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Fundamental Parameters of Sustainable Building Design: A Systematic Literature Review of Challenges and Trade-Offs

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ABSTRACT

The potential of sustainable construction solutions to reduce the negative environmental effects linked to the building industry has attracted a lot of scientific interest in recent years. For long-term sustainability, the design must prioritize financial viability and ensure the well-being of the building's stakeholders. The building blocks of a construction are its materials. The suitable design and the physical, mechanical, and synthetic qualities of the materials define the strength quality of the structure. Therefore, the first step in building a sustainable construction should be to choose and use eco-friendly materials with complementary or preferable features over traditional building materials. Effective decisions on a building's sustainability can be determined at the initial planning and pre-construction phases. On the other hand, the potential of making such early judgments is not supported by traditional building construction planning. Energy and performance evaluations are frequently performed after the architectural design, and they include additional construction documents and records. Therefore, there is a lack of involvement in the design process, which results in an inefficient process of making prior design changes to achieve a sustainable, environmentally friendly building. Very few academics have tried to organize qualitative discussions on sustainability perspectives concerning technology's interaction with constructed environments. In this review, the three fundamental parameters for sustainable building design development are examined. The main obstacles and the general economic and environmental goals connected to sustainable building design techniques are further examined.

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Introduction

Global warming and environmental pollution have become significant global issues in today's world. According to Sassi PA, green areas and animal species have been rapidly disappearing since the emergence of humanity, and by the end of this century, half of them may have vanished [1]. Various research and activities related to this issue have been conducted worldwide based on Agenda 21 (United Nations, 1992b), the UN Framework Convention on Climate Change (UNFCCC, 1992a), and others [2]. Buildings significantly impact the environment in terms of the surroundings, energy, material resources, and water usage. According to Yang RJ, et al., buildings are the reason for 32% of total energy use globally [3]. Additionally, as per Stipo FJF, architecture and buildings play a crucial role in reducing the intensity of global warming and improving their impact on humanity [4]. During the assessment process, links between responses to climate change and sustainable development have received more attention. This is partly because climate change is one more stressor that makes it more difficult to achieve the social, economic, and environmental goals that make up sustainable development.

To address these issues, sustainable architecture, which has high potential, is recommended. Asman GE. et al. and Akadiri PO. et al. note that sustainability enhances people's quality of life from social, economic, and environmental perspectives [5,6]. This study was conducted using library research to review the literature related to sustainability and sustainable architecture. Charles Kibert is credited with defining the term "sustainable" in 1994. He said, "Sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles". By utilizing sustainable design principles, buildings may reduce their environmental effect by using less energy and resources.

Eco-friendly, energy- and resource-efficient designs aim to reduce pollution, slow down the depletion of resources, and provide a secure and productive environment for those who live and work there. Green buildings use natural resources and do not affect the environment. They are good for the environment and community, socially conscious and hence well-liked, and frequently the most affordable and optimal operational option for companies. Sustainable development, an extensive concept, can be addressed and evaluated from the scale of a building to a global dimension. Therefore, buildings are considered a significant part of sustainability. Sustainable buildings are designed based on three fundamental parameters of sustainable development. As a result of this research, the parameters of sustainable building design are presented within a model framework.

Sustainability

Sustainability is a wide-ranging, complicated idea that has grown to be one of the most significant problems facing society. According to Williamson TE. et al., Sustainability is characterized by the constancy and preservation of resources, for example: (Sus.tain.able) as an adjective, it means to be sustainable or the method of using a resource without depletion or harm, which is compatible with the lifestyle of living beings [7]. As per Sassi PA, sustainable development is concerned with providing a better quality of life for everyone (both current and future generations) [1]. According to Tekbıyık G and Grierson, D. et al., The potential for sustainability is the ability to satisfy social, economic, and environmental requirements within a given cycle without affecting the capacity of future generations to satisfy their own needs, including the demands of today [8,9]. There are three basic parameters of sustainability, and for sustainable development to be achieved, economic, ecological, and social development must occur together.

