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Original Research

Urban Morphology and Environmental Performance of Campus Public Spaces in Hot–Arid Climates

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ABSTRACT

Campus public spaces in hot–arid climates often fail to deliver thermal and functional comfort despite generous land allocations. Using Wasit University, Iraq (Al-Kut, ≈31.5° N), as a representative case, this study tests whether the morphological continuity of the campus public-space network — rather than the sheer quantity of open space — governs its environmental performance and everyday usability.
A mixed-methods design combined (i) a GIS- and Space Syntax-based morphological analysis of the campus solid–void structure, pedestrian network connectivity, and shaded-path continuity, and (ii) a structured user-perception survey of 131 students, staff, and visitors using a five-point Likert scale (ten variables; Cronbach's $\alpha = 0.832$).
Results show that although open space occupies ≈66 % of the campus area (Figures 3–4), the pedestrian network exhibits low local connectivity ($\gamma = 0.42$, indicating limited route options at each node), very low network redundancy ($\alpha = 0.18$, indicating highly linear / non-alternative paths) and a poorly continuous shaded corridor system (SPCI = 0.28, where 1.0 represents fully shaded continuity). User responses confirm this spatial fragmentation: route choice is strongly driven by environmental conditions (Q9, M = 3.878 on a 1–5 scale; 62.6 % agreement), whereas night-time safety (Q6, M = 2.702) and support for informal study (Q7, M = 2.893) are weak. Spearman correlations link psychological comfort most strongly to cleanliness and maintenance ($\rho = 0.612$, $p < 0.001$), followed by greenery distribution ($\rho = 0.461$), lighting and ventilation ($\rho = 0.447$) and pedestrian continuity ($\rho = 0.421$); however, pedestrian continuity does not correlate significantly with route choice ($\rho = 0.112$, $p = 0.202$), revealing a perception–behaviour gap (see Figures 5–6 and Tables 4–7).
These findings demonstrate that environmental performance in hot–arid campuses depends less on the quantity of open space and more on the continuity, integration and climatic responsiveness of the public-space network. The study contributes a transferable morphology-continuity evaluation framework that links GIS-based configuration metrics with user-perception evidence, providing a climate-responsive diagnostic for retrofitting and designing campus public spaces in hot–arid regions.

Keywords: campus public spaces, hot–arid environments, urban morphology–environmental performance, walkability, GIS analysis, user perception

1. Introduction

University campuses operate as small urban systems whose buildings, paths, vegetation and outdoor environments jointly shape movement, social interaction and the time users spend outdoors [1]. In hot–arid climates, the quality of these public spaces is determined not by their gross area but by their ability to mitigate heat stress through configured shade, ventilation corridors and a coherent pedestrian network [2].
A growing body of work therefore argues that campus public space must be assessed through an integrated lens that couples spatial form, climatic performance and lived user experience rather than treating these dimensions in isolation [3]. Urban-morphology research has repeatedly demonstrated that the structure of a spatial network governs walking frequency, perceived accessibility and route selection: well-connected systems lower the

perceived effort of movement, while fragmented ones discourage outdoor use [4]. In climate-sensitive contexts, individual interventions such as shading devices, cooling elements or pockets of greenery yield little benefit unless they are aligned with the wider movement network and operate as a continuous environmental system rather than as isolated components [5], [6]. Despite progress in three interrelated areas — urban form and configuration, physical–environmental performance, and user perception of public space — published research still tends to treat them separately [7] [8]. This separation is particularly problematic in hot–arid university campuses such as Wasit University (Al-Kut, Iraq), where summer air temperatures routinely exceed 45 °C and where vast open quadrangles remain unused for most of the day, indicating that abundant open space does not automatically translate into thermal or behavioural comfort. The present study addresses this real-world problem of underused campus open space in hot–arid settings by testing the following central hypothesis: the environmental and functional performance of campus public spaces in hot–arid climates is governed primarily by the morphological continuity of the pedestrian–open-space network (connectivity, redundancy, integration and shaded-path continuity), rather than by the absolute quantity of open space provided. The key analytical concepts — urban morphology, pedestrian network continuity, shaded-path continuity, environmental performance and user perception — frame the investigation throughout the paper.
Accordingly, the study is guided by one main research question, with a single supporting sub-question:
Main RQ: How does the morphological configuration of a hot–arid campus public-space network shape its environmental performance and its users' spatial behaviour?
Sub-RQ: To what extent does the perceived environmental quality of these spaces (comfort, cleanliness, greenery, lighting and shaded continuity) mediate the relationship between spatial configuration and observed patterns of use?

2. Literature Review

2.1. Urban Morphology and Pedestrian Movement Networks

Research in urban morphology shows that pedestrian movement is shaped mainly by the structure of spatial networks, rather than by isolated physical features. Connectivity and network configuration influence both the likelihood and frequency of walking across different spatial scales [9]. At the city level, well-connected pedestrian networks have been found to improve walkability and support physical activity [10], More recent studies also show that spatial integration and network density are positively associated with higher walking levels [11].
On university campuses, however, movement systems differ from conventional street networks. Pedestrian circulation often occurs through paths, semi-open areas, and transitional spaces. This makes context-sensitive methods necessary. Morphological studies of campuses indicate that pedestrian-network-based models explain movement behavior more accurately than traditional road-based approaches [12].
In this context, walkability should not be understood only as mobility. It is also a spatial condition shaped by environmental comfort, clarity of movement, and overall usability. Coherent spatial networks tend to encourage outdoor activity and reduce dependence on motorized transport [13], In contrast, discontinuities create perceptual fragmentation and weaken the spatial experience [14].
Even so, much of the existing literature still focuses on network structure alone. It gives limited attention to environmental performance and user perception. This limitation highlights the need for broader frameworks that connect spatial configuration with environmental conditions and behavioral responses..

