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Nurturing Minds: Biophilic Campus Design for Comfort and Stress Reduction at Nizwa University

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Abstract Student connection to nature in an educational setting plays a vital role in nurturing their minds. This study examines the impact of biophilic design on the University of Nizwa's (UNIZWA) educational campus, located in Oman's arid and hot region. Currently, there is a rise in the student population, and the available biophilic infrastructure is insufficient to support this growing number of students. A connection to human nature is essential for maintaining a healthy balance in students' physiological, psychological, and sociological well-being, which in turn affects their academic performance. The three interconnected elements, Climate, Culture, and Context (3Cs) also influence human behavior; thus, this study explores how these elements shape student behavior. This research employed various methods to investigate challenges, analyze them, and develop design guidelines as strategies. These align with UN-Habitat's 3-30-300 formula and the UN Sustainable Development Goals (SDGs), contributing to addressing these challenges and providing solutions for educational campuses to foster healthy environments in arid regions. The methodology included in-depth questionnaire surveys, satisfaction level assessments, literature reviews, theories, and best practices that promote health-centric outdoor spaces to boost students' mental and physical well-being. Additionally, simulation-based thermal comfort assessments evaluated the impact of biophilic interventions such as tree canopies, vegetated facades, and green roofs on outdoor and semi-outdoor campus zones. This paper presents a model for a 3Cs-sensitive design framework that enhances student-centered, healthy spaces.

Keywords Student-Centric, Nature Connection, Biophilic, Physiological, Psychological, Sociological

Highlights

- Biophilic design: Incorporating nature into education enhances students' well-being, thereby boosting their academic performance.
- 3Cs impact: Climate, Culture, and Context shape student behavior and campus interaction.
- Sustainable design: UN 3-30-300 and SDGs guide nature-centric educational spaces in arid regions.

Abbreviations

- UNIZWA – University of Nizwa
- UN-Habitat – United Nations Human settlements program
- UNSDGs – United Nations Sustainable Development Goals.

Nomenclature

3Cs – Climate, Culture, Context

1. Introduction

Biophilic design incorporates natural elements into built environments to enhance connectivity with nature, promoting psychological, physiological, and social well-being. This research aims to encourage the use of vegetation, natural light, water features, and organic farms to create environments that reduce stress and improve cognitive performance. Studies have highlighted the effectiveness and importance of biophilic design in improving health and well-being. This study focuses on educational campuses and analyzes similar literature [1]. Joye discusses the psychological benefits of biophilic environments, while Salingaros highlights the role of biophilic patterns in sustainable design [2, 3]. These studies further emphasize the positive impact of biophilic design in educational spaces, suggesting that such interventions can improve focus, satisfaction, and academic productivity. The hot and arid climate of Nizwa has significantly impacted the social, academic, and campus life of students. This study aims to understand students' behavioral patterns in these conditions and analyze the adverse effects. Examples include physical exhaustion, unhealthy practices, heat-related illness, and mental health impacts. This research was conducted by a team of architecture students at the University of Nizwa on educational campuses. The idea of investigating biophilic components and stress factors affecting students emerged during brainstorming sessions in architectural classes, which aimed to understand the impact of built environments on human behavior. Students were encouraged to analyze how different spaces affect young minds in educational campuses and to identify what works well and what does not. This process generated a range of feedback, observations, and concerns. The majority of students highlighted the lack of connectivity between walkways, making it challenging to reach various destinations across the university. Some newcomers struggled with wayfinding, while others felt there were limited opportunities for outdoor recreational activities. The primary concern was the inadequate shading and green spaces, reflecting the harsh impact of Nizwa's hot and dry weather. Parking facilities were insufficient and lacked biophilic elements. Many students noted that relaxing spaces, such as cafes situated under the trees, provided some connection to nature. Indoor spaces, such as classrooms, labs, and libraries, depend on air conditioning and artificial lighting throughout the day and year. Visual connections to outdoor spaces from indoor areas are practically nonexistent, and sitting in outdoor areas is uncomfortable due to inadequate amenities and harsh climatic factors. These issues inspired the creation of nurturing spaces for students and other user groups to reduce stress levels. The students face numerous challenges, including study pressures, homesickness, extreme climatic conditions, and a lack of suitable spaces for physical activities, which ultimately lead to fatigue. The primary objective of this research is to create enhanced student-centric spaces by reimagining available areas with potential improvements to reduce stress. Case studies of well-known universities and their biophilic connections were examined. The team identified the types of biophilic interventions implemented in specific locations to enhance campus life, analyzed questionnaire surveys, and conducted direct discussions with students, teachers, and other user groups on campus. This highlighted how biophilic campuses can not only improve students' lifestyles but also aid in stress reduction. The findings highlighted the significant contribution of biophilic campuses to reducing stress and enhancing overall well-being. In this research, students conducted observational studies, interviews, and analyzed focus group surveys. By applying the theoretical framework to human responses in the natural environment, the students prepared health-focused design codes.

1.1. Research Objective

The research objectives are to promote a healthy atmosphere, focusing on the physiological, psychological, and sociological well-being of students, teachers, employees, and all other user groups on the university campus, as well as the broader society.

1.2. Research Gap

Natural elements such as native plants, shaded walkways, and water features play a crucial role in creating sustainable and comfortable environments [4]. However, despite these positive outcomes, notable gaps remain in the literature, along with a lack of comprehensive frameworks. Many studies focus on specific elements rather than adopting a holistic approach. Hence, more studies are required, especially in diverse cultural and geographical contexts and climates. Our research addresses these gaps by developing a comprehensive framework that integrates outdoor biophilic elements in response to the 3Cs.

2. Literature Review

The Health Enhancement Center at UNIZWA is dedicated to promoting holistic health, encompassing physical, mental, and social well-being, by creating environments that foster health. The center has determined that higher education institutions are among the best places to encourage healthy living and create safe environments for learning and working. According to the annual health report from the National Center for Statistics and Information, a Directorate General of Planning and Studies at the Ministry of Health in Oman, Omani youth aged 20–24 represent approximately 19% of the total population, with university students constituting about 19% of this group. Students spend up to seven years at university, often dedicating about a third of their day to campus activities. This extended presence helps them acquire healthy lifestyle behaviors and practices. Consequently, healthy environments are crucial for positively changing individual attitudes and behaviors, enhancing student health on campuses. Therefore, providing student-centric spaces and designated areas for physical activity that connect to nature is essential. Mental health problems and illnesses significantly affect students' educational achievements and daily lives. A survey conducted by the Health Enhancement Center at UNIZWA among higher education students revealed that 67.3% of female students and 70% of male students experience insomnia, 57.7% experience stress, and 52.8% suffer from depression.

In this study, the authors examined various case studies to understand how biophilic design can be integrated into educational campuses to create student-nature connections, which are essential for nurturing young minds and mitigating environmental stress. The findings reveal that providing outdoor play areas and recreation spaces within campuses enhances students' health and well-being. The North Stowe Healthy Living and Youth & Play Strategy [5] emphasizes the importance of accessible and engaging recreational spaces. The role of physical activity in health is well demonstrated in the Design Codes for Health and Wellbeing [6].

