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Beyond Buildings: How Does Sustainable Campus Design Shape Student Lives? Hail University as a Case Study

Emad Noaime [1,*], Mohammad Alshenaifi [1], Ghazy Albaqawy [1], Mohammed Awad Abuhussain [2], Mohamed Hssan Hassan Abdelhafez [2,3] and Mohammed Mashary Alnaim [1]

[1] Department of Architectural Engineering, College of Engineering, University of Hail, Hail 55476, Saudi Arabia; m.alshenaifi@uoh.edu.sa (M.A.); g.albaqawy@uoh.edu.sa (G.A.); mm.alnaim@uoh.edu.sa (M.M.A.)
[2] Department of Architectural Engineering, College of Engineering, Najran University, Najran 1988, Saudi Arabia; maabuhussain@nu.edu.sa (M.A.A.); mo.abdelhafez@uoh.edu.sa (M.H.H.A.)
[3] Department of Architectural Engineering, Faculty of Engineering, Aswan University, Aswan 81528, Egypt
* Correspondence: e.noaime@uoh.edu.sa

Abstract: Sustainable campus design plays a vital role in shaping student well-being, academic performance, and institutional adaptability. This study investigates how sustainable design strategies influence student life at Hail University, Saudi Arabia, a campus located in an arid, culturally specific environment that presents unique spatial and climatic challenges. By integrating empirical observations, structured surveys (n = 1186), and semi-structured interviews, the research adopts a mixed-methods approach to examine three core dimensions: social life enhancement, environmental sustainability, and student-centric design. The methodology incorporates both descriptive and inferential analyses, including correlation, regression, and ANOVA, to evaluate the impact of design features on student satisfaction, engagement, and resource efficiency. Results show that a 10% increase in social infrastructure correlates with a 6.5% rise in student satisfaction. The study further identifies gaps in climate-responsive planning, green space utilization, and participatory design practices. It offers a replicable, context-sensitive framework for sustainable campus development that aligns with multiple UN Sustainable Development Goals (SDGs), contributing new insights to the global discourse on higher education environments in arid regions.

Keywords: sustainable campus design; student well-being; environmental sustainability; social engagement; climate-responsive architecture; higher education planning; Saudi Arabia; Hail University

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1. Introduction

University campuses operate as entities transcending mere educational facilities; they act as vibrant ecosystems that significantly influence the intellectual, social, and personal growth of students. Thoughtfully designed campuses enhance collaboration, promote well-being, and integrate sustainability principles, ensuring long-term resilience and inclusivity [1,2]. In an era of rapid global change, educational institutions must adapt to evolving societal and environmental demands [3,4]. Sustainable campus design has thus gained significant attention as a strategic approach to creating vibrant, efficient, and adaptable academic environments [5–7].

The development of university campuses worldwide faces unique challenges influenced by regional climatic, urban, and cultural factors [8,9]. In Saudi Arabia, these challenges are particularly pronounced due to the harsh climate, urban isolation of campuses,

and cultural considerations [10,11]. Extreme temperatures and limited rainfall restrict the usability of outdoor spaces, reducing opportunities for social interaction and community engagement [12,13]. Additionally, many Saudi universities, including Hail University, are located on the periphery of cities, limiting their connectivity with urban centers and contributing to student isolation [14]. Cultural norms, such as the need for gender-segregated spaces, add further complexity to campus planning, requiring design solutions that respect local traditions while fostering inclusivity and interaction [15,16].

Hail University serves as a compelling case study for these challenges. The campus exhibits spatial fragmentation, with disconnected academic, residential, and social zones that hinder student interaction and limit the formation of an integrated campus community. Outdoor spaces remain underutilized due to the extreme climate, while indoor environments struggle with energy inefficiencies and limited access to sustainable resources. The campus additionally demonstrates a deficiency in adequate social and cultural environments, thereby diminishing the capacity of students to participate in extracurricular engagements. Furthermore, weak transportation and mobility networks, coupled with barriers to accessibility, exacerbate students' sense of detachment. The resolution of these challenges necessitates a comprehensive and sustainable design methodology that harmonizes ecological, social, and economic factors.

While sustainable campus design has garnered considerable attention in global academic discourse, a critical research gap persists in its application within arid climates and culturally distinct environments such as Saudi Arabia. Prevailing international frameworks often fail to account for the specific climatic, socio-cultural, and institutional variables that shape design outcomes in these regions. This study addresses this overlooked dimension by advancing a novel, empirically grounded model for sustainable campus development tailored to the Saudi context. Using Hail University as a case study, the research not only tests the adaptability of global sustainability principles but also generates new theoretical insights into climate-resilient and culturally attuned campus design. By integrating environmental analysis, spatial functionality, and social behavior within a comprehensive methodological framework, the study contributes original knowledge to the field. It establishes a clear scientific foundation for understanding how design can mediate the challenges of extreme environments and socio-cultural expectations, thereby expanding the applicability and depth of sustainable design theory in higher education contexts.

Research Objectives

This study focuses on three key attributes of sustainable campus design:

- Enhancing Social Life—Examining how well-designed community spaces, recreational areas, and amenities contribute to student engagement and inclusivity;
- Promoting Environmental Sustainability—Assessing the role of green spaces, climate-responsive architecture, and resource efficiency in fostering ecological resilience;
- Strengthening Student-Centric Design—Evaluating how functional, adaptable, and technology-driven learning environments support academic and personal development.

By analyzing these dimensions, the research provides data-driven insights into the potential of sustainable, student-focused campus development. This study's findings contribute to the broader discourse on university planning and sustainability, offering a model that can inform policy recommendations and future campus development strategies.

Ultimately, this research highlights how integrating environmental, social, and technological advancements into campus design can transform universities into resilient, engaging, and sustainable academic ecosystems that support both educational excellence and student well-being.

2. Theoretical Framework

The theoretical framework for this research is fundamentally guided by Sustainable Development Theory, which advocates for integrating environmental, social, and economic dimensions into campus design. This theory emphasizes balancing current resource needs with long-term sustainability, ensuring adaptability to future challenges [17]. In the context of Hail University, sustainable campus design aims to create spaces that enhance the quality of student life while promoting environmental stewardship and economic efficiency. This driver establishes the foundation for holistic campus planning that prioritizes resilience and inclusivity.

Social Capital Theory serves as a key driver for enhancing social life on the campus. This theory highlights the importance of fostering connections, trust, and collaboration through shared spaces and activities [18]. Diverse amenities such as cafeterias, co-working spaces, and recreational facilities provide opportunities for social interaction, strengthening campus community ties. Additionally, events, workshops, and volunteer programs encourage active participation, aligning with the theory's emphasis on community-driven development. By leveraging social capital, campuses can create vibrant, inclusive environments that promote student engagement and belonging.

Environmental concerns within the framework are grounded in Ecological Modernization Theory, which promotes integrating technological and environmental advancements into design without compromising modern functionality [19]. This theory is particularly relevant for incorporating green spaces, renewable energy systems, and sustainable resource management on campus. At Hail University, shaded areas, native landscaping, and water-efficient designs not only mitigate harsh climatic conditions but also enhance the ecological health of the campus. This approach underscores the importance of environmentally conscious design in fostering a sustainable academic ecosystem.

The framework is further strengthened by Resilience Theory, which emphasizes the need for adaptive solutions to withstand and respond to environmental challenges [20]. For campuses in arid climates like northern Saudi Arabia, resilience-oriented strategies such as passive cooling systems, energy-efficient materials, and water-saving infrastructure are critical. These solutions enhance the campus's ability to remain functional and comfortable under climatic stress while ensuring long-term sustainability. Resilience Theory thus drives the adoption of climate-responsive designs tailored to specific regional challenges.

A fundamental catalyst for the development of student-centric environments is the Human-Centered Design Framework, which emphasizes the necessity of addressing the requirements, behaviors, and anticipations of users [21]. This approach advocates for designing functional, attractive, and adaptable spaces that cater to diverse student activities. Flexible study areas, multi-use spaces, and collaborative environments support academic and social engagement, fostering a sense of ownership among students. By prioritizing usability and inclusivity, the Human-Centered Design Framework ensures that campus spaces align with student aspirations and preferences.

The incorporation of technological advancements within campus architecture is informed by the Technology Adoption Model (TAM), which elucidates the mechanisms through which individuals comprehend and embrace technological innovations [22]. Intelligent campus solutions, including interactive kiosks, Wi-Fi access points, and energy-monitoring systems, significantly augment functionality and convenience for the student populace. These technologies not only improve campus operations but also contribute to sustainability by optimizing resource use. The TAM framework emphasizes the importance of adopting user-friendly and impactful technological advancements to meet modern demands.

Another critical driver of this framework is the Biophilic Design Theory, which advocates for integrating natural elements into built environments to improve well-being and productivity [23]. Natural environments, ample illumination, and aesthetically designed landscapes serve to integrate students with the natural world, thereby mitigating stress and improving psychological well-being.

Finally, the Continuous Improvement Model drives iterative development based on feedback and evolving needs [24]. This model emphasizes the importance of involving students in campus design decisions through surveys, focus groups, and suggestion platforms. By acting on feedback, Hail University can ensure its campus remains relevant and responsive to changing requirements. This model supports dynamic growth, adaptability, and ongoing enhancement of the student experience, creating a campus environment that evolves alongside its community. See Table 1.

Table 1. Theoretical frameworks for campus design.

