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The Role of Sustainable Architecture Strategies in Optimization Environmental Building Performance

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Abstract

This study aims to identify the role of sustainable architecture strategies in optimization environmental building performance. qualitative approach was adopted to answer the question of the study through reviewing literature relevant to sustainable architecture and the environmental performance of buildings. The study found that the use of sustainable architecture strategies (active and passive) optimize the environmental performance of the building. The study recommends the necessity of applying the principles of architectural sustainability to optimize the environmental performance of buildings.

keywords: of Sustainable Architecture, Sustainable Architecture Strategies , Environmental Performance, Active Sustainable Design, Passive Sustainable Design

الملخص

تهدف الدراسة إلى التعرف على دور استراتيجيات العمارة المستدامة في تحسين الأداء البيئي للمباني. اعتمدت الدراسة المنهج الوصفي وذلك من خلال مراجعة الأدبيات ذات الصلة بالعمارة المستدامة والأداء البيئي للمباني. وجدت الدراسة أن استخدام استراتيجيات العمارة المستدامة (النشط والسلبي) يحسن من الأداء البيئي للمبنى. توصي الدراسة بضرورة العمل على تطبيق مبادئ الاستدامة المعمارية لتحسين الأداء البيئي للمباني.

الكلمات المفتاحية: العمارة المستدامة، استراتيجيات العمارة المستدامة، الأداء البيئي ، التصميم المستدام النشط، التصميمي المستدام السلبي.

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1. Introduction

The world witnessed a lot of changes at the end of the twentieth century, the concept of sustainability has become one of the most used concepts around the world, which is concerned with achieving justice for future generations and protecting their right to use the world and its resources. The concept of sustainability refers to the ability to meet current needs without compromising the ability of future generations. This concept has spread widely and is used in a large number of sectors (Sadollah, Nasir, & Geem, 2020).

The buildings and construction sector is one of the most energy-consuming sectors in the world. The buildings sector around the world consumes about (40%) of annual energy consumption and leads to the emission of (24%) of the total greenhouse gas emissions (Hasan, Mohamed, & Mohamed, 2015).

The concept of sustainability is used in architecture with the aim of describing the design trends associated with concern for the environment (Hasan, Murtin, & Sari, 2016). Sustainable architectural aime to reduce the depletion of resources such as water and energy and achieve compatipility between the elements of the natural and the built environmen (Ebeid, 2018).

Sustainable architecture relies on a set of principles, which can be achieved through technical and design methods. These methods are classified into Active Design Strategies (Systems and Equipment) and Passive Design Strategies (Design Characteristics) (Babcock, 2016).

With the development of architectural trends, many efforts have emerged to develop systems for evaluating building performance. Building performance is evaluated on multiple dimensions; Economic, social and environmental. Environmental Building Performance is related to the surrounding environmental conditions and how it responds to them. this term is used to address the environmental impacts that occur during the building occupancy process and the operations and maintenance activities (Maslesa & Jensen, 2019).

A building's environmental performance depends on many indicators that are determinants of sustainability. The idea for this research was to find out how to optimize the environmental building performance through sustainable architecture strategies.

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1.1 Problem Statements

The buildings sector consumes a large amount of energy annually, and buildings and its materials are responsible for a large proportion of waste and emissions of toxic gases that negatively affect the environment. In response to this problem, sustainable architectural trends began to emerge and spread widely in the architectural sector. Sustainable architecture is based on many principles and strategies that formed the applied basis for the concept of this architecture. With the development of building assessment systems, the endeavor began to improve the performance of buildings in the social, economic and environmental dimensions through the application of many strategies that would raise the performance of the building. With the great need to reduce the negative effects of the building on the environment and protect its resources, efforts have increased to optimize the environmental buildings performance . Therefore, the study problem was to identify the role of sustainable architecture strategies in optimizing the environmental building performance .

1.2 Questions of the study

The study seeks to answer the following main question**, "What is the role of sustainable architecture strategies in optimization environmental building performance**?"

In addition, the following sub-questions:

1. **What** is the role of active sustainable design strategies in optimization environmental building performance?
2. **What** is the role of passive sustainable design strategies in optimization environmental building performance?

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1.3 Objectives of the Study

The study aims to identify the role of sustainable architecture strategies in optimization environmental building performance. In addition, the following sub-objectives:

1. Identifying the role of active sustainable design strategies in optimization environmental building performance.
2. Identifying role of passive sustainable design strategies in optimization environmental building performance.

