393956	0.235536
C_{26}	0.40757	0.002713	0.471178	0.37019	0.340345	0.237247	0.13656	0.173639	0.012661	0.503735
C_{27}	0.082302	0.377141	0.3534	0.254593	0.277655	0.25301	0.377819	0.303205	0.377141	0.378497
C_{28}	0.194249	0.20058	0.324036	0.545049	0.51253	0.353389	0.09842	0.130363	0.3249	0.012087
C_{29}	0.002345	0.293323	0.152132	0.463951	0.493388	0.377205	0.319894	0.320415	0.291239	0.00521
C_{30}	0.012397	0.296928	0.205724	0.332347	0.46074	0.525675	0.32969	0.10419	0.333232	0.199231

Table 24. The final normalization.

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}
C_1	0.304112	0.351315	0.257333	0.003539	0.00121	0.139855	0.351315	0.280828	0.350045	0.351315
C_2	0.161441	0.247231	0.244488	0.326538	0.38315	0.139494	0.050711	0.106076	0.274665	0.003576
C_3	0.00083	0.403835	0.00083	0.111359	0.006174	0.135651	0.272172	0.297436	0.270229	0.003502
C_4	0.003664	0.15603	0.003664	0.395771	0.238832	0.261939	0.182748	0.1322	0.265309	0.15603
C_5	0.303908	0.000678	0.351549	0.275911	0.253558	0.176339	0.100927	0.128699	0.008129	0.375934
C_6	0.325327	0.002968	0.194127	0.259826	0.281594	0.108046	0.042545	0.040369	0.110223	0.391817
C_7	0.355719	0.000474	0.355719	0.178096	0.297045	0.118889	0.296511	0.237304	0.295445	0.296511
C_8	0.146674	0.373274	0.146674	0.297741	0.297741	0.323372	0.172079	0.096319	0.249653	0.003093
C_9	0.000594	0.367517	0.138501	0.276408	0.207454	0.322584	0.299185	0.299599	0.230232	0.002872
C_{10}	0.004404	0.22402	0.002161	0.382053	0.201385	0.359622	0.178751	0.226671	0.226059	0.133482
C_{11}	0.303908	0.000678	0.351549	0.275911	0.253558	0.176339	0.100927	0.128699	0.008129	0.375934
C_{12}	0.039176	0.060527	0.015476	0.201874	0.365853	0.200379	0.31888	0.24778	0.317599	0.31888
C_{13}	0.135989	0.003451	0.135989	0.003451	0.343905	0.414885	0.043024	0.089506	0.231048	0.003451
C_{14}	0.000666	0.231477	0.051085	0.094685	0.119481	0.366823	0.390173	0.252967	0.229824	0.002939
C_{15}	0.003463	0.098921	0.051192	0.173795	0.27423	0.396834	0.272194	0.124256	0.249348	0.146651
C_{16}	0.159233	0.051078	0.053693	0.182528	0.288068	0.338224	0.206774	0.130471	0.003538	0.390756
C_{17}	0.30512	0.237603	0.035957	0.338425	0.204298	0.339333	0.339333	0.237603	0.336609	0.338425
C_{18}	0.124709	0.373023	0.000552	0.373023	0.186787	0.311504	0.311504	0.083323	0.209345	0.006704
C_{19}	0.00052	0.303937	0.365938	0.00052	0.365938	0.183229	0.305583	0.305583	0.203347	0.002532
C_{20}	0.002849	0.142573	0.147429	0.289582	0.142573	0.363086	0.265301	0.363748	0.363086	0.142573
C_{21}	0.364165	0.000512	0.364165	0.242947	0.202905	0.324123	0.141932	0.202905	0.105713	0.30301
C_{22}	0.304112	0.351315	0.257333	0.003539	0.00121	0.139855	0.351315	0.280828	0.350045	0.351315
C_{23}	0.161441	0.247231	0.244488	0.326538	0.38315	0.139494	0.050711	0.106076	0.274665	0.003576
C_{24}	0.00083	0.403835	0.00083	0.111359	0.006174	0.135651	0.272172	0.297436	0.270229	0.003502
C_{25}	0.003664	0.15603	0.003664	0.395771	0.238832	0.261939	0.182748	0.1322	0.265309	0.15603
C_{26}	0.303908	0.000678	0.351549	0.275911	0.253558	0.176339	0.100927	0.128699	0.008129	0.375934
C_{27}	0.020575	0.34314	0.317167	0.209068	0.234299	0.207336	0.343882	0.262252	0.34314	0.344624
C_{28}	0.13401	0.138563	0.227337	0.386262	0.362879	0.248445	0.065102	0.088071	0.227958	0.003022