Attributes	Main Theory
Enhancing Social Life	Social Capital Theory
	Place-Making Theory
	Behavioral Theory in Architecture
Promoting Environmental Sustainability	Ecological Modernization Theory
	Resilience Theory
	Biophilic Design Theory
Strengthening Student-Centric Design	Human-Centered Design Framework
	Technology Adoption Model (TAM)
	Continuous Improvement Model

2.1. Key Attributes for Sustainable Campus Design

The delineation of essential characteristics for sustainable campus design in this investigation is predicated upon an exhaustive examination of extant scholarly literature and exemplary practices within the domains of sustainable architecture, urban planning, and the advancement of higher education. Analogous inquiries concerning university campuses situated in arid and urban contexts have underscored the significance of social engagement, environmental sustainability, and student-oriented design as pivotal elements of an effectively functioning academic milieu. Research on sustainable university planning has demonstrated that enhancing community spaces, optimizing resource management, and integrating climate-responsive infrastructure significantly improve both student well-being and institutional efficiency. By analyzing case studies of leading sustainable campuses worldwide, as well as incorporating theoretical insights from ecological modernization, resilience theory, and human-centered design, this study builds on established knowledge to define a set of contextually relevant attributes for Hail University. The findings align with existing literature and contribute to the ongoing discourse on how universities can integrate sustainability-driven solutions tailored to their specific environmental and cultural contexts. See Table 2.

Table 2. Key attributes for sustainable campus design.

Campus Design Element	Criteria	Brief Explanation
Enhancing Social Life	Amenities: Diverse Services [25]	Cafeterias, co-working spaces, and retail outlets for interaction and convenience.
	Recreation: Entertainment Spaces [26–28]	Parks, sports facilities, and cultural hubs to encourage engagement and relaxation.
	Engagement: Community Activities [29,30]	Events, workshops, and volunteer programs to foster community and collaboration.
Promoting Environmental Sustainability	Landscaping: Green Spaces [31,32]	Shaded areas, native plants, and seating to enhance eco-friendliness and comfort.
Strengthening Student-Centric Design	Adaptation: Climate-Responsive Design [33–35]	Passive cooling, energy-efficient materials, and renewable energy for resilience to climate conditions.
	Efficiency: Resource Management [36,37]	Water-saving systems, waste recycling, and renewable energy sources for sustainability.
	Design: Attractive Spaces [38,39]	Functional lounges, study areas, and multi-use spaces for diverse student activities.
	Technology: Smart Integration [40,41]	Interactive kiosks, Wi-Fi hotspots, and energy-monitoring systems for modern campus functionality.
	Feedback: Continuous Improvements [42,43]	Student input-driven updates and enhancements to align with evolving needs.

2.2. Advancing Sustainability: Key Campus Design Criteria and SDG17

Sustainable campus design aligns with global priorities set by the United Nations Sustainable Development Goals (SDGs), with SDG 17 emphasizing partnerships to achieve sustainability objectives. By incorporating thoughtful design principles, campuses can serve as models of collaboration, innovation, and environmental responsibility [44]. Three primary campus design elements—enhancing social life, promoting environmental sustainability, and strengthening student-centric design—serve as key criteria for fostering vibrant and sustainable academic environments [45].

Enhancing social life is essential to creating inclusive and interactive campus communities [46]. Amenities such as co-working spaces, cafeterias, and retail outlets encourage collaboration and provide accessible gathering areas for students and faculty [47]. Recreational spaces and cultural hubs foster well-being and community building, promoting SDG 11 (Sustainable Cities and Communities) [48]. Volunteer programs and collaborative events strengthen partnerships within and beyond the campus, aligning with SDG 17 (Partnerships for the Goals) [49]. By prioritizing social engagement, campuses create dynamic environments that support both individual and collective growth.

Promoting environmental sustainability focuses on designing campuses that minimize ecological impact while enhancing resilience to climate challenges. Elements that respond to climate, including passive cooling systems, designs that prioritize energy efficiency, and the incorporation of renewable energy, are in harmony with SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action) [50]. Native landscaping, sustainable water management, and resource efficiency further contribute to biodiversity and ecological health, addressing SDG 15 (Life on Land) [51,52]. These practices ensure that campuses operate as environmentally responsible entities while creating comfortable, eco-friendly spaces for their users.

The enhancement of student-centered design necessitates the establishment of flexible and inclusive environments that address the requirements of varied student demographics. Functional lounges, study areas, and multi-use spaces promote SDG 4 (Quality Education) by fostering collaboration and engagement [53]. Smart technologies, such as interactive kiosks and energy-monitoring systems, enhance innovation and infrastructure, aligning with SDG 9 (Industry, Innovation, and Infrastructure) [54]. Feedback-driven updates ensure that campus environments remain responsive to evolving student needs, reinforcing SDG 11 (Sustainable Cities and Communities) through inclusive and adaptive design [55].

These campus design elements are interconnected and contribute to the holistic advancement of sustainability [56]. Enhancing social life strengthens community bonds, which are essential for fostering collaborative environmental initiatives. Environmental sustainability, consequently, fosters the health and welfare of the campus populace while safeguarding resources for subsequent generations. A design approach centered on students guarantees that these initiatives are specifically customized to address the requirements and anticipations of the constituents they intend to assist, thereby establishing an equilibrium between practicality and creativity [57].

By integrating these criteria, campuses can position themselves as hubs of sustainability and partnership. The alignment with SDG 17 highlights the importance of collaborative approaches, engaging stakeholders ranging from students and faculty to local communities and global organizations. This multi-stakeholder model ensures that campus sustainability efforts are not only effective but also widely impactful, contributing to shared global goals. See Table 3.

Table 3. Campus design elements aligned with key SDG goals.

Campus Design Attributes	Main Criteria (Key Words)	Alignment and Contribution	Relevant SDGs
Enhancing Social Life	Amenities, Recreation, Engagement	-Encourages collaboration through co-working spaces, cafeterias, and retail outlets.	SDG 11 (Sustainable Cities and Communities), SDG 17 (Partnerships for the Goals)
		Promotes community building and well-being through recreational spaces and cultural hubs.	
		Strengthens partnerships via volunteer programs and collaborative events.	
Promoting Environmental Sustainability	Landscaping, Climate-Responsive Design, Resource Efficiency	Supports climate action with energy-efficient designs, renewable energy, and passive cooling systems.	SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), SDG 15 (Life on Land)
		Enhances eco-friendliness with native landscaping and sustainable resource management.	
		Drives biodiversity and resilience by incorporating water-saving systems and greenery.	
Strengthening Student-Centric Design	Attractive Spaces, Smart Integration, Continuous Improvements	Provides inclusive, adaptable spaces for student collaboration and engagement.	SDG 4 (Quality Education), SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities)
		Advances innovation with interactive technologies and energy-monitoring systems.	
		Ensures adaptability by integrating feedback-driven improvements aligned with evolving student needs.	

2.3. Contextualizing Sustainable Campus Design in Arid Climates

Recent scholarly attention has increasingly focused on sustainable campus development in hot-arid environments, reflecting the urgent need to align higher education infrastructure with region-specific climatic and socio-cultural conditions [58–60]. Several

universities in the Middle East have pioneered initiatives aimed at integrating environmental performance with student well-being and institutional adaptability, offering valuable precedents for this study.

Qatar University implements passive design techniques by incorporating shaded arcades with water-efficient landscaping and wind corridors. The design elements improve microclimatic comfort while decreasing the need for mechanical cooling systems [61,62]. The King Fahd University of Petroleum and Minerals (KFUPM) in Saudi Arabia uses a compact building layout with pedestrian-friendly spaces to minimize heat exposure while promoting social interaction through solar-responsive surfaces and transitional areas [63,64]. Both universities prioritize sustainable architecture to enhance the overall well-being of students and faculty members, creating a more environmentally friendly campus environment. By utilizing these design strategies, they are able to reduce energy consumption and create a more comfortable atmosphere for all occupants.

The University of Sharjah developed design guidelines using Quality Function Deployment (QFD), which established thermal comfort, student accessibility, and activity-based spatial programming as priorities to align built form with behavioral insights [39,65]. The United Arab Emirates University (UAEU) campus demonstrates a more technology-integrated approach by implementing energy monitoring systems, green roofs, and interactive digital services to support a smart campus model [66,67]. Sultan Qaboos University in Oman combines vernacular planning logics with sustainable zoning, using shaded courtyards and axial circulation paths to achieve thermal regulation and spatial cohesion while preserving cultural identity [68]. These examples highlight the importance of incorporating sustainable design principles and technological advancements in campus planning to create comfortable and efficient learning environments. By blending traditional architectural elements with modern innovations, universities can not only enhance student well-being but also reduce their environmental impact.

Thus, the initiatives share a common goal to reduce climate severity and improve user experience, but they differ in their focus points, where some choose technological advancement (e.g., UAEU) and others select cultural design approaches (e.g., Sultan Qaboos University). The tendency to focus on physical and environmental metrics continues to dominate, while student-centered integrative planning models that address psychological comfort, social engagement, and inclusive participation in campus life remain underdeveloped [69]. This lack of emphasis on holistic student well-being may hinder the overall success of these initiatives in creating sustainable and user-friendly campus environments. By incorporating a more comprehensive approach that considers both physical and psychological needs, universities can better meet the diverse needs of their student populations and create more inclusive and supportive campus communities.

This research finds its place at the point where environmental requirements meet cultural characteristics. The research examines Hail University as a partially developed campus that operates within an arid region with distinctive social characteristics to develop a comprehensive framework that goes beyond energy performance and spatial form analysis. The research combines ecological modernization with human-centered design and social capital theories to assess how campus design creates a holistic impact on student satisfaction, academic productivity, and institutional sustainability. It presents a balanced and replicable model that links sustainable spatial planning with student experience through lived experience, which addresses an essential knowledge gap between practice and scholarship.

3. Research Design and Methodology

This research utilizes a mixed-methods framework to collect and scrutinize data concerning the socio-economic and environmental ramifications of campus architecture at Hail University. Both primary and secondary methodologies for data acquisition are employed to facilitate an exhaustive comprehension of the topic at hand.

