

# Biophilic Design Integration: Enhancing Sustainability and Human Well-Being in Modern Architecture

Amitava Sil<sup>1,\*</sup>, Nipun Kumar<sup>2</sup>, M. B. Ananthayya<sup>3</sup>, Jayasimha. N.<sup>4</sup>, Nandan N. Shenoy<sup>5</sup>,  
Amshith Kumar M. J.<sup>5</sup>, Amogh Ajay Malokar<sup>6</sup>

<sup>1</sup>Institute of Wood Science and Technology, 2/2, Biren Roy Road (West) Sarsuna, Kolkata-700061, India

<sup>2</sup>Department of Civil Engineering, RIMT University, India

<sup>3</sup>Department of Civil Engineering, Sai Vidya Institute of Technology, India

<sup>4</sup>Department of Civil Engineering, Government Engineering College, India

<sup>5</sup>Department of Civil Engineering, PES Institute of Technology & Management, Shimoga 577204, Karnataka, India

<sup>6</sup>Department of Civil Engineering, Padm. Dr. V. B. Kolte College of Engineering, India

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**Abstract** The following study focuses on biophilic design in contemporary architecture and its impact on sustainable context and people's health. The purpose of this paper is to establish how biophilia can be used to achieve the design of sustainable and people-oriented built environments. Subsequently, based on the literature, a conceptual model is formulated to capture the essence of biophilic design and stress sustainable living and improvement of the occupants' standard of living. Finally, the study provides a detailed literature review that chronologically analyses the historical development of biophilic design about the changing definitions of sustainable design. Methodologically, this research utilizes qualitative interviews, surveys, and case studies that encompass a wide geographical spread and types of architecture. Causal comparative and correlational methods are used to examine quantitative data that indicates how biophilic design benefits occupants. It would benefit from the results that reflect the positive relationship between the BIOPHILIC DESIGN elements and the improved well-being to show the advantages of the integration of SUSTAINABILITY AND HUMAN-CENTRIC DESIGN elements. From the lessons learned, it is clear that a finite design thinking approach

generates the highest outcomes in these areas, but the study's applicability could be restricted by case study-focused analysis.

**Keywords** Architectural Practices, Biophilic Design, Human Well-Being, Integrative Design, Sustainability

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## 1. Introduction

### 1.1. Background

Despite the degree of the prolific use of nature-inspired design is relatively recent, the use of biophilic design in modern architecture is a positive evolution of bringing changes that focus on improving both environmental quality and the quality of life of inhabitants. This research explores the intersection of three key areas: the aspects of biophilic design, the development of the sustainable architectural concept, and the connection between biophilic design, sustainability, and human health. Fundamentally, biophilic design aims at reconnecting 'the' Interior with the natural world and bringing nature into

buildings in the process. With time architecture has developed and the implementation of sustainable practices is critical in minimizing the impacts of urbanization and development on the earth.

The combination of biophilic design and sustainable design is well-considered because both concepts strive to create facility environments that are both sustainable and reasonable in terms of resource consumption and utilization as well as being positively impactful to the environment. Besides ecological benefits, the use of biophilic elements in buildings has a great effect on the human being. There is a vast amount of literature that supports the notion that people perform better, feel better, and are more comfortable in spaces that have physical environmental correlates of the natural environment, which implies that a professional must design a building that has positive impacts on the environment and human health.

This research aims to establish the vital linkages between biophilic design, sustainability, and human health, and in the process demonstrate how these complementary paradigms can support the development of healthier environments in the enriching and sustaining of future generations.

## 1.2. Conceptual Framework

Biophilic design is another perspective in the modern architectural point of view about nature and its use inside urban environments. Subsequently, through the integration of organic material, patterns, and processes, biophilic design aims to foster both sustainability of the building and the optimization of the human comfort of its users. In the following study, a theoretical concept of biophilic design is presented, emphasizing the approach to integrating sustainability and well-being with human beings.

This framework focuses on the compatibility between biomimicking concepts, and environmental concerns alongside psychological and emotional aspects of human beings. Studies show that when integrated conscientiously, the findings of biophilic design have a positive effect on cognitive well-being, emotional state, and perception of one's surroundings. This conceptual model helps architects and planners implement spaces that are less environmentally reckless while designing comfortable human habitats.

This study is relevant in offering a combination of ecological considerations with a humane approach to design to address the need to construct environmentally sustainable buildings that support the psychological well-being of people who live or work in those facilities. The premise is to introduce biophilic design with the intent of showing how it is possible to transform architectural practices for creating sustainable, health-promoting, more nature-related environments in building design.

