

Investigation of Sustainable University Campus Design Factors in Case of the Middle East Countries^{*}

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Abstract

While many universities in the Middle East have tendency to achieve sustainable campuses, there is lack of research results on their success rate and evaluating the effective factors. This paper aims to recognize and determine the effective indicators to achieve green university campuses in the Middle East countries by case study analysis and evaluation. Additionally, university master plan solutions in programming and designing sector will be compared according to UI Green Metric criteria and then weaknesses and strengths of these criteria will be explored. Accordingly, progress and trend of green campus development and Middle East participation in "green" universities movement have been discussed and eight universities have been studied. According to results, the "Energy and Climate change" has the highest value in programming; while "Water" and "Education: have been evaluated as the neglected criteria in university campus master planning in the Middle East countries.

Keywords: sustainable, green, university, Middle East, UI green Metric.

Introduction

In last 20 years, many universities have attempted to implement changes in campus planning in order to transform them into "Green Universities". However, there is a lack of research results in this field from universities in emerging countries [1]. As shown in Fig.1, an increasing attention to the declarations, charters, and partnerships for sustainable development in higher education has been seen since 1990 [2]. Study on international academic events and their motivations shows that sustainable development in higher education has similarities and differences in various regions.

In Northern American and European countries, the work of green campus especially focuses on spreading the idea, publicity and education [3]. Since 1972 to 1994, some conferences hold to ask for the attention on the education of environment protection at colleges and universities [4-8].

The Australian National University has provided a set of sustainability targets and implementation

strategies for 2015 and beyond to guide environmental management, including the improvisation in environment protection, education and student participation and so on [9].

Unlike Northern America, Europe and Australia, the concept of "green university" in Asian countries focuses on practical programs and implementation. The green campus development in Asia started with the eco-technology and facility energy management with government persuasion and encouragement. This leads to deal with a set of important issues related to energy efficient campus. Finally this leads to promote universities to green campus [4]. Asian universities have experienced a rapid development in applying sustainability efforts through various green programs. In comparison with North America and Europe, there are more sustainable campuses in Asia planned to mitigate carbon footprints and educating the students about eco-preservation, biodiversity and so on simultaneously [10].

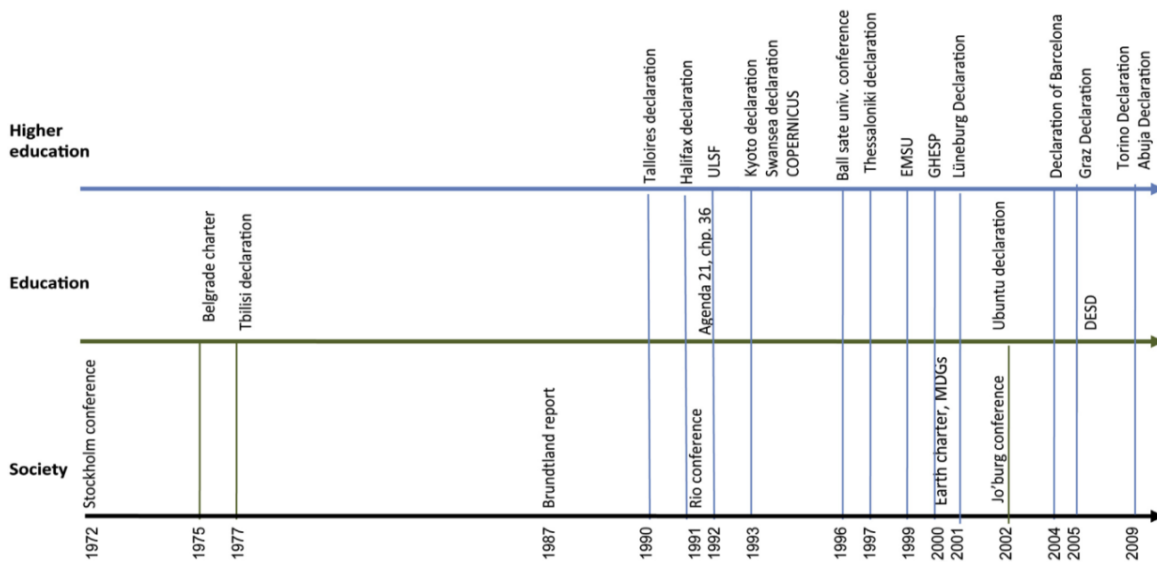


Figure 1: Evolution of the declarations, charters, and partnerships for sustainable development [11]