3.1. Case Study: Hail University Campus

Hail region is situated in northwestern Saudi Arabia. Ha'il serves as the capital and largest city of the Ha'il Region, with a population of approximately 498,575 as of 2022. Nestled between the Aja and Salma mountain ranges, the city is renowned for its agricultural productivity, particularly in the cultivation of grains, dates, and fruits, significantly contributing to the kingdom's wheat production. Historically, Ha'il prospered as a pivotal stop on the camel caravan routes during the Hajj pilgrimage. The city is also celebrated for its association with Hatim al-Tai, a legendary figure famed for his generosity, and serves as the ancestral home of the Rashid royal family. These elements collectively underscore Ha'il's rich cultural heritage and its strategic importance within Saudi Arabia [70]. See Figure 1.

Figure 1. Saudi Arabia and Hail Province. Source Maphill. "Physical Location Map of Hail". Maphill, www.maphill.com/saudi-arabia/hail/location-maps/physical-map/. Accessed 25 April 2025.

Hail University, established in 2005 it is located in the northern region of Saudi Arabia. The principal campus of the university encompasses an area of roughly 8 million square meters and accommodates a varied assortment of academic colleges, comprising Medicine, Engineering, Business Administration, and the Sciences. In addition to academic facilities, the campus features residential accommodation for faculty members and various service buildings that are currently under construction.

Beyond the main campus, the university operates additional educational complexes. The Women's Colleges Complex in the Aja neighborhood encompasses 14 colleges, 9 supporting deanships, and administrative offices dedicated to female students, covering an area of about 327,000 square meters. Previously, the Men's Colleges Complex on the Baqaa Road included faculties such as Education, Arts and Humanities, and Sharia. However, in December 2022, these faculties were relocated to the new university city, and the Baqaa complex has since been repurposed to host sports facilities, including football, handball,

and basketball courts. The university has also introduced investment opportunities in this complex, such as establishing a driving school.

The Hail University aims to consolidate all its colleges within the main campus upon the completion of ongoing construction projects. This strategic move is intended to foster greater integration among various disciplines and to provide a modern educational environment that supports research and innovation. See Figure 2.

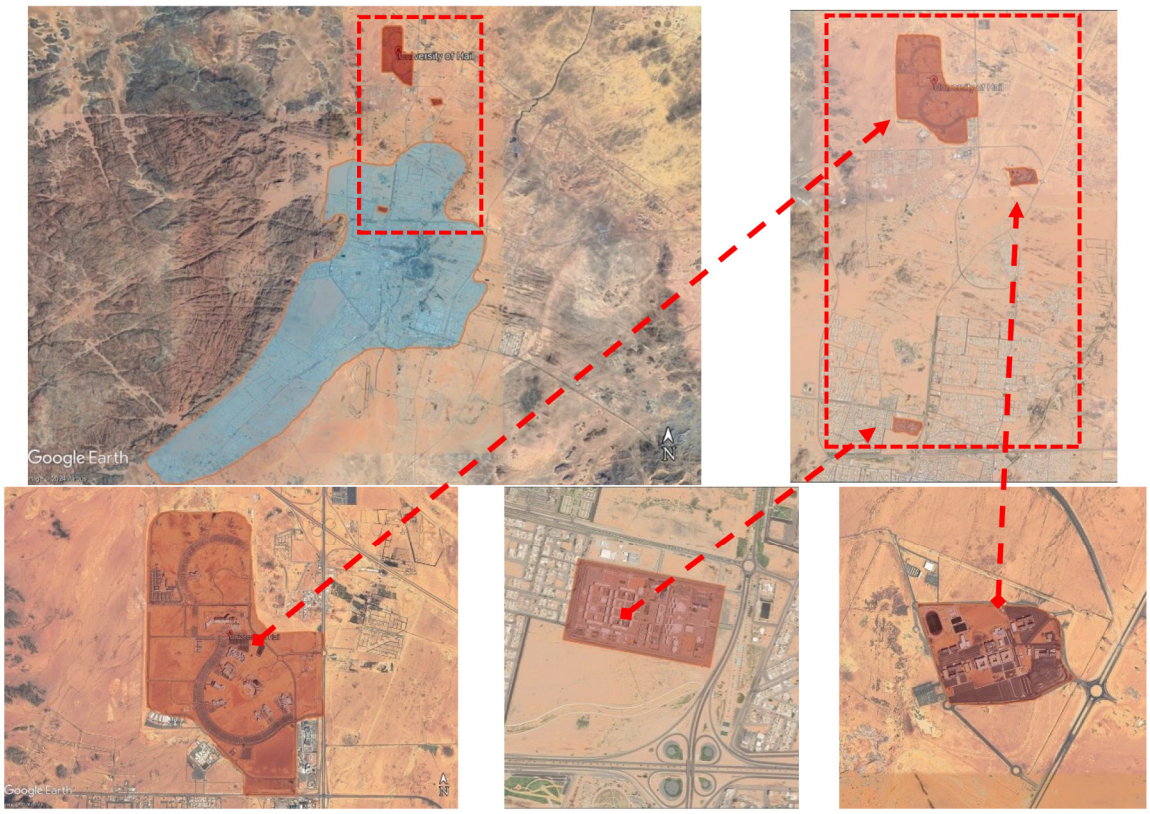

Figure 2. Different sites of Hail University against the background of Google Earth. Map illustrating three campus locations: (1) the main permanent campus situated at the top, serving as the primary academic and administrative center; (2) the men's temporary campus located on the middle right, accommodating male students during the transition period; and (3) the women's temporary campus positioned at the bottom, designated for female students during the interim phase.

Our research focuses on the main campus (see Figure 3), designed to accommodate all colleges and services. Currently, it is partially operational and remains under construction. This educational institution is designed to accommodate no fewer than 50,000 learners, 2000 academic personnel, and an essential complement of 200 administrative professionals.

The Hail University campus faces significant sustainability challenges due to its extensive horizontal layout and building density below 20%. This low-density configuration leads to increased maintenance and development costs, especially under the region's harsh climatic conditions. The sprawling design results in higher energy consumption for heating and cooling, as buildings are more exposed to external temperatures. Additionally, the vast distances between facilities necessitate greater transportation resources, further escalating operational expenses. Tackling these concerns is imperative for advancing the environmental and economic sustainability of the campus.

Figure 3. Main site of Hail University campus. Since the commencement of the Hail University campus construction in 2005, only about 40% of the master plan has been completed. This significant delay highlights the complexities inherent in large-scale construction projects, where evolving economic conditions and shifting priorities over time can substantially impact progress. Fluctuations in economic factors, such as oil price volatility, directly influence funding availability, leading to project slowdowns or redesigns. Additionally, changes in leadership or strategic objectives can result in the reallocation of resources, further affecting timelines. The Hail University experience underscores the necessity for adaptable planning and robust project management to navigate the dynamic challenges of long-term construction endeavors.

3.2. Data Collection Methods

To evaluate campus design elements based on specified criteria, a multi-method approach integrating observations, surveys, and interviews was employed. This triangulated methodology offered a comprehensive perspective, balancing direct physical assessments with user perceptions and expert insights, ensuring robust and nuanced evaluations of the campus environment.

3.3. Observations

Over a three-month period, observational research was conducted three times a week during peak university hours (10 AM–2 PM) to assess campus design elements related to social life, environmental sustainability, and student-centric spaces. This study monitored the use of cafeterias, co-working spaces, and retail outlets, evaluating crowd density, seating availability, and student interactions. Recreational areas, including parks, sports facilities, and cultural hubs, were observed for accessibility and engagement levels, while community activities such as workshops and events were assessed for participation and social impact. Green spaces, shaded seating, and landscaping were analyzed for their role in comfort and sustainability, along with climate-responsive features like passive cooling and renewable energy sources. Resource management practices, including recycling and water conservation, were examined for efficiency and student compliance. Additionally,

study lounges, smart technology features such as Wi-Fi and interactive kiosks, and student feedback-driven improvements were evaluated for their role in enhancing academic and social experiences. These observations provided valuable insights into campus functionality, sustainability, and student engagement, guiding recommendations for optimizing campus spaces to better meet student needs and promote an interactive, eco-friendly, and student-centered environment.

Briefly, Observations were carried out at various zones on campus (academic buildings, green spaces, recreational facilities, common areas) during peak student hours. The checklist included the following items:

- Frequency and type of student use in social spaces;
- Condition and accessibility of green areas;
- Presence of climate-responsive design elements;
- Evidence of smart infrastructure and signage;
- Student engagement in on-site events or gatherings.

The observation checklist focused on key indicators aligned with the study's framework (enhancing social life, promoting environmental sustainability, and strengthening student-centric design). Photographic documentation and field notes were used to support qualitative assessment and triangulate findings from the questionnaire. These systematic observations ensured that the analysis was grounded in actual user behavior and environmental response. They also provided a critical empirical basis for validating the study's conclusions and comparative insights.

3.4. Surveys

A total of 1186 individuals participated in the survey, including 537 students, 560 faculty members, and 89 staff members, to assess satisfaction with key campus design elements. It included Likert-scale questions for quantitative evaluation and open-ended responses for qualitative insights, distributed both online and on-site. The study focused on enhancing social life, promoting environmental sustainability, and strengthening student-centric design, ensuring alignment with evaluation criteria. Among students, all were aged 20–30, with 516 Saudis and 21 non-Saudis. Faculty members represented diverse age groups, with female faculty primarily between 31 and 50 years and male faculty more evenly distributed across 20–51+ years. Staff members were mostly aged 31–50, with 73 Saudis and 16 non-Saudis. Participants rated the accessibility and effectiveness of campus amenities, entertainment spaces, community activities, green spaces, climate-responsive design, resource management, and technology integration. These responses provided valuable insights into user experiences, revealing areas for potential improvement in campus facilities and services. See Table 4 and Figure 4.

