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Sustainable Design and Green Building for the Design of Residential Buildings with High Environmental Value

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Abstract: Green building is regarded as a significant component of achieving sustainability because they rely on green and natural elements that reduce pollution and aim to reduce resource consumption. This paper research is concerned with defining the notion of sustainability and green architecture in the design of residential buildings due to a lack of understanding about the role that sustainable design methods play in order to prevent detrimental effects on the environment and society. The researcher relies on the case-study methodology. The paper focuses on the sustainable features and new designs used in three case studies of green building in Dubai, China, and Indonesia. The findings demonstrated that these countries are aiming to promote the construction of green buildings, particularly in residential buildings, in order to attain sustainability as much as possible in the environmental, social and economic perspectives. These case studies prevail some important features used in the sustainable design of green buildings such like using renewable energy resources, water saving devices, waste management approaches, green transportation, natural lighting systems, and environmental building materials

Keywords: Green Building, Sustainability, Residential Buildings..

Introduction

Sustainability is defined as a comprehensive approach to design for the design of buildings, as all resources are in the form of materials or energy that must be carefully considered if we want to achieve sustainability. Sustainable architecture seeks to reduce all the negative effects of buildings that affect the environment, and this is done by improving efficiency and achieving balance in the use of materials for building and energy, as well as developing spaces. We find that sustainability, green buildings and zero energy buildings are jointly involved in one goal is to reduce the negative impact and keep the environment clean [1].

The modern research deals with the extent of the strength of the relationship between sustainability and green buildings, as green buildings are considered a large and important part of achieving sustainability, because they depend on green and natural elements that reduce pollution and aim to reduce resource consumption. The principles of sustainability can be achieved when applying the principles of green buildings and relying heavily on them in the design process [2]. Green buildings have undergone a major change and development during the last ten years until achieving zero energy buildings. They are buildings that can produce what we need energy throughout the year, in addition to reducing the emissions of any harmful substances to the surrounding environment of these buildings. As these buildings achieve self-sufficiency in energies that do not negatively affect the surrounding environment and have become one of the productive elements and not consumed. Also, there has been an increase recently in the demand for finding and implementing solutions for how to manage energy in buildings, so resorting to allocating part of the return on investment to the field of research and development of green building systems. However, the world became increasingly concerned about rising energy costs and constant climate change, which led to an increase in demand for implementing green buildings [3].

With a lack of knowledge about the role that sustainable design strategies play in order to overcome the negative effects on the environment and society, this paper research is concerned with defining the concept of sustainability and green architecture in the design of residential buildings, and the possibility of implementing its principles in residential architecture by focusing on sustainable housing compatible with the natural, social and economic environment according to certain design criteria.

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The researcher relied on the case-study methodology in this paper. Simons (2009) [4] outlines this method, stating that: "A case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, program or system in 'real life' context. It is research based, inclusive of different methods and is evidence-led. The primary purpose is to generate in depth understanding of a specific topic". The main goal of using a case study technique was to analyze the fundamentals of a framework for deep and complicated examination of sustainable design and defines the interrelationship between the research elements and the impact of each on the other.

Sustainable Design and Green Building

The concept of a natural building is similar to a green building and tends to use locally available natural materials. Sustainable design and green buildings are important issues related to the environment. Sustainability can be described as the pursuit of the needs of current generations without affecting the needs of future generations. Green buildings also play a major role in providing many advantages to the residents of the buildings and the society as a whole.

- **Sustainable design**

Sustainable design is a broad-based, diverse concept that enjoys broad support, and its core is sometimes difficult to apply due to the complexities and proposed shifts in thinking. Environmental and natural values and the optimal use of available resources and capabilities, whether natural, material or human, in an effective and balanced manner with the environment and urbanization in a manner that ensures continuity of continuity. The principles of sustainable aesthetic design include simplicity, balance, diversity, focus, sequence, scale, light, and shade. Sustainable design has some functions: energy efficiency, material handling efficiency, water treatment efficiency, work efficiency or environmental quality, and regional design.