According to Aldawoud [7], the *Qatar Foundation campus* has successfully integrated biophilic design principles to create a sustainable environment that is comfortable for its users, even in a hot, arid climate, with improved thermal comfort. As a result, the campus is more livable [8]. Similarly, research at Qatar University reveals that the campus environment promotes well-being and natural cooling through the use of green roofs, vertical gardens, and shaded outdoor spaces [9]. In their research on *KAUST, the authors* demonstrate how the built environment and natural landscape were created through biophilic interventions, utilizing native plants, shaded walkways, and water features, thereby creating a sustainable and comfortable environment [10].

Other studies have highlighted the importance of connectedness to nature, self, and others through biophilic design principles in campus environments. In particular, Attention Restoration Theory (ART) [11] posits that exposure to natural environments helps restore cognitive resources depleted by directed attention in academic tasks. According to Kaplan and Kaplan, ART identifies four key components: being away (psychological distance from routine), extent (the richness and scope of the environment), fascination (effortless attention), and compatibility (the alignment of the environment with individual needs). In the context of this study, shaded walkways, green courtyards, and views of the Jabal Akhdar mountains are hypothesized to provide 'fascination' and 'being away,' allowing students to recover from academic stress mentally. The survey results (Table 2) and observational findings support the idea that students experience greater psychological restoration in areas with strong biophilic features, aligning with ART's predictions. By integrating ART more deeply into the analysis, this research demonstrates that biophilic interventions are not only aesthetically pleasing but also fundamental in supporting cognitive well-being and academic performance.

By adapting these findings to the specific cultural and environmental context of Nizwa University, this study proposes culturally relevant and environmentally sensitive biophilic interventions. The gaps in the literature reveal a lack of comprehensive frameworks and recommendations for campus design that incorporate nature holistically. This approach focuses on contextual, cultural, and climatic (3Cs) [12] situations. Hipp et al. [13] found that students exposed to greener campus environments reported higher levels of restorativeness and overall well-being. Their research supports the use of biophilic design as a tool for reducing stress and enhancing comfort in academic settings. The aim is to develop detailed design codes and principles to enhance the psychological and physiological well-being of students by improving mood and reducing stress, thereby promoting overall well-being.

Table 1 presents a comparative outline of global case studies that show how biophilic design strategies, ranging from shaded courtyards to green roofs, affect the students' well-being. The table integrates important findings, methodologies, and theoretical frameworks, highlighting consistent empirical evidence of reduced stress, improved cognition, and improved social connections across many different campus environments.

Table 1. Summary of Case Studies of Biophilic Design and their impact on Student Well-Being. (Source: Authors.)

Case Study	Key Findings	Methodologies	Theoretical Frameworks	Empirical Evidence
Study 1: University Campus A	Biophilic designs have improved students' attention and reduced their stress levels.	Surveys, interviews, and observational data	Kellert's Biophilic Design Principles [14]	Statistical data signifies a 20% reduction in stress levels.
Study 2: Residential College B	The natural environment has been shown to enhance cognitive functioning and parasympathetic activity.	Experimental design with control groups	Attention Restoration Theory [11]	The measured increase in cognitive test scores following the intervention.
Study 3: Urban Campus C	Biophilic interventions have fostered social connectedness and self-reflection.	Mixed-methods approach	Alexander's Pattern Language [15]	Qualitative feedback from students has reported improved social interactions.
American University of Sharjah, UAE	Shaded courtyards and native vegetation are enhancing relaxation and reflection.	Observational studies and student surveys	Biophilic Design Principles [16]	Students are reporting improvements in mental well-being.
Qatar Foundation's Education City, Qatar	Green roofs and indoor gardens are promoting cognitive restoration.	Case study analysis	Attention Restoration Theory [11]	Evidence is seen in reduced stress levels among surveyed students.
King Abdullah University of Science and Technology (KAUST), Saudi Arabia	Landscaped courtyards and water features have been shown to support mental well-being.	Mixed-methods approach	Kellert's Biophilic Design Principles [14]	The student's satisfaction with the campus environment has increased.
Masdar Institute of Science and Technology,	One can find shaded outdoor spaces and green walls.	Observational studies and focus groups	Biophilic Design Principles [16]	Feedback on improved social connectedness is positive.

3. Methodology and Data Collection

Undergraduate architecture students carried out this study at the old campus of Nizwa University, which covers 266,737 square meters and accommodates more than 6,000 students, over 80% of whom are young Omani women. Most female students live on campus, while some male and female students stay off campus. On average, day students spend 9 to 10 hours on campus each day. Temperatures range from a low of 8 ℃ in winter to 45 ℃ in summer, with the hot, dry climate lasting about seven to eight months annually. The campus is located at the base of the Jabal Akhdar mountains, offering scenic views of the surrounding peaks from different spots. Besides educational activities, the campus hosts public ceremonies, conferences, seminars, and workshops, attracting a diverse group of users.

The research used both qualitative and quantitative methods to examine the relationship between outdoor campus spaces, student behavior, and the status of biophilic connection. The analysis employs the 3Cs framework to evaluate how these factors impact student behavior and stress levels in relation to academic performance. Data were collected through survey questionnaires, observational and photo studies, focus group interviews, and case studies.

A questionnaire survey was conducted with various users, primarily focusing on students' responses. Two teaching staff members and four undergraduate students carried out the data collection and analysis. The questionnaire aimed to assess students' satisfaction with outdoor spaces; however, a limitation of this research is the evaluation of indoor spaces. The study concentrated on outdoor areas and movement corridors for detailed analysis, rather than indoor environments. Surveys and feedback were used to understand students' feelings about their comfort and stress levels. The methodology employed multiple approaches to evaluate student experiences and environmental factors on campus thoroughly. Data collection involved photographic surveys, observational studies, and questionnaires to assess stress and identify its contributing factors. Thermal comfort levels with and without biophilic interventions were analyzed, along with the assessment of human-nature connections. Various methods for improving these connections were explored. The study evaluated outdoor activities and time spent in nature, as well as daily movement patterns and the interconnectivity of spaces.

Additionally, simulation-based thermal comfort assessments were conducted using hypothetical EnergyPlus models to evaluate the effects of biophilic design interventions, such as tree canopy coverage, vegetated facades, and green roofs. These simulations analyzed temperature reduction, solar control, and internal heat gain mitigation across outdoor and semi-outdoor campus zones. This empirical evidence provided insights into how biophilic interventions can support students' mental health and well-being. The anticipated outcomes highlight the importance of nature-connected spaces in relation to academic performance, offering guidance for current design enhancements and future campus development.