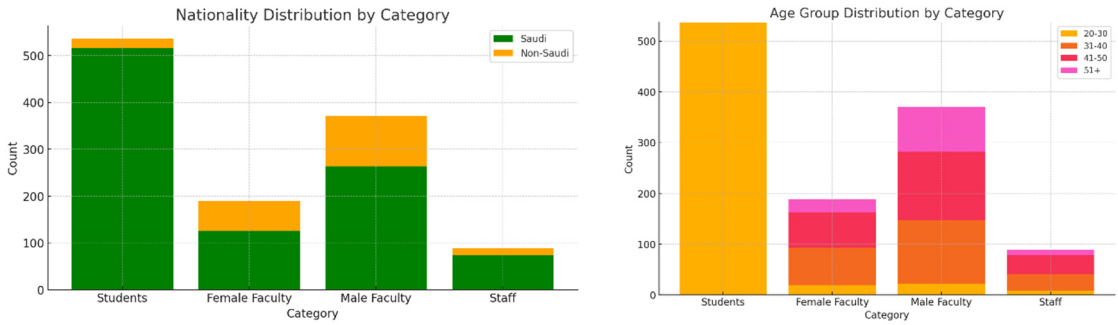

Figure 4. Survey sampling: This figure shows participant demographics to illustrate the scope and structure of data collection.

Table 4. Key campus design elements and evaluation criteria.

Campus Design Element	Criteria	Survey Keywords	Survey Question
Enhancing Social Life	Amenities: Diverse Services	Cafeterias, co-working spaces, retail outlets, student interaction	Are there enough on-campus services (cafeterias, retail outlets, co-working areas) that support daily student needs and foster social interaction?
	Recreation: Entertainment Spaces	Parks, sports facilities, cultural hubs, relaxation, engagement	To what extent do you feel that available recreational areas (e.g., sports facilities, parks, cultural spaces) enhance your campus life?
	Engagement: Community Activities	Volunteer programs, workshops, student events, collaboration, participation	How often do you participate in student events, workshops, or volunteer programs organized on campus?
Promoting Environmental Sustainability	Landscaping: Green Spaces	Shaded areas, native plants, seating, eco-friendliness, outdoor comfort	Do you find the availability and design of green and shaded outdoor areas to be sufficient and comfortable?
	Adaptation: Climate-Responsive Design	Passive cooling, energy efficiency, renewable energy, insulation, ventilation	Are campus buildings adapted to the local climate through features such as passive cooling or energy-efficient systems?
	Efficiency: Resource Management	Water conservation, waste recycling, solar energy, sustainability, resource use	Are you aware of sustainability initiatives on campus, such as recycling, solar energy use, or water conservation measures?
Strengthening Student-Centric Design	Design: Attractive Spaces	Study lounges, functional spaces, comfort, accessibility, modern design	Do study areas and communal spaces provide a comfortable, modern, and accessible environment?
	Technology: Smart Integration	Wi-Fi, interactive kiosks, digital screens, energy monitoring, smart campus	Is the integration of technology (e.g., Wi-Fi coverage, smart boards, digital signage) adequate for your academic and daily needs?
	Feedback: Continuous Improvements	Student input, campus updates, satisfaction, responsiveness, adaptation	Have you seen evidence that student feedback has led to tangible improvements in the campus environment?

3.5. Semi-Structured Interviews

The interviews provided in-depth qualitative insights from key stakeholders, including university administrators, faculty, and student representatives, regarding campus design elements. Semi-structured interviews explored themes such as planning processes, existing challenges, and opportunities for improvement. The research encompassed a total of 10 students, 6 female educators, 12 male educators, and 6 personnel members. Among students, all were aged 20–30, with 8 being Saudi and 2 Non-Saudi. Female faculty members ranged across age groups, with 2 Saudi and 4 Non-Saudi participants. Male faculty members were more diverse in age, with an equal split of 6 Saudi and 6 Non-Saudi respondents. Staff participants included 6 Saudis, primarily aged 31–50.

Stakeholders shared their perspectives on enhancing social life, responding to questions such as: Are there enough cafeterias, co-working spaces, and retail outlets to support student interaction and convenience? And what improvements would you suggest to enhance student social spaces? Additionally, participants evaluated the adequacy of sports and cultural facilities, addressing whether they meet student needs and suggesting new recreational or cultural spaces that could improve engagement. Community participation was also examined through questions like, Are there enough opportunities for students to participate in volunteer or community initiatives? And what barriers, if any, limit student participation in social and community engagement activities?

For promoting environmental sustainability and strengthening student-centric design, interviewees assessed green spaces and shaded areas, responding to the following: Do you think the campus provides enough shaded and green spaces for comfort? And how could the university improve its landscaping to support sustainability? Discussions on climate-responsive design focused on the following: Do you feel the campus infrastructure is designed to handle extreme weather conditions effectively? And how could the university improve its efforts in energy efficiency and passive cooling? Administrators and faculty also evaluated resource management efforts, addressing the following: Are there visible efforts by the university to promote water conservation and waste recycling? And how can the university improve in terms of renewable energy integration? Regarding student-centric design, interviewees provided feedback on study lounges, smart technology integration, and campus responsiveness to student input, answering the following: Do you feel there are enough well-designed spaces for studying and social activities? And do you feel the university takes student feedback into account when making improvements? Their responses highlighted key areas where enhancements could better support academic and social needs. See Figure 5.

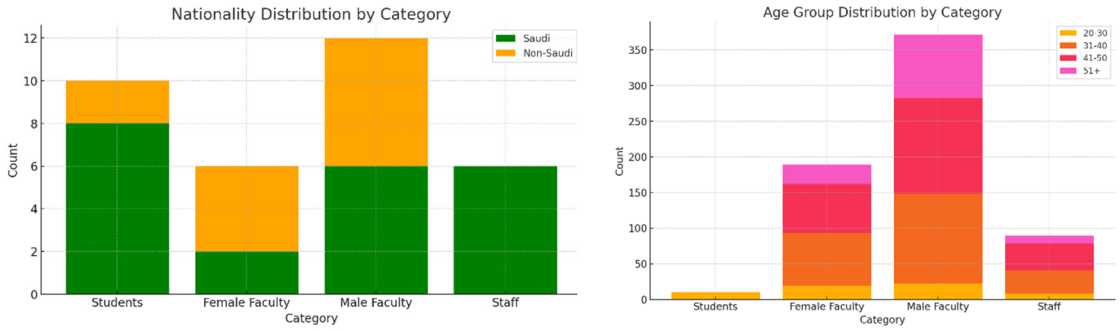

Figure 5. Interview sampling: This figure presents participant demographics to illustrate the structure and scope of the interview process.

3.6. Data Analysis Methods

This study employs both quantitative and qualitative data analysis methods to comprehensively examine how sustainable campus design influences student life at Hail University. Quantitative analyses, including descriptive statistics, correlation, and regression analyses, summarize and quantify relationships between campus amenities, environmental responsiveness, and student outcomes such as social interaction, academic productivity, and resource use efficiency, guiding targeted sustainable interventions. Qualitative methods, such as thematic and narrative analyses, provide deeper insights into individual experiences and perceptions, capturing nuanced understandings of how campus design shapes daily life. Comparative analysis across campus zones highlights specific strengths and weaknesses of design elements. To ensure reliability and validity, qualitative findings undergo inter-rater reliability checks, member checking, and triangulation across multiple data sources, ensuring comprehensive and credible research outcomes.

The Chiffre Evaluation uses a normalized scoring index (0–100%) based on weighted average ratings derived from Likert-scale survey responses, triangulated with observational and interview-derived scores. Each key criterion was scaled to a 100-point system for comparative visualization, where thresholds for low (0–39%), moderate (40–69%), and high (70–100%) performance were established. This approach allowed for standardized representation of qualitative and quantitative findings across different evaluation dimensions

In addition to descriptive statistics, this study employs inferential analysis to assess the broader applicability of the findings and determine statistically significant relationships between campus design variables and student experiences. Correlation analyses are used to investigate the magnitude and direction of associations between key variables. Multiple regression analysis quantifies the predictive value of specific design elements, such as climate-responsive features or smart technologies, on student satisfaction levels.

The use of an ANOVA (Analysis of Variance) was critical in comparing mean differences in energy usage and efficiency across different functional zones of the campus (e.g., academic buildings, administrative areas, student housing). A one-way ANOVA test revealed statistically significant variation in energy consumption between campus zones ($F = 4.62$, $p < 0.01$), indicating spatial disparities in resource efficiency tied to design and operational factors. These results are discussed in Section 6 under the heading "Promoting Environmental Sustainability".

Logistic regression was used to predict the likelihood of students reporting high academic satisfaction based on exposure to certain sustainable design features. A binary logistic model was developed where the dependent variable was a dichotomous outcome (high vs. low satisfaction). The model showed that students with access to technologically integrated and environmentally responsive learning environments were 1.8 times more likely to report high academic satisfaction ($p < 0.05$), demonstrating the statistically significant influence of physical and digital design variables on user experience.

Structural equation modeling (SEM) was also employed to investigate the causal pathways between latent variables, such as social engagement, environmental comfort, and academic productivity, revealing strong standardized regression weights (e.g., $\beta = 0.42$, $p < 0.001$) that support the theoretical framework. These combined methods ensure that the study's findings extend beyond surface-level observations, offering robust, evidence-based insights into how sustainable campus design shapes student life at Hail University.

3.7. Verification of Reliability

To verify reliability, findings from observations, surveys, and interviews were cross-validated through triangulation. This involved comparing results across sources for consistency. For instance, if a design element like shaded pathways received similar evaluations from observations and survey data, it was deemed reliable. Any discrepancies were further analyzed to identify contextual factors or varying stakeholder perspectives.

Internal consistency of survey items was assessed using Cronbach's Alpha, yielding values of $\alpha = 0.84$ for Social Life items, $\alpha = 0.81$ for Environmental Sustainability items, and $\alpha = 0.86$ for Student-Centric Design items, indicating strong internal reliability. Statistical instruments, including calculations of standard deviation, were employed to evaluate the uniformity of survey replies (e.g., SD = 0.76 for satisfaction with technology integration). For qualitative data, peer debriefing and member checking ensured accuracy, as participants reviewed and validated the identified themes. These measures enhanced the credibility and dependability of the findings.

