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The Future of Green Architecture in Saudi Arabia

By Faten Abdullah Bucklain

Effat University

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The Future of Green Architecture in Saudi Arabia

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Abstract- **Architecture plays an important role in the Environment sustainability. Through the time with the development of technology, new architecture techniques have emerged to improve the environment and limit pollution. In Saudi Arabia, the government is trying to improve the architecture sector by builds new green buildings that are suitable to the region. This research will explain the characteristic of green architecture, techniques to use for environmental sustainability, green techniques in Saudi Arabia, and the future of green architecture in Saudi Arabia.**

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I. Introduction

The architectural sector in this day is no longer in isolation from the environmental pressing issues which they noticed it in the last few years, and it started threatening the world. Architecture Considered as one of the main consumers of natural materials such as land and materials, water, and energy. On the other hand, the large and complex construction industry operations produce large amounts of noise, pollution, and waste. However, the energy and water Consumption still the most prominent environmental-economic problems in the buildings due to its continuity throughout the period of the building operation.



Figure 2: Building life cycle

In the present era, the world began to recognize the close link between economic development and the environment. The traditional forms of economic development are restricted to overexploitation of natural resources and, at the same time, cause a lot of pressure on the environment, for the reason of the harmful pollutants and waste produced from it. Now a day, Architecture is facing the challenge of its ability to perform its developmental role towards the achievement of comprehensive sustainable development concepts. Architecture Sustainability and Environmental management and control became one of the most important competitive standards in the twenty-first century. Several approaches emerged to protect the environment through architecture; the most prominent was Green Architecture. Green architecture is a global movement toward Environment. Sustainability is a global concern; all of the countries must take care of the environmental condition and deal with it without affecting negatively on it. Saudi Arabia is one of these countries that supported the architects in this approach.



Figure 1: Saudi Arabia Map

a) About Saudi Arabia

Saudi Arabia is a country locate in Southwest of Asia with 200 million square kilometers. It is the largest country in the Arabian Peninsula, and the second-largest geographically in the world. It's capital city is Riyadh. The Geography of Saudi Arabia is diverse, with forests, grasslands, mountain ranges and, most of its terrain consists of arid inhospitable desert or barren landforms.

The climate varies from region to region. Temperatures can reach over 110 degrees Fahrenheit in the desert in the summer, while in the winter temperatures in the north and central parts of the country can drop below freezing. Saudi Arabia gets very little rain, only about four inches a year on average (Saudiembassy).

This research will introduce you to green architecture; explain the different techniques and rating systems in green architecture, Also how these techniques can be applied in-country like Saudi Arabia and what is the future of this approach in Saudi Arabia.

II. Literature Review

Green architecture or sustainable architecture appeared from ancient civilization as a result of human

Author: dept. Architecture and Design, Effat University, Jeddah, Saudi Arabia. e-mail: Fbucklain@effat.edu.sa

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adaptation to the environment, by using the local material, the way of using the material and dealing with the climate of the region. In Egypt, we can see how the ancient Egyptian civilizations used the local materials, mud, papyrus, timber, and bricks in labors homes while they used the natural stone and sculptured the mountains for their sacred architecture, such as temples. In Islamic architecture, many environmental processors used, for example, the use Almalgaf, domes, vaults, and courtyard, as well as timber in the mashrabiyya. These techniques were in the context of human adaptation to its environment. This trend was prevalent through ages) Al-Zubaidi و Shahin(2008 ، (أبوحميد 2011).



Figure 3: Traditional techniques -mashrabiyya



Figure 4: Traditional techniques - Almalgaf

A human never ignore the environment, but rather attempted to cope with the environment elements until the beginning of the industrial revolution. Since the invention of the steam engine by James Watt in 1761, it caused a serious coup and severe impact on people's lives as a whole and urban planning. A new period of human history began with a new character different from all preceded periods. With this huge development in all majors, many different materials and methods appear in construction Architecture, for example Curtin walls, cement, Asphalt, and other oil derivatives. Using many of this material was responsible for the environmental pollution, and changes. Because the architecture has a major impact and reasonability toward the environment. The advanced industrial countries develop new concept and techniques in the designing and construction of architecture. One of these concepts is the green architecture, this concept reflects the growing interest among architectural and economic development under environmental protection to reduce energy consumption, optimum utilization of natural resources and greater reliance on renewable energy(محمود).

