



Sustainable Campus Landscape Designing and Planning: A Comparative Study of Implementation Strategies

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Abstract

Creating sustainable landscapes is one of the priorities in designing and planning for campuses, as they offer a healthy and safe external environment, a place to meet and exchange ideas, and increase social relations between the different campus groups. Furthermore, they enhance the site's aesthetics and achieve the elements of environmental, social, and economic sustainability. This research aims to identify the challenges and obstacles, and to develop essential strategies to transform local campuses and their landscapes into sustainable environments. It studied the campuses and landscapes of the King Abdullah University of Science and Technology in Saudi Arabia and the American University in Cairo, Egypt and compared them with those of the University of Baghdad. The study found that developing certain critical strategies to obtain a sustainable campus and landscapes would also promote high energy and renewable energy efficiency, and rationalize consumption and environmental compatibility. In this regard, the strategies promoted greater efficiency of building materials, resources, lighting, ventilation, maintenance, and efficient water use, besides acquiring the factors of sustainability.

Keywords: Sustainable landscapes, Environmentally friendly, Silent architecture, University of Baghdad.

تصميم وتحفيظ الفضاءات الخارجية المستدامة للحرم الجامعي: دراسة مقارنة لإستراتيجيات التطبيق

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الخلاصة

يعد توفير فضاءات خارجية مستدامة إحدى أولويات التصميم والتحفيظ المستدام للحرم الجامعي، إذ يوفر بيئة خارجية صحية وآمنة ومكاناً للإلقاء وتبادل الأفكار وزيادة العلاقات الإجتماعية بين فئات الحرم الجامعي المختلفة، فضلاً عن زيادة جمالية الموقع وتحقيق عناصر الإستدامة (البيئية والإجتماعية والإقتصادية). لذا فقد هدف البحث إلى تحديد التحديات والعقبات ووضع الإستراتيجيات الأساسية لتحول الحرم الجامعي المحلي وفضاءاته الخارجية إلى حرم جامعي مستدام. ولتحقيق هدف البحث، تم دراسة ومقارنة الحرم الجامعية وفضاءاتها الخارجية لجامعة الملك عبد الله للعلوم والتكنولوجيا في المملكة العربية السعودية والجامعة الأمريكية في القاهرة بمصر مع حرم جامعة بغداد وفضاءاته الخارجية. تم تحقيق الهدف من خلال إقتراح عدد من الإستراتيجيات والحلول المناسبة للحصول على حرم جامعي وفضاءات خارجية مستدامة، كما أنها تعمل على تحسين كفاءة الطاقة والطاقة المتجددة وترشيد الاستهلاك وتحقيق التوافق البيئي، فضلاً عن تمكناها من زيادة كفاءة المواد والموارد والإضاءة والتهوية وإستخدام المياه وتحقيق عناصر الإستدامة.

كلمات مفتاحية: الفضاءات الخارجية المستدامة، صديقة البيئة، الفضاءات الخارجية الصامدة، جامعة بغداد.

Introduction

Universities are critical factors in community development in all fields of life, and their implications are due to their imperative, activated, and distinguished role in achieving comprehensive sustainability in the environmental, economic, social, and other aspects. They are considered beacons for receiving experiences, exchanging ideas, and scientific and cultural communication. Therefore, the integration of outdoor spaces with campus buildings would enhance the feeling of safety, direction, and aesthetic appeal (27). Contemporary architectural trends have been linked to sustainability to advance universities by providing a safe environment, health and psychological comfort, consolidating social and cultural relations, exchanging experiences and ideas, and introducing modern technology to meet university requirements in the current era while preserving the needs and rights of future generations. This has been a defining concept in traditional architecture since ancient times. It aims to achieve ecological balance and improve the quality of human life (16).

Sustainable designing and planning for silent architecture is defined as the sum of procedures and measures for reading the future and predicting a clear vision of what it will be like to achieve the goals based on available options and alternatives for exploiting resources (natural and human) to create the changes for meeting current needs while preserving the rights and gains of subsequent generations (3 and 14). Furthermore, it is considered a scientific study conducted according to a sequential system that reaches its goals with less effort and cost and results in positive returns. Also, it is a dynamic and variable process that depends on environmental and temporal conditions to provide successful solutions to address the site's current and future negatives. All this seeks to evaluate current campus planning and design, forecast its future, set goals, develop strategies, consider alternatives, select preferred methods, and implement improvements to enhance campus efficiency and minimize risks in daily activities and events (10, 20 and 33).

Researchers also aim to facilitate organized coordination and improve the site's efficiency and effectiveness, help achieve a balance between all available resources and needs, and give an idea of the facts and goals to be achieved through a timetable and specific priorities (30 and 33). A university campus's planning influences education and its users' daily lives. Effective planning involves determining land uses, securing pathways for future expansion, and balancing the relationships between campus and city areas while ensuring flexibility to accommodate future developments (13). To attain this aim, a sustainable design is required to meet the functional needs of university staff. This design prioritizes environmental features that enhance human comfort and vitality.

Sustainability is crucial in university planning and design, encompassing environmental, social, and economic factors. It involves preserving the environment, minimizing waste and material consumption, and improving environmental management. Hence, it is vital to plan for a sustainable university campus that achieves all social, economic, and ecological goals and develops essential strategies to transform the local environment and its landscapes into a sustainable campus. This study highlights the challenges and obstacles and develop efficient strategies to transform local campuses and their landscapes into sustainable campuses.