Table 2. Summary of Questionnaire survey and responses on stress reduction in different spaces in the UNIZWA campus. (Source: Authors)

Space	Description	example	Focus group	Survey questions	Responses
Indoor Student Spaces	Areas within buildings designed for academic, social, or leisure purposes.	Classrooms, Labs, Study halls, Lounges, Common areas.	Students and Teachers	Do the indoor spaces incorporate natural elements such as Plants, Natural light, or Views of greenery?	Not at all.
Outdoor spaces	Open areas having interaction with nature and student-centric spaces.	Courtyards, Outdoor cafes, Seating areas, and bus stops.	Students and Teachers	How do outdoor spaces affect your relaxation and stress levels? What elements in outdoor spaces are attractive and inviting?	Although not very effective, it could be improved with the addition of more greenery and shaded seating.
Recreational spaces	Areas for physical fitness and leisure play activities.	Gym, Sports grounds.	Students and Teachers	Does engaging in physical and recreational activities help reduce stress levels? Do you have good, accessible recreational outdoor spaces?	Yes, it will reduce stress levels, but it is not readily accessible.
Relaxing spaces	There are quiet areas to relax or to study.	Student restrooms, indoor and open shaded regions.	Students	Are the relaxing spaces effective and comfortable for managing academic stress? What improvements would you recommend to make these spaces more effective in reducing stress?	More outdoor spaces with shaded and comfortable areas, featuring greenery, are required.
Pedestrian movement and corridors	Passageways for movement within the university campus.	Pedestrian corridors and passageways.	Students and Teachers	How does the design of movement corridors affect your stress levels? Do these spaces feel overcrowded, or is it efficiently designed?	The corridors don't connect all the designed blocks, creating confusion in wayfinding for new users.
Parking spaces	Designated zones for vehicular parking	Student/faculty parking lots.	Students and Teachers	How easy do you find parking spaces on campus? Does trouble finding parking raise your stress levels?	There is insufficient parking nearby for all the built-up spaces, and transitioning from parking to classrooms is challenging during the summer.

Table 2 presents a structured summary of the questionnaire responses from students and the Faculty of Unizwa, emphasizing the perceptions of stress reduction in different campus areas. The findings indicate that while recreational and relaxing areas show potential for stress relief, they prevent limitations in accessibility, greenery, and spatial connection; their full efficiency emphasizes the need for required biophilic interventions.

Availability and restrictions in green areas and outdoor spaces on campus play a key role in shaping student comfort, interaction, and general well-being. At Nizwa University, the contrast between spaces with and without biophilic elements is very much highlighted. Steel gazebos, lacking shade and thermal comfort, remain unused, while wooden sets under ripe trees naturally attract student collections. This scene emphasizes the importance of climate-responsive designs that integrate natural materials and vegetation. Cafes over the campus remain active regardless of their connection to nature, suggesting that social function can sometimes compensate for spatial limitations. However, gendered differences in outdoor use are apparent. Female students often gravitate towards areas that offer privacy and greenery, but these areas are underutilized by male students, highlighting the need for more inclusive and flexible outdoor environments. Female waiting areas near transport hubs are very dependent on artificial lighting and air conditioning, which creates a sensory connection to the surrounding landscape. These closed zones can be reimagined with shaded courtyards, filtered daylight, and native vegetation to promote a more restorative experience. The lack of diversity in outdoor environments, both in function and form, limits opportunities for informal learning, relaxation, and cultural commitment and reduces the vibrancy of campus life.

Table 3, as shown below, offers a detailed comparison of student-centric outdoor spaces that either lack or embrace biophilic designs. Spaces without green areas, shade, and thermal comfort, for example, intermediate corridors and poorly maintained courtyards, are largely inactive and underutilized. On the other hand, areas with wooden cover, natural seating, and thoughtful spatial layout show high engagement levels and reinforce the value of nature-integrated designs. However, poor wood selection and minimal landscape maintenance, especially during the peak months, can lead to research on thermal discomfort. Drying foliage and heating AC compressors destroy the sensory quality of outdoor zones, making them less appealing and less functional. To address these limitations, future design strategies should prioritize species choices that are suitable for dry climates, integrate passive refrigeration techniques, and create green areas with multiple users who support both academic and social activities.

Table 3. Illustrating Student-Centric Outdoor Spaces: An Analysis of Biophilic Connections and Green Space Availability and Limitations within the Campus of Nizwa University. (Source: Authors)

Connection Without or Limited Biophilia	Connection with Biophilia	Observation
		Unused seating and gazebos, with no consideration for thermal comfort or the natural environment, are uninviting to students. In contrast, the spaces with wooden seating under the trees are the most active and usable.
		Caf és with and without a student nature connection are active and usable despite differences in design. For the majority of female students, the available outdoor spaces with natural elements are used minimally by male students.
		Lack of variety in outdoor settings. The campus would benefit from diverse spaces offering a variety of activities to enhance inclusivity, engagement, and participation.
		The waiting area and restroom for female students rely on year-round air conditioning and artificial lighting, disconnected from outdoor spaces for privacy near transport hubs. The spaces between the buildings are poorly designed and rarely used. Trees dry out in summer, and AC compressors add noise and heat. Tree selection is crucial with minimal maintenance.
		

4. Analysis

This spatial imbalance disproportionately affects female students and those seeking quiet, restorative environments and limits their ability to handle academic stress effectively. Strengthening green infrastructure, thermal comfort, and sensory engagement on campus is crucial to promoting inclusion, wellness, and sustained student interaction. These findings indicate the urgent need to evaluate spatial distribution and user satisfaction to guide future design interventions. The following sections (4.1) are based on this by analyzing land use patterns, feedback from surveys, and navigation challenges on the campus to assess how biophilic connections and availability of green space form student experiences at the University of Nizwa.

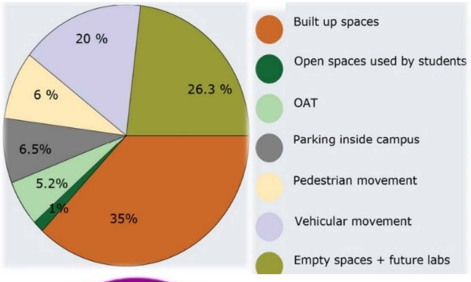
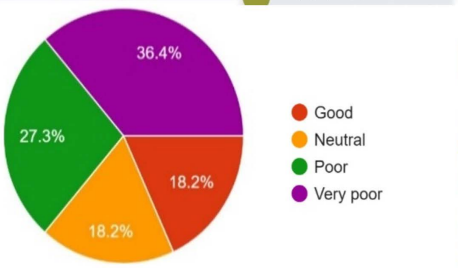
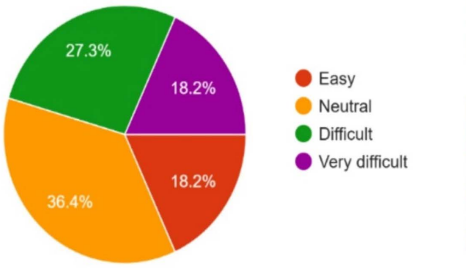
4.1. Land Use Analysis, Questionnaire, and Campus Navigation Survey

Table 4 shows that most outdoor areas on campus lack a strong connection to nature, making it difficult for students to enjoy a natural environment. Parking spaces are a frequent source of frustration, as many students report insufficient shade and inconvenient access, complicating their daily routines. Navigating the campus is also challenging due to poor connectivity, which increases stress as students move between different areas. Overall, the existing outdoor spaces fail to meet the standard required to foster a meaningful connection between students and the natural environment. Improving these areas with thoughtful planning and the addition of biophilic elements would create a more welcoming and functional environment for all.

4.2. Land Use Analysis, Questionnaire, and Campus Navigation Survey

As shown in Figure 1, the traced corridors for both vehicular and pedestrian movement highlight areas connected to and disconnected from natural elements. Figure 1 also identifies buildings that are isolated from shaded access and lack connectivity to these corridors. Supporting images further illustrate the impact of these design choices on accessibility and usability.