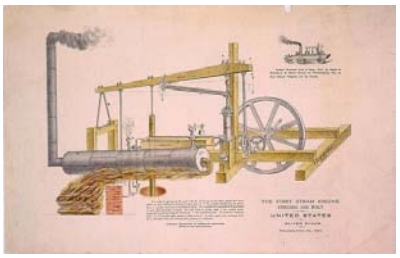

Figure 5: First steam engine

Green Architecture is an approach to architecture began in 1999, which aims to minimize the negative effects of human aims to, Energy and water conservation, minimize the waste, recycling, preserve the environment, the health of the population, and the economic benefit to provide operating expenses and long-term maintenance. Green Architecture is not only the construction of buildings according to certain environmental conditions or increase of green spaces, but rather, it intended to achieve compatibility between man, society, and the environment by linking three key elements (Efficient use of resources, Dealing with the prevalent climatic and geographical conditions and Response of the prevalent human, physical and social needs), While preserving the rights and needs of future generations (محمود).

According to Architect Ken Yeang "the green and sustainable architecture must correspond to the needs of the present without losing sight of the right of future generations to meet their needs as well".

Green architecture is a design process focused on the construction to be effective in terms of using resources, such as water and materials, reducing waste and environmental pollution. It is a High-efficiency system compatible with the vital surroundings with less negative effects. It is an invitation to deal with the environment in a better way to integrate with its determinants to Compensate for its deficiencies, repair its defects or take advantage of this environment and sources. This architecture term (Green) came from the plant that achieves success in its environment, taking full advantage of the surroundings to get its nutritional requirements. It did not creates with a full-fledged from its inception; rather as it increases in age it increases in length Until it reaches the phase stability. From this particular point, the green architecture coupled another term, which is (sustainable architecture and environmental architecture) these are two sides of the same coin. The first green building appears in china. It names TEDA H2 Low Carbon Building (المقدسة).

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Figure 6: World Rating systems

There are more than ten rating systems of global standards granted certification for the fulfillment of the requirements and standards of green buildings, the most well-known:

- (LEED) or Leadership in Energy & Environmental Design, founded by the US Green Building Council (USGBC).

- BREEAM is the world's environmental evaluation method and rating system for buildings.

- Saudi Green Building Forum (SGBF), under the supervision of the General Presidency of Meteorology and Environmental Protection. (in progress)

These rating systems provide special Codes for green building design. The most known rating system is LEED. It consist of different types of rating system; each one has requirements that address a specific needs of building types to the LEED certification. The project designers should choose a rating system to guide them (LEED).



Figure 7: LEED rating types

Each system is a combination of different categories. Within each category, there are specific prerequisites which the projects must satisfy it, to earn points. These points that earned will determine the level of LEED certification for the building (LEED).



Figure 8: LEED levels of certificates

LEED provides four levels of certification. Each level has several of points. Receive. The Certification levels are explained in the figure above. LEED rating system is one of the global sustainable systems that are always in improving toward sustainability of the building and environments (LEED).

a) Green building Techniques

The used techniques are differentiate from building to other depends on the type of the building and its users. The most important is to use a suitable technique to provide a very efficient green building. However, before deciding the method, the designer must take into consideration the microclimate of the area, site location, surroundings, environmental resources, building size, height, facilities, and the most important the occupancy of the building. However, There are some technology that can be used in any building (future) for example:



Figure 9: Green Architecture Features & goals

- The most basic is the orientation of the building to get the full advantage of the wind and sunlight.
- Using local materials to reduce transportation CO2 emission
- HVAC system to help you save energy and money without forgetting the importance of insulation to prevent Heating and cooling Leak.
- Green roof, especially in the flat slab buildings, will reduce the heat gaining through the roof, the plantation better to be native plants that canadapt to the climate of the area.
- Shading devise to minimize the sun's heat and glare by defusing the direct sunlight.
- Using solar panels to produce clean, sustainable energy.
- Eco-Friendly Lighting the LED and CFL these types are cost-effective because it last longer than the incandescent bulbs (future).



Figure 10: Average saving of green buildings

These are some of the basics and general green techniques. It can be used in homes and other buildings. However, the Green building can save up to 70% of solid waste, 50% of energy use, 40% water use and 35% of carbon emissions.