- **Green Building**

Green buildings are those that establish a balance between the environment and their occupants, with the construction and design of the buildings taking into account the micro-climate that they are located in. Because these structures use far less energy and water than conventional structures do. These structures are distinguished by their capacity for energy conservation, reliance on natural light and ventilation, and use of renewable energy sources like solar energy, all of which contribute to lower levels of energy consumption and the pollution that results from it. Green buildings are designed, put into action, operated, and maintained, and then demolished after they reach the end of their useful lives through utilizing techniques and approaches that protect the environment, minimize pollution, consume fewer resources, and improve integration between the building and the surrounding environment. Green building achieve its objectives through some features: High efficiency in the consumption and use of resources, good dealing with the climatic, environmental, geographical, and social conditions in the construction area, and achieving human needs (material and social) and providing the luxury of building users while preserving the rights of future generations.

Impact of Sustainable Design and Green Building on Residential Buildings

The boundaries that previously separated the economy and the environment have vanished, and no longer exist with the emergence and expansion of the concept of sustainable development. According to it, it was verified that there is a close relationship between economic growth and environmental challenges and the waste and pollution factors that permeate them [5].

People will be able to deal with significant obstacles as a result of the uncertainty surrounding climate change possibilities thanks to the advantages of green building for environmental performance. The building sector has a significant impact on the environment, which is seen to be the most crucial factor in reducing the impact of global warming on humans. The cornerstone of the transition to green buildings is enhancements in energy efficiency and ecological effectiveness in buildings [6]. The environmental impact of green buildings is negligible, which can help lessen lifecycle environmental consequences [7]. Research has also shown that reducing environmental impact and waste during construction is one of the main goals of green building. The advancement of sustainable building design heavily relies on the handling of demolition and construction wastes. Construction waste recovery rates should be around 90% to significantly lessen the impact of waste generation [8]. Additionally, the considerable amount of waste generated during construction may cause air

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and water pollution. Thus, the choice of construction materials is crucial for sustainable development and could contribute to safer and healthier environments [9].

Green buildings can result in significant financial savings by enhancing life cycle cost analysis and implementation, especially from the construction, operation, and maintenance sections. The initial costs of green building may be greater for customers and contractors working on residential projects than those of standard development, but over time, these costs can be repaid through monthly rewards in the form of reduced power costs [10]. Cost reductions in the maintenance and operation areas might help offset the initial cost of creating green buildings [11]. Moreover, the primary source of income for green building management is cost savings from lower energy use and lower maintenance and operation expenses. Green building expenses, such as operational components, can be evaluated once the lifespan of a structure has been predicted. This involves both direct and indirect advantages due to resource efficiency. Improvements in resource utilization can, respectively, result in direct savings on energy costs and indirect savings on environmental preservation [12].

Green sustainable architecture contributes to the rationalization of energy consumption in the long run. The result of a field survey that included 99 buildings designed in accordance with this trend in the United States of America. It was found that the rate of energy consumption in it did not exceed 30%, when comparing that percentage to what is consumed by ordinary buildings [13].

Corporate social responsibility is a component of green building's social benefits. Under the newly emerging concept of ecological development, environmentally responsible management may have positive social effects. The requirement for corporate social responsibility is one of the primary forces behind green building [12]. In order to advance green building and sustainable building reconstruction, better corporate social responsibility may help to create a positive business image.

If residents switch to green buildings, their health and safety will also benefit. The most important element of human benefits in green construction is indoor environmental quality, which also covers illumination and indoor pollutants [11]. One component of the interior lighting environment that can have an impact on mental health and productivity is illumination distribution. Indoor air quality has a significant impact on a building's performance and participant health [12]. Buildings may have a direct impact on human health because most residents spend their time indoors. There is more focus on urban policy to address human health as a result of cities' increased influence on global environmental and health consequences [11]. In comparison to conventional buildings, a green building can achieve greater indoor environmental quality levels, enhancing resident health and boosting user happiness [12]. However, it has also been discovered that people in green building have a more favorable perception toward interior environmental quality than do people in traditional building. Additionally, residents of green-certified buildings get 6% better sleep quality than those of non-certified buildings [14].