1. Types of campus designs

- Centralized design: featuring various public service facilities, including mobile restaurants, libraries, research halls, and student residential units centered around the main public services hub.
- Separate design: characterized by low building density and large-scale landscapes; however, the density increases at a smaller scale.
- Grid design: a homogeneous density of the landscapes within the campus boundaries, providing services for daily activities and events. It includes enclosed Open to Sky (OTK) landscapes, designed with precision due to building orientation.
- Longitudinal design: characterized by a high building density spread throughout the landscape, providing easy access to all sectors and landscapes (15, 22, 29 and 34).

2. Strategies for planning and designing the foundations of the university campus and its landscape

- Basic Plan Foundation: Comprises buildings, landscapes, and auxiliary elements like movement paths and services representing vital campus components such as pedestrian roads.
- Climatic Foundations: Planning methods must account for the university's climate, including wind direction evaluation, the addition of plant-covered walkways, and the strategic use of water bodies.
- Fundamentals of Movement: The distinct entrances, gates, and use of topography to create varying levels are designed to clearly define the area.
- Expansion Variables: The optimal planning strategy considers future expansion and construction in line with the campus's academic and social needs, utilizing interconnected planning systems for addition and alternation.
- Basic Movement Systems: The campus must ensure that pedestrian and car traffic axes, including the central linear, ring, and service vehicle axes, provide easy access to buildings and parking lots in minimum time (18, 23, 26 and 31).

Achieving sustainability in universities can reap some benefits, including enhancing the preservation of biodiversity and ecosystem services such as increasing water quality, managing rainwater runoff, and its sustainable collection. Improving the landscape on the university campus contributes to improving the green infrastructure. It provides a peaceful environment for promoting the scientific production and psychological comfort of students and alleviates stress and anxiety (14). Therefore, factors that may have a negative or positive impact on the design and planning of a sustainable campus must be taken into account, including:

- Natural factors: Soil geology, climatic elements, and pollution influence campus planning. Location, climatic elements, and pollution affect building shapes, plant distribution, and landscape distribution.
- Social factors: Campus planning involves understanding population distribution and values and gathering places to accommodate student numbers. Culture also influences planning, as mental perceptions of campus occupants determine their attitudes, ideas, and needs.
- Economic factors: Campus planning near urban communities is crucial for reduced access costs and services, while economic conditions impact campus planning, well-being, construction costs, and maintenance, affecting daily activities and events.

Political factors: State stability, natural resource availability, regulations, and space distribution directly influence campus planning and landscapes, affecting land uses, services, and green landscape percentages (1, 4, 9, 10 and 11).

Materials and Methods

The study compared the University of Baghdad, located in an area characterized by a hot, dry climate in summer or a semi-desert, and the King Abdullah University

of Science and Technology (KAUST) in Saudi Arabia and the American University in Cairo (AUC), Egypt.

Their selection is based on the similar climate characteristics and their strong application of the sustainability criteria in designing and planning their campuses. Various landscape sustainability criteria, such as layout, energy efficiency, and environmental compatibility, are examined to meet the study objectives. These objectives include diagnosing issues affecting the landscape and developing solutions for sustainable landscape designing and planning on the campus. The following methods were used to collect information and data for the study sample:

- Analysis of the study sample through field visits.
- Photography.
- Analysis of maps, and aerial and architectural plans (site plans).

Comparing previous studies on similar issues for this study's samples with the sustainability standards used at KAUST and AUC.

Results and Discussion

The characteristics of the two universities and their features in achieving sustainable planning and design for the university that were used for comparison:

King Abdullah University of Science and Technology: Located in Jeddah, Saudi Arabia, on the Red Sea, the KAUST was built from 2007 to 2009 and covers 36 km² (Figure 1). Its objectives are to support scientific research and graduate studies in science, technology, energy, and the environment (24). Despite facing challenges due to the subtropical climate, the university has integrated sustainable measures into campus planning, and landscape and building design. It is working on developing new technologies like desalinating salt water, earning it the 2010 AIA award.



Figure 1: Site Plan of KAUST campus.

Sustainability in the design and planning of KAUST (17 and 28):

1. Sustainable site planning: The sustainable campus and its landscapes were planned based on assembly and orientation factors. The campus's design is tailored to climate and site conditions, minimizing sun heat rays and providing daylight. It features a large reflective roof, solar panels, and glass-covered courtyards for daytime sunlight. The campus's streets and walkways feature local light-colored stones, reducing heat concentration, and enhancing indoor air quality and climate.

2. Solar power is utilized for electricity generation in buildings, covering all roofs with solar panels, providing clean energy without relying on fossil fuels and reducing environmental pollution. The cover comprises a transparent outer layer and an inner layer of solar cells. The hot climate and abundant solar energy make the campus ideal for this, ensuring clean electrical power without air pollution.

3. The campus utilizes local construction materials and natural resources to create buildings and landscapes. Recyclable materials are used in both buildings and industrial components, with 80% of the materials being recycled and reused. The campus was built 6 meters above the neighboring lands to remove soil salinity and groundwater, thereby protecting the buildings and landscapes from salinity and climate change patterns. This sustainable approach contributes to the campus's environmental sustainability.

4. Lighting and ventilation: The campus uses natural sunlight and green landscapes for ventilation, solar-powered lighting sensors for energy efficiency, and an automated system for pollution monitoring. High-efficiency lighting is used in all buildings and landscapes, enhancing productivity and health. A central system controls lighting sensors, while a ventilation system increases air efficiency by 30%. Buildings balance heat and sunlight through protrusions, ventilation openings, transparent glass ceilings, and mechanical shading systems.