Table 4. Illustrating satisfaction levels with use of outdoor spaces: An analysis of Biophilic Connections and Green Spaces availability and limitations within the campus of UNIZWA. (Source: Authors)

Survey	Findings	Scenarios	
Land Use			The land use analysis reveals that only 1% of the total usable student-centric spaces are connected to nature. This falls below the required threshold for fostering a strong connection between students and natural environments.
Quality of Parking Space, Survey Responses		 	Survey findings show that 27% of students felt parking spaces are inadequate in terms of amenities and connectivity. These areas lack proper shading and present navigation challenges, making them less user-friendly for students.
Campus Navigation Insights: Survey Responses		 	Campus Navigation Survey Responses: 18.2% of respondents found navigating the campus difficult. And 27.3% reported that it was very difficult.

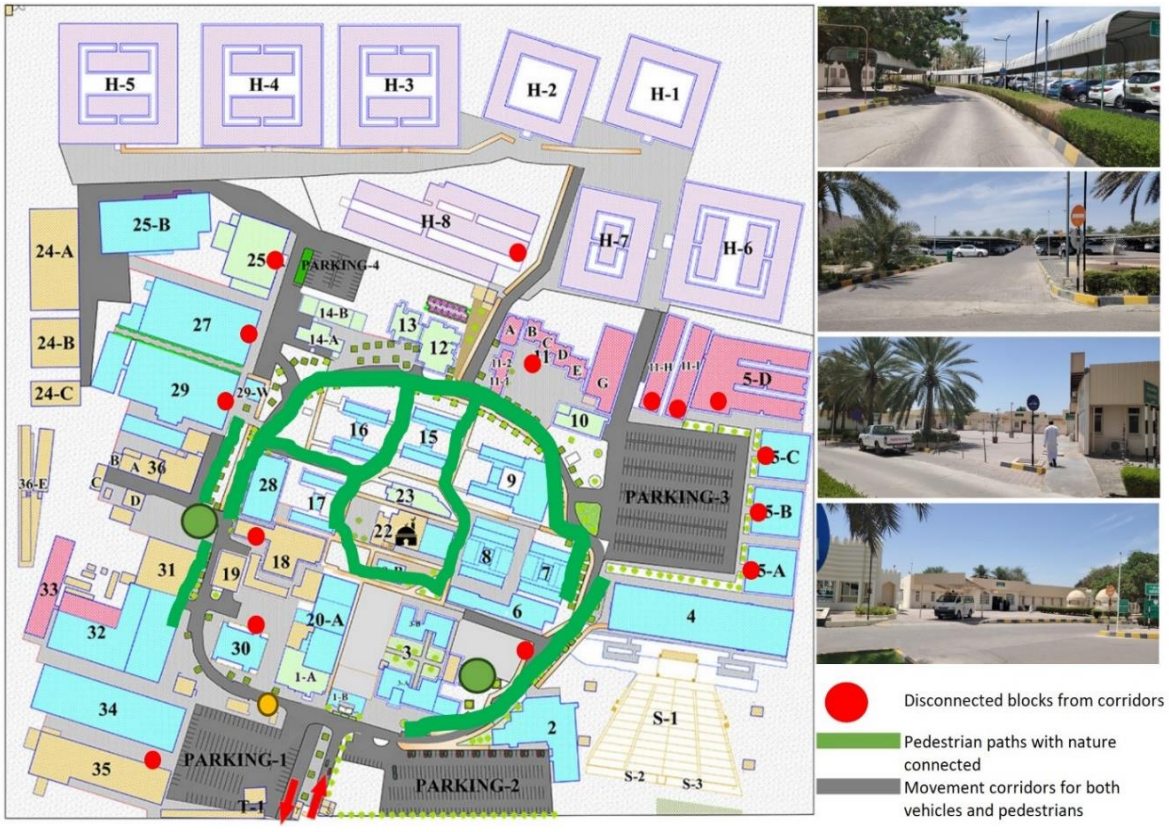


Figure 1. Movement Corridors and Building Connectivity Analysis. (Source: Authors)

Some campus paths are well-shaded and inviting, while others feel exposed and difficult to use, especially in summer. Buildings without shaded access make movement uncomfortable, and shared pedestrian-vehicular routes create safety concerns. Adding shaded walkways and greenery would improve accessibility, comfort, and overall student experience. Thoughtful design interventions can create a more inclusive and navigable campus environment.

4.3. Campus Locational Analysis

Figure 2 illustrates the spatial context of Unizwa's initial campus at Birkat al Mouz, situated between traditional date palm plantations and ancient falaj irrigation channels, which reflect the region's agrarian heritage. Its location at the base of Jabal Akhdar offers a dramatic natural backdrop, enhancing the campus's biophilic potential through visual connectivity with mountainous terrain and seasonal greenery.

4.4. Aligning with UN SDGS and UN-Habitat 3-30-300 Formula into Educational Campuses

Table 5 shows how biophilic designs at the University of Nizwa align with the UN-Habitat 3-30-300 formula and key UN SDGs. It emphasizes three nature-based strategies: visibility of trees from indoor rooms, 30% wood cover, and access to green areas within a 300-meter walk. These interventions support the student's well-being, improve sleep, reduce stress, and improve academic performance. Survey data confirms the positive effect of nature on mood, focus, and social interaction. The framework encourages climate-responsive planning, green infrastructure, and curriculum integration. Section 4.4 is based on this by proposing practical steps for the built-in biofile principles in campus design and policy.

Figure 3 highlights strategic improvements, including optimizing parking layouts to incorporate green buffers and reduce heat buildup, as well as enhancing pedestrian flow through shaded walkways that connect key academic zones. Clear wayfinding signs integrated with landscape features support easy navigation and create a more comfortable, climate-responsive campus experience.

Table 6 presents empirical findings and literature-based evidence supporting the 3-30-300 biofile design in campus environments. The evidence confirms that the visibility of trees from interior spaces correlates with reduced emotional stress and improved cognitive function, especially among female students. Thermal comfort simulations and field observations validate the role of tree cover in strengthening outdoor usability and mitigating heat stress. In addition, it has been shown that proximity to green areas within a radius of 300 meters promotes psychological well-being, social cohesion, and academic motivation. These correlations reinforce the scientific and practical relevance of biophilic planning in educational surroundings [22].