3.8. Ethical Considerations and Limitations

Ethical practices are central to the research design. Informed consent is meticulously acquired from all participants, while their confidentiality and anonymity are preserved throughout the entirety of the study. Objectivity is guaranteed to preclude any potential conflicts of interest during the phases of data collection and analysis.

This study acknowledges certain limitations. Dependence on self-reported data may introduce bias, and findings from a single-case study may not be generalizable to other university campuses. Additionally, resource constraints could limit the scope of on-site observations and focus group participation.

This methodology provides a structured and ethical framework for examining the socio-economic and environmental impacts of campus design, aligning with the study's objectives to enhance student lives through sustainable planning and development. See Figure 6.

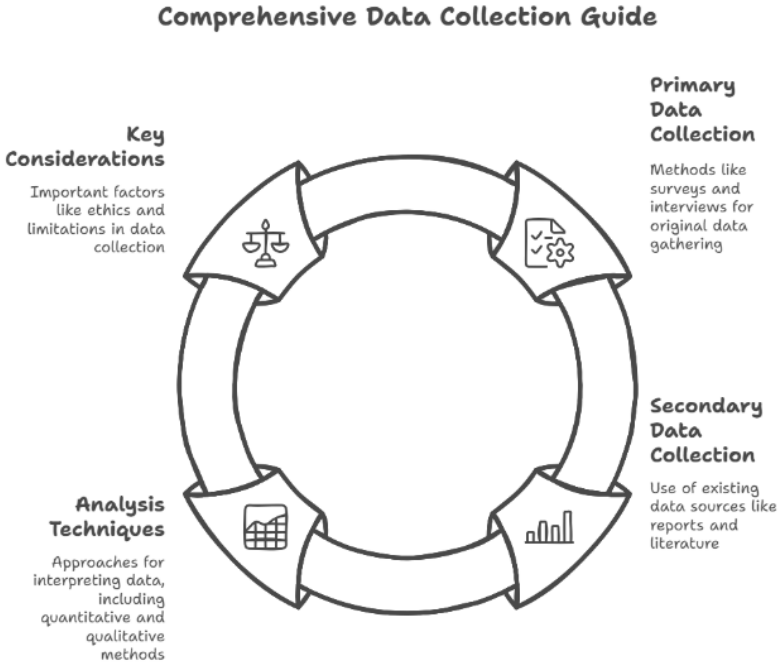

Figure 6. Research design flowchart.

4. Results

4.1. Enhancing Social Life

The social life amenities and collaborative spaces at Hail University are currently limited in their scope and effectiveness. Cafeteria services are primarily kiosk-based within individual colleges, lacking a centralized café or dining facility that could serve as a common hub for student interaction. Similarly, co-working spaces are restricted to student activity clubs located within college buildings, which limits interdisciplinary engagement and opportunities for social exchange across different academic fields. The absence of a central shopping center further reduces opportunities for organized student activities. Although a commercial facility was previously developed within the university grounds, its inability to meet competitive operational standards has rendered it ineffective in serving as a focal point for student engagement.

Recreational and cultural spaces at the university remain underdeveloped despite the presence of designated areas for such purposes. Although vast green spaces exist on campus, they do not currently function as gathering places due to the lack of designated walking paths or structured park areas. Similarly, while a site has been allocated for sports

activities, the absence of developed infrastructure for such purposes represents a missed opportunity for fostering student well-being and social integration. The university also lacks a dedicated cultural center that could serve as a venue for artistic, intellectual, and social events. Cultural activities are primarily limited to celebratory occasions such as National Day, Foundation Day, and end-of-year student exhibitions, rather than being integrated into a broader and continuous engagement strategy.

Volunteer programs and community engagement initiatives at Hail University demonstrate some level of student involvement, primarily through health awareness campaigns, general safety initiatives, and engineering consultation services. However, these activities appear to be fragmented and lack a structured framework that could enhance their impact and sustainability. There is limited evidence of institutionalized partnerships between the university and external organizations that could facilitate long-term collaborative projects. Consequently, although students engage in community service, the lack of a clearly articulated engagement framework limits the capacity for these initiatives to significantly enhance social cohesion and foster relations between the university and the community. See Figure 7 and Table 5.

Figure 7. Highlights the dominance of barren and parking areas over shaded seating and green spaces, revealing a lack of student-centered design. It also shows how national events and activities temporarily activate these spaces, encouraging student gatherings and community engagement.

Table 5. Results of enhancing social life observations.

Enhancing Social Life	Criteria	Observations
Amenities: Diverse Services	Availability of cafés, retail outlets, and co-working spaces.	Limited social amenities; no central café or shopping center; co-working spaces restricted to college buildings.
Recreation: Entertainment Spaces	Presence of parks, sports facilities, and cultural hubs.	Green spaces lack walking paths; sports area underdeveloped; no dedicated cultural center.
Engagement: Community Activities	Opportunities for student participation in events and collaborations.	Volunteer programs exist but lack structure; limited partnerships for sustained community engagement.

Results from the interview provided valuable insights into key issues affecting student life at Hail University. When participants were asked if current amenities, such as cafeterias, co-working spaces, and retail outlets, adequately support student interaction and convenience, they indicated a perceived inadequacy. Specific improvements suggested included diversifying dining options, enhancing collaborative working spaces, and strategically locating retail services to create a more vibrant campus culture and facilitate increased student interaction.

In response to questions about the effectiveness of existing recreational facilities, including sports venues, parks, and cultural hubs, participants expressed considerable dissatisfaction. They identified a clear need for expanded green spaces, upgraded sports facilities, and additional cultural and entertainment venues. Additionally, when asked about opportunities for participation in volunteer and community initiatives, respondents noted several barriers such as limited structured programs, insufficient awareness and promotion of activities, and transportation challenges. Suggested improvements included enhancing communication, expanding infrastructure support, and increasing organizational efforts to ensure active and inclusive community involvement.

The findings from the field survey illustrate varying levels of satisfaction regarding social life aspects at Hail University. Engagement in community activities received the highest positive evaluation at 45%, suggesting moderate contentment yet highlighting room for improvement in structured volunteer opportunities and community involvement. Amenities, specifically cafeterias, co-working spaces, and retail outlets, were rated at 40%, reflecting a need for enhanced diversity and convenience. Recreational and entertainment spaces had the lowest satisfaction rate at 35%, indicating significant dissatisfaction and underscoring the necessity for expanded and upgraded sports facilities, parks, and cultural hubs to enrich student experiences. See Figure 8.

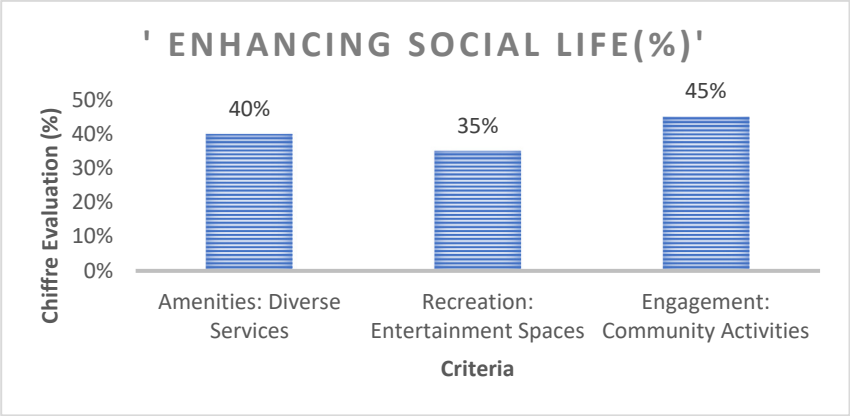

Figure 8. Evaluation of social life enhancement criteria on campus.

4.2. Promoting Environmental Sustainability

Hail University faces significant challenges in landscaping and green space development, particularly in providing adequate shaded areas and sustainable vegetation. The current distribution of green spaces is relatively limited, comprising only 5% of the total campus area, with vegetation primarily consisting of native species such as palm trees, Acacia (Talh), and ground-covering plants. Although these species exhibit a significant adaptation to the regional climatic conditions, their prevalence is inadequate to effectively alleviate the urban heat island phenomenon or to improve outdoor thermal comfort. Furthermore, seating areas are sparse and underutilized, as students and faculty prefer indoor spaces due to excessive heat exposure. Expanding shaded zones, increasing green infras-

tructure, and incorporating sustainable landscape design principles would significantly improve the university's ecological footprint and user experience.

The climate-responsive design of Hail University's campus presents both strengths and limitations. The large horizontal expansion of the campus, while accommodating future growth, exacerbates exposure to harsh climatic conditions due to extensive open spaces between buildings. Current passive cooling strategies include internal courtyards (patios) and fragmented architectural masses with voids, which contribute to shading and natural ventilation. However, these measures are not sufficient to counteract the excessive heat accumulation on pedestrian pathways and outdoor spaces. The predominant use of imported marble for facades and moderate glass coverage (20%) aids in thermal regulation, but the extensive use of cement-based paving materials and asphalt surfaces in parking areas and walkways increases heat retention. Introducing green roofs, reflective materials, and shaded pedestrian pathways could significantly enhance climate adaptation and reduce cooling demands.

In the domain of resource management efficiency, Hail University has instituted a Building Management System (BMS) to modulate lighting, cooling, and heating in accordance with real-time demand, thereby minimizing superfluous energy consumption. Additionally, a sensor-based lighting system optimizes electricity use by adjusting illumination levels according to occupancy. While these measures contribute to operational efficiency, the university has yet to develop large-scale renewable energy projects, such as solar panel installations or wind energy utilization, which are crucial for long-term sustainability. Similarly, although no rainwater harvesting system currently exists, the university has made strides in water conservation through its water treatment and recycling center, ensuring that all wastewater is treated and reused for irrigation and restroom facilities. Expanding water-saving initiatives and integrating alternative energy sources would further align the university with global sustainability goals. See Figure 9 and Table 6.