While few universities in the developing countries, especially in the Middle East, are planning to reduce the negative impact on the environment [15], it seems that a wave of sustainable thinking has been created in region and higher education institutes incorporate sustainability into their systems. Previous studies that investigated effective factors for achieving a green university can be found largely in the West and developing countries outside the Middle East [16]. Despite the key role of universities in development of environmental sustainability, there is no known study in the Middle East that explores and determines the effective indicators to achieve green university campuses. As such, this study attempts to fill this gap using case study analysis and evaluating them. The choice of indicators and the publication of case studies lead to identify priorities and the way of "Sustainability" implementation in different contexts [17] such as the Middle East. The main question of this research is that:

- Which factors are more effective to achieve a green university campus in the Middle East?

This paper has evaluated a very important issue in the Middle East because of the ongoing ambitious projects of establishing universities that are moving towards green campuses. So, recognizing and the effective solutions to achieve green university campuses in the Middle East countries can lead developers to a way of thinking that helps to create a sustainable society and protects the environment and natural resources.

In this paper, the progress and trend of green campus development in Middle East were

summarized, green design solutions in Middle East university campuses were investigated and then, the factors which are more effective for achieving green campus in Middle East were assessed in programming and design phase.

Progress and trend of sustainable university campus development in the Middle East

While in 1940 there were only ten universities in the MENA countries, by 2000 increased to 140 and by 2007 the number of universities reached 260-two-thirds of which were founded after the 1980s [18]. During the late 1900, a wave of university campus construction started in the region following the *Baghdad University* model [19]. Recently, governments, non-governmental organizations, and professional bodies are interested in sustainable development over the region. For example, the Moroccan government has announced the development of a national center for sustainable environment, while the United Arab Emirates (UAE), Egypt, and Jordan have introduced energy efficiency standards for buildings constructions [20].

The education and practice of sustainability in the Middle East can be found in contemporary university campuses. The overview of programming and sustainable design in these campuses demonstrates three approaches to sustainable design in the region: revivalist approach, progressive approach, hybrid approach. According to *Elgendy's* research regarding Middle East architecture [21], the revivalist approach to sustainable design can be described as using previously experienced architectural strategies and solutions to achieve sustainable and energy-

efficient design. Architects with progressive approach seek to use the latest technologies to achieve sustainable buildings. The hybrid approach, as its name demonstrates, represents designer's effort to combine the revivalist and progressive approaches. Buildings in this category, for example, are trying to balance the use of shading and thermal masses with optimizing building envelope and insulation techniques. The *King Abdullah University for Science and Technology*, the new campus of the *American University in Cairo*, and the *Masdar Institute for Science and Technology* are appropriate cases that are belong to this category [21-24].

Few universities in the Middle East are making the necessary adjustments to decrease the negative effects of campus operations on the environment [15]. UI GreenMetric WUR recently published a report that rates the environmental sustainability of campuses across the globe. As shown in Fig.1, only 28 universities which are located in 12 different countries have adopted any significant environment-friendly policies among more than 600 universities in the region (Fig. 2) [25]. According to fig.2, Turkey is rated in first place among Middle East countries for having 28 universities that is evaluated green.

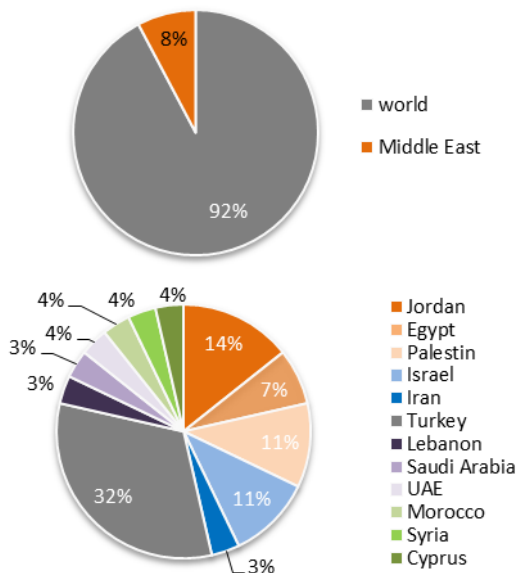


Figure 2: Middle East countries participation in green universities movement according to UI GreenMetric WUR, 2015.

Research Method

The aim of this research is the assessment of green design solutions in Middle East university campuses to achieve sustainability. Additionally, the factors which are more effective for achieving

green campus in Middle East will be assessed in programming and design phase. So, the inclusion criterion must be defined: green campus criteria.

