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A Framework Transformation of a Traditional Campus into a Bio-Tech Smart-Digital Campus

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ABSTRACT

The industrial revolution had begun in the 20th century, which resulted in pollution, the appearance of epidemics and diseases, and a demand for sustainability. Numerous cities have adopted the smart city concept to improve energy efficiency, manage services, improve the quality of life for users, and lessen and resolve environmental problems. Since it may be a route to the smart city, a smart university can be thought of as a mini city, and smart city strategies can be implemented in it. Digitization is a catalyst for transforming a traditional university that is based primarily on human practices into a smart university that uses artificial intelligence integrating intelligent learning platforms. The Smart Campus initiative aims to create a university where technology aids academics, staff, students, and visitors in performing daily responsibilities more efficiently and effectively and makes life inside a modern-campus easier. The smart campus has to be understood to identify and validate a framework and ultimately apply it to a university using the smart infrastructure technologies. In this Research; a comprehensive review of retrofitting universities to reflect the modern worldwide technological movement in renovating a sustainable technological architectural design and construction for a university to create a smart educational environment.

1. INTRODUCTION

A smart university can be defined as a small city since it can be a way to reach a smart city. The regulation of both academic and administrative processes and sustainability in universities is of great importance for the formation of self-sufficient campuses. The search about the socioeconomic organization of a city leads us to consider universities as perfect environments for small-scale testing. The Smart Campus concept can be created by applying the approaches of the smart city on the university area. The university campuses are characterized by their human resources, which ought to embrace and develop the innovations and facilities applied by smart approaches. Universities are areas where energy is consumed because of crowdedness. This consumption can be controlled in smart universities [1]. Traditional universities lack the requirements of the 21st century; most of the universities are old without any real renovation; as there is no totally smart-green campus, lack of smart infrastructure, buildings, and appropriate information technology, and so, many universities around the world need to adopt the smart university concept to improve the quality of education, ensure energy efficiency, and improve management services. The smart university uses advanced technologies to provide different services [2].

2. SMART-GREEN UNIVERSITY

A Smart Campus is an unavoidable shift within the development of a digital campus and requires many technological features to be integrated [3]. It can be defined as an intelligent, smart teaching, learning, and living environment that uses internet technology and applications in teaching, research, management, and the whole campus life [4]. It consists of applications integrated and combined based on the IoT, cloud computing, and GIS technology to support information acquisition, sharing, and services of the campus in order to improve the teaching, scientific research, and services [5].

2.1 Objectives of creating a smart-green university

This study aims to achieve goals such as reducing energy consumption, improving access to campus resources, enhancing employee productivity, and evaluating public resource utilization, contributing to the development of a smart university that emphasizes sustainability, efficiency, and excellence in education and operations.

2.2 Smart campus infrastructure

The Smart Campus applications require advanced

infrastructure to function effectively. These include; IoT (Internet of Things); it is a unified system that facilitates the sharing of information between sensors and actuators over a common network. It enables the development of innovative applications [6]. Cloud computing refers to a collection of programmable computer resources that can be easily and quickly accessed with minimal effort. This allows for timely access to resources when needed. Big data analytics; it is a process that provides a deeper and more comprehensive understanding by uncovering patterns and relationships within vast and complex information [7]. This plays a central role in the future development of Smart universities [8]. Hadoop is an open-source platform used for data storage and application execution. It offers immense capacity to handle various types of data and can manage a virtually unlimited number of tasks. Additionally, it provides substantial processing power and can store different forms of data, including log files, images, audio, video, communications, and structured, unstructured, and semi-structured data [9].

2.3 Smart campus applications

These applications provide a connected environment supported by the IoT, cloud computing, big Data Analytics and Hadoop [3], as shown in Figure 1.

Figure 1. Smart campus applications [3]

2.4 The UNEP sustainable university framework

The framework presents four core areas of the university: Environment & Climate - Teaching & Research - People & Society- Administration & Governance. Each Core Area consists of many aspects.

2.4.1 Environment & Climate

The university affects the environment and the climate in large Scale; including the built environment, ecosystems, and lifestyle choices. Like Looking at the university's wastes and designing a recycling scheme [10].

2.4.2 Teaching & Research

Universities have to start a conversation with the researchers about The UN Sustainable Development Goals.