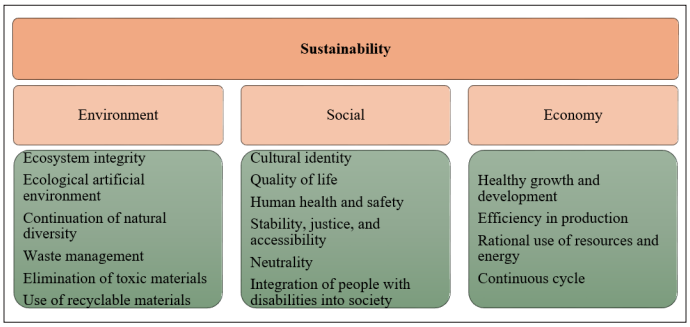

Figure 1: The Three Main Parameters and Strategies of Sustainability

The three basic parameters of sustainable development can be explained according to Figure 1. According to Özcan U. Processing or utilizing a resource in a way that prevents it from being completely used up, exhausted, or destroyed is known as sustainability [10]. As per Sassi PA, the main objectives of the principle of sustainability are as follows [1]:

- Environmental protection
- Providing a balanced and high-quality life for people in economic and cultural terms.
- Establishing a healthy and sustainable environment.

This development requires the simultaneous attainment of four main goals worldwide.

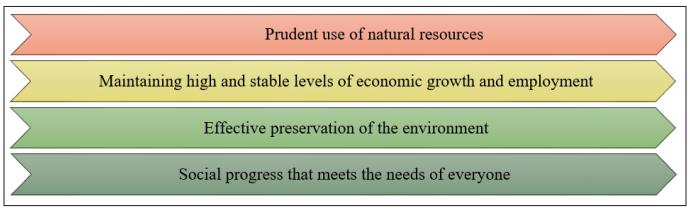

Figure 2: The Four Main Goals of Sustainability

The preservation of the natural resources on our planet for future generations is referred to as environmental protection. It covers issues including lessening the consequences of climate change, protecting biodiversity, and reducing pollution. Prudent use of natural resources entails utilizing resources such as water, minerals, and fossil fuels in a way that reduces waste and does not jeopardize their future availability. Acknowledging the need for a strong economy to support environmental conservation efforts and improve people's quality of life, this goal attempts to sustain high and consistent rates of employment and economic growth. It also emphasizes the necessity of environmentally safe, sustainable economic development.

Sustainability is a broad concept that encompasses all aspects of human life, and sustainable architecture is considered an important part of this development. According to Özcan U, sustainable development can be addressed and evaluated from the scale of a building to a global dimension, as seen in Figure 3 [10].

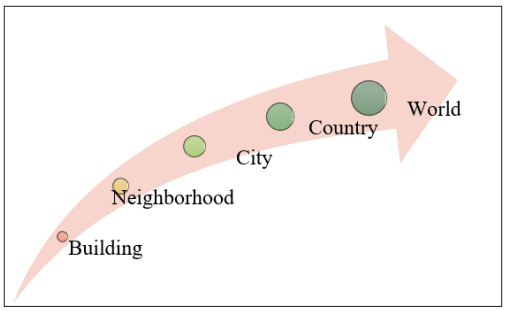

Figure 3: Sustainable Development Scale Relationship

In the contemporary era, it has been proven that buildings are one of the largest energy consumers and sources of environmental degradation in the world. The recommended way to mitigate this problem is through the use of sustainable architecture. Future generations' capacity to satisfy their needs must eventually be protected at all levels, from construction to global, by working together to meet the needs of the present.

Sustainable Architecture

Sustainable architecture is a design and application method that harmonizes with the environment, society, and economics as an important part of sustainable development. It has been used in the design and construction of buildings since ancient times. According to Williamson, T. E. et al., in the first century CE, Vitruvius advised that a home's design should be determined by its climate when designing houses in distant regions of the Roman Empire [7]. Williams DE, FAIA. states that a hundred years ago, architects used natural passive elements in the design of buildings, which include: warm air, prevailing winds, ventilation, daylight, and fresh air [2]. According to Williamson, T.E. et al., there was an approach to good architecture in ancient times, which meant protecting buildings from the climate, but later environmental protection emerged and has now become one of the most important issues [7].