5. Efficiency of water use and conservation: The university has implemented water conservation plans to reduce water loss in the hot, dry climate. Contaminated water is recycled for green landscapes and campus cleaning. A comprehensive plan has been developed to recover contaminated water and sewage for irrigation and cleaning. Resistant plants are grown in harsh conditions. Rainwater is collected, stored, and used while providing protected ecosystems and recreational facilities.

Achieving sustainability principles through a set of strategies implemented (17 and 25):

1. Strategies to achieve environmental sustainability and that of the elements and components of the campus and its landscapes:

a) Planning and designing university campus sectors: The east-west university campus orientation minimizes heat gain, particularly in summer, by grouping buildings under large roofs for shading and natural lighting. Transparent glass landscapes provide sunlight, and ventilation systems enhance air quality, eliminating pollutants and dust particles for thermal comfort.

b) Designing and planning landscapes: The campus site was chosen for its sustainability, considering its proximity to city services and biodiversity protection. The integrated design optimizes heating and cooling energy use. Solar panels are installed on roofs to reduce heat gain and combat the heat island effect. Trees and

local stones create a comfortable climate and improved thermal performance. A program was implemented to reduce water consumption by planting climate-tolerant plants. Rainwater and greywater were collected, treated, reused in irrigation, and incorporated into the design. Local stones are used to reflect sun rays and create a comfortable climate.

c) Path planning and designing: The campus has designed outdoor spaces to promote cycling and walking, with services on roads and walkways. It includes 20 buildings, student and faculty housing, schools, kindergartens, solar-generated lighting, and charging stations. These measures reduce walking distances, pedestrian safety, carbon emissions, and air pollution.

d) Planning and designing boundaries: The campus is designed to preserve biodiversity and minimize environmental impact by creating a 50-meter buffer zone to protect existing plants and neighborhoods from pollution caused by sewage water or industrial waste from the campus.

2. Social sustainability strategies: These strategies were used to follow local customs, traditions, and culture to find solutions. Five plans were applied to achieve social sustainability as follows:

a) The campus is designed like traditional Arab cities with a hot climate to reduce heat gain.

b) Follow the paths' shading to increase shading and reduce the heat resulting from direct sun rays while allowing the passage of sunlight to provide lighting in the landscapes and paths.

c) Campus buildings feature large roofs inspired by Arab Bedouin tents to reduce direct sun rays, thermal gain, and shade paths, while solar panels generate campus electrical energy.

d) Wind towers powered by solar radiation circulate air to campuses, reducing pollution and promoting thermal comfort.

e) Wooden roofs and shades are used in landscapes and courtyards to provide significant shade and reduce thermal gain while providing dim lighting to achieve visual comfort.

3. Strategies to achieve economic sustainability: Several major plans are applied, such as relying on local materials and natural resources close to the campus, as well as managing and recycling waste within the campus, as follows:

a) Efficient use of local materials and resources on campus: The campus uses natural compost from food and agricultural waste to improve soil properties, recycled 20% of materials in buildings and industrial landscapes, and used sustainable wood for industrial components, ensuring efficient use of local resources for durability, resistance to rust, corrosion, and salts and humidity.

b) Efficiency of management and recycling waste generated from campus buildings and landscapes: A campus program efficiently manages and recycles site waste from buildings and landscapes, including paper, glass, plastic, iron, metals, batteries, electronic devices, food scraps, and plant waste, using greywater and wastewater.

Table 1 and Figure 2 show the extent to which the strategies used on the KAUST campus to achieve the sustainability criteria and dimensions.

Table 1: Strategies for achieving the sustainability criteria and dimensions on KAUST campus.

Sustainability dimensions	Environmental					Social		Economic		
University campus components	Site sustainability	Transportation	Management and paths	Water consumption and management rationalization	Waste management and recycling	Pollution reduction	Energy management and consumption rationalization	Materials and resources	Local culture expressions	Participation and social justice
Campus sectors	6	3	3	6	3	6	6	3	6	3
Landscapes	6	6	6	6	3	3	3	3	6	6
Paths	6	6	6	3	3	3	3	3	3	6
External campus boundaries	6	6	0	3	0	6	3	6	6	3
Distinctive signs	3	0	0	0	0	0	0	3	3	3
Significantly Achieved = 6			Achieved = 3			Not Achieved = 0				