2.2. Morphological Configuration and Environmental Performance in Hot–Arid Contexts

In hot-arid environments, environmental performance is closely related to the spatial organization of urban form. The relationship between built mass and open space has a major role in controlling solar exposure and airflow [15]. Comparative studies show that dispersed building patterns and weak spatial enclosure often increase thermal exposure, even when shading or vegetation is available [16]. Likewise, fragmented spatial layouts in hot and dry settings are associated with lower thermal comfort and reduced outdoor activity [17]. The effectiveness of cooling strategies depends largely on how they are integrated into the wider spatial system. Research shows that vegetation and shading perform better when they are embedded within continuous spatial structures rather than introduced as isolated elements [18].
Recent human-centered environmental research reinforces this view. Morphological variables such as sky view factor, aspect ratio, and spatial enclosure directly influence perceived thermal comfort [19]. Systematic reviews also emphasize that climate-responsive design requires the integration of urban form, shading, vegetation, and

material strategies within a unified framework [20]. However, many environmental studies still rely mainly on simulation-based indicators. These studies often do not sufficiently connect environmental performance with spatial continuity and user behavior.

2.3 User Perception and Experiential Public-Space Performance

User experience is an integral metric for determining public space performance and reflects how well the environment has been perceived and experienced. Perceptions of environmental conditions such as perceived shade, amount of sun exposure, and the applicant's perception of spatial clarity have an effect on route choice and time spent in any particular location [16]. People move and participate in outdoor activities on college campuses based on their perception of thermal comfort [21].

The way people perceive the environment affects the way they interact and socialize with each other, especially in informal settings for learning and gathering together. Because of this, perception is often categorized as an individual variable rather than being considered in conjunction with the spatial relationship of the environment around the user. Recent reviews suggest that integrating user experience with spatial analysis will provide greater insight into how public spaces function [18]. It has been demonstrated through mixed-methods research that linking perceptions to spatial indicators offers a more complete understanding of people's behaviour [19]. Related to this, studies on spatial syntax have shown that the spatial integration of a particular area will affect both the perceived level of accessibility and the degree of comfort experienced by users of that space on campus [22]. Other findings regarding the effective evaluation of public spaces in environmentally vulnerable climates indicate that the performance of public spaces cannot be determined using only one indicator; as a result, further studies are needed to fill these existing methodological gaps.

One such gap is the failure to combine the urban morphology, environmental continuity, and user perception elements into a single analytical framework or study design. This discrepancy is magnified in hot-arid campus settings, where the spatial arrangement of structures must facilitate movement, create a good thermal environment and permit social interaction between users. A prior body of work has indicated the role of spatial configuration on environmental experience; however, there is a recent body of work that describes the need to combine thermal comfort with walkability when devising (or designing) climate responsive models for site development, as reflected in Table 1. Table 1 provides a systematic view of key research studies and their shortcomings. As indicated in Table 1, the area has made advances, but most research continues to consider three dimensions independently of one another..

Table 1. Synthesis of Previous Studies and Identification of the Research Gap.

Study	Main Focus	Method	Key Finding	Limitation in Relation to This Study
Asadi-Shekari et al. (2015)	Network morphology and walking	City-scale network analysis	Strong relationship between network structure and walking/biking	Not campus-specific; lacks environmental dimension
Ellis et al. (2016)	Connectivity and walking	Footpath network analysis	Connectivity is a key indicator of walkability	Does not integrate environmental perception or climate
Elzeni et al. (2022)	Morphology and campus walkability	Urban-form indicators in campus context	Campus form directly influences walkability	Limited linkage to thermal comfort and perception
Ning et al. (2023a)	Solar perception and comfort	Survey + thermal indicators	Perceived shade strongly affects comfort and behavior	No network-based continuity analysis
Guo et al. (2024)	Street morphology and thermal comfort	Multi-source modeling	Morphology directly affects perceived thermal comfort	Focused on streets, not campus systems
Zhu et al. (2024a)	User experience in public space	Systematic review	Need for human-centered and integrated approaches	Morphology only partially addressed
Zencirkiran & Suta (2025)	Spatial organization and campus experience	Space syntax + survey	Integration improves legibility and movement	Climatic continuity not explicitly considered
Abuwaer et al. (2025)	Walkability and thermal comfort	Contemporary review	Walkability is inseparable from thermal comfort	Lacks operational campus-scale framework
Alharthi et al. (2025)	Climate-responsive design	Systematic review	Urban form, shade, and vegetation act integratively	Not empirically tested in campus perception models

Study	Main Focus	Method	Key Finding	Limitation in Relation to This Study
Present study	Integrated campus public-space system	GIS + morphology + perception	Links spatial continuity, environmental performance, and user experience	Addresses identified gap

As shown in **Table 1**, existing research offers valuable insights but remains fragmented. Most studies focus on one or two dimensions, with limited integration across spatial, environmental, and perceptual aspects. In response, the present study proposes an integrated analytical framework that treats campus public space as a spatial–environmental–behavioral system .Within this framework, performance emerges from the interaction between morphology, environmental continuity, and user perception.

To operationalize this approach, a set of interrelated indicators is adopted. These indicators translate abstract concepts into measurable variables and are treated as components of a unified analytical structure rather than independent metrics.

As summarized in **Table 2**, the framework links spatial configuration with environmental exposure and user response, allowing campus performance to be assessed as a continuity-based system.