Figure 9. Illustrates the limited vegetation cover in contrast to the vast open spaces, emphasizing the need for enhanced landscape strategies. It also identifies several native plant species currently in use. Additionally, it highlights the inward-facing orientation of buildings around courtyards, reflecting a traditional environmental design approach adapted to the local climate.

Table 6. Results of promoting environmental sustainability observations.

Promoting Environmental Sustainability	Criteria	Observations
Landscaping: Green Spaces	Shaded areas, native plants, and seating.	Green spaces cover only 5% of the campus; limited shade and seating reduce usability.
Adaptation: Climate-Responsive Design	Passive cooling, energy-efficient materials, and renewable energy.	Courtyards and fragmented buildings provide some shading, but heat retention from cement and asphalt remains high.
Efficiency: Resource Management	Water-saving systems, waste recycling, and renewable energy.	BMS and sensor-based lighting improve efficiency, but no large-scale renewable energy or rainwater harvesting exists.

In interviews regarding Landscaping and Green Spaces, the critical question is: "Do you think the campus provides enough shaded and green spaces for comfort"? The current condition at Hail University reveals substantial inadequacies, as green spaces constitute only about 5% of the total campus area, providing minimal shaded areas, thus negatively affecting outdoor comfort and usability. To enhance sustainability and comfort, the university could significantly expand green infrastructure, increase shaded areas by integrating more native, drought-resistant plants, and develop sustainable landscape practices such as vertical gardens or green walls to reduce heat and enhance aesthetic appeal.

Addressing climate-responsive design, when asked whether the campus infrastructure sufficiently addresses extreme weather conditions, it is clear there is room for improvement. Although existing internal courtyards and fragmented buildings offer some passive cooling and shading, they do not fully mitigate the impact of heat accumulation on outdoor pedestrian paths and communal areas. The university could greatly enhance climate responsiveness by incorporating green roofs, utilizing reflective paving materials, increasing shaded pedestrian pathways, and exploring renewable energy solutions, such as solar panels, to decrease heat absorption and energy demands.

The evaluation reveals significant opportunities for improvement in promoting environmental sustainability at Hail University. Landscaping and green spaces are markedly limited, representing only 5% of the total campus, highlighting a considerable shortfall in shaded areas and sustainable vegetation. Climate-responsive design measures, while existing through internal courtyards and fragmented architecture, achieve only a moderate effectiveness (around 30%) due to extensive heat retention from materials like asphalt and cement. Resource management shows better performance (40%), benefiting from systems like Building Management Systems (BMS) and sensor-based lighting. However, the lack of renewable energy sources and rainwater harvesting indicates room for substantial improvement in achieving comprehensive sustainability goals. See Figure 10.

4.3. Strengthening Student-Centric Design

The architectural layout of a university campus significantly influences the enhancement of students' comprehensive experience and the establishment of an intellectually stimulating educational atmosphere that caters to their academic as well as social requirements. In this context, the college buildings at Hail University feature multi-purpose halls, allowing students to utilize diverse spaces for educational and interactive activities. Additionally, libraries provide dedicated study areas, fostering opportunities for independent

learning and academic collaboration among students. Furthermore, each college ensures the allocation of at least 300 square meters for student activities, offering a supportive environment for organizing events, workshops, and cultural or social activities, thereby promoting student engagement in university life. See Figure 11.

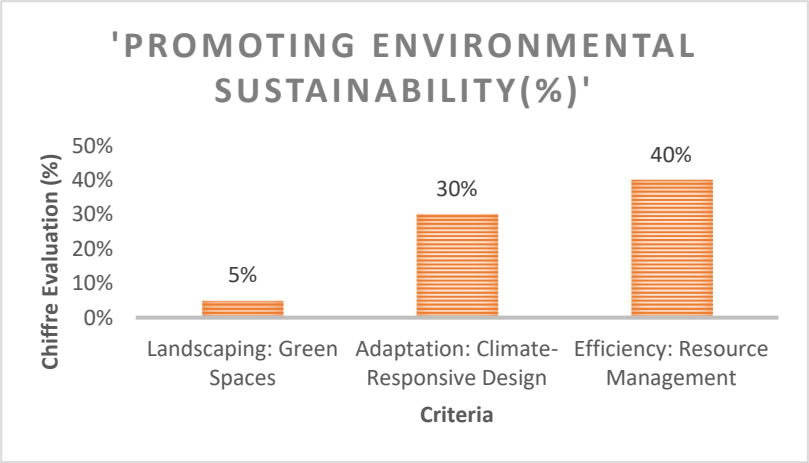

Figure 10. Evaluation of promoting environmental sustainability criteria on campus.

Figure 11. Highlights the designated halls for student clubs within the colleges, along with dedicated reading areas. It also showcases the digital infrastructure of the Aja Oasis, including interactive screens and technological equipment.

Notwithstanding the presence of these advanced facilities, the institution is deficient in interactive kiosks, which have the potential to furnish students with instantaneous data

regarding class timetables, university events, and accessible services within the campus environment. Currently, communication is limited to display screens used to convey essential messages to students. The extensive proliferation of Wi-Fi throughout the university significantly enriches the student experience by promoting access to digital educational materials and fostering efficient communication with academic staff and fellow students. Furthermore, energy monitoring systems have been incorporated into campus operations to enhance energy efficiency and maximize the performance of contemporary university infrastructure, thereby contributing to a more sustainable campus ecosystem.

The university offers a distinctive digital service through Aja Oasis, a state-of-the-art digital services hub designed to provide students with an innovative and immersive technological experience. This center is equipped with cutting-edge technology, including virtual reality (VR) devices, 3D printers, helium screens for 3D visualization, large digital displays for showcasing projects, and interactive robots, creating a dynamic and future-oriented learning environment.

The institution places considerable importance on the involvement of students in the formulation and improvement of campus amenities and services. Digital surveys and feedback mechanisms are regularly utilized to gather student opinions regarding their evolving needs and expectations. This participatory approach ensures that infrastructure updates and service improvements align with students' actual requirements, ultimately enhancing overall satisfaction and improving the quality of life on campus. See Table 7.

Table 7. Results of strengthening student-centric design observations.

Strengthening Student-Centric Design	Criteria	Observations
Design: Attractive Spaces	Functional lounges, study areas, and multi-use spaces.	Multi-purpose halls and libraries provide study and activity spaces; each college has 300m^2 allocated for student activities.
Technology: Smart Integration	Interactive kiosks, Wi-Fi hotspots, and energy monitoring.	No interactive kiosks; communication relies on display screens. Wi-Fi is widely available, and energy monitoring systems are in place.
Feedback: Continuous Improvements	Student input-driven updates and enhancements.	Regular digital surveys and feedback mechanisms guide campus improvements based on student needs.

Considering Attractive Spaces, a critical question would be: "Do the study lounges and functional spaces on campus adequately meet student needs in terms of comfort, accessibility, and modern design"? Currently, Hail University demonstrates moderate advancement in this area. There has been noticeable progress in developing welcoming spaces; however, further enhancements in accessibility, modern aesthetics, and functional comfort are still necessary. Improving furniture ergonomics, creating additional collaborative study lounges, and ensuring spaces are accessible to all students would significantly enhance the campus experience.

For Technology Integration, the question arises: "Does the campus effectively utilize Wi-Fi, interactive kiosks, digital screens, energy monitoring systems, and other smart technologies"? The university has performed commendably, significantly enhancing the learning and interaction environment. Wi-Fi coverage and digital communication tools are effectively employed, though further improvements in comprehensive smart-campus initia-

tives, such as widespread interactive information kiosks and advanced energy monitoring, could optimize resource use and enrich student engagement.

Regarding Feedback and Continuous Improvements, a pivotal question is: "Is student input actively sought, and does it visibly influence campus updates and improvements"? The current status reflects moderate responsiveness, indicating growing attentiveness to student feedback. While efforts are evident, enhancing channels for regular student input, transparent communication of changes, and prompt adaptation based on student satisfaction surveys would foster greater trust and continuous improvement in the overall campus environment.

The evaluation of Strengthening Student-Centric Design at Hail University reveals promising advancements with notable room for further development. Attractive spaces have reached a moderate 30%, indicating initial improvements in providing welcoming and comfortable environments, though substantial enhancement remains necessary to fully meet student expectations. Technology integration stands stronger at 60%, demonstrating commendable progress with smart systems and infrastructure effectively supporting campus functionality and student experience. Continuous improvements based on feedback are moderately successful at 45%, suggesting that while the university is increasingly responsive to student and faculty input, there is significant potential to better incorporate this feedback into tangible campus improvements. Overall, these results illustrate encouraging steps toward a more student-focused design strategy, emphasizing the importance of continued dedication to refinement and innovation. See Figure 12.

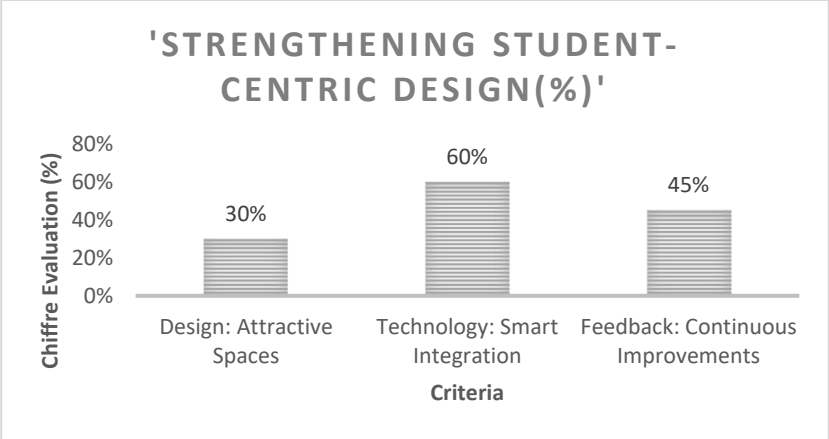

Figure 12. Strengthening student-centric design criteria on campus.