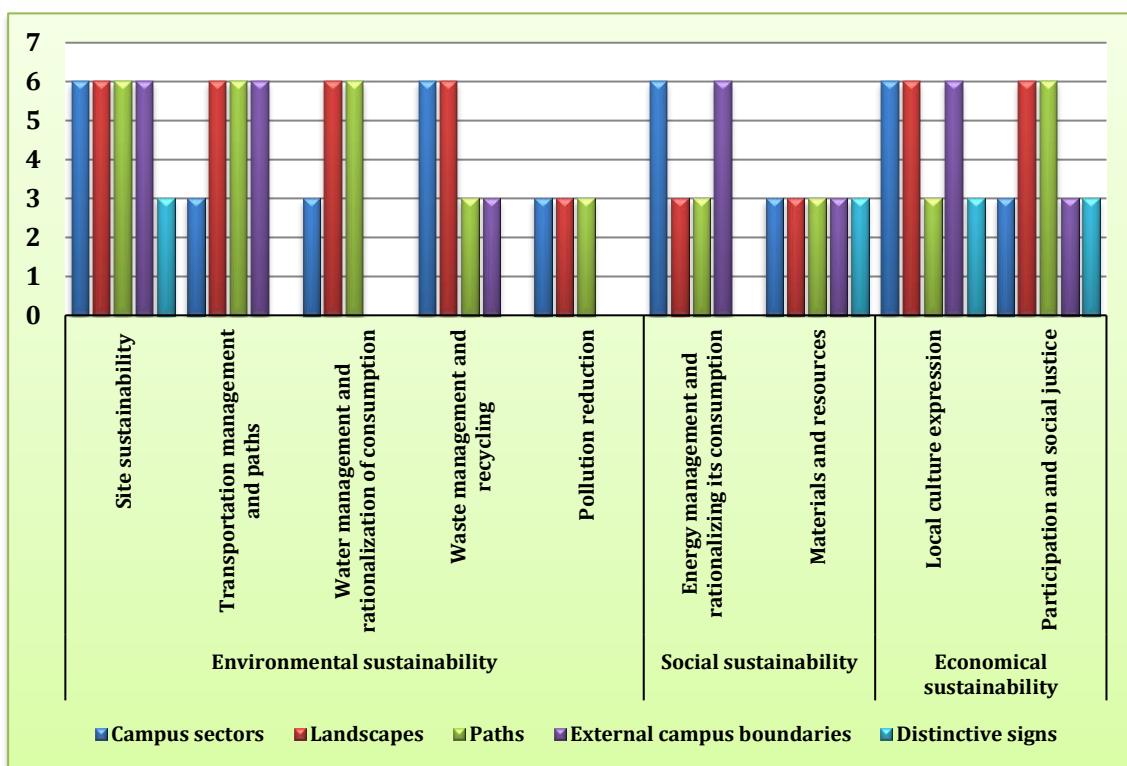


Figure 2: Strategies used to achieve the sustainability criteria and dimensions on KAUST campus.

The American University in Cairo (AUC), Egypt: Located in New Cairo in the Arab Republic of Egypt, the AUC grew in 2008 to 260 acres (Figure 3) to include Egypt's largest library, modern theaters, and sixteen research centers. An office was also established to study sustainability and environmental aspects. The university achieved significant results, reducing energy and water consumption by 33%, paper use by 32%, solid waste disposal by 27%, the environmental impact of heating,

ventilation, and air conditioning by 20%, and non-HVAC electricity by 24%. The university ranked 101 of 300 green universities evaluated globally, demonstrating its commitment to environmental sustainability. The university was awarded the ULI EMEA Excellence Award 2009 for its campus planning and design despite facing challenges. The AUC is situated on a high plateau with a slight slope, ensuring geological integrity and a groove separating its north and south sides.



Figure 3: AUC campus site plan.

Sustainable AUC campus planning and design (7, 12 and 19):

1. Sustainable site planning: The sustainable campus and its landscapes were planned according to the following:
 - a) AUC Park is an active space designed for daily activities, including gatherings, meetings, and events. It features restaurants, cafes, a museum, shops, and a metro for communication. The campus is surrounded by a green belt, sports fields, and outdoor spaces for running and walking.
 - b) Green outdoor spaces on the northern and eastern sides are designed for future expansion.
 - c) The campus design aims to create a city-like environment by integrating buildings and landscapes, connecting them through a main span, and reducing car traffic through parking lots, tree shading, and lighting.
 - d) The campus features a private tunnel, 8,000 trees, and 27 fountains to create a comfortable and functional environment with a walking-only layout.
2. Energy efficiency, renewable energy, and rationalization of consumption: The campus uses solar energy for natural lighting and a co-generation system for

electrical power, while wind energy provides natural ventilation through ventilation corridors. The buildings are designed using architectural processors, negative control systems, and mechanical systems to enhance indoor environment efficiency.

3. Efficiency of building materials and resources: The campus design, inspired by Islamic architecture, focuses on efficient building materials and resources. Energy management regulations reduce heating and cooling costs by 50%. Approximately 80% of the buildings are made of local sandstone, providing cooling and warmth. Marble, granite, and recycled stones are used for floors and walls. Sandstones also create industrial components for landscapes. Waste generated from these materials is reused and recycled, contributing to a sustainable future.

4. Lighting and ventilation: The campus's design prioritizes environmental compatibility and climate, incorporating climate elements and landscapes. Buildings and landscapes are oriented to achieve natural cooling and heating, using solar and wind energy for sustainable goals. Passive control systems are used for indoor environment efficiency, and the Illuminating Engineering Society of North America guide is used to determine lighting levels. Buildings are oriented north-south for efficient ventilation, and various fountains and water ponds were designed to protect against drought.

5. Water-use efficiency and conservation: Several methods were followed to conserve water, as water in irrigation and fountains was recycled and reused. Furthermore, local plants appropriate to the climate were chosen, together with an environment requiring little water.