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b) Green Architecture in Saudi Arabia

Saudi Arabia like other countries it environments have Contaminated as a result of the Pollutants resulting from industrial development. Recently they notice the effects of the pollution on human health, performance, and production. Although the government is trying to support the green building approach, but it still in the development stage toward this approach. However, there is many Government organization and regulations that emerged during the past few years which support the green architecture in the country. Moreover, there are many green projects in the design stages, some of them have been built, for example (KAUST),Establishment of the first solar plant and the use of alternative energy for lighting tunnels and streets in Jeddah. On the other hand, there are two organizations of green technologies and environmental sustainability.



Figure 11: Pollution in Saudi Arabia

i. *Green Building Chapter of the Saudi Council of Engineers (GGB)*

Its non-profit organization was founded in 2013 by the Saudi council of engineers under the royal decree no. 36/m dated 1-12-2002. Its objectives are to promote and facilitate the concept and the awareness of green buildings in professional practice and knowledge transformation, and highlight the jobs and investment in engineering creativity and innovation, for health and safety and the environment for the benefit of humans and the environment and the economy in Saudi (المباني الخضراء).

ii. *Saudi Green Building Forum (SGBF)*

It's an organization founded under the appointment of King Abdullah bin Abdul-Aziz of Saudi Arabia Royal Decree No. 7095/MB dated 5/10/1431 A.H. it aims to promote the green building initiatives in the kingdom by developing lows and regulation to support this approach, develop green architecture criteria to be a guideline for designing the green building in Saudi Arabia, and do a workshop to educate the people (Forum).

Although we still in the initial stage but the country is in the right way toward sustainability. It is changing, and the architecture green technologies will improve by time.

III. Research Methodology

This research consist of the case study method; this method can be quantitative or qualitative. In this research, I will use the qualitative case study approach to examine in deeps different types of case studies to better understand the research. By analyzing some previews researches and observes information this research needs, to provide a will clear knowledge about the topic.

a) Case Studies

The research will clarify two case studies located in Saudi Arabia to show the developments of the green building approaches and techniques that suit Saudi Arabia's conditions. On the other hand, to give an idea about Government attention towards architecture and environment in the country. These two case studies are:

- The King Abdulla university (KAUST) very deep explanation of the green technology of the campus.
- The King Fahd National Library in Riyadh.

i. *King Abdullah University of Since on Technology (KAUST)*

KAUST is Located in Thule on Red Sea coast, north of Jeddah, Saudi Arabia. It's about 496,000square meters, one the largest university cities in the world. Designed by HOK Architects. KAUST campus earned a Platinum rating on the Leadership in Energy and Environmental Design (LEED) (Minutillo, 2010) (KAUST, Green Campus, 2015).



Figure 12: KAUST Exterior View



Figure 13: KAUST- Site Plan

A. *Site plan*

The site planning of the university campus was designed to respond directly to the climatic conditions and the surroundings. The buildings were arranged and grouped in particular places to improve and take full advantage of the microclimate and the site natural environment and to reduce the harmful effect of the sun and the heat of the climate (KAUST, Sustainable Site Planning, 2015).

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B. *Orientation*

The overall campus was oriented to reduce the heat of the sun from east to the west in the morning and afternoon especially in summer. However, the height of the building is relatively short to allow the daylight to enter the interior spaces (KAUST, Sustainable Site Planning, 2015).

C. *Roofing System*

The design team decides to ingrate the building roofing system of the buildings to provide a concoction and shades between the buildings. these roofs include over 12,000 square meters of solar photovoltaic panels, which produce 3,300-megawatt of energy annually, while protecting the building from the solar gain. On the other hand, the campus atriums and courtyards were integrated to enhance the natural light and ventilation into the interior spaces (KAUST, Sustainable Site Planning, 2015).

D. *Paving color and use of Shade*

The choosing of the color and the material of paving was very accurate to fit the harsh climate of the region. They use light-colored Local stone which reflects the heat instead of observing it. The Shades espaliers to reduce the heat and improves the comfort of the user (KAUST, Sustainable Site Planning, 2015).