Staff and students seek to make changes in the campus to transform it into a smarter, more successful, and more sustainable one [10].

2.4.3 People & Society

Universities can create just, resilient and sustainable communities. It is very important to make sure that the university's message is not just about green issues but also includes social and financial aspects and People's health; this can help in increasing the number of people who think that sustainability is relevant and useful [10].

2.4.4 Ministration & Governance

For the university to be sustainable; there must be a strategic commitment at all levels within a university. At all levels, sustainable development requires effective leadership and management [10].

To increase the sustainability of the campus there are levels or steps for each aspect, that are emerging, progressing, established, and leading [10].

3. EXAMPLES OF INTERNATIONAL BIO-TECH SMART-DIGITAL CAMPUS

Three examples of international universities in United States of America and Japan are explained below. These universities constitute interesting examples of retrofitting to reach the smart - green campus, not only in the buildings but also to reach a green educational environment by creating a better, healthy and productive environment for the users.

3.1 Arizona State University (ASU), USA

Founded in 1885, ASU is one of the biggest public universities in USA, in the Phoenix metropolitan area. It consists of four distinctive campuses throughout metropolitan

Phoenix (Downtown Phoenix Campus - Polytechnic Campus - Tempe Campus - West Campus) [11]. by March 2014, ASU was the top higher education institution in USA for solar generating capacity. It now generates more than 24 MWh of electricity from the solar energy while in June 2012 the total electricity power was 15.3 MWh. The University has 88 solar PV installation sites containing 81,424 solar panels across the four campuses and the Research Park. The University's solar generating capacity is about 50 MWh [11].

3.1.1 Arizona State University Polytechnic Campus

A former Air Force base, the University campus consists of 21 acres divided into site work in association with five new classroom building complexes. The campus is located in the Sonoran desert which only receives 7 (178 mm) of rainfall a year [12].

Using a combination of concrete and stabilized decomposed granite, together with planted desert shade trees, the new University landscape now helps to reduce the urban heat island effect and reduces the glare. Drought tolerant native plants, such as Salvaged desert trees and small native shrubs, cacti and seed were used as these are fully adapted to the desert weather.

When it rains, constructed gulleys capture storm water, thus providing both water harvesting as well as deep watering to the vegetation.

The materials of the former Williams Air Force Base; asphalt, extensive concrete sidewalks and expanses of river rock that originally covered the base's ground were re-used for new outdoor spaces and parking areas. Harvested concrete paving was transformed into campus seating elements and retaining walls throughout the project. An amphitheater was built from recycled sidewalks [12].

3.1.2 Arizona State University Tempe Campus

This campus is considered to be eco-friendly as it is depending on renewable energy sources and uses smart infrastructure to reduce energy consumption [13].

Six wind turbines were installed on the school of Sustainability building's roof on the Tempe Campus in October 2008 [14]. These turbines produce enough electricity to power approximately 36 computers (Desktop pcs or laptops) [15].

Blue light poles are also located along the sidewalks of the Arizona State University's Tempe Campus acting as emergency call boxes for the university users. They also offer strategic positioning for smart technologies [16]. Three of these poles are fitted with smart devices connected via the Internet of Things (IoT), including sensors for sunlight, temperature, CO_2 levels, and suspended particulate matter counters. The data collected from these sensors help in creating an environmentally friendly and informative campus [17].

3.2 Shinshu University, Japan

Shinshu University is located in Nagano Prefecture, which is known for its high level of environmental protection. According to 2020 UI Green Metric World University Rankings, this University was ranked the 1st in Japan for the third consecutive year, and the 38th in the world [18]. It consists of five campuses, all of them are designated as Eco-Campuses aimed at reducing energy and water consumption in total, there are 1,581 PV panels having a power generation capacity of 300 KW. This helped in the reduction of energy derived from conventional fossil fuels by 95% since 2007 [19, 20].

The University also installed a fuel cell that is able to generate 100 KW. Its waste heat is also used for air conditioning and snow melting together, and to supply a constant underground water heating with a throughout the year [20].

The windows are automatically opened or closed depending on the outside temperature and humidity. Double skin insulation material has been used for campus buildings so as to reduce heat gain such as high heat insulation refractory metal and high insulated glass. This results in a reduced need of internal air conditioning [20].