Strategies used to achieve sustainable planning and design (2 and 21):

1. Strategies to achieve environmental sustainability of the elements and components of the campus and its landscapes:

a) Campus sectors: The campus is designed to respond to environmental and climatic conditions, considering future development and enhancing landscapes, buildings, and services using traditional Egyptian methods. It also provides services for occupants and disabled people, with a small city-like design for the campus center, central landscapes, and student housing. The library is located in the center for flexibility and communication, and increased opportunities for meetings and meetings are available for campus occupants.

b) Landscapes: The campus site was chosen to preserve agriculture and avoid other uses. Green landscaping provides comfort, beauty, and health, with local plants to unite activities. The landscape reduces heat island effects and uses northwesterly winds for ventilation. Clean energy sources like sunlight and natural gas are used for lighting and ventilation, and sewage is treated and reused for plant irrigation.

c) Pathways: The campus paths are designed for walking only, avoiding car traffic due to parking near the outskirts. Trees shade the pathways, and solar energy lights provide night-time lighting. An underground tunnel separates pedestrian traffic from cars, providing services and supplies. Wide pavements and walkways are created with visual attraction elements. Private lanes for bicycle movement and a parking area provided comfortable access to campus buildings

and landscapes. These strategies aim to achieve environmental sustainability in a short period.

d) Boundaries: The campus utilizes an 8m-deep slope groove for green landscapes and a plant fence to enhance its beauty and protect it from southwestern winds. Bridges connect the valley ends to campus paths, ensuring environmental sustainability.

2. Strategies to achieve social sustainability: The campus integrates all basic services, including schools, kindergartens, student housing, and commercial services, to achieve social sustainability. This allows for fair, diverse, and distributed services across various sectors, reduces walking distances and duration for occupants to access different services.

3. Strategies to achieve economic sustainability: The university has implemented strategies for economic sustainability, including efficient use of local materials, waste management, and water resource conservation. The university uses local materials for thermal insulation and industrial landscapes, has developed a waste recycling program, and reused organic waste for plant fertilizers. Water conservation measures include drip irrigation for green landscapes and gas-powered cooling equipment for heating, thereby reducing water consumption by 60% and demonstrating the university's commitment to sustainability.

Table 2 and Figure 4 show the extent to which the strategies used in AUC meet the sustainability criteria and dimensions.

Table 2: Strategies for achieving the sustainability criteria and dimensions on the AUC campus.

Sustainability dimensions	Environmental				Social		Economic		
University campus components	Site sustainability	Transportation management and paths	Water consumption and management	Waste management and recycling	Pollution reduction	Energy management and consumption	Materials and resources	Local culture expressions	Participation and social justice
Campus sectors	6	3	3	3	0	3	3	3	3
Landscapes	3	3	3	3	0	3	3	3	3
Paths	3	6	0	3	3	0	3	3	3
External campus boundaries	6	6	0	0	0	0	6	6	0
Distinctive signs	6	0	0	0	0	0	0	0	0
Significantly Achieved = 6				Achieved = 3			Not Achieved = 0		

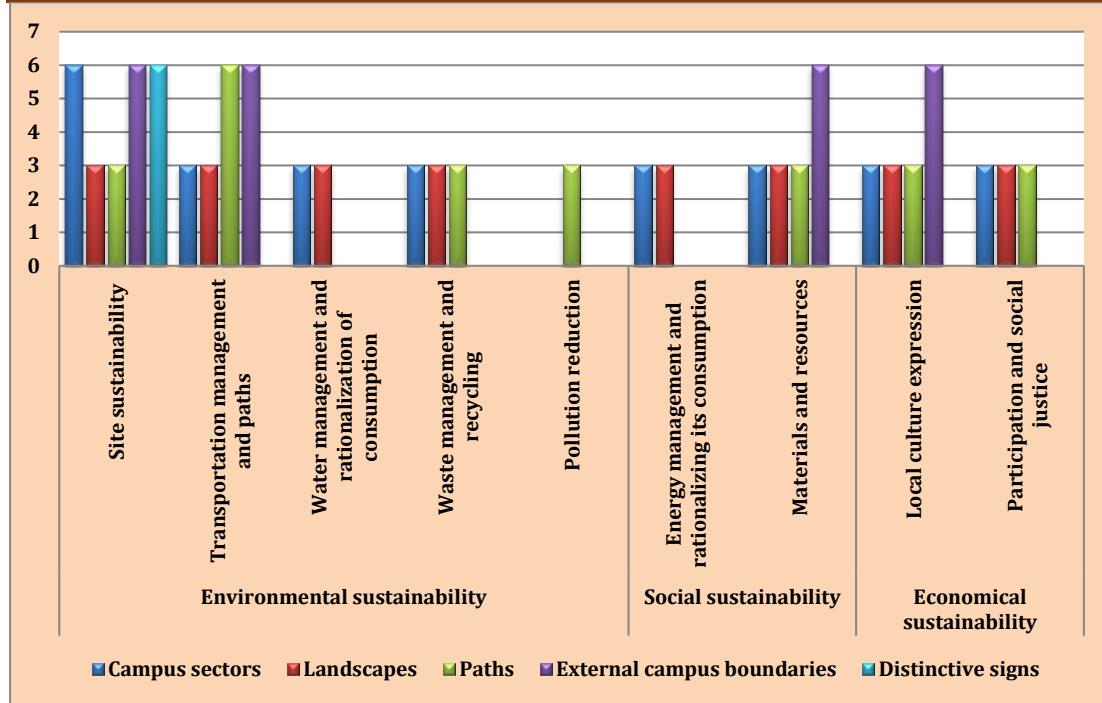


Figure 4: Strategies used on AUC campus to achieve the sustainability criteria and dimensions.

University of Baghdad, Iraq: In 1943, a committee was formed to explore the establishment of an Iraqi university. In 1956, the first law was passed to formalize the University of Baghdad. The university's foundation was laid in 1960 by TAC (The Architects Collaborative), led by renowned architect Walter Gropius, a key figure in twentieth-century modern architecture. The university is situated in a unique location within the Jadiriya area of Baghdad, on a peninsula surrounded by the Tigris River. It is an ideal setting for a distinctive university city, and covers an area of 1,300 dunams or 325 hectares or 3250000 m² (Figure 5).