Sustainable architecture is sometimes confused and is only associated with the environment, but it is also related to culture, economy, technology, and even people's lifestyles. According to Williams DE. FAIA, in sustainable architecture, society, the economy, and the environment are shown as interconnected cycles, and these are considered the fundamental and interconnected components of sustainable design [2]. According to Sassi PA, sustainable architecture generally carries two primary goals [1]:

- Sustainable buildings should "tread lightly on the earth," minimizing their negative effects on the environment and leaving minimal ecological footprints.
- Sustainable buildings should contribute positively and suitably to the social context in which they are located, improving the surroundings, and psychological and physical well-being by addressing the practical needs of people.

According to Türk ZB, there are several important considerations needed to address sustainable design, which are shown in Table 1 [11].

Table 1: Important İssues of Sustainable Architectural Design

Land and Climate	Community	Health	Supplies	Energy	Water
• Use of land suitable for construction • Reuse of existing structures • Appropriate density • Landscape Investment • Public transportation • New pedestrian paths • Effects on microclimates	• Consultation with the local community • Mixed development • Contribution to the economic and social welfare of the community • Enjoyment of open space • Visual enjoyment of the area • Aesthetic excellence • Collaborative operation involving all design disciplines	• Comfort of building users • Maximum use of natural light	• Conservation of natural resources • Use of recycled materials • Materials formed with low energy • Renewably sourced materials from a verifiable source • Avoidance of ozone-depleting chemicals • Avoidance of materials containing volatile organic compounds	• High energy efficiency • Use of renewable energy sources • Use of natural ventilation • Use of passive solar energy • User-friendly building management systems • Utilization of stable ground temperature • Use of planting methods for shading and cooling	• Efficient use of water • Collection and reuse of rainwater and greywater • Minimization of rainwater runoff

This framework essentially encourages a comprehensive strategy for sustainable design. It takes into consideration the effects that buildings have on the environment, society, and economy at every stage of their existence, from planning and building to using them and eventually eliminating them. When creating structures that satisfy the needs of the present without compromising the ability of future generations to meet their own needs, architects may appropriately align their work with the principles of sustainable development by considering these considerations.

Examination of Sustainable Buildings

Buildings are the world's biggest source of energy use, according to research, negatively impacting the environment and the economy. This has drawn people's attention, leading to extensive worldwide efforts and the development of strategies in this regard. According to Abousadi, A. et al., Cooling through passive techniques, energy generation, rainwater collecting, carbon dioxide consumption, vertical vegetation integration, natural ventilation, sunshine penetration, and the creation of rainwater purification sites are all part of the sustainable building design approach [12]. Several examples of sustainable buildings worldwide are shown in Table 2.

Table 2: Purpose and Design Parameters of Some Sustainable Buildings in the World

Name	Location	Project Objective	Approach
Eastern Sierra House [2]	United States	Designed to be energy independent. 	• Shading • High insulation and thermal mass • Prevents overheating in summer with cool night air • Solar hot water panels at the edge of the terrace provide a heating system and supply domestic hot water • A photovoltaic system provides the house's electricity • Various efficient and durable natural materials in the structure of the house
EDITT Tower [7]	Singapore	Established to rejuvenate an urban, non-organic area where the natural ecosystem has been completely destroyed. 	• 'Wind walls' redirect the wind into interior spaces • Solar panels • Mechanic connections designed amongst building components for rainwater collection, sewage greywater reuse facilitation • Over 55% of greywater can be reused • The EDITT Tower will achieve 40% energy self-sufficiency through the solar panel system.