1.4 Significance of the Study

There are no studies that have addressed the role of sustainable architecture strategies in optimization environmental building performance. It Contributes to develop theoretical knowledge about sustainable architecture strategies and environmental building performance .On the other hand, the results of this study maybe help architects to optimize environmental building performance by active or passive design strategies which also can achieving sustainability principles.

1.5 Methodology

The researcher will adopt qualitative approach to answer the question of the study through reviewing literature relevant to sustainable architecture and the environmental performance of buildings.

2. Sustainability and Sustainable Architecture Strategies

2.1 Sustainability

The emergence of the concept of sustainability is attributed to the industrial development and the large increase in population numbers at the end of the twentieth century. Consequently, countries sought to clarify policies that would ensure confronting the changes resulting from this development. In 1987 the report "Our Common Future", or what is known as the Brundtland Report, was issued by The World Commission on Environment and Development (WCED) . It was able to achieve integration between economic growth and environmental and social issues (Feria & Amado, 2019).

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The World Commission on Environment and Development (WCED) has defined sustainability as meeting the population's needs without compromising the needs of the future generation (Al-Surf, Trigunarsyah, & Susilawati, 2013).

Sustainability aims to provide a healthy environment in all dimensions (environmental, economic, and social) for current and future generations. In addition, it aims to design an environment with high efficiency in managing resources and balancing them and optimize environmental performance indicators (Rizqa, 2016).

The concept of sustainability has been widely discussed. This concept is influenced by the discipline or field in which it is discussed (Sadollah, Nasir, & Geem, 2020). In this paper we will be devoted to talking about the concept of sustainability in the buildings sector.

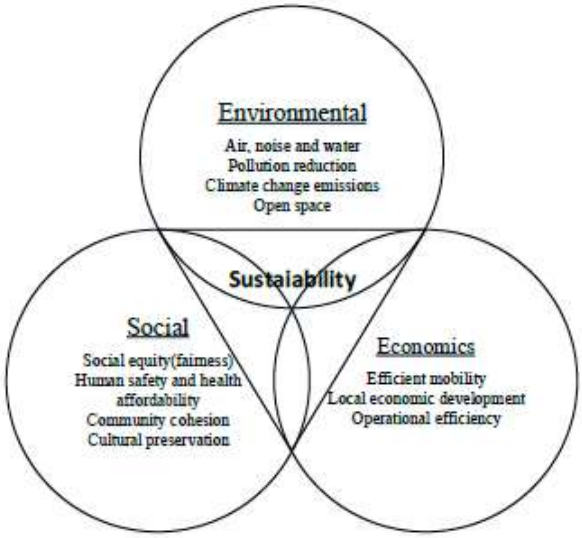

Figure (1): The dimensions of sustainability, source: (AbuEltayef, 2014)

2.2 Sustainable Architecture

The buildings sector around the world consumes about (40%) of annual energy consumption and leads to the emission of (24%) of the total greenhouse gas emissions (Hasan, Mohamed, & Mohamed, 2015). Therefore, It is important to integrate the concept of sustainability into the buildings sector.

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The concept of sustainability began to be used in the construction and building sector with the beginning of the nineties following the holding of the Rio de Janeiro Conference in 1992. This conference had major repercussions in the field of employing the concept of sustainability at architectural level.

The concept of sustainability is used in architecture with the aim of describing the design trends associated with concern for the environment. Sustainability appeared in architecture through many theories such as "sustainable building, sustainable design, green architecture, energy-saving, compact city, earth bag, shared space ". Sustainable design is a design concept that aims to enhance the quality of the indoor and outdoor environment, and reduce or avoid negative impacts on the environment (Hasan, Murtin, & Sari, 2016).

In 1994 the First International Conference on Sustainable Building was held in Tampa, Florida. A sustainable building is defined as "the creation and operation of a healthy built environment based on ecological principles and resource efficiency" (Feria & Amado, 2019, p. 2) , On the other hand, the International Council for Research and Innovation in Building and Construction (CIB) defined sustainable construction in 2004 as "the sustainable production, use, maintenance, demolition, and reuse of buildings and constructions or their components" (Rizqa, 2016, p. 15).

Sustainable architectural design aims to achieve harmony between the elements of the natural and the built environment. In addition, contributes to reducing the depletion of resources such as water and energy and reducing the negative impacts of the building on the environment (Ebeid, 2018).

Sustainable architecture forms an architectural approach and philosophy based on the energy efficiency and internal environmental quality of the building, which achieving by effectively employing energy systems that make buildings less harmful to the natural environment, more able to provide suitable conditions for human use, and less depletion of non-renewable natural resources. Thus, preserving the environmental assets for future generations (Kalan & Oliveira, 2014).