3.1. Green campus criteria

The growing importance of sustainability in general in universities has led to the creation of sustainability rankings [26]. Lozano and Huisingh [27] published an innovative conceptualization of sustainability which determines sustainable university campus criteria which are based on the followings: conventional economic; non environmental degradation; integrational perspective, environmental and social dimensions; encompassing the economic; intergenerational perspective; and holistic.

Thomashow [28] reported the experiences of the president of a small college in the U.S. who instituted sustainability throughout the institution which uses are categorized into three groups: 1. infrastructural aspects including energy, food, and materials; 2. community aspects which include governance, investment and wellness and 3. Learning aspects which include curriculum, interpretation and aesthetics.

Based on global campus sustainability evaluation instruments, there are five major sustainability evaluation systems: 1. The Holcim Awards; 2. STARS; 3. The college sustainability report card; 4. GREENSHIP; and 5. UI GreenMetric WUR [17,29,30]

The latest university sustainability evaluation system, UI GreenMetric WUR, provides an evaluation system by a set of criteria and clear target issues. These issues are: 1. Setting and Infrastructures (SI), 2. Energy and Climate Changes (EC), 3. Waste (WS), 4. Water (WR), 5. Transportation (TR) and 6. Education (ED) [31].

The fundamental of the presenting paper is based on eight case studies in a 5 point- scale according to UI GreenMetric. The solutions for each project can be assessed according to the six criteria. So each case is scored in a scale of 1-5 according to the Table 1. Scoring system is as follows:

Table 1: Scoring system

Score	Type of Solution
1	suggesting no solution
2	suggesting common solutions
3	suggesting a practical solution dependent on technology
4	solutions taken from traditional architecture
5	hybrid practical solutions

The final scores will be compared, then strength and weak points are assessed and the criteria with stronger effects will be collected. Data are mainly collected by studying the university plans, assessing perspectives, goals of missions of

universities based on their information on their websites. Furthermore, some information is provided by interviews. Below is the flowchart of the research process (Fig. 3).

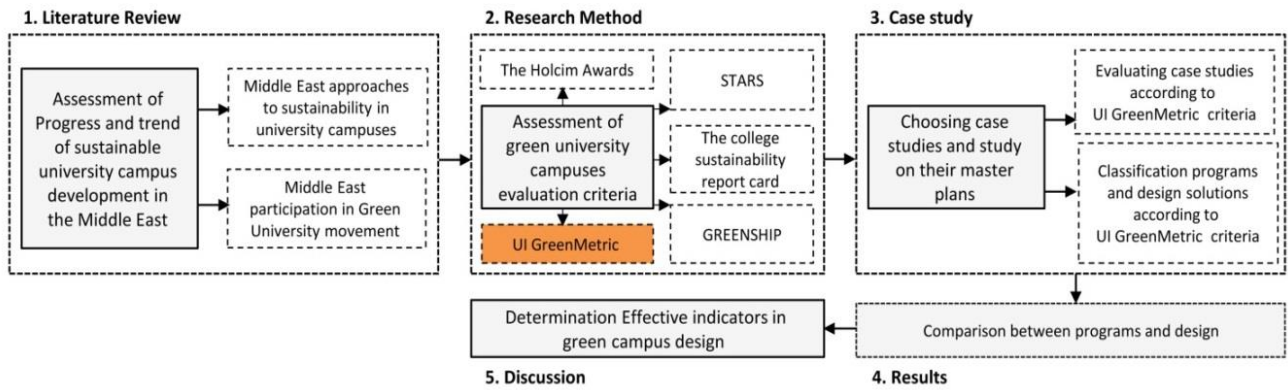


Figure 3: Flowchart of the research process

Case studies

A case study can be described as a qualitative method for finding “which factors are involved in an empirical investigation of a particular contemporary issue within its real life context [32]. Nowadays, in the Middle East, there is significant growth in the use of green building technologies. The challenge of moving towards green architecture, particularly for universities, has become an effective competition in different Middle Eastern countries [33]. In this study, four different cases of universities in the Middle East countries which are known to be successful green projects have been surveyed. Efforts have been made to choose universities which had been evaluated by the UI GreenMetric World University Ranking system as green buildings or known as successful green projects. Also according to Fig.4





a suitable geographical distribution over the region is taken in order to conclude more accurate and real. The eight cases that have been studied in this paper are as below:





Masdar Institute of Science and Technology, American University of Cairo, King Abdullah University of Science and Technology, Ferdowsi University of Mashhad, Jordan University of Science and Technology, American University of Beirut, Qatar University, University of Balamand.