The university's design encompasses main systems, including academic facilities, residential areas, sports facilities, and service areas. The academic scope includes the faculties of engineering and sciences, and social, cultural, and public activity buildings, which are central to social life, exchange of opinions, and scientific, intellectual, and cultural horizons. The university has various buildings, including a main hall (1,700 capacity), a central library (capacity of one million books and 2,700 readers), a headquarters tower, and general administration. The student center features a restaurant, cafeteria, post office, health center, exhibition, games, sports hall, and spaces for student activities. Some spaces are utilized by the university's centres and institutes, such as the Educational and Physiological Research Center, Continuing Education Center, and institutes for Laser, and Genetic Engineering and Biotechnology postgraduate studies.

The university supports public life outside Ring Street by constructing buildings such as the President's House, mosque, and sports facilities. Colleges and institute centres, including the Colleges of Political Science, Education for Women, Science for Women, Post-Graduate Institute for Accounting and Financial Studies, Market Research and Consumer Protection, and Center for Strategic and International Studies, currently occupy these buildings.

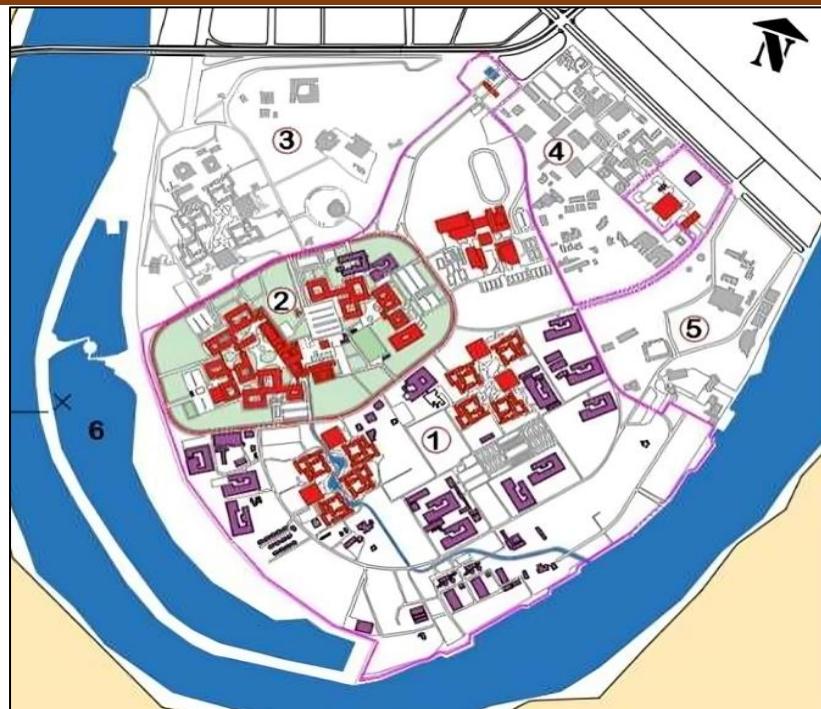


Figure 5: Site plan of the University of Baghdad.

1. Sustainable Campus Planning: The University of Baghdad is one of the first Iraqi universities to have implemented planning strategies for achieving a sustainable transformation of its campus and landscapes through the following (5, 8 and 16):

a) The campus aims for mixed land use, providing services to all sectors and encouraging development through rehabilitating and maintaining buildings and landscapes. It creates a distinct campus with easy movement between services and spaces. Buildings are designed in multiple zones, assembled, and distributed through pre-study, providing necessary services and noise isolation.

b) The campus has designed green landscapes using ecological design, incorporating native plants and modern agricultural methods to protect environmental resources and limit pollutants. Transportation efficiency has been improved by separating cars and occupants, providing services, and incorporating industrial components for comfort and safety. Trees provide shade, parking lots, and directional signs are placed for easy access. A public transportation system reduces pollution and emissions and results in a more efficient and comfortable campus environment.

c) The campus's future development plan considers academic, social, and administrative organization, allowing for a 15% increase in accepted students. A well-planned expansion system, including addition, overlap, and interconnection, was developed, utilizing a 36 m^2 construction network for educational department buildings.

d) The campus focuses on efficient energy use and conservation, reducing consumption through environmental aspects such as managing building-landscape relationships, reducing water consumption for irrigation, and preserving materials.

2. Energy efficiency, renewable energy, and the rationalization of their consumption:

- a) The campus has been optimized for energy efficiency and renewable energy consumption by utilizing its suitable climatic characteristics.
- b) Planning for wind and solar rays to provide clean energy and directing wind movement for ventilation and air pollution disposal.
- c) Convergent planning and a relationship between outdoor and interior spaces have been implemented to reduce heat island effects.
- d) Energy consumption is rationalized by reducing its usage during work periods and requiring devices to be turned off before leaving the building.

3. Efficiency of building materials and resources

- a) The construction of buildings and external walls utilize thermally efficient materials that reduce heat gain.
- b) Solar shields were designed for the southern and northern facades, while the eastern and western facades were reduced to protect against sun rays and thermal loads.
- c) Light colors and soft textures increase the reflected sun rays. Strategies were developed to reflect local heritage, using elements from Arab Islamic civilization and respecting customs.
- d) The main entrance gate and the mosque's conical dome were designed using modern construction technology.
- e) The design aimed to achieve functional relationships through repetition, containment, and progression, break boredom, create vitality in the movement system, and achieve unity and diversity.