Table 2. Core Indicators for the Spatial–Environmental–Perceptual Framework .

Analytical Domain	Indicator	Operational Definition	Tool	Interpretive Role
Urban morphology	Mass–void structure	Distribution of built and open space; degree of enclosure	GIS / Figure-ground	Explains exposure vs containment
Movement network	Connectivity	Degree of linkage between routes	Network analysis	Indicates accessibility
Movement network	Integration	Relative centrality of routes	Space syntax / GIS	Predicts movement intensity
Movement network	Redundancy	Availability of alternative paths	Graph metrics / GIS	Enhances flexibility
Environmental performance	Shaded continuity	Continuity of shade along paths	GIS + field audit	Key for walkability
Environmental performance	Solar exposure	Degree of direct radiation	GIS / observation	Explains thermal stress
Environmental performance	Environmental integration	Alignment of shade/trees with movement	Mapping	Distinguishes presence vs effectiveness
Spatial perception	Legibility	Ease of spatial understanding	Survey	Explains navigation
Environmental perception	Perceived thermal comfort	User evaluation of heat and shade	Likert survey	Links environment to behavior
Social performance	Social usability	Suitability for interaction and stay	Survey + observation	Explains space use
Psychological outcome	Psychological comfort	Sense of environmental satisfaction	Survey / regression	Core dependent variable
Behavioral outcome	Outdoor use	Walking and staying behavior	Survey + observation	Final system output

The integration of these indicators allows the study to move beyond descriptive analysis toward a structured interpretation of campus performance, where environmental quality and user behavior are understood as outcomes of spatial continuity.

3. Materials and Methodology

3.1. Research Design

This study adopts a convergent mixed-methods research design that combines quantitative spatial analysis with quantitative user-perception data to evaluate the performance of campus public spaces in a hot–arid context. The design integrates (i) a GIS- and Space Syntax-based morphological analysis (case-study approach at Wasit University) and (ii) a structured questionnaire survey, so that spatial-configurational evidence and lived user experience can be triangulated. Following recent practice in campus and urban-morphology research [11], [13], [19], the two strands are analysed separately and then synthesised in an integrated interpretation, consistent with mixed-methods methodology rather than purely descriptive–analytical approaches.

The underlying research logic assumes that environmental performance emerges through the interaction between spatial configuration, environmental continuity and human experience, rather than from any single dimension in isolation.
Accordingly, the study conceptualises campus environmental performance as a spatial–environmental–behavioural condition shaped jointly by network structure, climatic support and user perception.
Figure 1 illustrates this research logic and presents the methodological framework that connects spatial analysis, environmental continuity, and user perception.

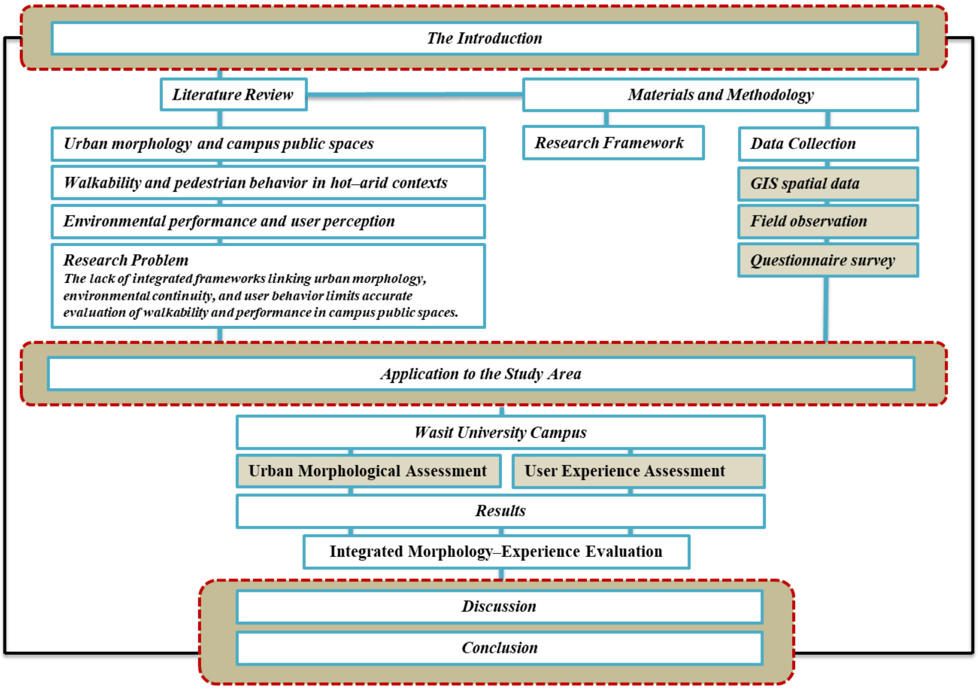

Figure 1. Methodological Framework for Spatial–Environmental Assessment in a Hot–Arid Campus Context.

3.2. Study Area

The study was carried out at Wasit University in Al Kut, Iraq. The area falls within a hot-arid climatic zone marked by intense solar radiation, high summer temperatures, and strong seasonal variation in outdoor thermal conditions.
These characteristics make the campus a suitable case for examining how spatial configuration affects environmental performance under climatic stress.
The campus has a high share of open space. Open areas account for about 66% of the total campus area, while built-up areas represent around 34%. This distribution offers a useful setting for testing whether the availability of open space actually leads to better environmental performance in terms of comfort, usability, and pedestrian movement.
Figure 2 shows the campus within its wider geographical setting, including its location in Iraq, its urban position in Al Kut, and its internal spatial structure.

