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Investigating the Impact of Effective Green Design Factors in the Formation of Green Hospitals

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Abstract: With the growing population and increasing human dominance over nature, the disruption of nature's order has emerged as a new phenomenon. One of the results of environmental destruction has been the emergence of green architecture, aimed at saving energy and optimizing the use of natural resources. In this regard, sustainable development, which involves the continuous and rational use of natural resources, has been proposed. Among these, the relationship between nature and buildings has been introduced as a fundamental principle of green architecture. This topic has garnered more attention from architects in recent years. Hospitals, considered one of the most polluting sources of the environment, are a particular focus for designers to create more environmentally friendly hospitals by considering effective green design factors.

In this regard, the use of modern technologies, green architecture, and design and construction of green hospitals are being studied. The present research aims to examine the topic and effective factors in the formation of green hospitals with a focus on quality and efficiency.

Keywords: Green architecture, Energy conservation, Green hospital

1. Introduction

Human, nature, and architecture are three interconnected elements that have always guided designers in their plans . Humans have always sought tools from architecture for living in nature (Wazir,2019), because energy is dynamic and derived from nature, making its denial impossible (Wakhidah,2024). Since the 1970s, with increasing awareness of the environmental crisis, sustainable development emerged to preserve nature, leading to sustainable architecture as one of its branches (Yakut,2022). Green architecture is also considered a nature-friendly technique that promotes environmental protection.

Recent studies further reinforce the significance of integrating green design principles with emerging smart technologies and environmental modeling tools. For example, Shafa (Shafa,2024(a)) highlights how smart materials like ETFE membranes and phase change materials (PCMs) play a critical role in increasing the energy efficiency and environmental adaptability of buildings, aligning perfectly with the goals of sustainable hospital design. Similarly, the importance of integrating intelligent energy management systems in smart buildings—particularly through lighting systems, environmental sensors, and renewable resource optimization—has been ranked as a crucial factor for

sustainability by experts in the field (Shafa,2024(b)). Complementing these architectural insights, Shafa (Saghaei,2025) demonstrate how machine learning models for drought classification can support climate-responsive design strategies, offering data-driven tools to assess site-specific environmental risks and optimize building performance under varying ecological conditions. These interdisciplinary approaches underscore the necessity of combining smart systems, data science, and material innovation to enhance the ecological footprint and operational efficiency of green hospitals.

In fact, the emergence of sustainable development and green architecture stems from the increasing demand for energy caused by population growth and the need to counteract the destructive consequences of industrial civilization. In global discussions on sustainable development, green architecture is considered one of the primary strategies. The main goal and primary principle of sustainable development is to protect natural resources and the environment to meet human needs on Earth. Green hospital architecture technologies have been proposed as one of the responses to sustainable development. These technologies aim to save resources and prevent waste, not only for hospitals but also for other public facilities like schools and universities (Ragheb,2016). The current research focuses on the factors of green design in the architecture of hospitals.

2. Research Method

The current research can begin by asking how green design factors, sustainable approaches, and green design can be incorporated into hospital architecture. The aim of this research is to investigate the impact of effective green design factors in the formation of green hospitals.

The research method is descriptive-analytical and uses library studies as its foundation. This includes gathering data from reliable sources. In this method, theoretical concepts are presented in a diagrammatic format based on the researcher's perspective and the reality of the subject. The selection of design factors was primarily derived from an extensive literature review and supported by expert opinion and international standards in sustainable hospital design. Researches that interpret the data themselves and provide qualitative descriptions are descriptive-analytical studies. The researcher uses content analysis and interpretation to express the outcomes and achievements of others' work. In this research method, it is believed that effective green design factors in hospital architecture can be described and evaluated.

3. The Concept of Green Architecture

Today, as a result of the negative consequences of the industrial world, the preservation and conservation of the world's natural resources have become one of the most important concerns of modern times. In this direction, green architecture can be seen as a way to seek solutions to minimize the negative impacts of buildings on the environment (Williams,2007). From energy conservation, reducing the use of fossil fuels, and building materials, to creating harmony between buildings and residents' environmental and cultural behaviors, green architecture can be defined as such. Rogers (Rogers,2005) defines green architecture as an approach aimed at reducing environmental damage and enhancing human health and the environment.

In the definition by Shafa (Shafa,2024(b)), green architecture is a form of architecture that is in harmony with nature and the environment and is considered one of the branches of sustainable architecture. Sustainable architecture is shaped by understanding nature and using it in the building process, and it aims to coexist with nature by increasing energy efficiency, optimizing the use of resources, and expanding space.

Green architecture strives to select materials and building methods compatible with the environment and suitable for water and air, and to protect the land. Green design goals can be presented clearly in this way.