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Sustainable design is characterized by a set of elements that distinguish it from other designs, they include; Effective lighting and ventilation techniques, water-saving equipment, electrical energy conservation, solar energy production units, environmentally friendly building materials , space utilization, and an effective thermal insulation system (Mahdiraji, Arzaghi, Stauskis, & Zavadskas, 2018).

There are five principles of sustainable design including:" Sustainable site planning, Maintaining water and its efficiency, Energy efficiency and its renewal Materials and resources conservation and The quality of indoor environments" (Hasan, Murtin, & Sari, 2016).

1. Sustainable site planning: refers to choosing a site that provides a high degree of accessibility and flexibility of services, designing outdoor spaces to reduce the impact of climatic factors, reducing energy requirements, and working on designing and directing the building in a manner commensurate with the nature of the site and taking advantage of its features without causing radical changes on the site and its natural features.
2. Energy Efficiency: Adopting design strategies and applications that reduce the use of non-renewable energy (fuel and gas) and relying more on renewable materials (sun, wind, and natural air) in heating and air-conditioning processes, whether through passive design strategies. design, or technology technologies (Active Design).
3. Water conservation and efficiency: rationalize water consumption in the building by limiting its leakage, using low-flow equipment, collecting rainwater and using it in various uses such as irrigation. Reuse of gray water after treatment and use it in special applications such as cooling operations and toilets, in addition to the use of plants that do not require large amounts of irrigation water.
4. Preservation of materials and resources: This principle is achieved through rationalizing the consumption of materials and relying mainly on renewable resources, and working within a set of principles; Such as reclamation (the use of an element that was considered waste), reuse of the buildings or parts of them as building materials in other buildings in addition to reducing the waste resulting from maintenance and operation.

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5. The quality of the indoor environment: which achieved through the use of low-carbon materials that do not emit toxic gases, the provision of all tools that achieve the purity of the indoor air and the use of everything necessary to obtain appropriate rates of thermal, acoustic, and optical comfort. (Sassi, 2006)

2.4 Sustainable Architecture Strategies

Sustainability in architectural design can be achieved in a variety of approaches. These approaches can be classified into two strategies; Active Design Strategy, and Passive Design Strategy

2.3.1 Active Sustainable Design Strategies

The active strategy refers to the equipment, devices and technologies that are used to rationalize energy consumption, raise the environmental performance of the building, and adjust the thermal, acoustic, and optical indicators in it include; heating and air conditioning systems, fire protection systems, sound systems, and automatic lighting control systems (Mochtar, Triyadi, & Surjamanto, 2012; Kang, Ahn, Park, & Schuetze, 2015) . The active strategy is trying to produce energy in the building itself through renewable resources such as the sun, wind, and geothermal energy then use it to meet the energy demand to stop the depletion of natural resources (Babcock, 2016).

The active strategy is of high cost, and the equipment requires large amounts of energy, especially if it is overused. However, it is a popular choice for the user due to its ability to efficiently and quickly secure suitable environmental conditions. Therefore, it is important to use of an active strategy supports energy-producing strategies such as solar and photovoltaic systems (Mochtar, Triyadi, & Surjamanto, 2012).

2.3.2 Passive Sustainable Design Strategies

The passive strategy refers to all the design measures that the designer follows to reduce energy use and provide adequate heat rates in the building without the use of equipment and devices, it include the study of building orientation, building envelope and its materials (windows, doors and insulation materials), site plan design, shading, natural lighting natural ventilation (Mochtar, Triyadi, & Surjamanto, 2012).

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In passive strategies, solar radiation is exploited to provide lighting and heating for the building, the heat exchange between the building and the surrounding environment is controlled through the thermal properties of building materials and the design characteristics of the building envelope elements (Babcock, 2016).

The passive strategy contributes to achieving the thermal comfort of the building through the Design procedures, the direction of the building, self-shading, plants shading, shading by buildings in the area of high building density, regulating the heat capacity of building materials and their characteristics such as texture and color. Therefore, the goal of the passive strategy is to improve the environmental conditions inside the building to contribute to reduce the use of the use of devices and equipment that consume energy and increase the emission of toxic gases is minimized (Rodriguez-Ubinas, et al., 2014). In addition, it is important to conduct a detailed study of the location of the building and the surrounding climatic conditions to ensure the success of this strategy. Reference must also be made to note the importance of integration between the tools and methods of this strategy in order to reach the minimum energy consumption (Zebari & Ibrahim, 2016).

3. Environmental Building Performance

3.1 The concept of environmental building performance

Building performance is usually evaluated based on three dimensions: Economic, environmental and social. In this study, the focus will be on the environmental dimension of the building.