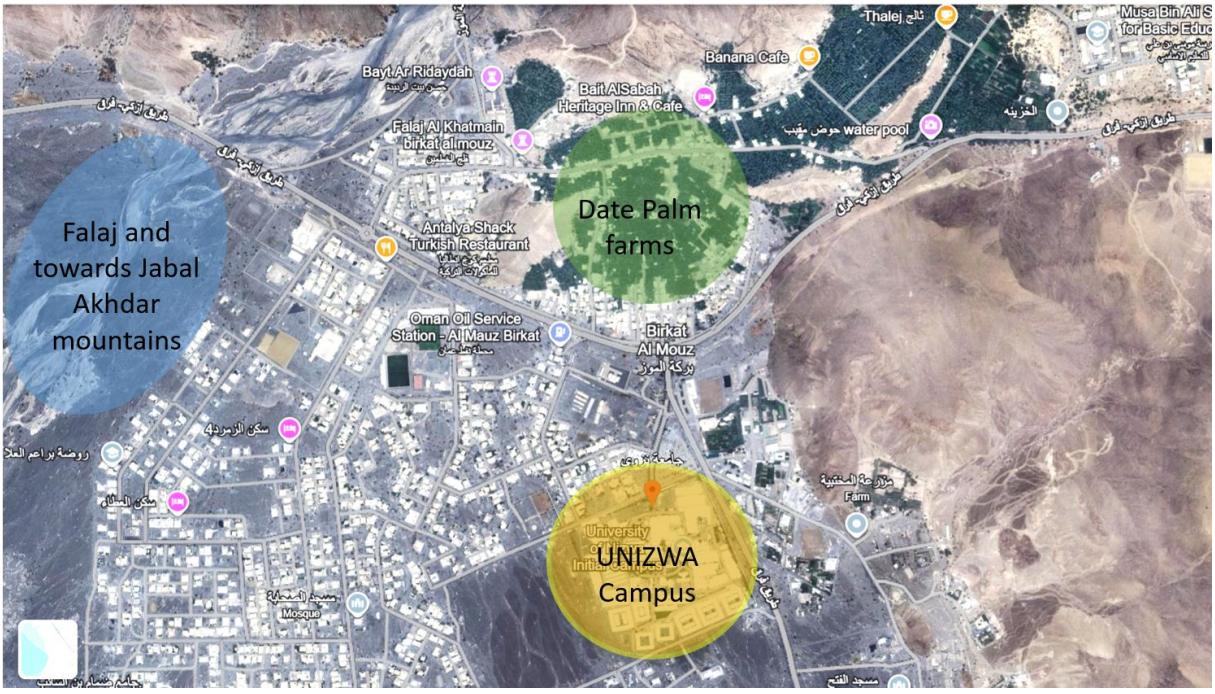


Figure 2. The spatial context of Unizwa's initial campus. (Source: Google Map)

Table 5. Illustrating the framework of Biophilic Design for the campus integrates the UN-Habitat's 3-30-300 formula and the UN SDGs, which have a measurable impact on students' well-being. (Source: Authors)

Biophilic Design 3-30-300 formula [12]	**Design Recommendation**	**Alignment with UN SDGs**	**Impact on students**	**Way forward and future implications**
3 Trees visible from all Interior spaces	*Enhance Nature visibility from Interior spaces:* All classrooms, labs, study areas, and workplaces should have visual access to view at least three trees through glass, openings, or windows, as well as courtyards [4].	*SDG – 3:* Good health and well-being *SDG – 4:* Quality education [7], [17] on nature–wellness correlations	Survey results showed that 67.3% of female and 70% of male students struggled with sleep; a lack of access to nature was a contributing factor. With the incorporation of green visual access, there is an improvement in mental health, academic learning, and cognitive performance [7]. A reduction in stress, anxiety, and insomnia [15], as well as increased focus and learning retention, can be expected [1].	Implement green building policies that prioritize visibility of nature. Standardize tree-view benchmarks in architectural guidelines. Embed nature-visual design principles across all campus typologies [11], [16].
30% Tree Canopy cover	*Increase tree plantations* on campus: Climate-responsive landscape design, rooftop gardens, vertical green walls, shaded walkways, organic farms, indigenous trees adapted to arid conditions [18].	*SDG – 11:* Sustainable cities and communities *SDG – 13:* Climate Action [15], [17]	Improvement in comfort level in outdoor spaces with improved microclimate encourages outdoor learning and awareness of the environment by the students [1], [6], [15].	Promote climate-responsive landscape designs and nature-based solutions on campuses, and advocate for ecosystem-based planning strategies. Develop green prints or green masterplan for every educational campus, Encourage faculty–student engagement in landscape stewardship initiatives [4], [13], [17].
Proximity to Green Space every 300-meter walk	*Incorporate nature-based solutions:* Parks, gardens, and shaded study areas within 300 meters proximity within the campus.	*SDG – 3:* Good Health and well-being *SDG – 4:* Quality Education *SDG – 11:* Sustainable cities and communities [6], [15], [20].	Strengthened peer interaction, physical activity, and social cohesion. Survey feedback showed improved mood and lifestyle awareness when green zones were accessible [6], [18], [19].	Biophilic Campus policies to be developed for all educational campuses, introducing nature-based design solutions in the curriculum to know the importance of sustainability [5], [13], [17], [20].

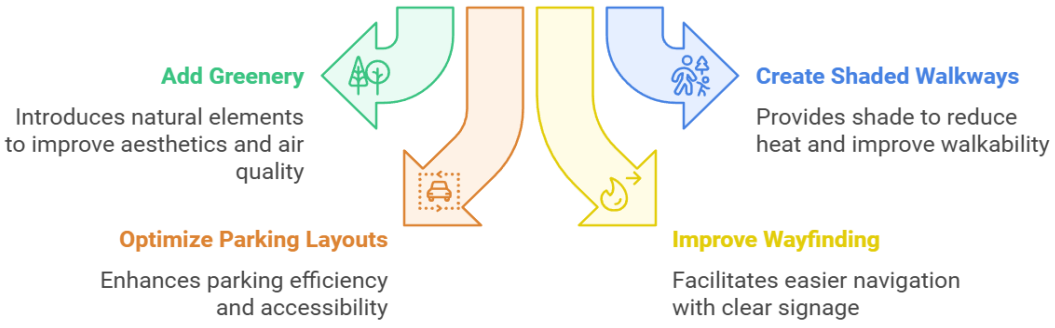


Figure 3. Illustrating how green infrastructure, shade, and mobility interventions can enhance the campus experience for students and staff. (Source: Authors)

Table 6. Empirical Evidence & Literature Discussion on the framework of Biophilic Design for the 3-30-300 [16]. Formula for Campus. (Source: Authors)

Biophilic Design Parameter	Correlation between evidence & literature analysis correlation
3 Trees Visible from Interior Spaces	Primary data collected from student surveys shows a high prevalence of sleep disturbances and elevated emotional stress, particularly among female student respondents (67.3% reporting insomnia). These findings align with research by Hipp et al. [13]. This establishes a correlation between perceived greenness and psychological restoration in campus settings. Additionally, Joye and van den Berg [1] suggest that affinity to nature may be genetically rooted, emphasizing the need to integrate visible greenery into educational environments to foster emotional resilience and cognitive functioning [19].
30% Campus Tree Canopy Cover	Field observations and thermal comfort assessments conducted using EnergyPlus simulations indicate that shaded outdoor spaces significantly enhance student engagement and usability during peak heat periods. These findings are consistent with Zhong et al. [18], who emphasize tree canopy cover as a pivotal strategy for mitigating urban heat. Aldawoud's [7] study on the Qatar Foundation campus similarly highlights the role of biophilic design in improving thermal regulation and spatial quality within arid urban contexts [8].
300m Walkable Access to Green Space	Survey responses showed that students who lacked regular access to nearby green spaces reported higher levels of mood instability and decreased motivation. These findings align with the existing literature by Marcus and Sachs [20] and Caughtry [19], both of whom argue that proximity to nature supports not only psychological well-being but also enhances social cohesion and academic performance. Spatial accessibility within a 300m radius appears essential for promoting restorative experiences and fostering inclusivity in campus design [21].