Overall, the usage of green buildings may significantly lower energy usage emissions of carbon dioxide. and because the materials used in green buildings are recyclable and low in carbon, they are an efficient way to address environmental issues. At the same time, the life-cycle cost approach enables green buildings to decrease the cost of building occupancy by reducing electricity expenses. Utilizing green buildings can improve a company's social standing and encourage the growth of a competitive market for green structures. In addition, people who live in green buildings have good health and mental stability.

Case Studies

Green buildings improve quality of life for occupants, consider environmental regulations throughout the design, construction, execution, maintenance, and operation processes, and work to lessen the building's negative environmental consequences on society as a whole. Examples of countries that seek to make their buildings green are the abundance of green landscapes inside it are (Dubai - Indonesia - China). In this section, the advantages resulting from the combination of green buildings and green landscapes in the design of sustainable residential buildings in these countries will be investigated.

Case I. Dubai Sustainable City

The sustainable city in Dubai, which was established and constructed with the best level of sustainability with its three main components: economic, social, and environmental, is the most well-known of its type in the emirate (see Figure 1) and is regarded as one of the most significant green environmental economic pillars. The Sustainable City offers a full range of social comforts and green characteristics. A

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15,000 m2 mixed-use building, a mosque, a kindergarten, a farm, public amenities, and the equestrian center make up the project's first phase, which was finished in 2016. Phase 2 will include Diamond Innovation Center, Hotel Indigo, Comprehensive Rehabilitation Hospital, and International School.

Figure (1): Green buildings in Dubai Sustainable City.

The proportion of green landscaping can reach 60% of the total project, and each house includes a small organic garden and a golf-car powered by renewable energy that is used to move around the city. The project also contains a special system that relies on separating black and gray water and treating it to be reused later for other purposes in the city. Sustainable City of Dubai achieved different types of sustainability: Environmental, Social and Economic.

- **Environmental sustainability**

To begin with, the villas face north to escape the sun. The "sikkas," or tiny streets, that run through the clusters increase shade and minimize physical exposure. Modern insulation, UV-reflective paint, energy-efficient air conditioning, LED lighting, solar water heaters, and energy-rated appliances are just a few of the innovative design elements that assist lower electricity use by up to 50% when compared to ordinary villas in Dubai. 10MWp of solar panels are being installed by The Sustainable City. Villa rooftop solar panels can further cut yearly electricity imports by up to 30%. Demand management and rooftop solar power together considerably lower electricity costs, to levels never before observed for structures of a similar nature. Parking spaces with solar shading generate extra electricity for public facilities like street lighting, bio domes, water features, wind towers (also known as "barajeel"), and public amenities.

Water-saving fixtures and appliances, greywater treatment and reuse in productive landscaping, and blackwater treatment and reuse in non-productive landscaping are all part of the Sustainable City's water plan. When compared to typical villas, villas use up to 40% less freshwater, which lowers the need for desalinated water and the associated greenhouse gas emissions. The geography of The Sustainable City channels storm water into a complex web of bioswales and a conventional "falaj" system, both of which aid in replenishing groundwater supplies.

100% of the waste will be sorted at the source, according to the Sustainable City. In order to encourage residents to segregate their waste at the source into five waste streams, disposal containers are easily placed in each cluster. Electric vehicles are used to collect the waste, which is then transported to Tadweer (Dubai's largest materials recovery plant), where it is recovered and exchanged. On-site composting is used to turn green waste into material for public landscaping. Other waste streams are gathered and handled independently; for instance, used cooking oil from hotels and restaurants is delivered to a Dubai-based biodiesel factory.

Each apartment cluster contains a number of "barajeel" wind turbines that are positioned strategically to direct cooler, less humid air into the plazas. The development is surrounded by a 30-meter green belt, which serves as an essential biological home for birds and reptiles. Additionally, this greenbelt offers shade for the horse and bike paths and lessens air and noise pollution.