Affordable and Sustainable High-Density Residential Complex [13]	Australia	Highly innovative mixed-use and mixed-tenure dwellings offering sustainable and affordable living 	• Shared open space (inner courtyard) • Skylight windows and voids to maximize daylight and winter sun • Openings oriented towards the building core to increase cross-ventilation • Central gas-boosted solar hot water system and water recycling treatment plant • Introduction of landscaped shared open space and privacy hierarchy • Access to building design

From the perspective of sustainable architecture, existing buildings are the first and most significant indicators of a sustainable environment. Therefore, the initial stage in addressing sustainability in an environment is the design and implementation of sustainable buildings. Generally, as shown in Figure 3, the sum of sustainable buildings or a complex constitutes sustainable neighborhoods, cities, countries, and the world.

Parameters of Sustainable Building Design

Various approaches and methods can be employed to address sustainable buildings; however, based on the sustainable fundamental parameters shown in Figure 1 (environment, social, and economic), and the examination I conducted, three general goals can be established as methods for designing and constructing sustainable buildings.

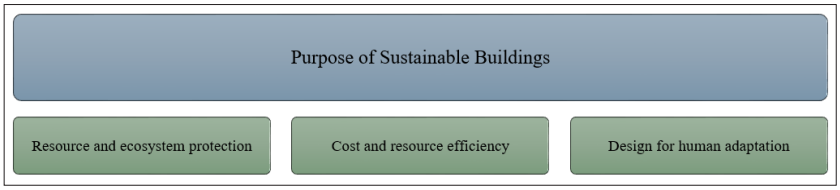

Figure 4: The Purpose of the Design of Sustainable Buildings

The above-mentioned objectives determine the sustainability of buildings in accordance with the parameters of sustainable development. Creating healthy interior environments and minimizing environmental impact via resource efficiency are the two main goals of sustainable building design. It places a strong emphasis on user health and encourages community integration. It also guarantees economic sustainability by considering long-term cost reductions. The ultimate goal of this all-encompassing strategy is to design buildings that enhance economic growth, advance human well-being, and protect the environment. This is in perfect alignment with the fundamental principles of sustainable development. In order to meet these objectives, appropriate strategies are required in the design and structure of buildings. Based on the elements shown in Figure 4 and my own examination, the following areas should be carefully considered for the integration of sustainable architecture in building design:

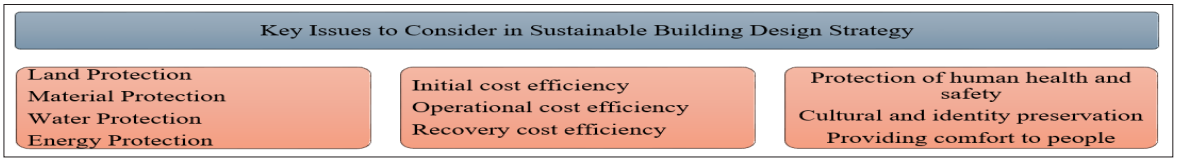

Figure 5: Issues That Need Attention in the Strategy of Designing Sustainable Buildings

Practitioners in the building business have begun to focus on reducing and regulating the environmental harm that results from their operations. Implementing sustainability goals throughout the architectural development phase of a building project is a special opportunity for architects, designers, engineers, and other construction process participants to lessen environmental consequences. Building sustainability is taken into consideration as part of the larger global goals and strategic objectives that are the focus of current sustainability efforts, strategies, and processes. Sustainable building design involves more thought than simply utilizing environmentally friendly materials. Complex technology and greater initial expenses might be obstacles, but life cycle costing and creative financing can help reduce the gap. For the long-term benefit of the environment, inhabitants, and the community, more effective rules, educational initiatives, and designs that combine utility, visual appeal, and sustainability are needed in response to inconsistent regulations, a lack of enforcement, and user behavior.

Discussion

Sustainable building design, although providing major environmental advantages, presents a distinct set of issues that require a multifaceted approach. This section examines these issues and suggests some potential solutions.