Obstacles to achieving campus sustainability:

Certain strategies have been lacking at the University of Baghdad compared with KAUST and AUC and studies which define the major components for achieving a sustainable university campus (6).

- 1. The campus heavily relies on fossil fuel generators, contributing to environmental and air pollution, and lacks significant solar energy reliance. Additionally, a planning and design proposal was not developed for future expansion, creating a significant design gap.
- 2. The campus lacks comprehensive waste recycling plans, with recycling limited to certain materials like iron. Additionally, there are no strategies for recycling greywater, as the campus relies on traditional methods and lacks modern irrigation technologies.
- 3. Campus plans for managing climate change and reducing greenhouse gas emissions have not been implemented, focusing on canopies instead of double glazing, reflective glazing, smart windows, and tinted glass. Additionally, plans to monitor and mitigate CO₂ emissions have not been enhanced, posing potential harm to campus occupants.
- 4. The campus lacks strategies to improve energy efficiency and rationalize consumption, including energy-saving devices and campus sensors. Additionally, no devices are installed to measure energy and water consumption despite attempts to develop plans to reduce these aspects.

5. The campus landscapes were inadequately designed to cater to the comfort needs of its occupants due to the unequal distribution of services, including amenities like restaurants, seating, and shading, as well as the lack of green spaces and industrial components.

Visions and strategies to promote campus sustainability:

Comparisons between the universities showed that some of the issues preventing the achievement of sustainability at the University of Baghdad can be addressed by adopting some of the following strategies:

1. Site uses:

a) It indicates whether the campus deserves to be named a green campus. The goal is to encourage the university to contribute to providing more space for green landscapes, environmental protection, and sustainable energy development.

b) Green landscapes in urban areas are essential for students, reducing psychological pressures, promoting comfort, preventing air pollution, and improving climate. Plants reduce carbon dioxide, increase oxygen levels, and offer recreational opportunities. Ecological diversity in green spaces enhances academic life and makes them valuable resources.

c) The University of Baghdad places much importance on green spaces (Figure 6), with planted areas of low grasses, ornamental plants, and climbers covering 7,971,685 m² or 75% of its total area. They also include high plantings, such as trees covering 1,945,306 m², which act as natural air purifiers.

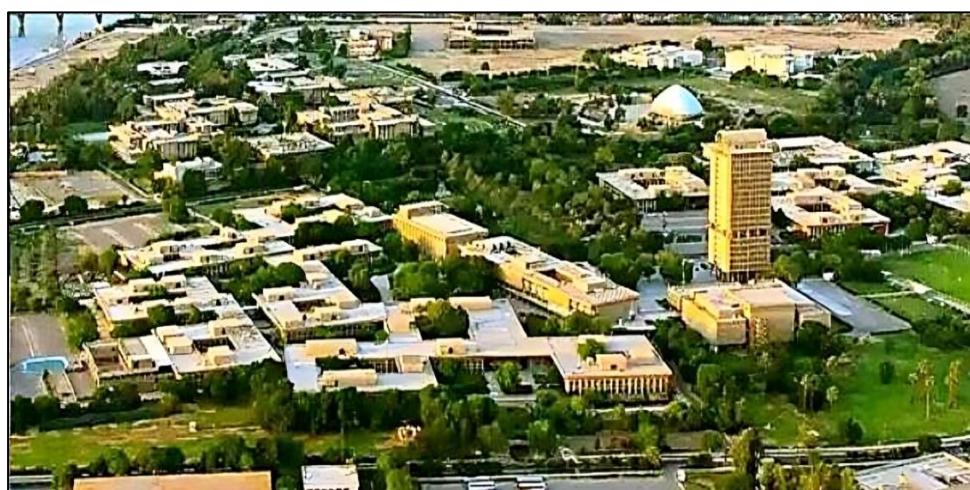


Figure 6: Green landscapes across the University of Baghdad campus.

2. Waste management and recycling:

a) The university prioritizes waste management and recycling to create a sustainable environment. It collects data on waste types, establishes waste sorting projects, and benefits from them.

b) Volunteer teams assist in waste management, develop employee capabilities, and educate members and students about paper and plastic usage. The goal is to reduce consumption and raise awareness about the harms of these materials.

c) The strategy for storing and disposing of toxic waste involves using containers in different colors for waste segregation and implementing a waste treatment and recycling program.

d) The university is considering a project to increase its economic returns by converting solid waste revenues into environmentally friendly biological and organic fertilizers (6 and 17). The project will convert waste into nitrogenous, phosphate, and potash bio-fertilizers using various bacteria and fungi genera like Rhizobium, Azotobacter, blue-green algae, and mycorrhiza.

3. Energy management:

a) The university is committed to enhancing energy efficiency in its buildings and landscapes, focusing on nature and energy resources. This includes implementing energy-saving devices, renewable energy policies, conservation programs, green buildings, climate change adaptation, and reducing energy consumption.

b) The plan involves implementing energy efficiency criteria in buildings by providing affordable appliances, collaborating with academics, raising awareness, holding workshops, and installing sub-meters.

c) Conducting campus electrical energy consumption studies, transitioning to alternative energy, and developing environmentally friendly transportation plans. A central cooling and heating system is also crucial for reducing energy consumption and environmental protection (19).

4. Water management: Implementing water conservation strategies, promoting rationalization of water use, and recycling water for plant irrigation are crucial. Implementing air conditioner water collection and awareness programs for students and employees can also help reduce water consumption (7 and 12).