Moreover, internal commuting by staff and administrators on campus is done using electric vehicles having specialised software dedicated for car sharing service using block chain technology [21].

3.3 University of California, Riverside, USA

This University constitutes one of the ten campuses in California [22]. In 2020, Money Magazine named UC Riverside as America's most transformative public university and one of the top 10 public Universities in the country [23]. In 2018, it was ranked 145th in the overall Worldwide Universities Rankings. Six factors went into the ranking: setting and infrastructure, energy and climate change, waste management, water, transportation, and education. The campus received the highest ratings for its waste reduction and recycling, water conservation and recycling, as well as for its transportation [24, 25].

The University adopted a strategy for Energy efficiency that resulted in reduction of utility bills of around 285 million USD since 2005. In so doing, it also reduced greenhouse gas emissions by 15% since 2009. In 2019, the University also established a total of 53 efficiency projects in that are expected to save 1.2 million dollars annually [26]. Meanwhile, its multidisciplinary research building had achieved a LEED Platinum certification for meeting the highest energy-efficiency standards [24]. The University owns a total of 9,600 solar panels installed in two parking lots on campus that generated nearly 7 million kilowatt-hours of energy in a 13-month period [22], as shown in Figure 2.

Figure 2. Parking's solar panels (www.ucr.edu/)

University aims 40% bio-methane substitution for natural gas by 2025 [26]. Solar tables were also installed at several sites on campus to provide a clean and renewable source of energy for charging mobile devices and laptops [27]. Such a project inspired the University to re-fit its spaces to become more inviting and attractive [28].

3.4 A case study-Alamein International University (AIU)

AIU is a fourth-generation smart university located in New Alamein City, Egypt. Its campus spans 150 acres and features a central library, outdoor theater, hospitals, administration building (Figure 3), faculty buildings, and accommodation towers. The design prioritizes natural light and ventilation, while local materials are utilized in construction. The infrastructure integrates ICT and IoT technologies to enhance sustainability and efficiency. Data centers monitor and manage smart systems, optimizing water and energy consumption. Occupancy sensors and waste management systems reduce energy use and improve waste disposal. These initiatives contribute to a more eco-friendly and technologically advanced smart campus [29].

Using technological infrastructure that allows fast internet speeds. All of the university's smart systems are monitored by data centers. The data centers serve as the memory and brain of the smart campus; they keep track of all the university's smart systems and collect user complaints (from students, faculty, and staff) so that experts may electronically resolve them. a control center manages water and energy use to ensure that it is at ideal levels; by analyzing real-time data from smart water and electricity meters. Water-consumption tracking can help in reducing usage by up to 50%. Use sensors like occupancy sensors to significantly reduce energy use by switching off electric loads when a normally occupied area is vacated. The garbage containers' fill levels are measured by sensors used by the waste management systems, which then alert the services responsible for emptying the containers. By using these applications, the volume of solid waste per person can be reduced by 10-12%, as well as solid waste that cannot be recycled [30].

Studying at the university depends on the use of digitization and interactive activities. Most of the faculties' books and exams are electronically using computers instead of traditional paper. This reduces the effect on the environment and saves many trees from being cut down. This increases the effectiveness of the role of universities in serving the community.

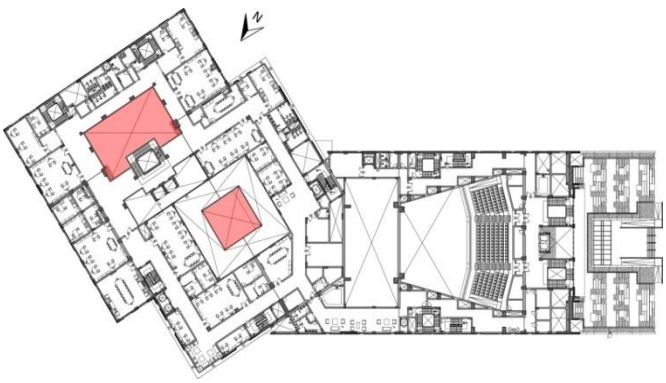

Figure 3. Administration building (Urban communities authority)

4. SCIENTIFIC SURVEY (SMART - GREEN UNIVERSITY SURVEY)

As shown in Figure 4, an important questionnaire was designed to measure people's awareness of sustainability and smartness in the educational university campus. About 200 people with different identity, age, point of view, and study fields answered the questionnaire; some of the different answers will be presented and compared to find out how the issue of smart-green university matters among different categories of people inside Egypt and decide if the traditional Egyptian campus transformation to a Bio-Tech Smart-digital campus is important to them or not.