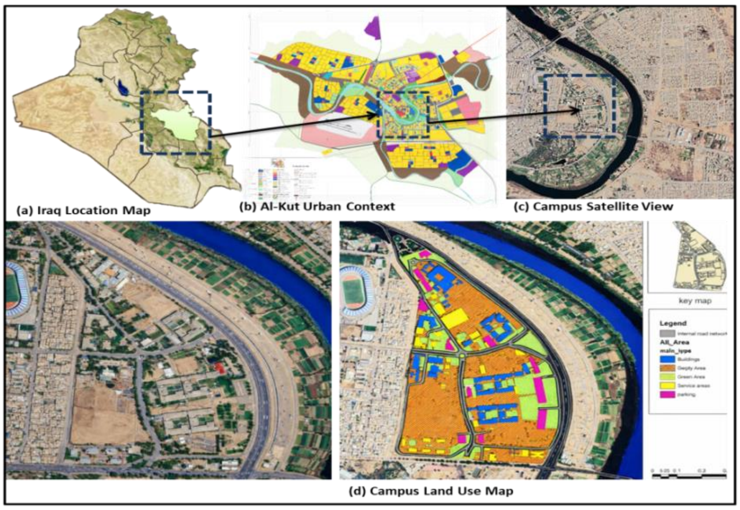

Figure 2. Location and Spatial Context of Wasit University.

3.3. GIS-Based Spatial and Morphological Analysis

The spatial analysis is based on GIS examination of the campus layout. Its purpose is to evaluate the morphological structure of public spaces and pedestrian movement systems. The analysis focuses on four related dimensions:

1. the built-open space structure,
2. the connectivity and continuity of pedestrian networks,
3. the spatial distribution of open and green areas, and
4. the environmental support provided by shaded circulation paths.

To measure these dimensions, the study uses a set of complementary morphology-based indicators that combine GIS metrics with Space Syntax analysis. These indicators include connectivity (γ), network redundancy (α), global integration (Rn), and the Shaded Path Continuity Index (SPCI).
Connectivity (γ) reflects local accessibility by showing the number of directly connected segments. Integration (Rn) indicates global spatial centrality and the relative ease of movement across the network. Network redundancy (α) measures the availability of alternative routes. The SPCI evaluates the continuity of shaded pedestrian paths.
Together, these indicators provide a multi-scalar reading of spatial structure. They link accessibility, integration, and environmental performance. In this study, the quantity of open space is not treated as a sufficient indicator of performance. Greater attention is given to spatial continuity, configurational coherence, and environmental usability. Environmental performance is therefore understood as a spatial-environmental condition produced by the interaction between morphological configuration, network accessibility, and shaded path continuity.
This approach relies on morphology-based and perception-based indicators rather than full thermodynamic simulations such as PET or UTCI. The reason is that the study is concerned mainly with spatial-behavioral relationships, not detailed microclimatic modeling.

3.4. User Perception Survey

To complement the spatial analysis, a user-perception survey was conducted to capture the experiential dimension of campus public-space performance. The survey targeted students, faculty members, administrative staff, and campus visitors. A total of 131 valid responses were collected .
The total on-campus user population of the Wasit University main campus during the survey period was approximately 10,790 individuals, including about 9,800 regularly enrolled students and approximately 990 academic and administrative staff members. Online students were excluded from the population estimate because the study focuses specifically on in-situ spatial behaviour and campus public-space use.
A stratified convenience sampling approach was adopted. Respondents were approached at the principal pedestrian nodes within the four main campus precincts: the academic core, the library/cafeteria zone, the dormitory edge, and the main entrance plaza. This strategy ensured representation of the major functional sub-

areas of the campus while acknowledging that respondents within each precinct were recruited on a convenience basis.

The final 131 valid responses correspond to a sampling margin of error of approximately ±8.5% at a 95% confidence level for this population. This level is considered acceptable for a localized spatial–behavioural mapping study, although it is not intended for population-level generalization.

The study also explicitly acknowledges a temporal bias in data collection. Approximately 71.8% of responses were collected during morning hours (08:00–12:00), corresponding to peak campus occupancy and the most thermally usable period of the summer day. Although this timing improved respondent accessibility and the reliability of in-situ environmental judgments, it under-represents afternoon and evening users and is therefore treated as a study limitation.

Students constituted 51.9% of the sample, followed by faculty members (37.4%), administrative staff (6.9%), and visitors (3.8%). In terms of gender distribution, 49.6% of respondents were male and 48.1% were female, while 2.3% preferred not to disclose their gender. The largest age group was 20–25 years (35.9%), followed by the 26–35 and 36–50 age groups, each representing 26.0% of the sample.

The questionnaire employed a five-point Likert scale and included ten variables aligned with the analytical framework presented in Table 2. These variables addressed environmental quality, spatial continuity, movement behaviour, and user experience. They included natural lighting and ventilation, green-space distribution, pedestrian continuity, cleanliness and maintenance, psychological comfort, nighttime safety, informal study support, place preference, environmental influence on route choice, and support for social interaction.

For analytical clarity, the variables were grouped according to their functional roles within the analytical framework. The classification distinguishes environmental, spatial, behavioural, and outcome dimensions. This organization allows user perception to be interpreted as part of an integrated spatial–environmental system, as summarized in Table 3.

Table 3. Structure of Perception Variables and Analytical Roles.