E. *Building material*

Choosing Building materials for a large project like King Abdullah University Play an important in building sustainability. The designing team selected materials to limit the negative effects of and to the Environment. It includes, Local recyclable concrete and steel, Interior finishes and furniture with high levels of recycled content (carpet tile, ceiling tiles, gypsum board, paints, millwork, adhesives), all the wood is from sustainability managed forests and more than 75% of the construction waste was recycled. On the other hand, the university has made a sustainable recycle Program to guaranties that natural resources are not wasted. It will includes many materials for recycling like glass, metals, plastic, electronics, paper, compact fluorescent lights and more (KAUST, Building Materials, 2015).

F. *Water conservation*

Collecting storing the rainwater to be used in irrigation of green spaces in KAUST, which don't require additional water. Selected of native plants large amounts of water to survive, this will minimize the overall water Consumption. The wastewater (gray water and black water) will be recycled by the wastewater treatment the plant (WWTP) that located to the south side of the campus to be use in irrigation needs such as Golf Course Irrigation (KAUST, Water Conversation, 2015).

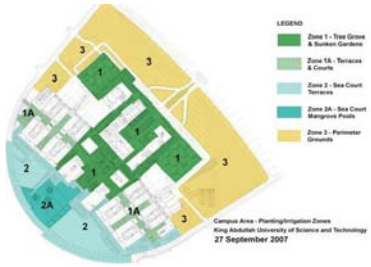

Figure 14: KAUST- Planting organization Zones

G. *Energy Efficiency and Renewable Energy*

1. *Solar Towers and existing Wind situation*

With placing two iconic solar towers on the campus to create a difference in the passive pressure will create a by using the sun and the dominant winds conditions from the northwest and winds blowing in from the Red Sea, to provide a constant air waft along the shaded areas.



Figure 15: KAUST Solar Tower

The solar tower skin consists of two curtain wall layers, the outer layer is completely transparent to allow observation of a maximum amount of solar energy. Whereas the internal layer consists of a tinted glass that characterized with it extremely absorbent surface to gathers the solar energy for maximizing the hot air inside the tower, while the hot air transfer to the top and move out of the tower through the shaft, it is replaced with cooler air from the courtyard. These effects of these techniques will provide a comfortable atmosphere for the occupancy of the campus (KAUST, Energy Efficiency and Renewable Energy, 2015).



Figure 16: KAUST- Green technologies

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2. *Natural Daylight*

Saudi Arabia Climate needs a dedicated balance to control the solar heat gain and at the same time allow enough light to enter into the occupied spaces, to ensure this in the campus they utilizes many different systems such as, dynamic exterior louvers, fixed exterior louvers, overhangs, skylights, mechanical shading systems, and atria to ensure that this balance is achieved.

3. *Renewable Energy*

The sun conditions in Saudi Arabia offer an opportunity to utilize solar power more than any other place. The huge roofing system of the campus buildings designed to contest of a large number of solar thermal arrays to provide the hot water to all buildings. Moreover, solar photovoltaic to produce electrical power to the whole campus. On the other hand, these future arrays can be added to supply the increase of energy load. This energy production from clean energy sources will save almost 1,700 tons of carbon emissions per year (KAUST, Energy Efficiency and Renewable Energy, 2015).

H. *Ventilation and lighting*

The designer takes into consideration the Natural daylight, natural ventilation, exterior views, and indoor air quality to ensure a comfortable, productive, and healthy environment for the campus occupancy. As result of the extremely sun heat in this region, the defuse daylight is preferred to minimize the sun heat in the entire campus. The exterior and interior spaces will consist of CO2 monitoring sensors to ensure the high quality of veneration, because of the increase of CO2 level cloud affects the production of the building users. The ventilation rates are more than 30% of the standards ventilation in the buildings to granite the good and fresh air all over the campus. Also, they use construction methods that reduce negative effects of the airborne, for example, the installation of MERV 13 and 14 filters (figure 18) in the heating ventilation air-conditioning (HVAC) systems to ensure removing the particles in the ventilation stream inside the buildings. Also, the Walk-off grates (figure 17) were installed to clean foot at all buildings entrances to ensure that the sand, dust and particles will not transfer from outside of the buildings(KAUST, Ventilation and Lighting, 2015).



Figure 17: MERV Filters



Figure 18: Walk-off grate

I. *Recycling and Composting*

The campus and community of King Abdullah University implemented an inclusive program for recycling paper, corrugated, cardboard, glass, plastics, and metals. All the campus residents will have integral chutes on all floors to collect all the organic waste and convert it into natural fertilization for re-use to improving the soil. Provide outdoor recycling bins distributed in the dense pedestrian areas (KAUST, Recycling and Composting, 2015).