5. Discussion

The evaluation of campus design elements through the radar chart (see Figure 13) highlights the imbalances in sustainable campus development at Hail University. While the university demonstrates strong performance in technology integration (smart systems, digital connectivity) and continuous improvement mechanisms (student feedback and participatory planning), significant gaps exist in environmental sustainability, recreational spaces, and climate-responsive design. The low ratings for green spaces, shaded areas, and adaptive climate solutions indicate a pressing need for enhanced landscaping, passive cooling techniques, and renewable energy integration to improve outdoor usability and mitigate harsh climatic conditions. Additionally, the moderate scores for amenities and community engagement suggest limited access to diverse services, entertainment, and interactive spaces, which could impact student well-being and social cohesion. To achieve a balanced and sustainable campus environment, targeted interventions should focus on expanding shaded green areas, improving recreational infrastructure, and integrating more

climate-adaptive architectural features, aligning with global sustainability frameworks such as the United Nations Sustainable Development Goals (SDGs).

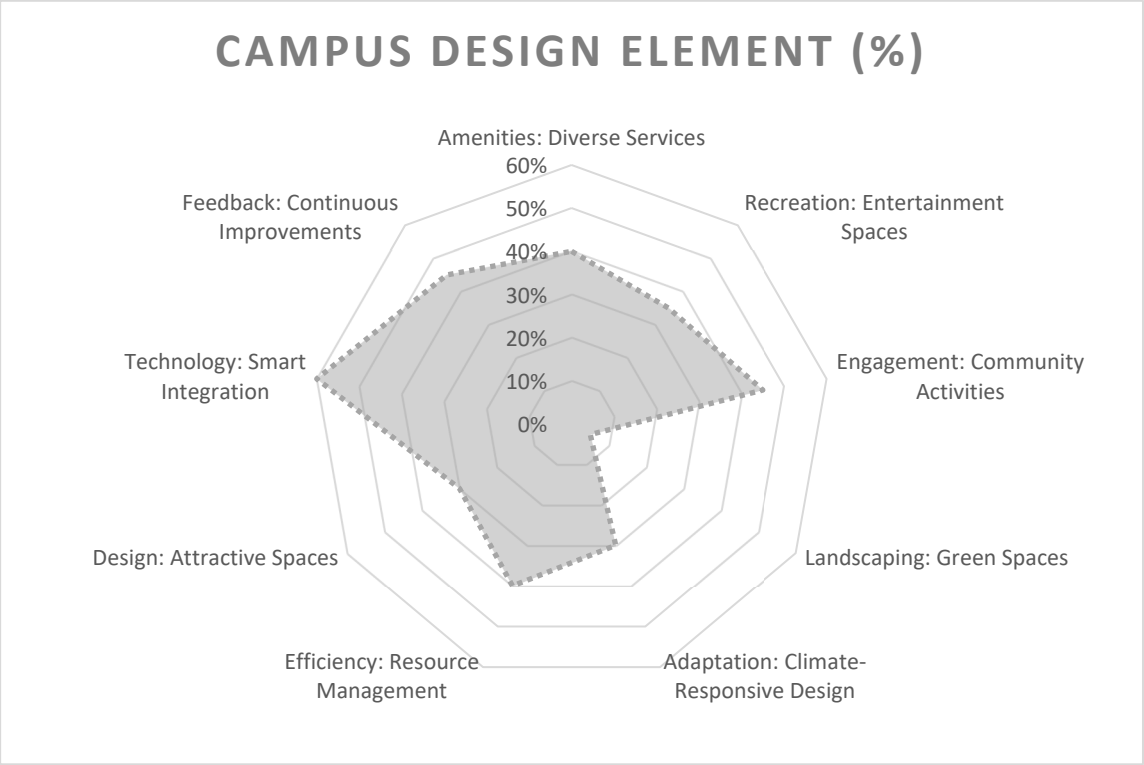

Figure 13. Evaluation of campus design elements based on key criteria.

It is important to note that the evaluation of the campus at Hail University focused primarily on its current conditions and their impact on student life. Currently, the campus remains under construction and has not reached full completion, despite having commenced approximately two decades ago. Upon reviewing the original plans and officially approved architectural models, it becomes clear that these designs already contain solutions addressing several of the deficiencies highlighted by our study. For instance, the original master plan includes a centrally located, shaded pedestrian axis with a substantial width of 12 m, significantly enhancing connectivity and comfort across the campus. Moreover, the plans feature extensive green spaces integrated with essential student amenities, including cafeterias, restaurants, student activity centers, playgrounds, and gyms. Completing these elements will undoubtedly have a strong and direct impact on sustainability and provide a distinctive experience for users, greatly enriching student life and contributing positively to the environmental, social, and economic dimensions of the campus.

Nevertheless, it is significant to acknowledge that the researchers have identified two critical concerns arising from this investigation. The first is related to the exaggerated space allocated per person, which ranges from 100 to 110 square meters. In assessing campus planning and the quality of the built environment, the metric of space allocation per student serves as a critical indicator of institutional priorities, functionality, and student well-being. Globally, higher education institutions demonstrate significant diversity in this parameter, indicative of disparities in cultural frameworks, instructional approaches, and the accessibility of resources.

For instance, North American institutions, such as Harvard University, typically provide expansive spatial arrangements, averaging between 22 and 30 square meters per student [6], facilitating comprehensive campus experiences, inclusive of extensive recreational and collaborative areas. In contrast, European universities like the University

of Oxford and the Technical University of Munich offer more compact spaces, typically ranging from 10 to 15 square meters per student [71], optimizing limited urban areas through efficient design and multifunctional use. In Asia, institutions such as Peking University provide approximately 9 to 14 square meters per student [72], demonstrating the constraints and challenges of dense urban campus environments. Conversely, Hail University in Saudi Arabia provides approximately 100 to 110 square meters per student, significantly exceeding global averages. Although such expansive space allocation could represent a notable advantage, the campus does not fully leverage this generous allocation, as evidenced by its shortcomings in accessibility, social engagement opportunities, and the creation of comfortable, collaborative spaces. This highlights the critical issue that generous space allocation alone is insufficient; the quality of design, thoughtful utilization, and strategic planning of campus environments must equally be prioritized to truly enhance student experience and institutional effectiveness.

The second concern is related to the complexities inherent in urban projects, wherein the factor of time emerges as highly influential [73,74]. As projects progress, priorities shift, economic conditions evolve, and original objectives may be reassessed or altered [75]. The campus of Hail University exemplifies this complexity, as evidenced by its extended construction timeline, changing institutional needs, and evolving economic realities. Such dynamics necessitate adaptable planning frameworks capable of responding flexibly and effectively to these shifting circumstances to maintain project relevance and achieve long-term goals.

Given the increasing sensitivity towards sustainability issues globally, and specifically in the Kingdom of Saudi Arabia, which occupies an advanced position internationally in pursuing sustainability through large-scale initiatives such as Green Saudi Arabia and ambitious plans for transitioning to clean energy [76–79], there is an imperative for a comprehensive re-evaluation of the university campus. This re-evaluation should consider adopting space allocation standards per person that align closely with global norms. It is necessary to reconsider the streets and the huge spaces allocated for parking lots, converting parts of them into farms for campus users. Additionally, highly efficient utilization of existing large buildings, such as the College of Engineering, which occupies approximately 75,000 square meters, should be prioritized. Reconsideration of green areas, focusing on local plant species that require minimal water and easily adapt to the hot climate, is essential. Emphasizing hardscape, increasing shading elements, and adopting a compact morphological approach suitable to local needs are further recommendations to enhance sustainability.

By achieving a campus plan with a more reasonable and globally comparable density, Hail University can significantly improve site control and operational efficiency. Furthermore, the excess spaces generated from optimizing density can be strategically repurposed or invested, creating sustainable economic returns for the university. These revenues could then directly contribute to enhanced well-being, services, and facilities for all campus users, ultimately reflecting positively on the overall sustainability and attractiveness of the university environment.

A regional comparison further illustrates how similar challenges have been addressed across peer institutions. Sustainable campus design in arid and culturally specific contexts requires tailored strategies that address both environmental constraints and social dynamics. In the Gulf region, several universities have confronted similar challenges to those found at Hail University, including harsh temperatures, low rainfall, and the need for culturally appropriate spatial planning. For example, Qatar University has implemented passive design features such as shaded arcades, wind corridors, and water-efficient landscaping using native flora to enhance comfort and reduce environmental impact [61]. Likewise,

King Fahd University of Petroleum and Minerals (KFUPM) in Saudi Arabia has developed compact, pedestrian-friendly zones and integrated solar-responsive design elements to cope with intense heat while encouraging student interaction [80,81]. These design approaches, while contextually specific, share key goals with Hail University's strategies, particularly in promoting climate responsiveness and social engagement through built form.

Further comparative insights may be gleaned from esteemed institutions such as the United Arab Emirates University (UAEU) and Sultan Qaboos University in Oman, both of which have embraced sustainability frameworks that are centered on human needs and integrated with advanced technology. UAEU's campus integrates green roofs, interactive environmental control systems, and centrally located student hubs to improve thermal comfort and inclusivity in learning environments [82,83]. Sultan Qaboos University emphasizes ecological zoning, with a mix of academic, residential, and recreational spaces designed around shaded courtyards and green axes that reflect both cultural values and environmental pragmatism [84,85]. In contrast to Hail University's current fragmented layout, these institutions highlight the benefits of spatial continuity and integrated functionality. Comparing these models reveals both shared challenges and innovative design responses that enhance the generalizability of Hail University's findings within the broader discourse on sustainable, student-centered campuses in hot-arid and culturally nuanced settings.