Code	Variable	Analytical Domain	Measurement Type	Role in Analysis
Q1	Natural lighting and ventilation	Environmental quality	Likert scale	Independent variable
Q2	Green space distribution	Environmental quality	Likert scale	Independent variable
Q3	Pedestrian continuity and clarity	Spatial continuity	Likert scale	Independent variable
Q4	Cleanliness and maintenance	Operational quality	Likert scale	Independent variable
Q5	Psychological comfort	Experiential outcome	Likert scale	Dependent variable
Q6	Nighttime lighting and safety	Environmental quality	Likert scale	Independent variable
Q7	Informal study support	Functional use	Likert scale	Independent variable
Q8	Place preference (environment-based)	Behavioral response	Likert scale	Mediating variable
Q9	Environmental influence on route choice	Movement behavior	Likert scale	Behavioral variable
Q10	Social interaction support	Social performance	Likert scale	Outcome variable

3.5. Reliability and Statistical Analysis

The survey data were screened, coded, and analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to provide an overall picture of perceived environmental performance.

High agreement was expressed as the percentage of responses rated 4-5, while lower evaluations were represented by ratings 1-2.

The internal consistency of the scale was tested using Cronbach's alpha. The result was $\alpha = 0.832$, which indicates good reliability.

Because the data are ordinal, Spearman's rank-order correlation was used as the main method for examining relationships between variables. Pearson correlation was also applied as a robustness check and produced similar patterns. Statistical significance was assessed at the 0.05 level.

The analysis followed the structure presented in Table 3. It focused on the relationships between environmental variables, psychological comfort as the dependent variable, movement behavior, and social use. The main associations examined included the link between pedestrian continuity and route choice, the relationship between environmental quality and comfort, and the connection between functional use and social interaction.

To strengthen the analysis, an ordered logistic regression model was also used to test the predictive influence of environmental and spatial variables on psychological comfort.

This helped move the analysis beyond simple association and allowed the study to identify the relative contribution of the main factors shaping user experience.

4. Results

4.1. Spatial–Morphological Structure of Campus Public Spaces

The GIS-based analysis shows that Wasit University contains a high proportion of open land compared with built-up area. Open spaces account for approximately 66% of the total campus area, while built-up areas make up about 34%. At first glance, this suggests strong potential for environmental buffering and pedestrian use. However, the findings show that this potential is not fully translated into effective public-space performance.

As summarized in Table 4, the campus structure is constrained by weak integration between built and open spaces, fragmented open-space distribution, and discontinuous pedestrian-supportive elements. Many open areas function as residual or poorly defined spaces rather than as parts of a coherent and climate-responsive public-space network.

This finding suggests that the quantity of open space alone is not a reliable indicator of environmental quality. The current configuration creates uneven continuity between buildings, open areas, and circulation paths. As a result, shading, enclosure, and outdoor usability remain spatially inconsistent. Under hot-arid conditions, this fragmentation reduces the functional value of public spaces, especially during daily movement between academic buildings.

Figure 3 illustrates the fragmented solid-void structure of the campus. Figure 4 further shows the configurational implications, where connectivity and integration are concentrated along a limited number of corridors, while peripheral areas remain weakly connected and spatially segregated.

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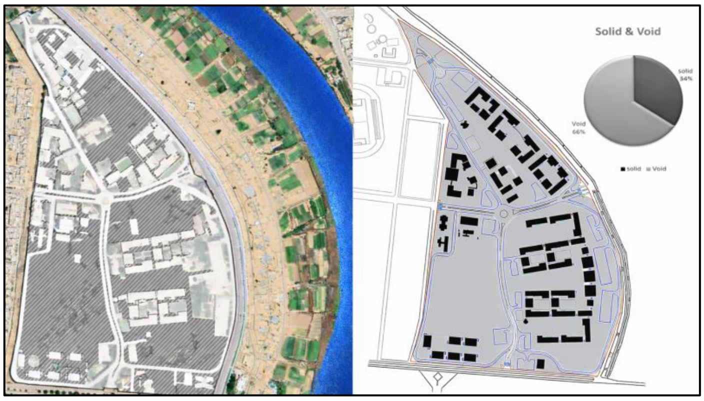

Figure 3. Spatial–morphological configuration and solid–void structure of Wasit University campus.

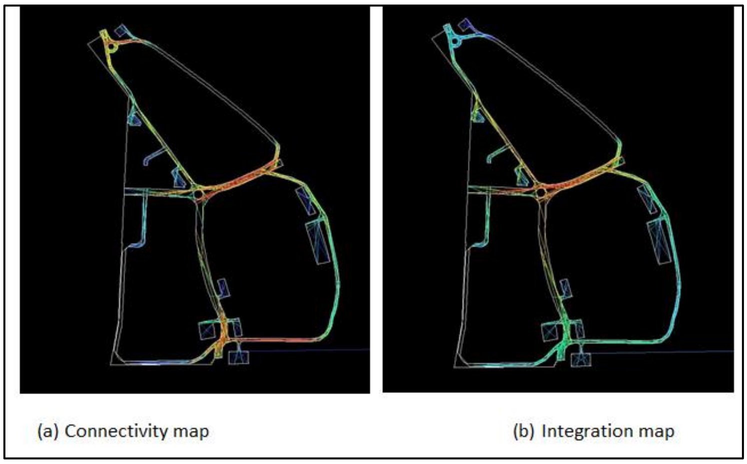

Figure 4. Spatial network structure of the campus: comparative analysis of connectivity (γ) and integration (Rn).

Table 4. Summary of Spatial-Morphological Findings. Source: Author.