Figure 4: Case studies location in the Middle East.

Table 2: Green design solutions according to UI GreenMetric criteria.

Green Metric Criteria	Solution			
	Masdar Institute of Science and Technology, Abu Dhabi, UAE	American University of Cairo, Egypt	King Abdullah University of Science and Technology, Saudi Arabia	Ferdowsi University of Mashhad, Iran
				
SI	locating in desert for maximum use of solar energy, applying	strong geometric urban order with an informal desert garden	Locating in coast of Red Sea; Providing the 5.5 million square	Locating in an urban area; paying special attention to ecology and

	advance environmental systems		feet research facility	natural environment
EC	Angular grid of the city to minimize solar penetration of the streetscape, Using rooftop PV array for producing electricity and shading the roofs, using wind catcher,	Making shelters by planting to preventing from harsh desert winds, using traditional Arabic "mashrabiya" for sun-protection, wind catchers to capture prevailing winds and circulate fresh air, using shukshaykhas to remove hot air	compressing the campus as much as possible to minimize the amount of exterior envelope exposed to the sun and to reduce outdoor walking distances, Solar panels covering the surface, creating air flow in pedestrian walkways by iconic solar-powered wind towers passively, using "mashrabiya" to shade windows	Employing photovoltaic cells and wind towers for providing electricity directly, using the roof top spaces and moderate the temperature by employing green roofs and roof ponds,
WS	Full on-site waste segregation and recycling, Prefabrication of façade elements and bathroom pods, using local materials such as palm wood	Using the sandstone all from one mountain quarry in Kom Ombo north of Aswan	Implementing a recycling and composting program to reduce the amount of waste produced by the University	Segregation and recycling programs
WR	using low flow fixtures and fittings; recycling water for irrigation	-	-	Collecting grey waters; reuse of threated waters for non- potable uses
TR	electronic personal rapid transit (PRT), shaded colonnades between buildings	shaded walkways for transition among the campus	an alternative transportation plan to provide fuel efficient transportation options for all residents	Utilizing tramway or monopod, creating bicycle paths and developing walkways
ED	To establish a sustainable academic and scientific research institute, To study a number of renewable technologies for applying in the desert	Establishing the Research Institute for a Sustainable Environment (RISE), promoting environmental research and education, To implement recycle programs and raising public awareness	To provide facilities for studying sustainable solutions to basic requirements of water, food and energy	Holding "Green and Health life" workshops, adding environmental concern courses to the curriculum
UI Green Metric Criteria	Solution			
	Jordan University of Science and Technology, Irbid, Jordan	American University of Beirut, Lebanon	Qatar University, Doha, Qatar	University of Balamand, Souk El-Gharb, Lebanon
				
SI	a master plan with two axes, a social axis, and opens to public and connects the campus	enhancement and nurture of the middle campus, the unique vegetation-covered	located away from Doha's commercial district to create a dramatic setting, The	Locating the campus on a steep hillside overlooking the Mediterranean Sea;

	with nearby city; A 72 m ² square grid	lime-stone escarpment separating the upper and lower campuses; no use of high ozone depleting, reduced heat-island effect by utilizing underground parking	academic buildings are located within a ring road, with sports and ancillary facilities on the outside	preserving and restoring the connectivity between its forested ravines, olive groves and terraces, and vegetated valleys; conceiving campus as a village on a hill; The campus is designed as a didactic, sustainable environment
EC	planted courtyards placed at a 45 degrees angle	roof integrated solar collectors for hot water and swimming pool heating; building slab integrated heating/cooling system; volume distribution creating local microclimate; radiative and evaporative cooling by water walls; natural and wind forced ventilation; interior daylight; and energy-efficient lighting fixtures	Applying wind-tower structures to provide cool air and reduce humidity; controlling the harsh sunlight by Towers of light; use of wooden lattices and screens and some stained glass to serve to mediate the environment; Open and partially covered courtyards with plants and often fountains; using thick External walls; Employing octagonal build units to moderate heat absorption	Framing campus plazas, courtyards, and lawns by colonnades; orienting buildings according to optimum solar radiation, maximizing daylighting and minimizing energy consumption; orientating the campus plazas, courtyards, and passageways according to natural ventilation from the prevailing southeast winds; the tightly-knit fabric of buildings and open spaces tied together by colonnades and arcades
WS	using prefab concrete panels and blocks	high-efficiency chilled water generation plant using sea water wells for system cooling	use of repetitive pre-cast panels for both cladding and structural elements	To reuse of available building elements and local materials, use of campus agricultural products
WR	Rainfall harvesting for potable or non-potable uses; waste water treatment	grey water collection; low potable water consumption; standby rain water collection system; reuse of swimming pool backwash water; water-efficient landscaping	-	-
TR	large network of walkways for pedestrians	Pedestrians were to replace automobiles almost everywhere, development and extending walkways and plazas	a ring road for vehicles, considering Walk around campus Retrieved from Qatar's individual circumstances	To transform the campus into a pedestrian environment to recognize landscape better
ED	sustainable educational programs, Energy center and a center For Environmental Science & Technology	To provide an excellent liberal arts and professional education for students from the Middle East and the world	-	Following the premise that learning happens anywhere; extension of the learning environments inside buildings

