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ARCHITECTURE AND GREEN BUILDING PRACTICES: A PERSPECTIVE OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

Green architecture, also known as "sustainable architecture" or "green building," is a multi-aspect method of approaching the idea generation, scientific analysis, and design of the built environment where environmental sensitivity, resource conservation, and energy efficiency are indivisibly woven together. This review discusses the evolution, principles, and benefits of sustainable architecture, enumerating its use in solving environmental, social, and economic challenges of contemporary construction practices. The evolution from conventional energy utilization to the environmentalist movement of the twentieth century is discussed, along with it marking a transition towards green building technology, particularly post-1970s energy crisis. The key characteristics of green architecture, water conservation, energy efficiency, sustainable materials, indoor environmental quality, and waste management are covered together with their application through technologies like renewable energy systems, rainwater harvesting, and recycled materials. The research also identifies the visual value of green designs, reconciling Biophilic principles and indigenous materials to bring buildings into harmony with their environments (Tabb & Deviren, 2017). Green buildings are examined for social, economic, and environmental advantages, with findings indicating high energy and water conservation, healthier occupants, and more ecological balance. This research reiterates the role of sustainable architecture in playing a part in achieving the Sustainable Development Goals, pushing for ongoing innovation and cooperation.

Keywords*: Green Building, sustainable architecture, key characteristics, advantages*

Introduction

Green Architecture, also referred to as "sustainable architecture" or "green building," involves the theory, science, and design of buildings created in alignment with environmentally friendly principles, conserving resources, and enhancing energy efficiency (Ragheb et al., 2016). This approach integrates eco-friendly materials, renewable energy sources, and strategies for reducing waste, ultimately aiming to create spaces that are both environmentally responsible and beneficial for occupants (Owen & Dovey, 2008). It offers a fresh perspective on managing human impact on

the environment, enabling long-lasting positive outcomes that benefit human societies as a whole (Abdelfattah, 2020). Integration of the ecosystem with the built environment can play an important role in resource-conscious design (Green Building Practices Around the World - ProQuest, n.d.) This type of integration can help replace the conventional manufactured system and complex technologies in controlling external building load, processing waste, absorbing storm water, growing food, and providing natural beauty (Kibert, 2016; Yudelson, 2007).

Sustainable buildings encompass several key principles such as: buildings should generate all their water and energy needs on-site and be tailored to the local climate, adapt over time as conditions change, they must operate without pollution and produce no waste that is not beneficial for other processes within the building or its surroundings, the design should enhance the health and well-being of all occupants, akin to a thriving ecosystem, energy-efficient integrated systems should be employed to maximize both efficiency and comfort, sustainable buildings should enhance the health and diversity of the local ecosystem instead of harming and lastly, they should possess aesthetic qualities that inspire creativity and aspiration.(Hayles & Kooloos, 2005) The public is becoming more aware of the benefits of green construction as prominent sources of information highlight the impact of the built environment on greenhouse gas emissions and natural resource consumption. Higher energy prices, increased costs of building materials, and regulatory incentives are some of the other factors that are also pushing the green building market to grow and expand (Robichaud & Anantatmula, 2011)

This review aims to analyze key aspects, challenges, and innovations in green building practices. It further highlights the integration of renewable energy systems, the use of recycled and bio-based materials, and the role of green roofs in urban sustainability, as well as aesthetic appeal.

Methodology

An online search was conducted using Google Scholar, focusing on peer-reviewed articles published between 2013 and 2023. The search strategy employed a combination of keywords such as “sustainable architecture,” “green building practices,” “energy efficiency,” “renewable materials,” and “sustainable urban design”. Articles were included in this review if they discussed sustainable architectural designs, green construction technologies or environment friendly building practices, and were included. Non-peer-reviewed materials, such as blogs, news articles, or reports, and articles unrelated to the built environment were excluded. The searched literature was organized using the reference manager Zotero standalone.