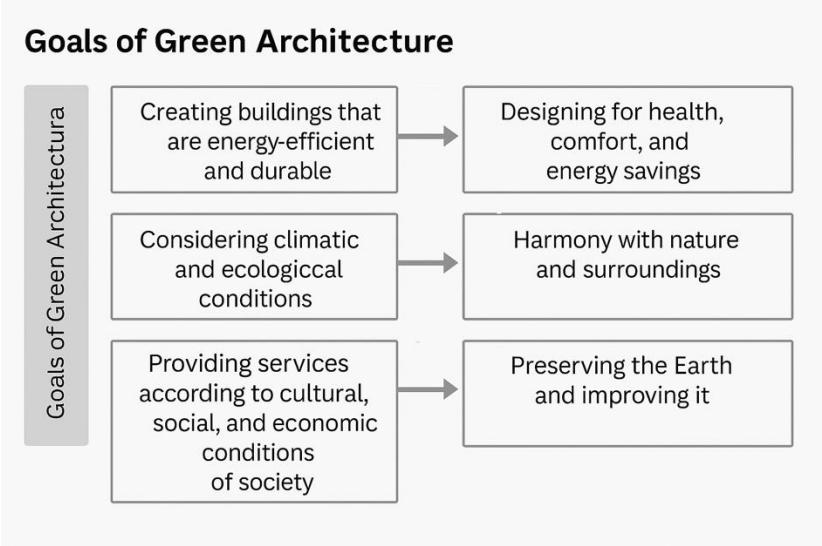

Figure 1: *Goals of Green Architecture – highlighting the core objectives such as energy efficiency, user well-being, and environmental harmony in hospital design.*

4. Principles of Green Architecture

A. First Principle: Energy Conservation

Every building should be designed in such a way that the need for fossil fuels is minimized (Calder,2021). The necessity of embracing this principle, given the construction methods and materials of the past, is undeniable in today's era due to the vast diversity of materials and modern technologies. This principle, once fundamental in traditional buildings, has largely been forgotten in contemporary architecture. Today, with the use of diverse and combined materials, buildings and environments are being adapted to the changing needs of users.

B. Second Principle: Working with the Climate

Buildings should be designed in a way that utilizes the local climate and energy resources. The layout and positioning of a

Figure 2*: Resource Efficiency Cycle – showing the cyclic process of resource usage in sustainable buildings.*

building and its interior spaces should allow for a design that improves comfort levels inside. For example, proper insulation can lead to a reduction in fossil fuel consumption. Designing based on climate to provide comfort inside the building is not limited to heating regulations; in many climates, architects must design cool spaces to provide suitable internal conditions. In today's world, mechanical air conditioning systems are commonly used, often in contradiction with climate conditions, and are accompanied by significant energy consumption and pollution. Even the energy efficiency systems used today can be highly wasteful if incorrectly implemented (Yuan,2017). Figure 2 illustrates an example of energy-saving and efficiency based on this principle in building design.

C – Third Principle: Reducing the Use of New Resources

Buildings should be designed in a way that the use of new resources is minimized, and at the end of their useful life, those resources can be reused to create other structures. Although this approach is emphasized in other green architecture principles, it must be remembered that most of the world's existing resources are artificial materials already used in buildings. Improving and renovating the current condition of these buildings to reduce environmental impacts is just as important as creating new, eco-friendly structures.

D – Fourth Principle: Respect for Users

Green architecture respects all the individuals who use a building because it addresses both their physical and emotional needs. Therefore, it gives special importance to human dignity. The green architecture process includes respect for all shared human resources involved in the construction of a building. This respect is not only limited to users outside the structure but also applies to everyone building it, since buildings are created by humans and for humans.

In some cases, this truth is observed in the dimensions of human presence in the design process. For example, greater respect for human needs and energy can lead to a distinct path from conventional professional construction. Attention to safety and the health of materials and processes used in the building is crucial. Also, it is important for society, especially

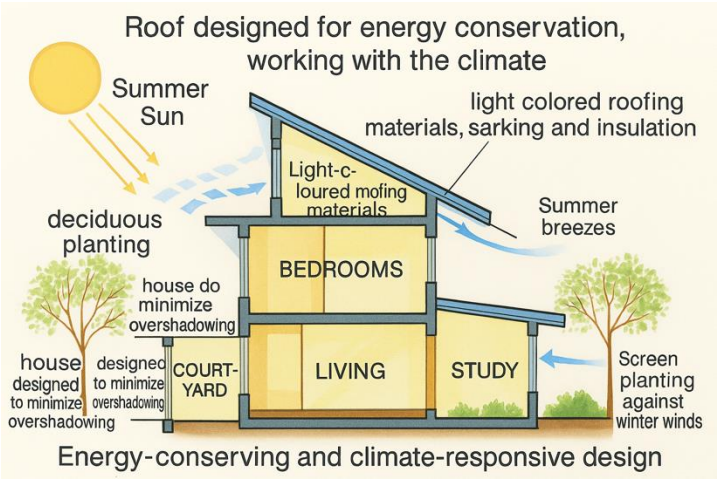

Figure 3: *Energy-Conserving Design – illustrating practical building strategies for energy reduction.*

the labor force and users, who are the main beneficiaries. Moreover, collaboration and the involvement of users in the design and construction process is another form of human-centered engagement.