Results and Discussion

The Middle East is where countries are in a special climatic and geographical situation. So, these countries have lots of traditional architecture solutions in various fields such as energy and climate, water, material, waste and etc. from bygone era. Recently, most of Middle Eastern universities are enthusiastic to apply the green technologies in their constructions and compete with each other [34-36].

According to research methodology, scoring to cases demonstrates that solutions how much are feasible, efficient, up to date and inspired by traditional architecture. So, the more a case gets higher scores, it means the suggested solution meet all the features mentioned.

Studying solutions indicates that there is tendency for employing modern technology in case studies and most of solutions in both programming and design are depended on technology and a few numbers of cases have inspired from traditional architecture such as applying 'mashrabiya', wind-catchers and planted courtyards. But, in 'EC' sector there is large number of hybrid solutions (Fig.5).

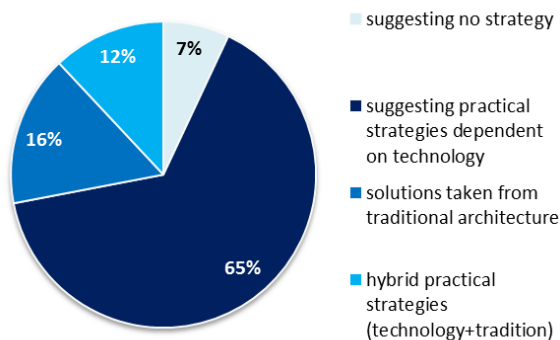


Figure 5: Comparison of types of solutions.

Table 3: Evaluation case studies according to UI GreenMetric criteria.

Case studies	Scores					
	S	E	W	W	T	E
	I	C	S	R	R	D
Masdar Institute of Science and Technology	3	5	5	5	5	3
American University of Cairo	4	5	2	1	4	3
King Abdullah University of Science and Technology	5	5	4	1	5	3
Ferdowsi University of Mashhad	3	5	2	3	3	1
Jordan University of Science and Technology	5	4	2	3	2	3
American University of Beirut	5	5	3	3	2	2
Qatar University	4	4	4	3	2	1
University of Balamand, Souk El-Gharb	5	5	3	1	4	2

• **Setting and infrastructures:** The criterion that is the most significant after "Energy and Climate changes". In cases, three are located in suburb areas away from residential and commercial district or in deserts, two are in seashore, two are located at the top of green hills overlooking to sea and one is in urban area. It can be concluded that choosing natural settings away from overcrowded urban areas leads to better utilization of nature and its potential and is a factor for creating a green campus. Utilizing of land slop for rainfall harvesting, maximum solar energy in suburb areas and deserts, sea wave energy are among solutions in which natural setting facilities are used.

According to recent works on spreading sustainability in developing countries, it can be found that social infrastructures and government participation have a key role in some target issues such as education and awareness [36].

• **Energy and Climate changes:** The climate change is not a completely new phenomenon in the Middle East. According to *Andersen's* report [37] people in MENA region have been faced with water scarcity and heat, and have developed various solutions and to solve these environmental problems." As such, MENA have a valuable set of traditional knowledge and design strategies that are experienced over the time and evolved gradually [38].

Energy consumption of the universities and colleges increased significantly following the dramatic development of higher education in the Middle East. Improving energy efficiency in universities and colleges plays a vital role for region's countries to achieve the evolution of an environmental-friendly and energy-saving society [34-36]. According to *Yuan & Zuo* [15] work on Chinese universities, colleges consumed 8% of China's total energy. Additionally, the average energy consumption per college student is 4 times of the average value of Chinese residents [39].