Key Aspects of Green Architecture

Sustainable architecture goes beyond simply being a method of construction; it's a way of answering the increasing call for environmentally responsible design. It aims to fashion spaces that lessen their impact on the ecosystem while actually boosting human comfort and health. This requires a delicate equilibrium between using energy wisely, conserving water, selecting sustainable materials, and cutting down on waste, all without sacrificing beauty and practicality. By incorporating renewable energy sources, cutting-edge building techniques, and well-considered design approaches, green architecture doesn't just use fewer resources; it also promotes environments that are healthier and more resilient. In a time when city growth and climate issues are closely connected, architecture is about more than just providing shelter; it becomes a driving force for living in a more sustainable, mindful way.

Energy efficiency: It involves designing buildings to use less energy for heating, cooling, lighting, and other functions. It is mostly achieved through the use of high-performance insulation, advanced HVAC systems, and energy-efficient windows (Sayigh, 2013). Renewable energy sources like solar panels, wind turbines, etc., also contribute to reducing the reliance on fossil fuels for everyday activities and energy production (Udawatta et al., 2020). Most buildings in today's date seem to disregard the weather and its effects, and the need for cooling increases energy consumption, yet the rapid depletion of energy appears because of the continuous demand for energy to design and coexist within the buildings, but users or poor building design often waste this energy, making it exhausting over time, so the role of the architectural designer becomes necessary to solve these problems, and many desirable trends promote the use of renewable energy, like solar and wind energy, which adjust with the basics and principles of green architecture that is ecologically friendly (Hayles & Kooloos, 2005).

Based on the basics and principles of green architecture, this trend has resulted in many real goals, such as the provision of a good thermal environment to the user, and arrangement for proper ventilation and natural lighting which can be accomplished by using various applications and other methods to help rationalize the amount of energy consumed and use of modern mechanical methods for the production of energy in a cleaner and renewable way which is considered as the main goal to create a building in tandem with the environment and comfortable for its users to assist them in conveniently performing their daily activities (Sarbu & Sebarchievici, 2013).

Water conservation:

The Leadership in Energy and Environmental Design (LEED) was launched by USGBC as a new green building rating system in late 1998. LEED is a system of rating that scores performance in five categories: (1) sustainable site design, (2) water conservation, (3) energy savings, (4) selection of materials and their usage, and (5) quality of indoor environment. LEED rating is based on a point and credit system where the points are awarded to the buildings that tend to accomplish the factors mentioned in the five categories mentioned above (Das et al., 2015). LEED rating also differs according to the type of building, such as a new building, an existing building, a commercial building, a house, and so on. Water conservation during the whole life span of a building can be achieved by designing dual plumbing that recycles the water used in water closets and the water used to wash cars, using water-efficient fittings and fixtures such as ultra-low flushing toilets, bidets, and low-flow shower heads. Other technologies, such as rainwater harvesting and recycling, and reuse of greywater, etc., are also being used.

Sustainable materials:

In green architecture, choosing the right materials is key. Non-toxic materials like low-VOC paints, clay plaster, and formaldehyde-free boards improve indoor air quality. Recycled materials such as reclaimed timber, recycled steel, and fly-ash concrete reduce resource demand and construction waste. Indigenous materials like adobe, bamboo, and locally quarried stone are sustainable, cost-effective, and culturally relevant, making them ideal for environmentally responsible design.

They are designed in such a way that they minimize the environmental footprint and also include reduced amounts of greenhouse gas emissions.(Xie et al., 2017) Energy efficiency and recyclability, and contribution to long-term environmental sustainability are some of the key features of sustainable

materials. The adverse effects of the construction industry can be mitigated by the adoption of sustainable practices, which help to reduce nonrenewable materials and efficiently recycle materials (Capeluto, 2022). The use of modern building materials should be carried out paying attention to the energy intensity of materials; the natural resources and raw materials consumed; the recycling and safe disposal; and the impact on the environment (Cabeza et al., 2013). The use of sustainable materials in the construction of buildings ensures the preservation of natural resources, the reduction of chances of resource exhaustion for future generations, and so on.