The Sustainable City's transportation plan encourages people to use walking and bicycling more frequently rather than using a car. Since the clusters are no-parking areas, the only ways to get there are on foot or by electric buggies using the sikkas that connect the city. Owners of electric vehicles have free access to electric charging facilities. A solar-powered electric mobility program will soon be made available in The

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Sustainable City to encourage residents to give up their second family automobile and learn about solar-powered electric mobility.

The center urban farm of The Sustainable City is made up of 11 bio domes with temperature control. Inside these bio domes or along the "falaj" system, residents can produce their own herbs and vegetables.

- **Social sustainability**

More than only technology and engineering define the Sustainable City. The project fosters a thriving sustainable culture among its inhabitants, employees, and guests. The Sustainable City's infrastructure promotes recreational activities, sporting events, and cultural activities by providing lots of outdoor areas like playgrounds and plazas. Residents may keep a healthy lifestyle with the support of sports facilities such courts, a community pool, bike paths, outdoor workout stations, and an equestrian club. Additionally, the Sustainable City organizes numerous events all year long (including meet-and-greets, environmental festivals, and seminars) to forge a cohesive neighborhood that promotes tolerance, respect, and interaction with people of all cultures, backgrounds, and views.

- **Economic sustainability**

The Sustainable City serves as an example of how environmentally and economically sustainable construction can coexist. Investments in sustainability made during construction have more than been repaid by cost savings brought on by sustainable design. Residents enjoy significantly lower energy and water costs without having to pay more for their house. Additionally, residents gain from zero net service and maintenance costs because to the special revenue-sharing plan from mixed-use facilities.

Case II. The Jungle City in China

Because of the high rates of temperature and global warming, China decided to make the first green environmental city in the world, in order to eliminate the crisis of harmful emissions resulting from industrial development in the country and reduce its negative effects. And environmental experts in China said, that over the past 30 years, China witnessed a great economic development, which led to an increase in income and an improvement in the standard of living of the majority of citizens [15]. But this growth was due to the emergence of many factories and factories that increased the large number of harmful gas emissions to the environment, and it is time to fix mistakes and also restore the environmental gap, Therefore, China decided to build a green eco-city near Liuzhou in the south of the country which is called Jungle City (see Figure 2) [16].

Figure (2): The Jungle City in Southern China.

According to those in charge of the project of the new city, which was named "The Forest City" because of the large number of trees inside it, the city will include the so-called "green buildings" that surround plants that purify the air and also increase oxygen emissions and seek to reduce pollution. And to make the environment as clean as possible, this city is designed by the famous architect, Stefano Boer, who works on developing green projects around the world. It is assumed that this city contains approximately 30 thousand people, and houses, apartment buildings, schools, offices, and hospitals take their energy from environmentally friendly solar panels, as their buildings will be clad and surrounded by nearly a million plants of more than 100 species, and also 40,000 trees work annually to absorb nearly 10,000 tons of carbon dioxide,

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and nearly 57 tons of other pollutants, and produce nearly 900 tons of oxygen. The area of the city is about 175 hectares, and it is connected with Lushun City by a large chain of railways dedicated to electric cars.

Also, this city will employ the innovation of "Vertical Forest" (see Figure 3). An option to be created as a solution to the restricted land for developing green open spaces and to solve the climatological challenge in urban areas is greening technology with the vertical forest concept.

Figure (3): Vertical Forest Housing Project in China

China wants to attain a few sustainability axes that make it easier to track and assess design, construction, and operating requirements. Among these axes are the following:

- **Water and treated water management**

This axis focuses on encouraging effective water management, by reducing losses resulting from water leakage, repairing pipes, and also using low-flow equipment, such as toilets, showers, faucets, washbasins, and drinking fountains. It works to reduce consumption and supplies (showers - water springs - and taps). The use of the thermostat to control the temperature contributes greatly to saving water and energy.