4.5. Simulated Performance of Biophilic Design Elements in Arid Nizwa Campus Contexts—Thermal Comfort Assessment Simulations

Simulation Summary 1: Tree Canopy and Outdoor Thermal Comfort

A hypothetical Energy Plus analysis, as shown in Figure 4, suggests that increasing tree canopy coverage to 30% in open courtyards across campus could reduce surface temperatures by approximately 6–8 ℃ during peak summer hours. Native species with broad foliage not only provide shading but also improve mean radiant temperature levels, contributing to comfortable microclimates in pedestrian corridors and informal outdoor learning spaces. This is also supported by the literature of Zhong et al. [23] and Salem & Sattineni [9].

Simulation Summary 2: Vegetated Facades and Green Roofs

Simulated models based on arid-climate precedents indicate that incorporating green roofs and vegetated facades, as seen in Figure 5, particularly on south- and west-facing elevations, can reduce internal heat gain by 12–15%. These vegetated surfaces act as thermal buffers, enhancing ambient comfort in semi-outdoor zones and decreasing cooling demand in adjacent academic spaces. Supported by Detommaso, M., Gagliano, A., Marletta, L., & Nocera, F [24], they highlight how green roofs and vegetated facades function as layered insulation systems, reducing thermal transmittance and helping buildings stay cooler in extreme climates. Hussein & Lambert [24] further emphasize that vegetation in hot, arid zones not only lowers air and surface temperatures through shading and evapotranspiration but also significantly improves thermal comfort in academic courtyards and semi-outdoor learning spaces. Together, these studies support integrating nature-based solutions as both climate-responsive and pedagogically supportive strategies in campus design.

Simulation Summary 3: Tree Placement and Solar Control

As shown in Figures 6 and 7, strategic placement of trees along courtyard edges and around building perimeters demonstrates optimized shading angles that block 40–60% of direct solar exposure between 10:00 and 16:00, aligning with the peak heat periods in Nizwa's summer climate. These results highlight the significant impact of tree orientation and species selection on both outdoor comfort and the performance of building envelopes. Yousefian S, Pourjafar M, Moshfeghi M, Mahdavinejad M. [25] emphasize that tree morphology and spatial configuration, such as staggered or continuous planting, can enhance shading effects by overlapping canopy coverage and decreasing radiative heat transfer. Similarly, Shabbir, N. K. D., Mahdavinejad, M., & Ghorbani, A. [26] advocate for species selection that balances canopy density with evapotranspiration potential, ensuring that shaded zones remain thermally comfortable while enhancing the passive cooling performance of adjacent buildings.

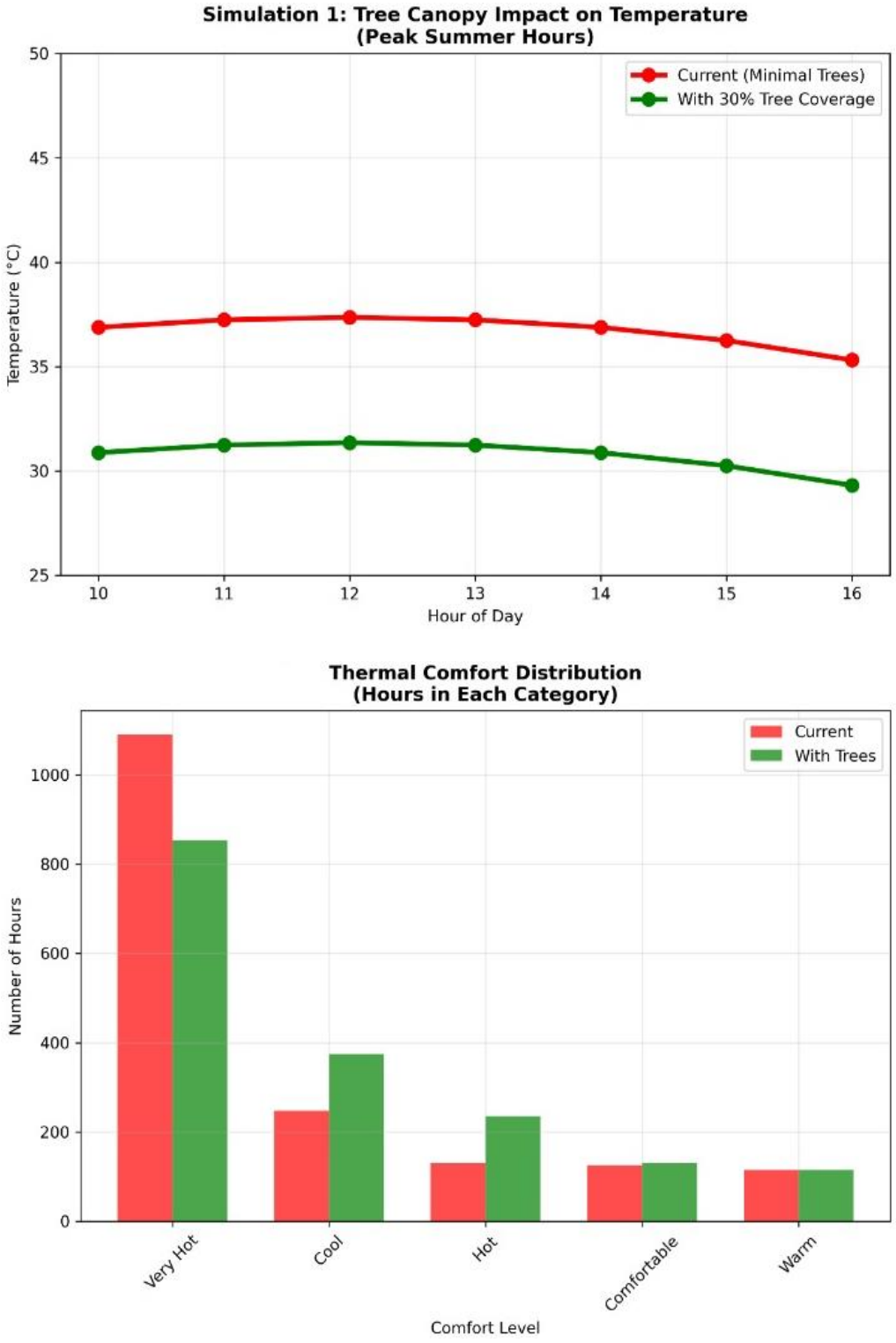
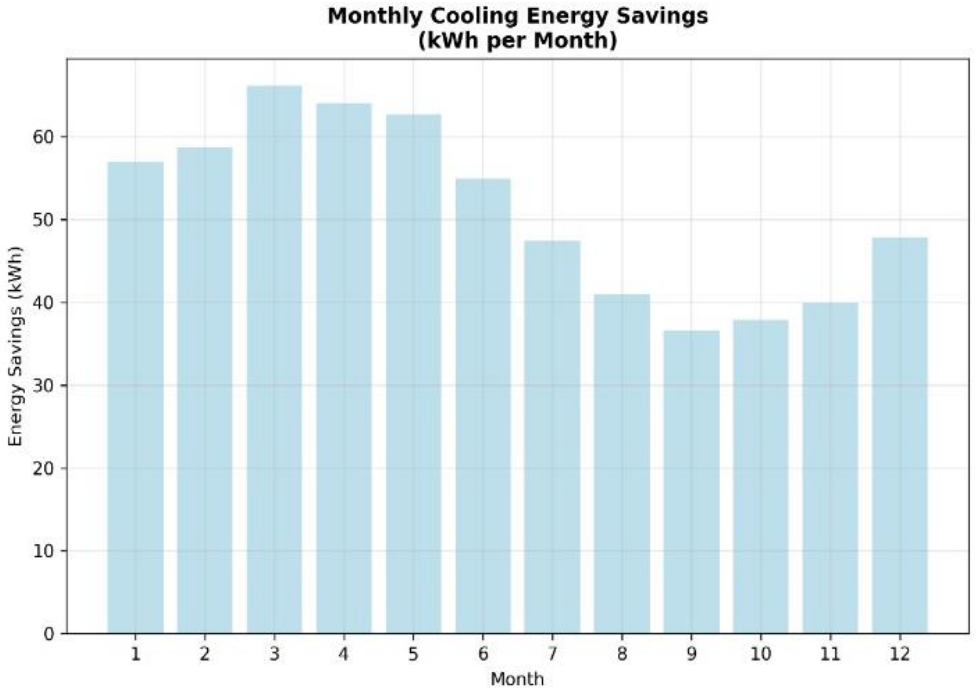