E – Fifth Principle: Respect for the Site

Every building must gently and calmly touch the earth. A building that consumes energy flows, produces pollution, and causes discomfort to its users is considered alien.

F – Sixth Principle: Holism

All principles of sustainable architecture must be applied in an integrated process that leads to the creation of a healthy environment. Green architecture must be viewed as a comprehensive process because building an artificial environment requires integrated collaboration. In fact, green architecture should include a system that goes beyond the individual building. The city, a broader existence than the building itself, is a system of forms that constantly interact and evolve. These forms, when seen as keys, help us visualize and design the face of future cities.

5. Green Design

Green design is a method of designing whose rules are rooted in nature and is grounded in combining diverse perspectives in the areas of energy, environment, and ecology (Shafa,2024(b)). This design approach encourages interdisciplinary cooperation, including mechanical engineering and architecture. In addition to common design factors such as creativity, beauty, adaptability, shading, and freshness, green design also emphasizes long-term environmental, economic, and human factors. The core principles of green design can be summarized into three basic foundations (Shafa,2024(b)):

1. **Resource Conservation Phase**: This principle focuses on the proper and efficient use of resources and renewable energy, such as fossil fuels, to reduce consumption. On the other hand, it involves controlling and optimally utilizing natural resources as renewable storage. The resource utilization process can be illustrated as shown in Figure 3.

2. **Design Phase for Life Cycle Return**: The second principle of sustainable architecture is based on the idea that any material must be reusable in another form without losing its effectiveness. This allows it to become beneficial again without turning into waste.

3. **Design Phase for Humans**: This principle emphasizes maintaining the quality of life for all components of the ecosystem. It can be considered aligned with the humanitarian goals of respecting all pillars and various resources of life (Reller,2000).

6 – Green Hospital

Hospitals around the world aim to innovate in patient care while maintaining high standards. In implementing this innovation, hospitals always consider the impact on the natural environment to reduce harm to patients, staff, and surrounding communities. Therefore, hospital administrators prepare management programs to preserve energy, properly handle medical waste, and ensure safe drug administration. These programs introduce the concept of a green hospital (Reller,2000).

A green hospital is one that continuously reduces environmental impacts and contributes to eliminating diseases by improving public health. These hospitals recognize the connection between human health and environmental health. They identify and understand environmental needs and align their operations and strategies accordingly. Through environmental measures and active community participation, they commit to improving health and the economy. They take preventive measures to minimize environmental damage and demonstrate a strong commitment to both environmental and public health. A green hospital, often assessed through certifications such as LEED (Leadership in Energy and Environmental Design) or the WELL Building Standard, meets specific criteria in energy

efficiency, environmental quality, and resource management.

One of the key features of green efficiency strategies in hospitals is economic efficiency, which, alongside care quality, targets reducing healthcare costs. With a new focus on environmental health and the use of green technologies, tools, and methods, these hospitals aim to minimize environmental consequences. Accordingly, various hospitals worldwide have practically implemented these green strategies. For instance, the Dell Children's Medical Center in Austin, Texas, became the world's first hospital to achieve LEED Platinum certification, demonstrating the feasibility and success of comprehensive green hospital strategies.

7. Conclusion

A green hospital is a branch and subcategory of sustainable architecture; however, there are key differences in its perspective compared to green buildings. The first foundational principle is that the hospital must be patient-centered. The architecture should improve healing outcomes, making it effective in treatment.

Secondly, hospitals and medical centers are considered major contributors to urban pollution. With a sustainable and green approach in design, they can transform into clean environments. One of the main discussions in green hospital design is the ability to receive green certification.

The current study aims to present effective design factors for green hospitals, which are referenced in Table 1.

Table 1: *Effective design factors*

Factor	Description
Site Selection	Choosing a suitable location for hospital construction before design and project implementation, considering local environmental conditions, land usage, topography, distance from pollution sources, and ecological conditions.
Transportation and Access	Creating access for patients and staff via public transportation and eco-friendly routes.
Energy	Using renewable and clean energy technologies, reducing fossil fuel consumption, and improving equipment and system efficiency.
Environmental Pollution Control	Reducing environmental pollutants like CO2, hospital waste, and sewage; adopting waste treatment technologies and eco-friendly materials.
Material Selection	Selecting materials with low pollution potential and energy use; using recyclable, local, durable materials to reduce environmental impact and cost.
Water Management	Controlling water consumption in all areas including gardens and toilets; using advanced water-saving technologies.
Indoor Environmental Quality	Improving indoor air quality through ventilation systems, natural lighting, and non-toxic materials.
Green Presence	Incorporating green design into hospital layout using green spaces, green roofs, and sustainable materials.

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