The Advantages of Sustainable Buildings

- By utilizing renewable energy sources, eco-friendly building materials, and energy-efficient technologies, sustainable buildings help to mitigate the loss of resources, carbon emissions, and environmental deterioration.
- Natural lighting, thermal comfort, and indoor air quality are given top priority in green building designs, creating more healthy and more comfortable interior environments. As a

consequence, residents may have a lower incidence of allergies, respiratory conditions, and other health problems.

- Sustainable buildings often have lower operating expenses throughout their lives, even though they might require a larger initial investment. Several elements work together to provide favorable economic results, including improved water and energy efficiency, less maintenance needs, and the use of stronger materials.
- Sustainable buildings include water- and energy-saving fittings, lights, and appliances, which lowers utility costs and lessens the demand for natural resources.
- Sustainable buildings are frequently considered more attractive in the real estate market owing to their environmental abilities, energy efficiency, and improved interior environmental quality, resulting in higher property values and more marketability.

Challenges of Sustainable Buildings

- For many developers and property owners, the initial expenses associated with incorporating sustainable features, such as energy-efficient technology and environmentally friendly materials, may be unaffordable.
- Project complexity and time constraints may arise when sustainable techniques are included in building design and construction.
- The limited availability and high prices of sustainable resources and equipment may provide difficulties for designers and builders attempting to satisfy sustainability goals within economic limits.
- For sustainable buildings to function as planned for the duration of their lives, ongoing monitoring, maintenance, and operation are necessary. Continuous expenditures in maintenance procedures, monitoring systems, and training are therefore required.

Designing sustainable buildings takes into account climatic, topographic, economic, social, technical, and technological conditions. There are various principles and methods worldwide to design sustainable buildings. However, focusing on the major parameters of sustainability based on the environment, society, and economy, sustainable architecture carries the same objective worldwide. In order to achieve these objectives, when designing sustainable buildings, attention should be focused on certain parameters, as illustrated by the model in Figure 6.