Figure 4. Simulations compare the heat gain and temperature reduction resulting from the implementation of biophilic interventions. (Source: Authors)

Figure 5. Illustrating green walls and green roofs in Arid climates. (Source: Google)



Figures 6. Another simulation comparing heat gain and temperature reduction with biophilic interventions. (Source: Authors)

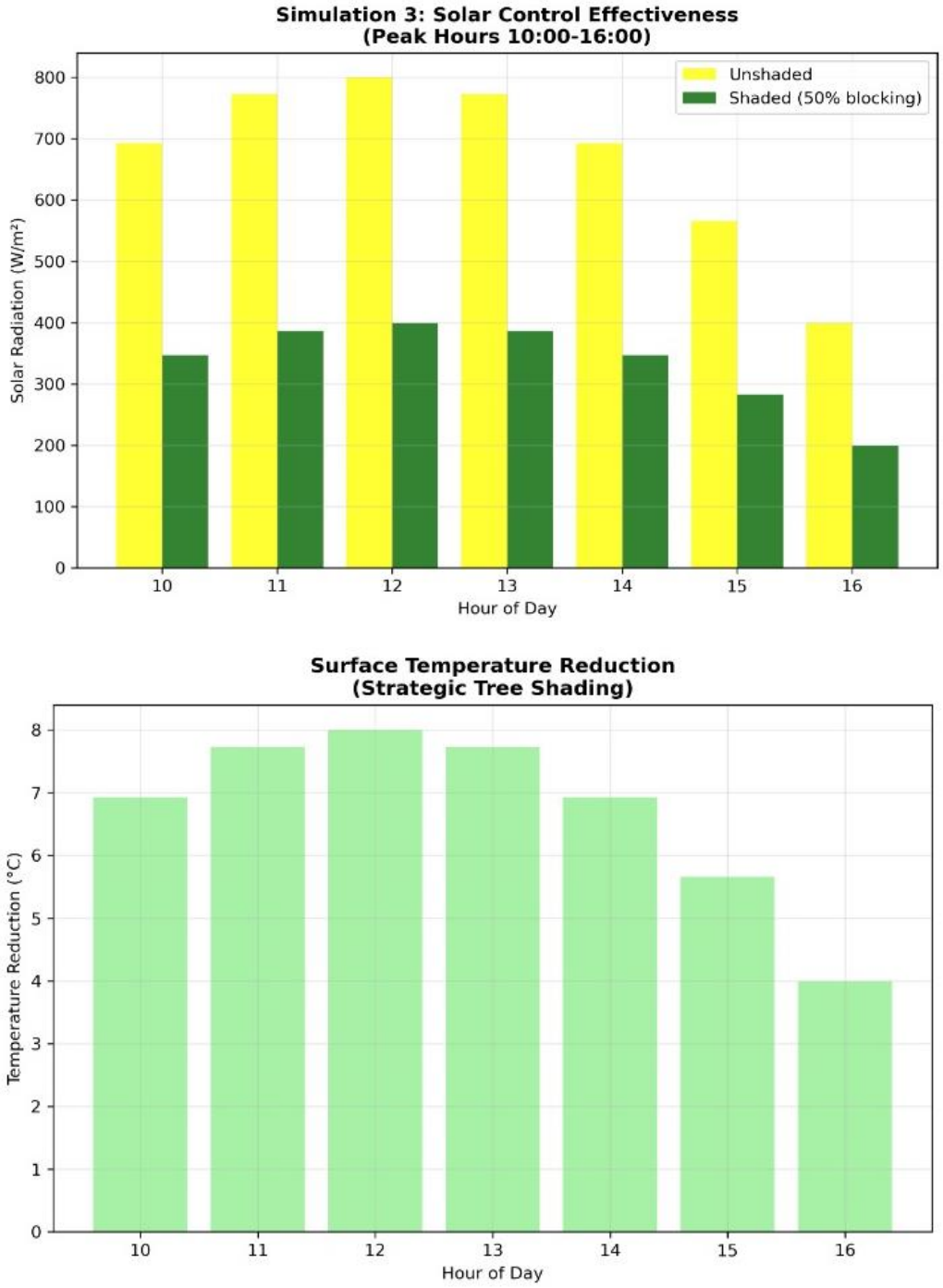


Figure 7. Displaying further simulation results comparing heat gain and temperature reduction with biophilic interventions. (Source: Authors)

This framework, as illustrated in Figure 8, shows how biophilic elements, such as shaded walkways, green courtyards, and interactive outdoor zones, can promote cognitive engagement, physical activity, and social interaction among students and faculty. By incorporating nature into daily campus experiences, the design encourages not only thermal comfort but also psychological well-being and collaborative learning. The spatial layout fosters movement between indoor and outdoor areas, reinforcing the campus as a lively, health-supportive environment [26], [27].

Table 7 analyzes biophilic campus design using the 3Cs framework—Climate, Culture, and Context—aligned with the UN SDGs and the 3-30-300 formula. Physiological benefits include improved air quality, thermal comfort, and physical health. Psychological impacts include reduced stress and improved focus, influenced by seasonal changes and a sense of affinity with nature. Sociological outcomes highlight stronger peer connections, cultural engagement, and improved campus life. The 3Cs guide inclusive, climate-responsive design that supports student well-being and sustainable development.