Local sourcing reduces transportation emissions and supports local economies, while choosing non-toxic and durable materials ensures the health of occupants and longevity of the structure. Ideal building materials from the consideration of low carbon emissions, least carbon footprint, and potential for recycling and reuse are natural materials like soil, stones, and timber/biomass. Unprocessed or least processed natural materials have limitations, particularly concerning strength and durability aspects (Venkatarama Reddy, 2009). Processing and transport of natural materials involve energy expenditure, resulting in carbon emissions. To minimize carbon emissions, it will become essential to device technologies to produce building materials and products with the minimum amount of energy expenditure (Olubunmi et al., 2016). The affordability of viable materials for designing and constructing buildings has caused it to become one of the prioritized choices.

Certain viable materials may be costly upfront, but they prove financially profitable for building longevity (Ghisellini et al., 2018). Energy-efficient materials, , help reduce operating costs. This makes them economically profitable in the long run (Sustainable Construction: Green Building Design and Delivery - Charles J. Kibert - Google Books, n.d.). The enhancements in producing viable materials and increased demand for them have caused a growth in their market sales. This has contributed to competition in pricing and easy access to environmentally-friendly alternatives in constructing buildings (Ghisellini et al., 2018).

Indoor environmental quality:

The vast majority of people spend approximately 80–90% of their lives within buildings, emphasizing the critical role that architectural and environmental design play in meeting both the practical and emotional needs of occupants. These structures must fulfill a wide range of requirements, encompassing objective factors like safety, functionality, and energy efficiency, as well as subjective factors such as comfort, aesthetics, and psychological well-being. Efforts to increase energy efficiency and reduce greenhouse gas emissions, coupled with the lack of adequate ventilation, have sometimes exacerbated the indoor air problem by making buildings more air-tight (OECD, 2003).

In today's time for both existing and future buildings, there is a growing emphasis on energy efficiency and indoor environmental quality (IEQ). The energy consumption of buildings is generally dependent on the standards set for the indoor environment, including temperature regulation, ventilation systems, and lighting conditions (Venkatarama Reddy, 2009). Although these criteria are not technical concerns, they tend to directly influence the building's design, construction, and other operational strategies. Significant reduction can be observed in the energy demand through efficient building design, all while maintaining high standards of comfort and functionality.

In a green building, keeping the air fresh and healthy starts with good ventilation, whether through open windows, natural airflow, or efficient systems that bring in clean air. Choosing safe,

low-chemical materials for paints, furniture, and finishes helps reduce harmful emissions, while proper design prevents dampness and mold by keeping humidity in balance. Clean filters, a touch of greenery, and plenty of natural light also make the indoor environment feel healthier. With regular upkeep of systems and simple monitoring, the building continues to provide a comfortable and safe space for people to live and work.

Waste management and pollution reduction:

Reduction of pollution can be a critical strategy for advancing sustainable building practices and effective management of waste. The construction and operation of buildings are major contributors to environmental degradation, releasing pollutants such as toxic dust, harmful solid and water waste, air pollutants, and noise pollution. Addressing these impacts is essential to creating environmentally responsible structures that promote both ecological and human well-being (Udawatta et al., 2020). The triple bottom line (TBL) is a key concept in sustainable development, focusing on social, financial, and environmental performance. It ensures that building projects balance economic viability with social equity and environmental protection, aligning construction goals with sustainability objectives.

To minimize environmental harm, sustainable buildings prioritize waste reduction at every stage, from construction to the end of their lifecycle. Recycling programs play a significant role in diverting materials from landfills, allowing components like metal, wood, and concrete to be repurposed. Modular construction techniques like prefabricated wall panels, steel frame modules, and cross-laminated timber (CLT) are another solution, enabling more efficient use of resources by fabricating building elements in controlled environments, which reduces waste and optimizes precision. Furthermore, sustainable designs often incorporate the principle of deconstruction, ensuring that buildings can be dismantled at the end of their use and their materials reused or recycled (Amaral et al., 2020). This approach minimizes the consumption of raw materials and supports a circular economy.