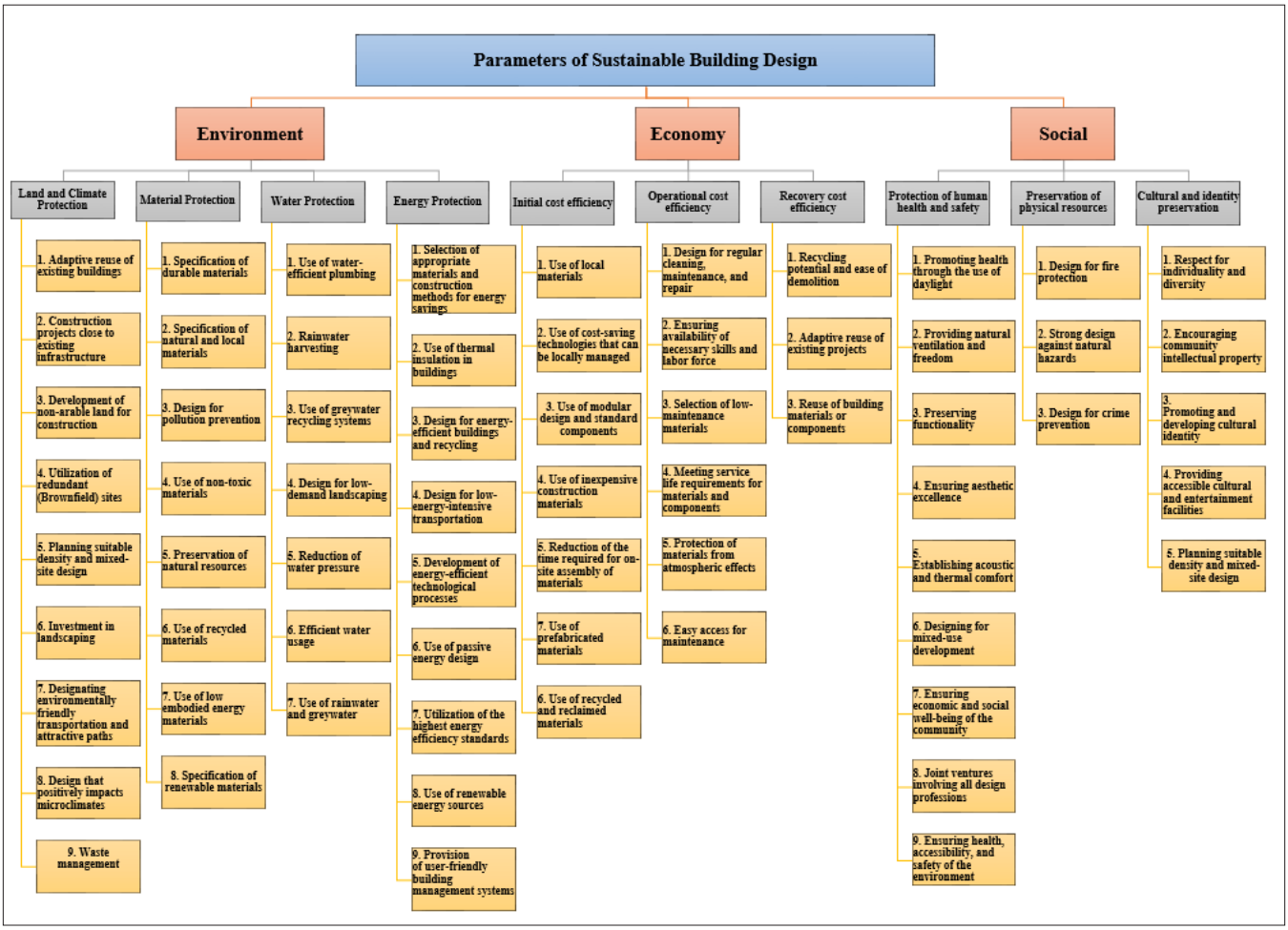

Figure 6: Important Parameters in Sustainable Building Design

By concentrating on these factors, designers and architects may produce structures that guarantee long-term economic viability, enhance human well-being, and respect the environment. This is in complete accordance with the fundamentals of sustainable development.

Results and Recommendations

After reading several books, articles, and theses on sustainability and sustainable architecture, the following conclusions have been drawn from this research:

- Sustainable architecture shares the same goal worldwide, but its implementation can vary depending on the climatic, topographic, economic, social, technical, and technological conditions of the environment.
- Sustainable development, which has three main parameters: environment, society, and economy, encompasses all aspects of people's lives. As part of this, sustainable architecture contributes to resource and ecosystem protection, cost and energy efficiency, and human adaptation based on these three main parameters.
- In sustainable design, the environment, society, and economy are considered as the four legs of a chair. If one is missing, sustainability is lost. Therefore, in order to implement sustainability in a building or environment, these parameters should be used together and developed during the design and construction phases.
- Different methods are used in different regions of the world to achieve the sustainability of buildings. However, the indicators and design parameters of sustainable architecture are similar in every corner of the world. As a result of this research, after examining sustainable design strategies and constructed sustainable buildings around the world, the parameters for sustainable building design have been proposed in a model form.
- In conclusion, sustainable building design techniques play a crucial role in fostering a healthier environment, reducing environmental impact, promoting social well-being, and creating sustainable structures that benefit both current and future generations.

Conclusion

This study revealed the key parameters of sustainable building design to mitigate negative environmental impacts. It offers a valuable contribution to the considerations in sustainable architecture. The paper outlines the parameters and strategies that can be implemented to achieve this objective. Focusing on these critical factors mentioned in this paper has the opportunity to create buildings that not only ensure long-term economic sustainability but also promote human well-being and environmental stewardship. This aligns perfectly with the core principles of sustainable development, emphasizing the importance of balancing economic prosperity, social equity, and environmental conservation in architectural design and construction. Through a comprehensive examination of sustainable design strategies and exemplar projects across the globe, this research has culminated in the delineation of a model framework encapsulating parameters essential to sustainable building design. Building on the established principles of sustainable design, future work should focus on developing context-specific solutions through regional collaboration and knowledge sharing. Additionally, integrating advanced technologies and prioritizing research in sustainable materials, renewable energy, and life cycle analysis is crucial. Policy and advocacy efforts that promote green building standards and public awareness will further incentivize sustainable practices. Finally, a focus on life cycle assessment and optimizing buildings for long-term performance will ensure that sustainable design delivers lasting environmental and social benefits [14-16].