The Environmental Building Performance is an indicator of the building's response to internal and external environmental conditions. Moreover, the environmental performance of buildings also refers to operating in a responsible manner towards the environment through optimal utilization of resources, minimizing waste and disposing of them in a safe manner on the environment, the efficiency of the building’s energy use and minimizing the negative impacts of the building materials on the environment. In summary, the term Environmental Building Performance is used to address the environmental impacts that occur during the building occupancy process and the operations and maintenance activities (Maslesa & Jensen, 2019).

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Buildings that are characterized by an effective environmental performance are able to address the economic, social and environmental impacts of buildings as they show adequate rates of thermal, acoustic comfort and health safety for building users, and they do not affect the environment in a negatively (Ren, 2013).

The Environmental Building Performance is evaluated on several axes such as energy, water, waste, toxic gas emissions, building materials, recyclability, and the quality of the internal environment. (Maslesa & Jensen, 2019).

3.2 Design principle of building with high environmental performance

The design of buildings with effective environmental performance emphasizes a comprehensive principle for all aspects of the good environmental performance of the building, (efficient use of the construction site, energy, water, materials and other resources, etc...), in a way that reduces the environmental loads of the building and provides a healthy and comfortable living environment. The following are illustrates the most important this principles (Ren, 2013):

1. Efficiency: efficiency is the basic principle for achieving effective environmental performance. Energy and water efficiency is an important factors in improving the environmental performance of buildings. Energy efficiency can be achieved through reducing the use of fossil fuel energy (non-renewable) and replacing it with renewable energies such as solar energy. While, water efficiency, it is achieved through the use of conservation equipment.
2. User satisfaction: the building with effective environmental performance enhances communication between its users and the natural environment, and provides a healthy environment for users, thus improving their level of satisfaction and their sense of comfort while using it. To achieve this, a good level of ventilation, a renewable nature, must be provided, indoor air quality, thermal comfort, acoustic comfort, adequate lightness ... etc.
3. Respect for local conditions: a design that takes into account local conditions helps to create buildings with an efficient environmental performance. Respecting the climatic and geographical nature of the region contributes to achieving greater harmony between the building and the external environment, which helps to raise the level of the building's environmental performance.

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3.3 Managing environmental building performance

The process of managing environmental building performance is complex, requiring a wide range of interrelated categories. Maslesa et al. (2018) identified eight environmental categories that should be considered when managing environmental building performance; energy management, water management, emissions, space management, waste management, building materials, indoor environmental quality and recycling potential. While Degani & Cardoso (2008) identified fourteen environmental categories; relationship between building and surroundings, choice of materials and construction systems, low impact sites, energy management, water management, waste management, maintenance of performances, hydrothermal comfort ,acoustic comfort, visual comfort, olfactory comfort, sanitary quality of the spaces, sanitary quality of the air and Sanitary quality of water.

4. Use sustainable architecture strategies in optimization environmental building performance.

The implementation of sustainability standards increases the environmental performance of the building. These buildings become more energy efficient and more in harmony with the surrounding environment. Buildings designed according to sustainable design strategies and principles are characterized by providing a comfortable, safe, healthy and high-quality living environment that operates at a high level of environmental efficiency. Using sustainability principles reduces the building's negative impacts on the environment. It helps to apply the foundations of passive design and active design that can save 30-50% of the total energy used in buildings (Ren, 2013).

The principles of sustainable architecture constitute a means to evaluate the environmental performance of the building, through which attention can be achieved to achieve the highest levels of environmental performance. The application of sustainability principles improves the efficiency of water and energy consumption, as well as helps reduce emissions of toxic gases, and improves waste management. Moreover, sustainable architecture strategies contribute to providing better ventilation and lighting rates, which improves the user's comfort level and helps to improve the quality of life within the environment (Chen, Liu, & Yang, 2017).

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With the increase in the emergence of sustainable architectural trends and the growth in awareness of the importance of this concept and its applications in the buildings sector, some countries have begun issuing systems aimed to assess the environmental performance of the building through a set of sustainable design standards . These systems are methods of verifying the degree to which architectural projects meet environmental sustainability requirements based on specific criteria. The following illustrate the most important of these systems:

1. **Building Research Establishment Environmental Assessment Method – BREEAM**: This system was established in 1990 in Britain by the Building Research Establishment. This is the first system of its kind around the world for evaluating building performance. Buildings are evaluated in this system through a set of criteria including energy efficiency, water efficiency, degrees of carbon dioxide emission, impact of building materials used and their sources, surface water management, waste management, recyclability, pollution level, health and well-being, management (presence Sustainable procurement, sustainable construction practices, building impacts on the site, security within the building), and transportation (accessibility, proximity to amenities, bicycle use and parking capacity) (Haroglu, 2012).
2. **Leadership in Energy and Environmental Design- LEED**: This system was established in 1994 by the American Green Building Association. This system is one of the most popular systems used in evaluating sustainable buildings and has greatly influenced the development of sustainable design standards. The evaluation in this system is based on seven basic criteria which include; Sustainable location, energy efficiency, water efficiency, materials and resources, indoor environmental quality, innovation and regional priority (Tolksdorf, Peterson, & Ulferts, 2014).
3. **Comprehensive Assessment System for Built Environment Efficiency-CASBEE**: It is a system used to evaluate the efficiency of the built environment, which was issued by a cooperative research committee in Japan (Japanese Association for Sustainable Buildings and the Ministry of Land, Infrastructure, Transport and Tourism) in 2001.

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This system aims to improve the quality of life and reduce the depletion of natural resources. The evaluation process in this system is based on four main work axes: Energy efficiency and performance, resource efficiency and performance, the external environment, and the internal environment (Ikaga, 2013).

4. **Pearl Building Rating System:** It is one of the Arab systems used in evaluating sustainable buildings. It was issued by the Abu Dhabi Urban Planning Council. This system was developed in the stadium into a LEED system, and its evaluation is based on seven criteria: the integrated development process, natural systems, the suitability of the internal and external environment for life, the importance of water, energy sources, resource management, experience and training on innovation (Ramani & Soto, 2021).

The process of managing and optimizing the environmental building performance is based on sustainability assessment systems. Specialists provide models for improving the environmental performance of the building by analyzing these systems and studying their methodology, which confirms the direct connection between sustainability and the efficiency of the building's performance. Degani & Cardoso (2008) proposes a model to improve the environmental performance of the building based on the following sustainability elements:

1. Integration of the building with its surroundings: One of the most important factors that determine the environmental performance of the building is the level of its harmony with the surrounding environment, this point refers to infrastructure, services, availability of safe and comfortable transportation. Moreover, the amount of external noise and the quality of the surrounding landscape.
2. Materials, systems and construction processes: The environmental performance of a building depends on the building materials, their thermal properties, and their durability during the building's life cycle. In addition , the building operating systems (cooling systems, lighting systems, etc.), which must be maintained during the building's life cycle to ensure their effectiveness and ability to achieve the required level of comfort.

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3. Energy: Energy is one of the most important indicators of a environmental building performance . it is achieved by the using of all strategies that contribute to reducing energy consumption, controlling the thermal permeability of the building envelope, relying on renewable energy and materials with low toxic emissions. Moreover, keeping an accurate knowledge of your total energy consumption and permissible limits.
4. Water: Rationalizing the quantities of water consumption, collecting rain water, treating sewage, and reusing treated water for various uses such as cooling and toilets.
5. Waste: Waste is one of the indicators that determine the environmental performance of a building. Where buildings should generate a low level of waste. it is achieved by choosing building materials which can be recycled or used after the end of their useful life.
6. Technical devices: The environmental performance of the building is enhanced through equipment and devices that help monitor performance and find faults in the building's operating systems, which helps prevent energy waste, and maintain comfort indicators at an appropriate level.
7. Comfort and health: Thermal, acoustic, visual, and olfactory comfort indicators are easily observable environmental performance indicators. The human health and comfort inside the building is affected by the air quality and the efficiency of the operation of sanitation facilities.

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Conclusion

It is evident from the previous presentation that the principles of sustainable architecture work to create a built environment that is more compatible with the natural environment, it constitutes a tool to protect the components of the natural environment and protect it from depletion. this is achieving through its focus on the process of rationalizing consumption and turning to renewable energy alternatives. These principles are also concerned with the comfort level, and the provision of the required levels of ventilation and natural lighting suitable for the exercise of his life activities.

These principles are achieved through various strategies, (active and passive strategies) the active ones depend on equipment and systems that provide suitable environmental conditions and work on producing energy from alternative sources such as solar and photovoltaic systems. The passive strategy based on the design of the building (location, orientation, building envelope, building materials, shading, surrounding vegetation, ... etc). Given that the environmental performance indicators of the building are based on different categories of the principles of sustainability (Degani & Cardoso, 2008), the application of sustainable architecture strategies greatly contributes to improving the environmental performance of the building, and this is consistent with what (Ren, 2013) study found, which indicated that the environmental performance of the building in terms of energy, can be improved By (30-50%) through the integration of active and passive design strategies.

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