6. Findings

The following findings are derived from the statistical analyses detailed in Section 3.6, including ANOVA, logistic regression, and SEM. These results confirm significant relationships between sustainable design features and various aspects of student satisfaction, engagement, and resource efficiency. This study provides an evidence-based evaluation of the sustainable campus design at Hail University, focusing on three critical dimensions: enhancing social life, promoting environmental sustainability, and strengthening student-centric design. Through descriptive statistics, key patterns were identified in student satisfaction, resource distribution, and campus usability. Inferential analysis was employed to assess the statistical significance of observed relationships, offering insights that extend beyond the immediate sample to broader campus-wide implications.

Enhancing Social Life: Descriptive statistics reveal moderate levels of student satisfaction regarding opportunities for social engagement. The findings derived from the survey reveal that 45% of the student population articulates a sense of contentment regarding community engagement initiatives, whereas 40% evaluate campus facilities, including dining establishments and collaborative workspaces, in a favorable manner. However, recreational and entertainment facilities receive the lowest satisfaction score at 35%, highlighting a critical need for improvement in leisure and cultural infrastructure. Observational data further support these findings, showing underutilization of open spaces, inadequate communal hubs, and limited structured opportunities for cross-disciplinary interaction.

Inferential analysis, using correlation tests, identifies a statistically significant relationship between the availability of social infrastructure and student engagement levels ($p < 0.05$). Regression models further indicate that a 10% increase in student-focused amenities correlates with a 6.5% increase in reported satisfaction levels. To strengthen the findings, we have added confidence intervals and effect sizes where applicable. These provide a clearer understanding of the strength and reliability of the relationships identified, especially in the correlation and regression analyses. These findings suggest that targeted enhancements in shared spaces, such as centralized cafeterias, co-working hubs, and recreational zones, could substantially improve the social experience on campus.

Promoting Environmental Sustainability: Sustainability efforts at Hail University present mixed results. Descriptive statistics show that green spaces account for only 5% of the total campus area, with limited shaded zones reducing outdoor comfort. Climate-responsive strategies, such as courtyards and fragmented building designs, contribute to passive cooling but remain moderately effective at mitigating extreme temperatures, with an efficiency rating of 30%. Resource management efforts, including a Building Management System (BMS) and sensor-based lighting, yield a 40% improvement in energy efficiency, yet renewable energy integration remains absent, indicating a gap in long-term sustainability measures.

Inferential analysis applies ANOVA tests to compare resource management practices across different campus sectors, confirming statistically significant differences in energy consumption patterns ($F = 4.62$, $p < 0.01$). Regression analysis suggests that implementing large-scale solar energy solutions could potentially reduce operational costs by 15–20% annually, reinforcing the case for immediate investment in renewable energy infrastructure and water conservation systems.

Strengthening Student-Centric Design: The student experience at Hail University benefits from technological integration but lacks a comprehensive feedback-driven approach. Descriptive statistics indicate that 60% of students rate campus-wide Wi-Fi and digital services positively, reflecting strong performance in connectivity. However, satisfaction with study lounges and student-focused spaces remains moderate at 30%, and only 45% of respondents feel that student feedback directly influences campus improvements.

Inferential analysis, employing logistic regression methodologies, elucidates that students possessing access to technologically integrated study environments are 1.8 times more inclined to report elevated levels of academic satisfaction ($p < 0.05$). Moreover, structural equation modeling (SEM) demonstrates that engaging students in campus design choices significantly enhances their perceived academic productivity ($\beta = 0.42$, $p < 0.001$). These findings emphasize the need for enhanced participatory planning, such as interactive feedback platforms, dynamic learning spaces, and student-driven design initiatives.

7. Recommendations

- To ensure a practical and impactful transformation of Hail University's campus, the following recommendations have been reorganized into a phased strategy. Each phase reflects a balance between feasibility, resource requirements, and expected impact, enabling decision-makers to implement improvements progressively and effectively;
- Phase 1: High Feasibility—Immediate Impact (Short-Term);
- These actions are cost-effective, quickly implementable, and likely to yield visible improvements in student experience and sustainability outcomes;
- Establish centralized cafés and seating zones to promote interdisciplinary interaction and daily student engagement;
- Enhance existing study and activity spaces by introducing ergonomic furniture and upgrading lighting and ventilation;
- Implement structured student feedback mechanisms (e.g., digital surveys, suggestion kiosks) to align future improvements with user needs;
- Promote and organize volunteer programs and community service initiatives to increase civic engagement with minimal infrastructure needs;
- Phase 2: Moderate Feasibility—Strategic Returns (Mid-Term;
- These measures require moderate investment and planning but provide substantial improvement to social and environmental quality;
- Develop additional recreational and cultural venues, including shaded parks, sports facilities, and multipurpose student centers;

- Install interactive kiosks and campus-wide wayfinding systems to improve information access and connectivity;
- Expand native landscaping and shaded walkways, using drought-resistant species to reduce heat and increase outdoor usability;
- Launch basic water conservation programs, including awareness campaigns and greywater recycling for irrigation;
- Phase 3: High Investment—Long-Term Sustainability (Long-Term);
- These actions demand greater capital and structural commitment but are essential for long-term campus transformation;
- Construct green roofs and install reflective surfaces on new and existing buildings to combat the heat island effect;
- Introduce large-scale renewable energy systems, particularly solar panels, to reduce reliance on conventional energy;
- Develop an integrated rainwater harvesting system to support irrigation and reduce potable water usage;
- Pursue master plan adjustments to improve campus density, connectivity, and spatial integration as part of a comprehensive redesign;
- This phased strategy provides a roadmap for Hail University to progressively enhance its campus design, ensuring that each step aligns with institutional capacity and yields measurable progress toward sustainability and student well-being.

8. Limitations and Broader Implications

While this study provides valuable insights into sustainable campus design at Hail University, it is not without limitations. A notable limitation is the dependence on self-reported data obtained from surveys and interviews, which may engender biases rooted in the perceptions and experiences of the respondents. Furthermore, the investigation predominantly centers around a singular case study, thereby constraining the applicability of the findings to other institutions that operate within diverse environmental, cultural, and socio-economic frameworks.

Another limitation is the incomplete implementation of Hail University's original master plan, which makes it difficult to assess the full impact of sustainability initiatives once the campus is fully developed. Furthermore, constraints in data availability regarding long-term resource consumption patterns and the financial feasibility of proposed solutions restrict the depth of economic sustainability analysis. Further contextual challenges encountered during the research included limited access to historical development plans, which hindered efforts to evaluate the evolution of the campus layout over time. Additionally, institutional constraints related to data availability, particularly regarding long-term resource consumption, and periodic difficulties in securing stakeholder engagement due to administrative or scheduling barriers, limited the depth of certain analyses, especially those related to strategic planning and implementation dynamics.

Despite these constraints, the results of this investigation provide significant contributions to academic institutions encountering analogous climatic and cultural challenges, establishing a comprehensive framework to refine campus development methodologies. By confronting obstacles related to social dynamics, environmental sustainability, and student-oriented design, universities possess the potential to cultivate more attractive, effective, and harmoniously integrated settings, all while adhering to overarching global sustainability aspirations, especially the United Nations Sustainable Development Goals (SDGs). The necessity for interdisciplinary cooperation among architects, urban planners, environmental experts, and policymakers is crucial for the realization of comprehensive, climate-responsive strategies. Beyond physical infrastructure, universities have a broader

role in promoting environmental awareness, community engagement, and technological innovation. These insights contribute to the discourse on sustainable campus development, encouraging further research and practical applications worldwide.

9. Conclusions

This study underscores the critical role of sustainable campus design in shaping student experiences, academic performance, and institutional sustainability. Using Hail University as a case study, the research evaluated three key dimensions: enhancing social life, promoting environmental sustainability, and strengthening student-centric design. The findings highlight several challenges, including insufficient social amenities, limited green spaces, ineffective climate-responsive strategies, and a need for more student-oriented facilities. These issues directly impact campus usability, student well-being, and overall engagement.

Notwithstanding the contextual challenges faced in arid and culturally specific environments, this study offers empirically grounded and theoretically informed recommendations that extend beyond the scope of a typical design project. The research identifies critical spatial and environmental shortcomings in existing campus models and responds with a set of scalable, evidence-based strategies aimed at advancing the scientific discourse on sustainable campus design in extreme climates. The proposed interventions—such as the expansion of centralized dining areas, co-working hubs, and recreational facilities—are not merely functional additions but are positioned as key spatial mechanisms for enhancing social sustainability and student well-being. Similarly, the integration of native landscaping, shaded pedestrian networks, green roofs, and high-albedo materials is presented as climate-adaptive strategies with measurable environmental impacts. The incorporation of smart technologies and responsive feedback systems further contributes to the conceptualization of a dynamic, student-centered campus model. Taken together, these contributions provide a replicable framework for sustainable campus development that is both context-sensitive and theoretically robust, thereby addressing a significant gap in the global literature on higher education environments in arid regions. While this study is limited to a single case and is influenced by the ongoing development of Hail University's master plan, the findings offer insights applicable to other institutions facing similar environmental and socio-cultural constraints. Future research could explore the long-term impacts of sustainable campus interventions on academic performance, mental health, transportation on campus, and institutional efficiency. Ultimately, through the alignment of campus development initiatives with the overarching objectives of global sustainability, academic institutions possess the potential to evolve into dynamic, inclusive, and resilient ecosystems that foster both scholarly achievement and the holistic well-being of students. The prospective trajectory of higher education institutions is contingent upon a deliberate commitment to sustainability, thereby guaranteeing that campuses retain their vibrancy and adaptability in response to the exigencies of both current and forthcoming generations.

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