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Author Contribution

Conceptualization, Hasibullah Khan; methodology, Hasibullah Khan; data collection, Hasibullah Khan; formal analysis, Fazalrahman Ikhlas; writing original draft preparation, Fazalrahman Ikhlas; writing review and editing, Ahmad Jawad Niazi; supervision, Qudratullah Ahmadi; project administration, Qudratullah Ahmadi. All authors have read and approved the final manuscript.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Ethics Declarations – Competing Interests

The authors declare that they have no competing interests.

References

1. Sassi PA (2006) Strategies for Sustainable Architecture. France. Taylor & Francis https://www.taylorfrancis.com/books/mono/10.4324/9780203480106/strategies-sustainable-architecture-paola-sassi.
2. Williams DE, FAIA (2007) Sustainable Design/Ecology, Architecture and Planning. New Jersey, John Wiely & Sons https://www.wiley.com/en-us/n%3A+Ecology%2C+Architecture%2C+and+Planning-p-9780471709534.
3. Yang RJ, Carre A (2019) A feasibility study and assessment: distributed solar system in high-density areas. In Energy Performance in the Australian Built Environment 167-180.
4. Stipo FJF (2015) A standard design process for sustainable design. Procedia Computer Science 52: 746-753.
5. Asman GE, Kissi E, Agyekum K, Baiden BK, Badu E (2019) Critical components of Environmentally Sustainable Buildings Design Practices of office buildings in Ghana. Journal of Building Engineering 26: 100925.
6. Akadiri PO, Chinyio EA, Olomolaiye PO (2012) Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. Buildings 2: 126-152.
7. Williamson TE, Radford AN, Bennetts HE (2008) Understanding Sustainable Architecture. France Taylor & Francis.
8. Tekbıyık G (2018) The use of renewable energy sources in sustainable architecture: Examination of application methods and examples in public buildings. Master's thesis, Fatih Sultan Mehmet Vakıf University, Institute of Engineering and Natural Sciences.
9. Grierson D, Moultrie CM (2011) Architectural design principles and processes for sustainability: Towards a typology of sustainable building design. Design Principles and Practices 623-634.
10. Özcan U (2013) A proposed model for evaluating climatic comfort criteria in residential buildings from a sustainable architecture perspective. Doctoral dissertation, Beykent University, Institute of Science and Technology, Istanbul.
11. Türk ZB (2018) Nature-Inspired Approaches for Sustainable Architecture: The Impact of Nature-Inspired Ideas on Building Envelopes. Master's thesis, Gazi University, Institute of Science.
12. Abousadi A, Mahmoud A (2018) Sustainable Design of a Residential-Mixed Use Mid-Rise in the Junction Triangle Neighbourhood. Master's thesis, University of Waterloo https://files01.core.ac.uk/download/pdf/161400917.pdf.

13. Woo J, Moore T (2019) An end-user-focused building energy audit: A high-density multi-residential development in Melbourne, Australia. In Energy Performance in the Australian Built Environment 75-90.
14. Brophy VI, Lewis JO (1999) A Green Vitruvius – Principles and Practice of Sustainable Architectural Design. Malta. James & James https://hydi.um.edu.mt/discovery/fulldisplay?vid=356MALT_INST:356MALT_VU1&docid=alma99000035300020395 6&context=L.
15. Nguyen AT, Truong NSH, Rockwood D, Le ADT (2019) Studies on sustainable features of vernacular architecture in different regions across the world: A comprehensive synthesis and evaluation. Frontiers of Architectural Research 8: 3-14.
16. Smith PF (2004) Eco-Refurbishment /a guide to saving and producing energy in the home. New York: Architectural press 13-126.