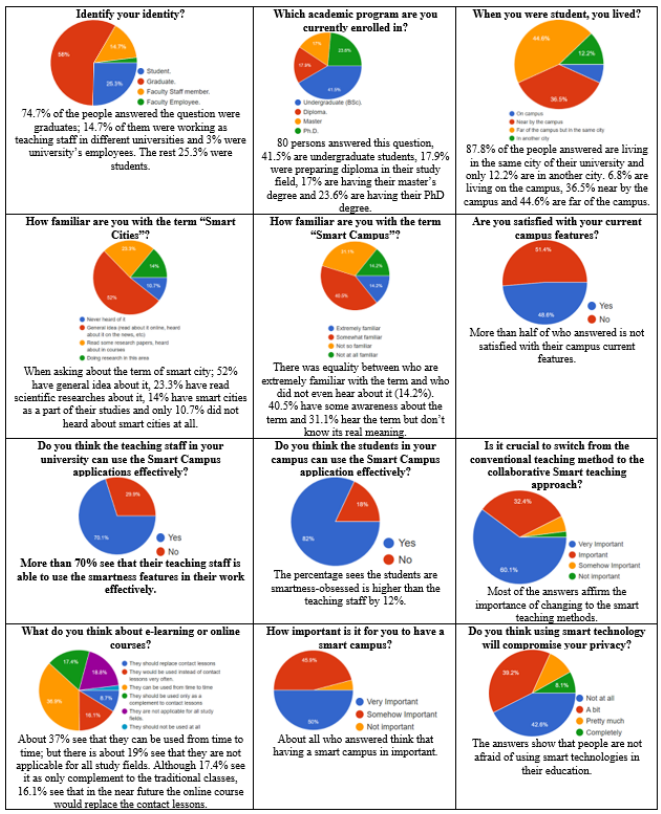

Figure 4. Smart-Green university survey with its results
The authors, 2022

5. SURVEY CONCLUSION

According to the study, a majority of participants, more than 60%, possess limited expertise in smart technology but possess a grasp of the ideas behind "smart city" and "smart campus. 50% of respondents expressed contentment with their present campus facilities. Nevertheless, participants believe that substantial financial resources would be necessary to implement smart features. The transformation of classrooms into smart environments emerged as a primary focus for the respondents. Figure 5 explains a smart - green university framework.

The intended outcomes to be achieved include:

1. Reducing energy consumption.
2. Decreasing waiting times for utilizing campus facilities.
3. Improving staff efficiency.
4. Enhancing the quality of classroom education.

5. Ensuring the active participation of all campus users in problem identification and resolution.

6. Conducting thorough data analysis to assess the utilization of public resources.

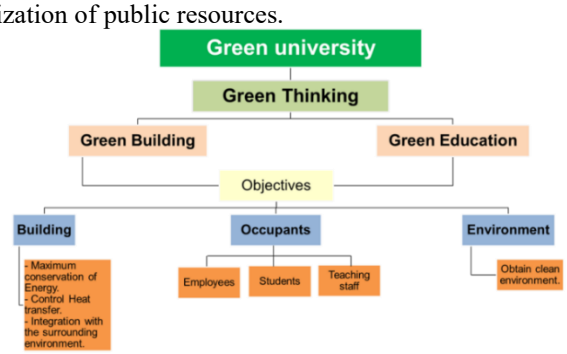

Figure 5. A Smart - Green university framework

6. A METHODOLGICAL FRAMEWORK TO HAVE A SMART AND SUSTAINABLE CAMPUS (SMART - GREEN CAMPUS CRITERIA)

According to the previous studies, discussions and the Results from the survey; the following recommendations for Smart green campus is revealed consisting of 6 main tips:

•Construction materials should prioritize local and recycled options.

• Passive lighting and ventilation systems should be implemented.

• Retrofitting existing buildings can reduce reliance on conventional energy for heating and cooling.

•Creating campus gardens can enhance the appearance and provide opportunities for cultivating fruits and vegetables.