Spatial Dimension	Observed Condition	Environmental Implication

Open-space share	66% of campus area	High spatial potential but not equivalent performance
Built-up share	34% of campus area	Dispersed massing pattern
Built-open relation	Weak morphological integration	Reduced spatial definition
Pedestrian structure	Discontinuous and unevenly legible	Limited walkability
Functional outdoor quality	Transitional rather than active spaces	Reduced environmental and social performance

4.2. Descriptive Results of the User Perception Survey

A total of 131 valid responses were analyzed. The descriptive findings indicate a moderate overall perception of campus environmental performance, with clear variation across individual dimensions.

As shown in Table 5, the highest-rated variable was the influence of environmental factors on route choice (Q9; M = 3.878, SD = 1.150). This suggests that pedestrian movement is strongly affected by environmental quality, not only by distance or geometric efficiency.

In contrast, nighttime lighting and safety received the lowest score (Q6; M = 2.702, SD = 1.135). This points to weak environmental support during evening use. Moderate scores were recorded for lighting and ventilation, pedestrian continuity, psychological comfort, green-space distribution, and social interaction, with mean values ranging roughly between 3.0 and 3.3. These results suggest that environmental support is present, but not consistently distributed across the campus.

Lower scores for informal study support and place preference also indicate limitations in long-term outdoor usability.

Table 5. Descriptive Statistics of User Perception Variables Related to Spatial–Environmental Performance (N = 131)

Code	Variable	Mean	SD	Agree (4-5) %	Disagree (1-2) %
Q1	Lighting & ventilation	3.260	1.225	38.9	22.9
Q2	Green space distribution	3.198	1.274	40.5	28.2
Q3	Pedestrian continuity	3.229	1.238	44.3	30.5
Q4	Cleanliness & maintenance	3.084	1.301	43.5	33.6
Q5	Psychological comfort	3.221	1.230	42.7	25.2
Q6	Night lighting & safety	2.702	1.135	19.8	38.9
Q7	Informal study support	2.893	1.229	29.8	38.9
Q8	Place preference (comfort)	3.046	1.246	38.9	32.8
Q9	Environmental influence on routes	3.878	1.150	62.6	13.0
Q10	Social interaction	3.191	1.158	41.2	26.7

4.3. Reliability of the Survey Instrument

The internal consistency of the perception scale was assessed using Cronbach's alpha. The result was α = 0.832, which indicates good reliability. As shown in Table 6, the questionnaire provides a stable and coherent measure of perceived environmental performance.

Table 6 . Reliability of the Perception Scale Source: Author.

Measure	Value
Number of items	10
Valid responses	131
Cronbach's alpha	0.832

4.4. Correlation Analysis of Environmental Perception Variables

The correlation analysis reveals significant relationships between key environmental and experiential variables. These results confirm that perceived comfort is shaped by several interacting factors rather than by a single condition.

As shown in Table 7, psychological comfort (Q5) has moderate positive correlations with green-space distribution (ρ = 0.461), lighting and ventilation (ρ = 0.447), and pedestrian continuity (ρ = 0.421), all at $p < 0.001$. This indicates that comfort is experienced as a combined outcome of environmental quality and spatial continuity.

A significant correlation was also found between comfort and place preference (ρ = 0.405, $p < 0.001$). This suggests that environmental perception is translated into actual spatial behavior. The strongest relationship appeared between cleanliness and comfort (ρ = 0.612, $p < 0.001$), which highlights the importance of maintenance and operational quality in shaping user experience.

By contrast, the relationship between pedestrian continuity and route choice was not statistically significant (ρ = 0.112, p = 0.202). This may mean that route decisions are influenced more by immediate environmental conditions than by perceived network continuity on its own.

Table 7. Key Spearman Correlations. Source: Author.

Variable Pair	ρ	p-value	Interpretation
Greenery ↔ Comfort	0.461	<0.001	Moderate positive
Lighting ↔ Comfort	0.447	<0.001	Moderate positive
Continuity ↔ Comfort	0.421	<0.001	Moderate positive
Comfort ↔ Place preference	0.405	<0.001	Moderate positive
Study ↔ Social interaction	0.454	<0.001	Moderate positive
Cleanliness ↔ Comfort	0.612	<0.001	Strong positive
Continuity ↔ Route choice	0.112	0.202	Not significant

Interpreting the route-choice anomaly. At first sight, the high mean score for environmental influence on route choice (Q9, M = 3.878) seems to contradict the non-significant correlation between pedestrian continuity and route choice (ρ = 0.112, p = 0.202; Table 7). The two findings are, however, complementary rather than contradictory. Q9 captures users' acute, micro-scale sensitivity to immediate environmental stressors: respondents deflect toward individual shaded spots, cooler edges and small comfortable pockets along their walks. By contrast, the continuity variable expresses a global, macro-network property — the systemic continuity of shaded, well-integrated pedestrian links across the campus. Users do not consciously plan their walks using global network-continuity indices; they react locally to whatever shade, vegetation or enclosure is nearest. Consequently, route choice can be strongly environment-driven (Q9) while remaining statistically uncorrelated with a continuity index that measures a property users do not directly perceive. This perception–behaviour gap reinforces the central argument of the paper: improving environmental performance in hot–arid campuses requires aligning the macro-network's continuity with the micro-scale environmental cues that actually steer pedestrian decisions.

4.5. Integrated Interpretation of Spatial and Statistical Findings

When the spatial and statistical findings are considered together, a clear pattern emerges. Although the campus contains a large proportion of open space, it does not function as a fully integrated environmental system. Its performance is limited by weak spatial continuity, fragmented open areas, and uneven environmental support.