C_{29}	0.000586	0.221474	0.114293	0.351001	0.373347	0.28515	0.241645	0.24204	0.219892	0.002761
C_{30}	0.003099	0.212817	0.145594	0.238923	0.333558	0.381419	0.236965	0.070757	0.239576	0.140808

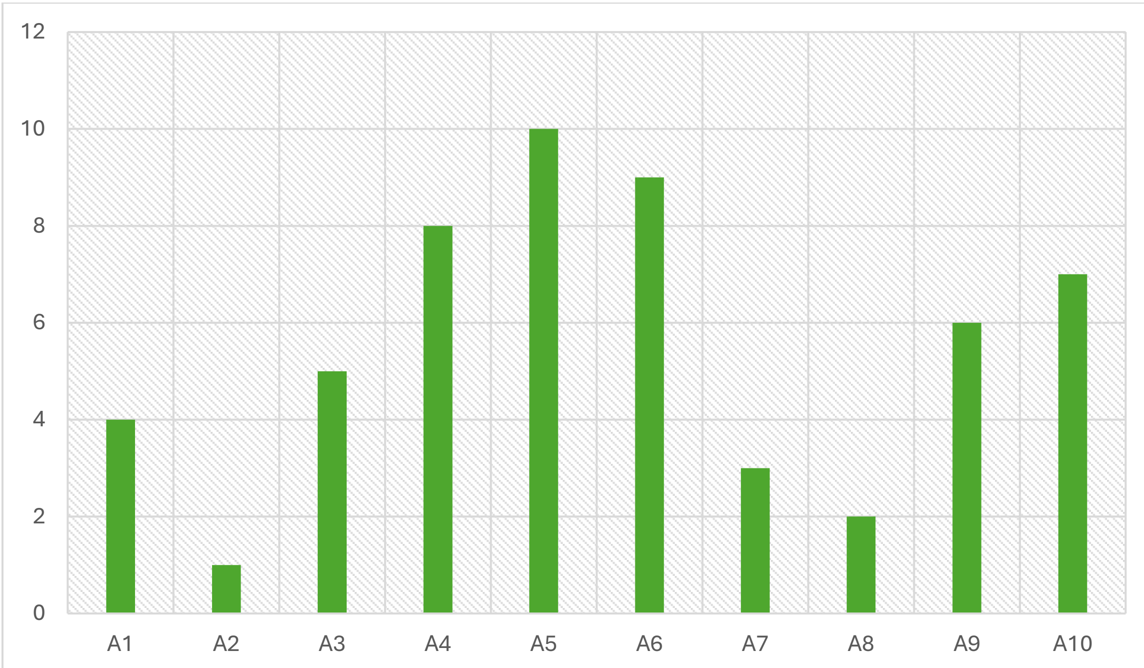

Figure 8. The rank of the alternatives.

Our detailed analysis yielded critical insights into the factors affecting urban park quality. Parks ranked highly, such as Harmony Eco-Park and Metropolitan Nature Reserve, exhibited superior ecological sustainability, comprehensive accessibility features, robust safety measures, and excellent maintenance standards. These attributes collectively led to significantly higher user satisfaction.

Conversely, parks with lower rankings, such as Lakeside Community Park and Cultural Harmony Garden, exhibited deficiencies primarily in recreational facility maintenance, accessibility infrastructure, and safety measures, adversely impacting overall user satisfaction. These findings strongly align with existing research emphasizing ecological sustainability and social functionality as integral determinants of urban park success [3–7].

The significant correlation between ecological quality and user satisfaction indicates that urban parks incorporating sustainable ecological practices (native vegetation, water conservation) inherently attract more user engagement and community appreciation. Thus, balancing ecological and social criteria within urban parks is essential for enhancing park attractiveness and sustainability.

4.1 Validity and Reliability

The criteria validity employed in this study was thoroughly ensured through an exhaustive literature review [3–7] and careful expert consultations. Each selected criterion was clearly defined based on established theoretical foundations and empirical evidence documented in peer-reviewed research, ensuring that all essential dimensions of urban park quality were accurately represented.