By analyzing the scores related to each criterion, we'll find out that "Energy and Climate changes" is of the most importance in programing and design, and university master plans have paid special attention to this criterion. The mean score of this criterion is 4.75. This high score is mostly due to the climate situation of the Middle East which make the developers think of solution in order to save energies. Solutions those mainly inspired from traditional architecture are: compressing the building envelop, placing masses at 45 degrees angle, applying wind catchers for natural air circulation, planted curt-yards, casting a shadow on facades and windows, creating semi-open paths,

using water and fountains in campus for moderating the air temperature, etc.

- **Waste:** The "waste" criterion demonstrates the manner of using materials in a university campus. This criterion has scores 3.13 in programming section and is in 4th place of significance. Presented solutions can divide into three parts: 1. Use of pre-fab elements for facades, structure and cladding; 2. Employing native materials such as palm wood, stone, sandstone, clay and etc.; 3. On-site segregation and reuse of them in campus construction.

- **Water:** Scarcity of water is the major natural problem in the Middle East. The region only has 1% of the world's available fresh water and overall is hot and dry. Despite of all, steep population growth, poverty and the consequent degradation of natural ecosystems is common [35].

As mentioned, the lack of water sources and rainfall in Middle East is one of difficulties in university campus design. Nevertheless, the comparisons show that the "Water" criterion has the lowest score in both programming and design phase. It means this criterion has the lowest importance and has less practicable solutions. Only three cases have suggested solutions including using low flow fixtures and fittings, recycling water for irrigation, Rainfall harvesting for potable or non-potable uses, grey water collection and treatment.

- **Transport:** According to Geneidy's works on transportation in MENA region despite the fact that walking is the most sustainable way of transport over a university campus, this form of moving has been largely neglected in both planning and infrastructural level [40].

The "transport" is in third place of significance after EC and SI. Development of pedestrian is the common solution in university master plans and design. In two cases a set of transportation system is offered and people can choose one of them, including: side-walks, bike path, trolleybus, tramway, monorail and car pod; but in design phase most of cases used motor vehicles. Only in one case (Masdar Institute of Science and Technology) PRT system (Personal Rapid Transit) is considered and employed for moving from entrance to the center of the campus. This is a smart pathfinder and has no chemical and noise pollution.

- **Education:** The training and involvement of university students in environmental education in developing countries have been largely neglected [41,42].

According to Table 3, the "education" criterion has been placed at 5th. It means that suggested solutions are common and not enough. Presented solutions can divide into three parts: 1. Establishing the professional energy and sustainability studies center in university campuses; 2. Considering the energy efficiency, environmental health and sustainability issues as the main vision of the university; 3. Raising public awareness about energy crisis, pollutions, food. Based on the findings about lack of sustainability opportunities, most of strategies are on-campus life experiences for students, as suggested by *Lozano* [43] which include: holding workshops about energy efficiency; waste reduction and rising public awareness; and promotion of sustainable transport for students.

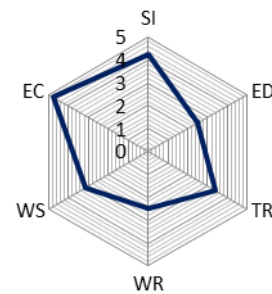


Figure 6. Comparison of the criteria scores

Conclusion

The current research studied the university campus efforts for achieving sustainability and develop green campus design criteria in the Middle East countries. These indicators have been resulted from a set of criteria and target issues that is derived from sustainability evaluation systems and instruments. According to case studies, Middle Eastern countries have proven their ability towards all kinds of environmental challenges such as hot-arid climate, scarcity of water, lack of public awareness and education facilities. The Middle East region is particularly vulnerable to climate change. It is one of the world's most hot regions with high dependency to architectural and urban programming and design solutions in such a hot-arid climate. Due to key role of the university campuses in achieving sustainability, it is necessary to study and evaluate their efforts in planning and implementation in regional level.

The current work finds that 'Energy and Climate change', 'Settings and Infrastructures' and 'Transportation' are significant indicators in university master planning over the region. Despite of water scarcity in the Middle East and global attention and programs about this problem, the 'Water' has been reported as the neglected criterion

in implementation sector. Recent efforts for participating students in environmental managing can be mentioned as the university proceedings in 'Education'. Despite of all, this criterion is on the first steps of the way.

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