In addition to waste reduction, sustainable buildings emphasize the use of environmentally friendly and recyclable materials, such as reclaimed wood, recycled metals, and low-impact composites. These materials help reduce the ecological footprint of construction while maintaining structural and aesthetic quality. By integrating these strategies, sustainable building practices address the pressing challenges of pollution and resource depletion, paving the way for buildings that are not only functional and durable but also aligned with the principles of sustainability.

Aesthetic appeal:

Aesthetic appeal in sustainable buildings is achieved when both visual design and environmentally conscious practices resonate with each other. The use of various sustainable materials such as bamboo, reclaimed wood, and locally sourced stone adds unique textures and tones, enhancing the character of the design. Green roofs, living walls, and large windows not only contribute to the building's ecological performance but also make it visually dynamic. Biophilic design helps in incorporating elements like greenery, natural light, and organic forms to create soothing and inspiring spaces. Thoughtful integration of these elements ensures that sustainable buildings are not only functional and eco-friendly but also beautiful and engaging spaces.

In sustainable building, it not only focuses on beauty but also reflects a design that harmonizes with its surroundings and expresses the values of sustainability. Thoughtful design can inspire occupants and communities, fostering a connection to nature and promoting sustainable practices. Incorporating these aspects into building design creates a holistic approach that not only addresses environmental concerns but also enhances the quality of life for occupants and the surrounding community.

Architecture and Sustainable Development Goals

In 2015, the UN established Sustainable Development Goals (SDGs) as an international call to action in order to end poverty, protect the environment, and ensure that everyone lives in peace and prosperity by the year 2030 (Moondra & Khan, 2024). Architecture also plays a crucial role in the achievement of these goals by the integration of sustainable building practices in the design and construction of the building (Katila et al., 2019a). Some of the ways architecture aligns with SDGs can be discussed as:

According to SDG 1, i.e., no poverty, can be achieved with the design of affordable low-income housing communities, the use of cost-effective and sustainable materials to reduce construction costs, the development of communities that foster economic growth, etc. SDG 2 talks about zero hunger, which in an architectural context can be achieved with the incorporation of urban agriculture and vertical gardens in design to increase food production, and the design of spaces for local markets to promote access to fresh produce (Katila et al., 2019b). Proper ventilation, natural lighting, and thermal comfort in order to promote a healthy living environment and design of hospitals and clinics that prioritize patient and energy can be related to the point mentioned in SDG 3 (Hák et al., 2016). For SDG 4, in the architectural aspect, we can design schools with sustainable materials and energy-efficient systems, and also incorporate inclusive design for accessibility and adaptability. SDG 6 can be achieved through the design of buildings with rainwater harvesting systems and efficient plumbing, and also by incorporating wastewater recycling systems. For SDG 7, i.e., affordable and clean water, we can integrate renewable energy systems like solar panels in building design and promote energy-efficient design that reduces reliance on non-renewable resources. SDG 9 talks about industry, innovation and infrastructure, so the use of innovative construction techniques like modular and prefabricated designs and also building resilient infrastructure that can withstand natural disasters (What Is Sustainable Development? Goals, Indicators, Values, and Practice: Environment: Science and Policy for Sustainable Development: Vol 47, No 3 - Get Access, n.d.) SDG 11 can be considered the most important one because it works for sustainable cities and communities, which can be achieved by promoting green architecture and the smart city concept, and also designing spaces that reduce urban sprawl and prioritize walkability. Coming to SDG 13 works on climate action, can be architecturally achieved by designing energy-efficient buildings that reduce carbon emissions and also by incorporating green roofs and urban forests to mitigate the urban heat island effect. And SDG 14 and 15 i.e. life below water and life on land can be worked out by avoiding construction near sensitive ecosystems and designing buildings and landscapes that preserve biodiversity and minimize habitat destruction.