IV. King Fahd National Library

KFNL is Located in Riyadh, Saudi Arabia. It's about *87,000*square meters, Designed by Gerber Architekten. (archdaily, 2014)



Figure 19: King Fahd National Library

This project is a renovation of King Fahad National Library. It is one of the important culture centers in Riyadh. The building was completed on 2013. It's one of the most important urban development and culture projects. This building was challenging to design within the existing Surrounding buildings and respect the culture. The design functions as the powerful force behind a piece of urban development and rearrangement.(archdaily, 2014).

The design represented the national library as a new building to attract people to the central knowledge center. The most essential change was in the building façade, changing the classic façade of the stone dome and arches, to a new cubic modern attractive skin. This skin was carefully designed to fit the environment and culture conditions(Tobojini, 2014).

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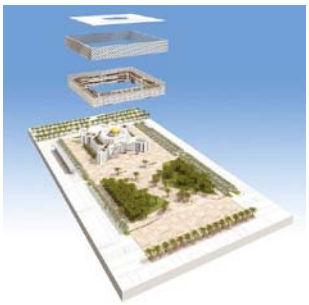

Figure 20: KFNL- building Skin Layers

The skin consists of curtain wall covered with white fabric units Interconnected together with roped stainless-steel. This unites frequently repeated to form an attractive pattern. The white fabric material is a local Tents fabric; also, the design of the skin units is similar to the tents which give the feeling of belonging to the Saudi culture (Tobojini, 2014)(archdaily, 2014).

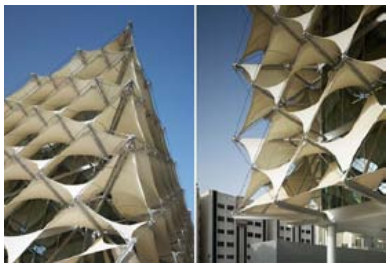

Figure 21: KFNL - Section

This huge transferring of the façade design effect the interior spaces positively. It provides natural daylight that the library needs, however minimizing the heat gain and glare by defusing the sunlight through the creative skin (archdaily, 2014).



Figure 22: KFNL- interior views

Also, the use of LED light to safe energy and to provide a good light radiation. Using local plants (Palm tree).



Figure 24: KFNL- native Plants



Figure 23: KFNL- lighting

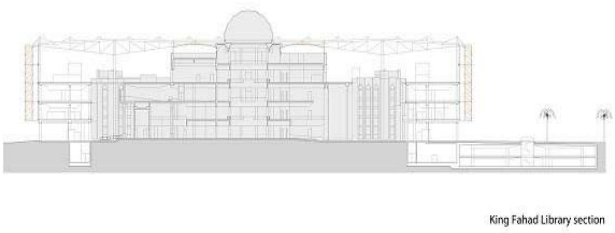

Figure 25: KFNL - Section



Figure 26: KFNL-Old Building

In these previews case studies, the green techniques were used to fit Saudi Arabia region. Because the most majority problem is to provide natural daylight without entering the sun's heat to the spaces, so the use shading devices but in different forms. Also, the use of local materials which can be very helpful for the environment and, at the same time reducing the cost. Using the native plant can help in water conservation. For KAUST. They use more advanced techniques to increase energy-efficiency. However, all the buildings satisfied the user's needs and environmental sustainability from one side or more.

V. Conclusion

The world is always in constant evolution. This evolution brings new technologies and methods for humans. With this evolution, there are side effects that could harm humans. The people must take care of the new technologies and try to invent sustainable systems to granite a healthy life for the future generations.

Architecture plays a big role in this evolution, and it affects the sustainability of the world positively if it used in the right way, and vice versa. Architecture is improving, and new techniques discovered. Thus, the green architecture techniques will be improved. Although there will be several types of Green building technologies, but it doesn't matter, what matter is the result of using these techniques. Sometimes using these techniques in specific conditions could have a negative effect on the environment and the people living within this environment.

In Saudi Arabia, the future of green architecture is very bright due to the government financial and moral support. This will improve the green building and

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maximize the number of it in the country for the next years. The growth in this sector will provide environmental sustainability and guarantee a healthy life for the citizens and future generations.

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