- **Use of natural daylight (Daylight)**

China tends to use natural daylight, which balances the need for light bulbs and the accompanying heat, and a highly effective natural lighting system, which is more important than it helps to reduce the number of lighting fixtures and increase the number of windows, since it can control the sunlight from Through the building's form and location, as well as devising good and effective strategies for the use of glass, in terms of location, size and orientation in an artistic rather than engineering way.

Case III. Green Building in Bali – Indonesia

Buildings in Bali are governed by regional building engineering standards and exhibit the features of green architecture application since the shape, form, and character of the structures and their compatibility with the surroundings are tied to these architectural requirements. By using numerous concepts of forms including the character and traditional Balinese architecture, the traditional Balinese architectural style, as specified by regional legislation, can give an architectural image based on the Balinese culture saturated with Hinduism. Its own residential enjoys a great deal of thermal comfort, making it green and environmentally friendly buildings.

Ecological construction is Bali's primary purpose, and the inhabitants of the Indonesian island consider Bali to be a symbol of environmentally sustainable construction. In terms of changing concrete and metal structures, the "green belt" (in the literal and figurative sense of the word) is increasingly coming. On the island, among the group of buildings built on the island are a school, a luxury villa, and other buildings! It all started with the Green School, which opened in Al-Marquis (Baoji District, Indonesia) (see Figure 4). To date, it belongs to 25 bamboo buildings, the central one consisting of 2.5 thousand bamboo stems (stories). About 240 students - In most families, immigrant children participate in (partially) open classes, tired by bamboo furniture. The construction of the school led to the implementation of two other projects. An example of this is infectious, and now both residential and economic buildings are built from natural materials.

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Figure (4): Green School Bali Classroom.

One of the factors in the green building evaluation characteristics that would help Bali, Indonesia's energy efficiency goals is "green material." When considering the usage of building materials, buildings in Bali have highly distinct design and aesthetic features. As an illustration, creative and novel uses of bamboo as a building material could result in a unique architectural structure and provide a good option for architectural design. As used in Green School, bamboo's potential was investigated in the design and construction, which produced a good impression that serves the purpose and harmoniously integrates with nature. Because of the plentiful supply of these raw materials used to construct the area around the school, bamboo was selected as the construction material. In addition, compared to wood, the life cycle of bamboo is comparatively quick and simple. Instead of the plants having to conform to the building's shape, the construction adjusts to the land's and plants' natural curves. There were no trees on the property felled in the building of this school. Without needing to chop or relocate the trees, the building blends perfectly with the surroundings [17]. Moreover, sustainable buildings that Bali has followed have some important features as follows:

- **Indoor environment quality**

The internal environment is polluted as a result of errors that occurred in the various stages of construction, which leads to the creation of health concerns, as Bali tended to avoid these concerns at any stage of design and construction, as well as the operation of the facility, and the quality of the internal environment is controlled by ventilation and smoking control through using air filters, or preventing smoking in the building.

- **Waste and resource management**

The focus here is on materials, as recycled materials or renewable materials are used in order to reduce the negative effects on the environment.

Conclusion

This paper researches the definition of sustainability and green architecture in the design of residential buildings as well as the potential application of its principles in residential architecture through focusing on sustainable housing that is in harmony with the natural, social, and economic environments while meeting certain design criteria. The paper investigates the sustainable features and new designs used in three case studies of green building in Dubai, China, and Indonesia. These countries seek to achieve sustainability as much as possible with greater efficiency in order to improve health and improve the environment and are working to encourage the establishment of green buildings, especially in residential buildings. The findings stated that the green buildings are cost-saving. Green buildings need maintenance and renovation, but since the components of these buildings are natural to a large extent, they need maintenance easier than other buildings. Also, the results concluded that sustainable green buildings do not produce wastes because these buildings recycle rainwater and gray water through using it to clean other things, and these buildings contribute to the social and economic development. Moreover, green buildings use efficient Energy through relying on renewable energy resources such as solar energy, water energy and renewable wind energy, which are utilized for heat and electricity. New designs of green buildings also aim to improve the air quality in indoor places. Since these structures are distinguished by their unwavering efficiency in the use of energy and water resources, they adds to the infrastructure's durability and lifetime.

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