In terms of resource management, the survey indicated the following measures to decrease energy and water consumption:

•Incorporate renewable energy sources such as solar panels and water power.

• Replace conventional lighting with energy-efficient options like CFL or LED bulbs.

•Install occupancy sensors to optimize energy usage.

•Implement water recycling systems, including rain barrels and treated greywater.

•Address any damaged water or plumbing pipes to prevent water wastage.

•Regularly monitor, record, and analyze energy and water usage data to identify areas for improvement and cost reduction.

For waste management, the survey highlighted the importance of the following practices:

•Composting organic wastes, including food scraps from the cafeteria and kitchen service.

•Implementing recycling programs with sufficient recycling bins placed throughout the campus.

•Encouraging the use of water bottle refilling stations to reduce plastic bottle waste.

Regarding smart transportation, the survey recommended the following strategies to reduce vehicle emissions and pollution:

•Promote walking, cycling, and biking as alternative modes of transportation.

•Encourage carpooling among students and staff.

•Improve access to public transportation options around the campus.

•Introduce shuttle buses running on biodiesel or electric power.

•Utilize mobile applications for car park monitoring to minimize fuel consumption and search time.

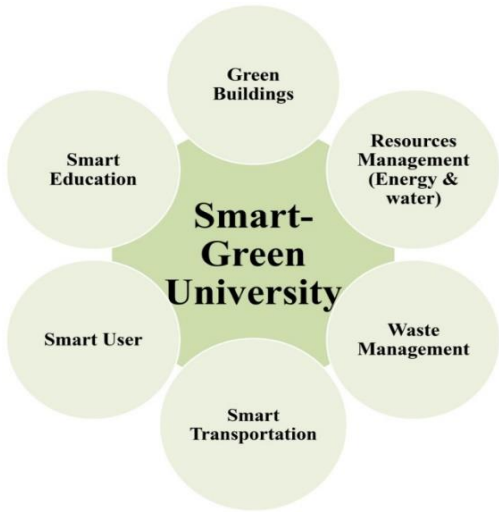

Figure 6. Smart - Green university main features

In terms of smart education, the survey highlighted the following suggestions:

•Transition to digital educational resources and platforms.

•Encourage electronic note-taking instead of using paper notebooks.

•Consider implementing solar outdoor classrooms.

•Promote reduced paper usage by printing on both sides and minimizing margins.

•Encourage online submission of research papers and homework assignments.

•Offer environmental degrees and courses to educate students about sustainability and climate change.

Lastly, the survey emphasized the importance of smart user practices, including:

•Conserve energy by turning off lights and unplugging devices when not in use.

•Use reusable mugs and plates in the cafeteria to decrease single-use disposables.

•Purchase reusable bags for various purposes, including classroom items.

•Keep the five R's (Refuse, Reduce, Reuse, Repurpose, and Recycle) in mind when making decisions to promote sustainability. Figure 6 concludes a smart - green university main features.

7. CONCLUSION

The emergence of smart environments, leveraging IoT technology and internet-connected devices, offers opportunities for enhanced security, mobility, energy efficiency, and other aspects in cities, campuses, businesses,

and homes. Universities serve as ideal testing grounds for smart city concepts, reflecting the socioeconomic structure of a city on a smaller scale. The research aims to deploy a comprehensive smart infrastructure system within a university campus environment, adapting smart technologies in teaching, research, and management. The study outlines the journey towards realizing a smart campus in a large university, involving various stakeholders to articulate a vision for smart infrastructure and its applicability in improving educational institutions. By implementing technical, environmentally friendly, and social initiatives, a campus can transform into a smart environment. However, the authors emphasize that the content and organization of higher education should evolve alongside societal changes. To meet this demand, a reference smart city system is proposed, encompassing infrastructure, interactions, reasoning, and visualization. This system aims to enhance the campus experience for all users, emphasizing the importance of engaging with the community and prioritizing services that ensure comfort, safety, and effective learning.

8. THE RIGHT TO THE SMART UNIVERSITIES

Further research can be conducted to explore the implementation of smart city strategies in universities and the integration of artificial intelligence in creating intelligent educational environments. The authors recommend conducting a thorough and detailed investigation into the technical aspects of smart capabilities, specifically in the context of education. Future studies can focus on the objectives of universities that aspire to become smart institutions and explore various approaches to achieve those goals.

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