The high score for environmental influence on route choice (Q9), together with moderate comfort levels, suggests the presence of adaptive movement behavior. Users appear to choose routes based on environmental advantages such as shade, comfort, and perceived quality, rather than moving through a consistently supportive pedestrian system.

Figure 5 summarizes this interpretation in the form of a causal model linking urban morphology, environmental quality, and user behavior. The model suggests that fragmented spatial structure leads to discontinuous environmental support, which then affects psychological comfort, route choice, and patterns of space use.

Overall, the results show that the performance of campus public spaces at Wasit University is shaped by the interaction between spatial configuration and perceived environmental quality. Although the campus has a substantial amount of open space, its fragmented morphology weakens environmental continuity and limits functional usability. The survey findings also confirm that users are highly responsive to environmental conditions and that psychological comfort is closely associated with greenery, lighting, pedestrian continuity, and maintenance quality.

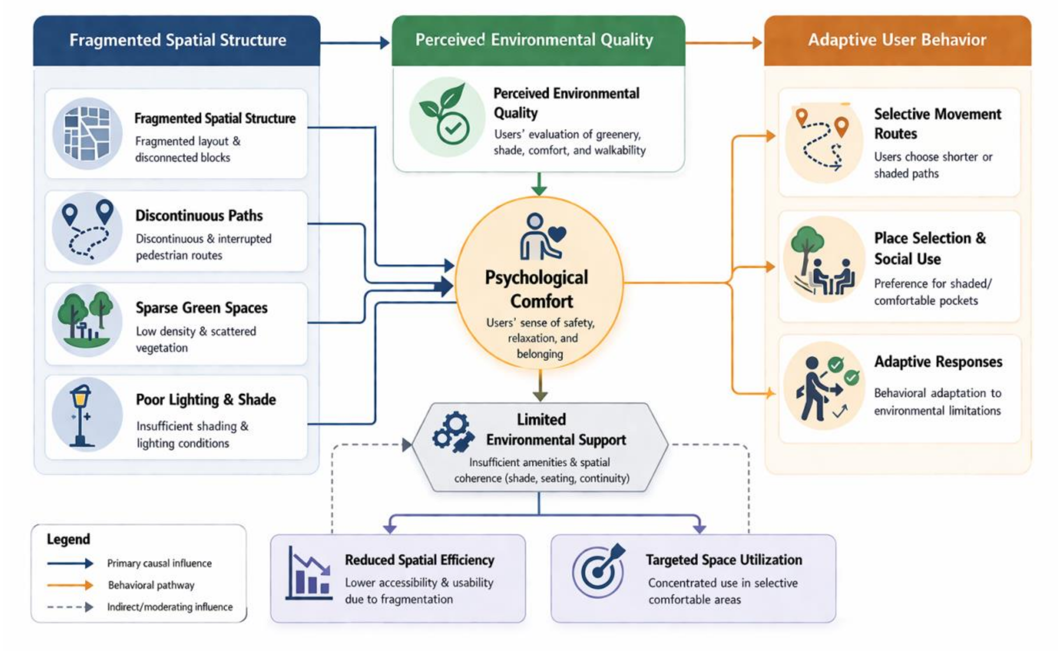

Fig. 5. Causal Model Linking Urban Morphology, Environmental Quality, and User Behavior in Campus Public Spaces. Source: Author.

5. Discussion

The findings offer a clear interpretation of campus public-space performance as a result of the interaction between spatial configuration and perceived environmental quality. By combining GIS-based morphological analysis with statistical evidence, the study shows that environmental performance in hot-arid campuses depends not simply on the amount of open space, but on the continuity and integration of the spatial system.

The spatial analysis (Table 5) shows that the campus contains a high proportion of open space, about 66% of its total area. However, the campus also shows weak morphological integration and discontinuous pedestrian-supportive structures. This means that spatial availability does not automatically lead to functional or environmental effectiveness. The fragmented arrangement of open spaces limits their ability to work as a coherent environmental network. As a result, their contribution to walkability and outdoor usability remains limited.

This interpretation is supported by the perception results (Table 6), where most environmental variables fall within a moderate range. The overlap between spatial fragmentation and moderate user evaluations suggests that environmental qualities such as shading, greenery, and ventilation do exist, but they are not well aligned across the campus. In other words, environmental support is experienced in scattered locations rather than as part of a continuous system.

One of the most important findings is the strong role of environmental conditions in shaping movement behavior. The high rating for the influence of environmental conditions on route choice (Q9; Table 6) suggests that users give priority to comfort rather than to geometric efficiency alone. This interpretation is reinforced by the absence of a statistically significant relationship between pedestrian continuity and route choice (Table 8). The result indicates that spatial connectivity by itself does not guarantee usability in hot-arid settings. Instead, users appear to move selectively through routes that offer more favorable environmental conditions. This reflects an adaptive behavioral response to the spatial and environmental qualities of the campus.