5. Transportation management:

a) The campus transportation policy should be adjusted to limit vehicle usage and encourage walking among students and employees. Instead of private cars, the policy should focus on environmentally friendly public transportation, considering the economic feasibility of the campus's transportation system in terms of environmental damage and maintenance costs (5 and 8).

b) The university encourages campus occupants to walk or use electric bicycles instead of private cars. The campus has pedestrian roads, with a main path over 3.5 km, and secondary roads are isolated from car roads, reducing environmental pollution from car exhausts (Figure 7).

c) The university offers a safe and efficient transportation service using buses to shuttle employees and students to affiliated colleges and institutes. Regular maintenance ensures vehicle longevity and repair. This service also promotes walking to work, reducing environmental pollution caused by toxic vehicle emissions.

Figure 7 shows the pedestrian paths through the landscapes at the University of Baghdad campus.



Figure 7: Pedestrian paths through the landscapes of the University of Baghdad campus.

Table 3 and Figure 8 show the extent to which the strategies used at the University of Baghdad achieve sustainability criteria and dimensions.

Table 3: Strategies to achieve the sustainability criteria and dimensions at the University of Baghdad.

Sustainability dimensions	Environmental				Social		Economic		
University campus components	Site sustainability	Transportation management and paths	Water consumption and management rationalization	Waste management and recycling	Pollution reduction	Energy management and consumption rationalization	Materials and resources	Local culture expressions	Participation and social justice
Campus sectors	3	3	0	0	3	0	3	0	3
Landscapes	3	3	0	0	6	0	3	0	3
Paths	3	3	0	0	3	0	0	0	3
External campus boundaries	0	3	0	0	3	0	0	0	3
Distinctive signs	0	0	0	0	0	0	0	0	0
Significantly Achieved = 6				Achieved = 3			Not Achieved = 0		

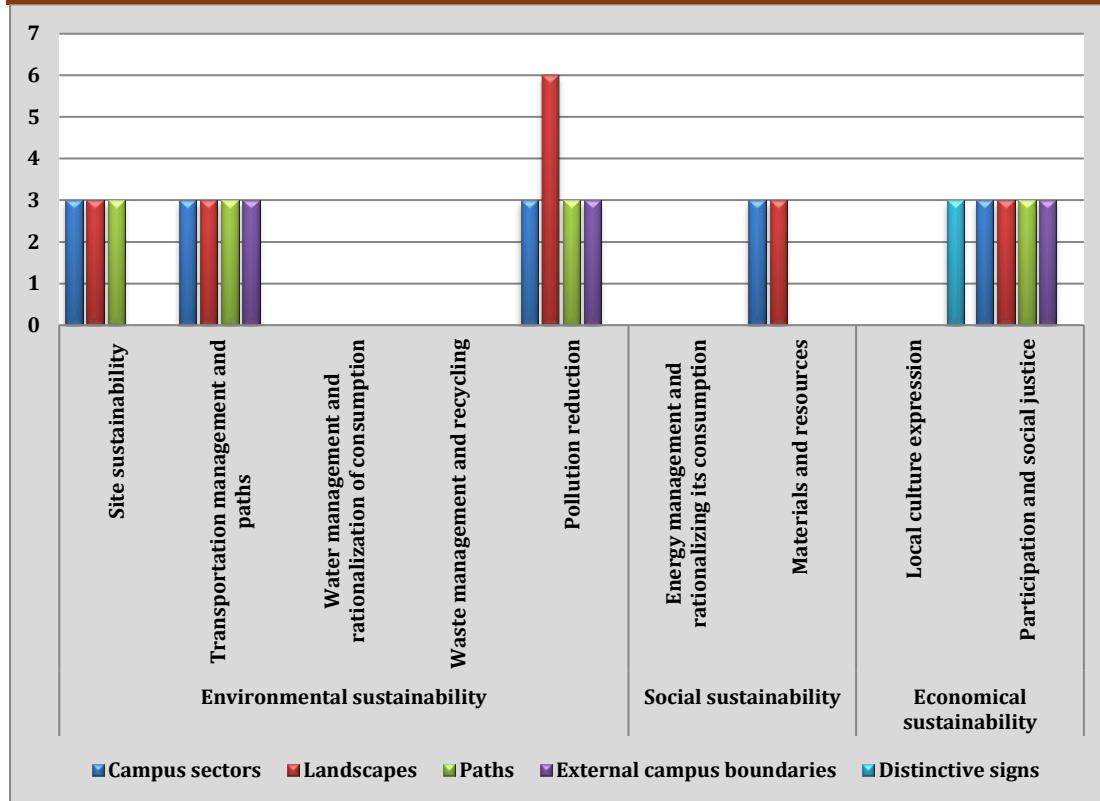


Figure 8: Strategies used to achieve the sustainability criteria and dimensions at the University of Baghdad campus.

Conclusions

The above review of international universities and their campus landscapes in regard to sustainable planning and design with a focus on KAUST and AUC shows that the sustainability criteria were applied and internationally accredited certificates were obtained. Compared to the two universities, the University of Baghdad lacks many aspects of sustainable planning and design. Thus, this study formulated a number of strategies and solutions towards developing a sustainable university campus and landscape through appropriate planning and design based on the criteria and dimensions. It would also improve high-energy and renewable energy efficiency, and rationalize consumption and environmental compatibility. In this regard, the resolution strategies would facilitate the increased use of efficient building materials, resources, lighting, ventilation, maintenance, and water use, besides acquiring the three basic factors of sustainability, namely environmental, social, and economic aspects.

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