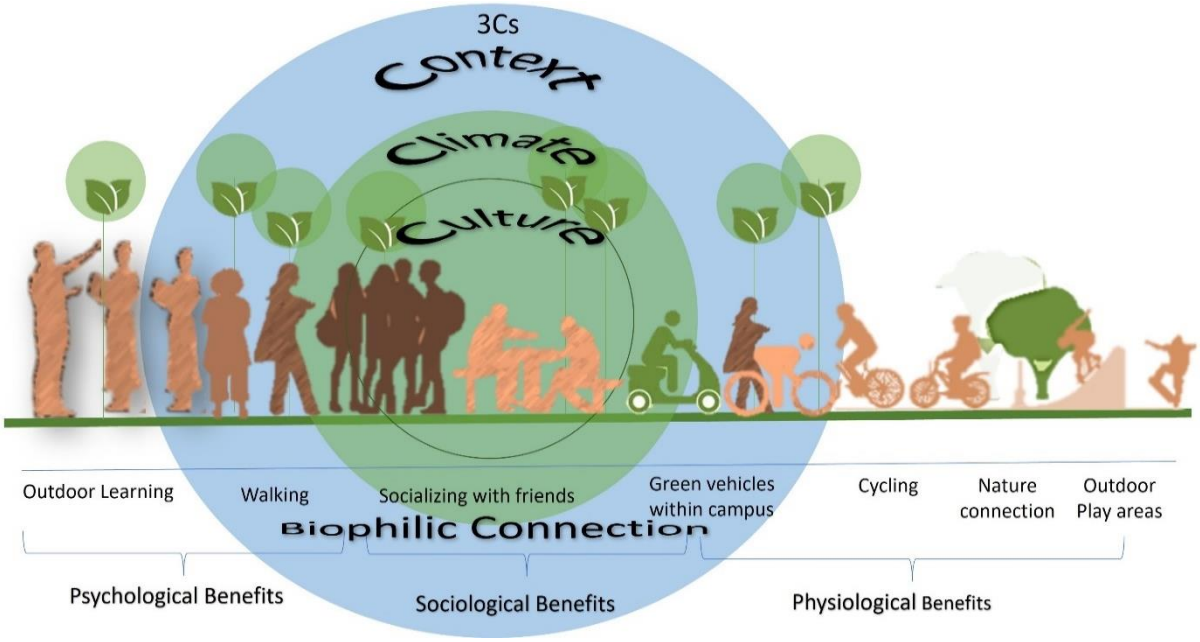


Figure 8. Summary of the relationship between nature, movement, learning, and social connection, providing a framework for biophilic campus design. (Source: Authors)

Table 7. Analysis with 3Cs, aligning with UN SDGs, and applying the UN Habitat 3-30-300 formula: Table showing the Analysis framework of the improved version of the biophilic campus with 3 Cs. (Source: Authors)

Dimensions	Focus	Impact on students	3Cs Connection
Physiological	Air quality, movement, green elements	Increasing outdoor activities, enhancing comfort, and improving physical health [15], [19], [26], [28].	Climate: Enhanced thermal comfort with green elements [6], [17], [24]. Context: Improved accessibility and spatial layout [4], [5], [13].
Psychological	Stress reduction, improved mental health, positive attitudes, and emotions	Improved ability to tackle the academic stress with positive moods and focus on performance levels. [19], [20].	Culture: Better attitudes toward nature, time spent connecting with nature [11], [21]. Climate: Seasonal changes can affect stress levels and mood, potentially impacting mental health [15], [17], [29].
Sociological	Social interactions, active participation, and engagement in cultural activities in green spaces contribute to innovative design [28].	Improved connections, collaborative learning, improved academic life [15], [17], [19], [30].	Culture: Enhanced social behaviors, confidence, and self-awareness; improved community engagement [12], [18]. Context: Comfortable environments lead to a good campus life, as indicated by the Green Campus Index [5], [13], [31], [32].

5. Discussion and Contribution to Literature

This paper examines how integrating biophilic design into educational campuses can enhance students' *physiological, psychological, and sociological* well-being, particularly in a hot, arid climate. As shown in Tables 3 and 4, the surveys and satisfaction analyses reveal significant gaps in the current campus design, including insufficient green spaces and poor connectivity. Figure 1 illustrates the spatial distribution of shaded and unshaded walkways, along with the conceptual framework that aligns with the UN-Habitat 3-30-300 guideline and the United Nations Sustainable Development Goals (SDGs).

Evaluating the findings in light of the literature, this study confirms prior evidence that nature-connected spaces reduce stress and improve student satisfaction [5, 15, 18, 21]. However, as described in Table 5 and Figure 4, the unique climate and cultural context of Nizwa present additional challenges that are addressed through the 3Cs framework (Climate, Culture, Context). The simulated performance results (see Figures 4, 6, and 7) demonstrate the thermal comfort benefits of increased tree canopy and green roofs, supporting UN SDG targets for health, well-being, and sustainable cities (SDG 3, SDG 11, and SDG 13).

This research contributes to the literature by:

- Providing empirical data on student preferences and stress factors in an arid educational setting (Tables 2, 3, and 4).

- Demonstrating, through simulation and survey, how biophilic interventions mapped to the 3Cs and UN SDGs can optimize campus comfort and sustainability (Figures 3 and 8, Tables 5, 6, and 7).
- Offering a transferable framework for similar arid-region campuses seeking to align with global sustainability and well-being agendas.

In summary, the discussion integrates quantitative and qualitative findings, accompanied by visual references to tables and figures. It explicitly aligns the campus design recommendations with the UN SDGs, thus providing a holistic and actionable contribution to the literature.

6. Conclusions

This study demonstrates that integrating biophilic design into the Nizwa University campus can significantly enhance students' physiological, psychological, and sociological well-being, particularly in Oman's challenging, hot, arid climate. Currently, the campus lacks sufficient green areas, shaded walkways, and natural connections to students, resulting in increased stress, discomfort, and a decline in academic performance among students. Survey results and observational studies indicate that students are seeking more accessible, shaded, and nature-connected spaces to relax, socialize, and engage in physical activity.

By aligning proposed design strategies with the UN Habitat 3-30-300 formula and SDGs, this paper provides a comprehensive framework for creating healthier, sustainable, and student-centric educational environments. The findings suggest that enhancing visual and physical access to nature, increasing tree canopy cover, and ensuring proximity to green spaces can reduce stress, improve mental health, and foster a stronger sense of community in campus life. To enhance student well-being in hot climates, campuses should adopt climate-responsive landscape design by integrating shaded walkways, courtyards, and native, drought-resistant trees to improve thermal comfort. Green roofs and vertical gardens help reduce heat and maximize green spaces without occupying extra land. Water features such as fountains and ponds contribute to a cooler microclimate while enriching the outdoor experience. Additionally, ensuring proximity to green spaces within 300 meters, in line with the 3-30-300 formula, fosters accessibility and strengthens the connection between nature and academic environments.

This study encourages the development of green master plans, climate-responsive landscape designs, and the integration of biophilic principles into campus policies and curricula. These steps are essential for nurturing student well-being and promoting sustainable campus development in hot, arid areas.

Ethics Approval and Scientific Research Permit

This study was conducted with the approval of the University of Nizwa's institutional ethics committee, and a scientific research permit was obtained before data collection.

Authorship and Contribution

- Adi Al Farei developed the research concept, conducted data collection and surveys, and contributed to the initial draft of the manuscript.
- Nasreen Kauser Dummi Shabbir provided guidance throughout the research, enhanced the final writing, served as the research supervisor and AI text validator, and ensured the technical integrity of the paper.
- Mohammed Faisal Ghazi Al Kazee edited the final manuscript, acted as the corresponding author, performed plagiarism and AI text validation, and ensured the technical integrity of the paper.

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Data Availability Statement

The data supporting the findings of this study include the draft manuscript, site pictures from the survey, the questionnaire survey form, and its results. These materials are openly available in Google Drive at the following link: https://drive.google.com/drive/folders/1SrhNocFxzEXxikbfBkuSYY9M5XteJ1ws?usp=sharing.

Conflict of Interest

The authors declare that they have no potential conflicts of interest concerning this research. There are no financial, institutional, or personal relationships that could be perceived as influencing the study's objectivity.

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