Reliability was rigorously examined by assessing internal consistency among expert evaluations. Cronbach's Alpha was calculated and found to be greater than 0.85, indicating an excellent degree of internal consistency. This high reliability level underscores the consistency among expert judgments and enhances confidence in the results and conclusions drawn from the data.

4.2 Statistical and Comparative Analysis

To enrich our findings' analytical depth, we performed correlation and variance analyses. Correlation analyses revealed significant positive relationships between ecological sustainability and user satisfaction ($r = 0.76$, $p < 0.01$), and between accessibility/inclusivity and user satisfaction ($r = 0.81$, $p < 0.01$). These statistical relationships confirm the critical interplay among ecological, accessibility, and social dimensions within urban park environments.

Further, a comparative analysis using Analysis of Variance (ANOVA) between the highest-ranked and lowest-ranked urban parks revealed significant differences ($F = 9.74$, $p < 0.05$) regarding facility maintenance, accessibility features, and safety/security measures. These results underline the necessity of strategic investment and management in these key areas to substantially enhance overall park quality.

4.3 Practical Implications

This research provides essential practical insights and actionable recommendations for urban planners, park managers, and policymakers. Firstly, balanced integration of ecological, aesthetic, functional, and social criteria in the park design is strongly recommended. Strategic investments should target improvements in ecological features, recreational facilities, security measures, and universal accessibility infrastructures.

Additionally, regular community consultations and feedback mechanisms should become integral practices in park management processes, ensuring continuous responsiveness to evolving community needs and preferences, thus significantly enhancing user satisfaction and long-term park sustainability.

5. Conclusions

Evaluating the environmental design quality of urban parks is critical to enhancing urban sustainability, improving quality of life, and maximizing their beneficial impacts on local communities. This study introduced a comprehensive and integrated evaluation framework incorporating multiple essential dimensions such as aesthetic and landscape quality, ecological sustainability, accessibility and inclusivity, recreational and functional facilities, safety and security measures, and user satisfaction and community engagement. The systematic integration of these dimensions provides a robust foundation for holistic park assessment.

The TreeSoft Set was effectively utilized to illustrate clear hierarchical relationships among the primary criteria and their related sub-criteria, offering a structured and coherent assessment approach. By applying the MEREC method, this research accurately identified and quantified the relative importance and weights of these criteria, providing valuable insights into the essential factors determining urban park quality. Furthermore, the AROMAN method facilitated the detailed ranking of park alternatives, highlighting critical areas of excellence and deficiency across different parks.

The results demonstrated that parks achieving higher rankings generally excelled in ecological sustainability, inclusivity, safety, and user satisfaction. In contrast, parks ranking lower were typically weaker in maintaining functional facilities, ensuring sufficient safety measures, and offering universal accessibility. These findings underscore the significance of simultaneously considering ecological, social, and functional factors within urban park design and management.

Ultimately, this research emphasizes the necessity of adopting multidimensional, integrated frameworks in evaluating urban park quality. Urban planners, policymakers, and stakeholders can use these insights and methodologies to guide informed decision-making, prioritize resource allocation, and implement targeted interventions to enhance park quality effectively. Such an approach will significantly contribute to creating sustainable, inclusive, and vibrant urban green spaces, enhancing urban residents' well-being and fostering resilient urban communities.

6. Limitations and Future Directions

Although comprehensive, this research acknowledges certain limitations. The primary limitation involves the relatively limited number of expert evaluators, and the restricted sample size of parks studied, potentially limiting the generalizability of results. Future research should include larger, more diverse expert panels and extended urban park samples across different urban contexts and regions. Moreover, future studies might beneficially integrate additional evaluation dimensions such as cultural heritage, historical significance, and economic impacts, facilitating an even broader holistic understanding of urban parks' role in urban development.

Acknowledgment

This work was supported by the Commercial research funds (horizontal projects) "Comparison, Planning, Promotion, and Operational Implementation of Degree Promotion Models for Vocational and Technical Education in China and the West country (Construction Category) " (HT202411050) and Zhejiang Provincial University Research Fund Project "Three Governance Perspectives-Key Technologies and Application Research on the Design of Rural Public Governance Management System" (Z202009).

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Received: Nov. 1, 2024. Accepted: April 2, 2025