As shown in Figure 6, psychological comfort emerges as a key mediating variable between environmental conditions and behavioral outcomes. Cleanliness and maintenance have the strongest association with psychological comfort ($\rho = 0.612$). They are followed by greenery distribution ($\rho = 0.461$), natural lighting and ventilation ($\rho = 0.447$), and pedestrian continuity ($\rho = 0.421$). This pattern shows that environmental perception is shaped not only by spatial configuration, but also by operational quality. Psychological comfort is also

positively associated with place preference (ρ = 0.405), which confirms that environmental quality has a direct effect on how spaces are used.
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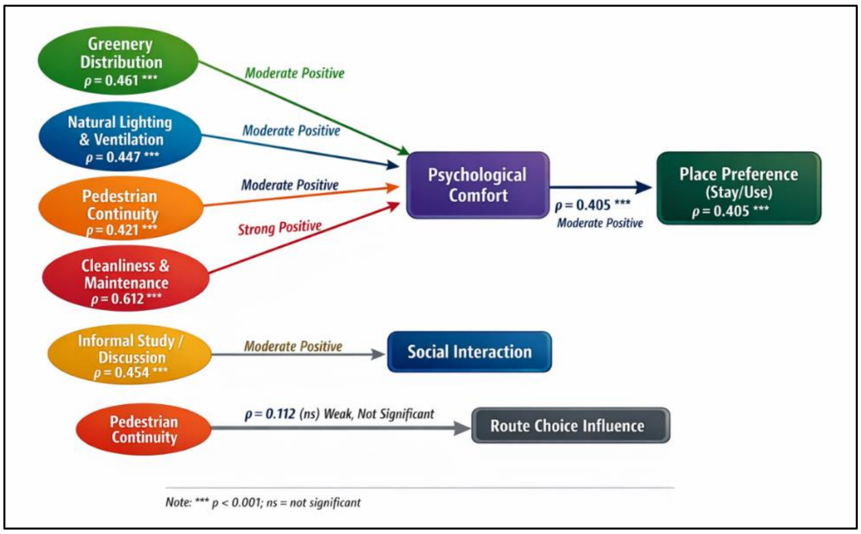

Fig.6. Causal relationships between environmental quality, spatial continuity, and user perception influencing psychological comfort and place preference in campus public spaces. . Source: Author

By contrast, the weak and non-significant relationship between pedestrian continuity and route choice (ρ = 0.112) suggests that movement decisions are driven more by immediate environmental conditions than by network structure alone. These findings support a dual understanding of environmental performance. On one hand, it depends on spatial configuration, which determines how environmental support is distributed. On the other hand, it depends on operational quality, which shapes user perception and experience.
Another important observation is the gap between users' environmental sensitivity and their reported comfort levels. Although respondents show high awareness of environmental conditions, overall psychological comfort remains only moderate (Table 6). This suggests that the campus does not provide comfortable conditions in a consistent way. Environmental performance is therefore fragmented, and prolonged outdoor use remains limited. The low score for nighttime safety (Q6) also indicates that campus usability is concentrated mainly in daytime hours. Overall, the results confirm that campus public-space performance is produced through an interactive system in which spatial configuration, environmental conditions, and user perception work together. Effective performance depends on the alignment of these components rather than on the presence of any single factor alone. From a planning perspective, the findings suggest that improving campus performance does not require adding more open space. What is needed instead is better continuity and stronger integration of environmental support within the spatial network. Priority interventions should therefore focus on strengthening shaded pedestrian corridors, aligning vegetation with major movement paths, improving spatial enclosure, and maintaining consistent standards of cleanliness and maintenance.
Taken together, these findings support a shift from space-based evaluation to a continuity-based and morphology-driven approach. In this perspective, spatial configuration becomes the main factor shaping environmental performance in hot-arid campus environments.

6. Conclusions

Returning to the main research question, this study has shown that the environmental and functional performance of campus public spaces in a hot–arid context is governed primarily by the morphological continuity of the pedestrian–open-space network, rather than by the absolute quantity of open space. The mismatch observed at Wasit University — extensive but fragmented open areas that fail to deliver consistent thermal or behavioural comfort — supports the central hypothesis and confirms that spatial availability alone is a misleading proxy for environmental quality.
With respect to the sub-question, the analysis shows that perceived environmental quality (comfort, cleanliness, greenery, lighting and shaded continuity) genuinely mediates the relationship between spatial configuration and observed patterns of use. Users adapt their movement to the environmental cues they encounter locally, which

explains why route choice is strongly environment-driven yet only weakly aligned with macro-network continuity. This perception–behaviour gap is itself a finding: it identifies where morphological reconfiguration could be expected to deliver the greatest behavioural payoff.

Theoretically, the study contributes a transferable morphology-continuity framework that integrates GIS-based spatial metrics, environmental indicators and user perception within a single evaluative system. This reframes campus public-space assessment as a question of continuity-based performance rather than space-based provision.

Practically, the findings indicate that improving hot–arid campus environments does not require additional open space. Priority should instead be given to (a) strengthening continuous shaded pedestrian corridors aligned with the principal Space-Syntax movement axes; (b) integrating vegetation and shading devices with — rather than apart from — the movement network; (c) upgrading night lighting and operational maintenance, the two dimensions that emerged as weakest in the user evaluation; and (d) treating spatial enclosure, environmental support and operational quality as interdependent components of campus design.

Finally, the study acknowledges its limitations: environmental performance was assessed through spatial-configurational and perceptual indicators rather than through full thermodynamic simulation (PET / UTCI), and survey responses were temporally skewed toward morning use. Future research should validate the proposed framework across multiple campuses, couple it with micro-meteorological sensing or immersive VR-based walkthroughs, and extend it longitudinally to capture seasonal variations in hot–arid campus behaviour.

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Notation List

Table 8. Notation List.

Abbreviation / Symbol	Meaning
GIS	Geographic Information Systems
SPCI	Shaded Path Continuity Index
gamma	Connectivity index of the pedestrian network
alpha	Network redundancy index
Rn	Global integration value in space-syntax analysis
Cronbach alpha	Coefficient of internal consistency
rho	Spearman rank-order correlation coefficient
M	Mean
SD	Standard deviation
Q1-Q10	Survey variables used in the perception questionnaire
PET	Physiological Equivalent Temperature
UTCI	Universal Thermal Climate Index

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