Hence, architecture serves as a powerful tool in advancing the Sustainable Development Goals by fostering innovative and sustainable design practices that address critical global challenges. From

reducing poverty through affordable housing to combating climate change with energy-efficient buildings, architecture integrates environmental, social, and economic considerations to create resilient, inclusive, and sustainable communities. By applying these principles, architects and planners can ensure that built environments contribute meaningfully to achieving the vision of a prosperous, equitable, and sustainable future for all by 2030.

Benefits of Sustainable Buildings

Social perspective: The acceptance of green building guidelines in different communities can be traced back to the long history of this movement. Today, the "feel-good" factor is a major social reason for building green, especially in big cities. The social benefits of sustainable building design are mainly about improving the quality of life, health, and well-being. Well-designed sustainable buildings offer the most value to people, which in turn has positive effects on society(Owen & Dovey, 2008). This means that the indoor air quality in sustainable buildings is better for comfort and economy, and these buildings are more likely to attract buyers because they directly affect health and happiness. In contrast, non-green buildings often contain hundreds of harmful chemicals in the materials used to build them, which can cause issues like childhood asthma and adult respiratory problems. Sometimes called "sick building syndrome", these contaminants affect the health of the occupants directly in metropolitan cities. However, these can be easily eliminated by the use of green materials.

Economic perspective: Although the initial cost of designing and building a sustainable building is almost 10 times higher than the usual starting investment, the long-term financial advantages of these buildings are much greater. The savings over the building's lifetime, especially in utility and maintenance costs, make green buildings very attractive to owners. Some aspects of sustainable design also align with value engineering principles by making the building and its systems more efficient. Life cycle analysis (LCA) is an important means of making architectural design more cost-efficient, by enforcing in the comparison of various designs the principle of taking into account not only the costs of implementation but all the expenses arising during the useful life of a building, including the costs of a possible demolition (Kunszt, 2003). A sustainable building should be constructed or renovated using methods, technologies, and materials that reduce the need for fossil fuels and minimize waste (Gissen, 2002). Without a doubt, the most valuable benefit of green buildings is that they help lower energy and water bills. One survey of 99 sustainable buildings in the US found that, on average, green buildings consumed 30% less energy compared to non-green buildings. Likewise, studies' results revealed that sustainable buildings can save: 36% of total energy use and 65% of electricity consumption; 30% of greenhouse gas emissions; 30% of raw materials use; 30% of waste output, and 12% of potable water consumption (Abdelfattah, 2020).

Environmental perspective: The buildings and the built environment play a major role in the natural environment. Interestingly, green buildings have the potential to reduce the negative effects on the environment and provide business and occupant health-related benefits. Unlike conventional buildings, sustainable buildings consume energy, land, and water more efficiently and produce less waste and pollution. Materials used in green buildings are often recycled or low or non-toxic (Grierson & Moultrie, 2011). Protecting the environment is one of the major benefits of sustainability in the construction industry.

Nowadays, a building should consider environmental issues and follow sustainable criteria to construct and renovate buildings in different areas, such as site selection, materials and resources, energy use and air pollution, water quality, and indoor air quality (Aliamin, 2021). According to USGBC, a building project should measure and indicate that all processes in constructing and renovating a building are safe and clean for the environment. Maybe the easiest way is to understand the principles of sustainable building design and how the negative impacts of the buildings can be reduced or eliminated through more effective planning, design, construction, and operation in sustainable building projects based on the guidelines of green standards (Ghisellini et al., 2018).

Conclusion and way forward

In conclusion, the reviewed studies underscore the growing importance of sustainable architecture in mitigating various problems in recent days due to the construction of buildings in a less efficient manner. The article suggests that sustainable practices can significantly help to improve the social, economic, and environmental aspects of human life. However, there is still much to be understood about the long-term effects of these practices on the environment and functionality aspects. Further research is needed to better quantify the benefits of diverse areas included in green building practices, such as sustainable materials, indoor environmental quality, etc., particularly in developing regions. Future studies should also explore how policy frameworks can support the widespread adoption of sustainable architectural techniques in practice. Overall, while the progress made is promising, continued research and policy innovation are essential to achieving the global Sustainable Development Goals.

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