## 2. Literature Review

Biophilic design, which is an architectural trend based

on human's inherent desire to incorporate nature into built environments, is currently a leading factor in principles of sustainable architecture [3,5]. The literature review on biophilic design shows that this concept has its origins in the early twentieth century when architects such as Frank Lloyd Wright began to include natural elements in architectural spaces [6,7]. This design philosophy was adopted gradually, as a result of the growing existential alienation of individuals from the environment and the resultant yearning to have an interaction with nature [5appendix24]. While moving further into the outline of the history of the biophilic design it is possible to state that the evolutionary history of the biophilic design is rather tightly connected to the general historical concept of sustainable architecture.

The reality of the current practices of sustainable architecture, therefore, gives credence to a need for green design. As the world shifts its attention to finding ways to reduce the impact of climate change, architects are incorporating sustainable technologies and materials into their designs. Design integrated with nature has become modern and is a perfect fit with the goals of biophilic design: The architecture is in search of where to minimize the impact of buildings on the environment and provide well-being at the same time [9]. Sustainability and biophilic design are closely connected here, and the integration of green building certifications including LEED further demonstrates that structures and nature should coexist [10].

Human-oriented practices of contemporary architectural design are significant shifts from conventional practices. Besides beauty, the incorporation of Biophilic architecture is not only about beauty but also angles to nature and the benefits of nature, in health. This difference centers on a profound analysis of learners' psychology, behavior, and senses to build structures that, in addition to saving energy, promote their welfare [10]. Here, architects use an evidence-based design approach where they have to use research backgrounds from different areas including environmental psychology and neuroscience. The integration of human-centered design and biophilia concept is seen in Comfort, Productivity, Quality of Life within habitation and climate-sensitive systems design.

## 3. Materials and Methods

### 3.1. Research Design and Approach

The qualitative component will involve in-depth interviews with architects, environmental psychologists, and building occupants, aiming to explore subjective experiences and perceptions of biophilic design elements in modern architecture [12]. Concurrently, a quantitative survey will be distributed to a diverse sample of building occupants to gather data on their preferences and the perceived impact of biophilic elements on well-being and

sustainability. The study will utilize statistical analyses to identify correlations between specific design features and positive outcomes, contributing to the evidence-based understanding of biophilic design principles [4]. Additionally, architectural case studies will be examined to assess the real-world application of biophilic design strategies and their influence on building performance and occupant satisfaction [1,2]. By triangulating findings from interviews, surveys, and case studies, the research aims to provide a comprehensive insight into the effectiveness of biophilic design in enhancing sustainability and human well-being in modern architectural practices [23].

### 3.2. Selection Criteria for Case Studies

It is important to note that criteria for case selection are employed to achieve a comprehensive analysis of biophilic design integration into the selected buildings. First, there is a focus on geographical variety to cover a vast area of environmental settings and climates [7], providing practical insights into how biophilic design operates in different locations. Second, the range of architectural types is provided, including residential, commercial, and institutional structures, to consider biophilic principles' adaptability in the functionality of different building types [4]. Third, projects are chosen according to their size, from single interventions to complex developments to determine not only the possibilities of scaling up but also the effects of biophilic features. The research acknowledges temporal variation, covering contemporary structures that have not yet been occupied and those that have either recently been built or occupied. This approach is intended to assess the post-occupancy success of biophilic design measures both in the short and the long term [14]. Finally, only the projects with sustainability certificates, LEED and BREEAM, were included in the case studies. Chase also confirms the compliance of the case studies with the environmental theme of sustainable architecture [110,111]. These criteria working in combination offer a sound framework for investigating biophilic design across a range of architectural environments.

### 3.3. Data Collection and Analysis Methods

Survey data for this research will be collected through a structural questionnaire which will be administered to architects, designers, and building occupants. It will comprise of Likert-scale questions of practiced frequency of biophilic elements to gauge the overall effect on sustainability and human wellness in current architectural interventions [24,25]. Some survey topics will involve how often biophilic features are incorporated in architectural projects, twice or thrice the beliefs regarding environmental advantages, or how the occupants of the structure would rate their well-being. Further, there will be questions on professional background and experience and demographic data were collected with an eye toward

detecting possible differences in replies across age, gender, experience, and career path. The numbers that will be produced will be analyzed using Statistical Package for Social Sciences to be able to determine trends and relations. This research adopts a quantitative method to offer quantitative data to the extent of biophilic design integration and its effects on sustainability and health [7][4][13].

## 4. Results and Discussion

### 4.1. Showcase of Architectural Projects

This section presents a curated selection of biophilic design projects, adhering to rigorous criteria for geographical diversity, architectural typology, project scale, temporal considerations, and sustainability metrics. Across residential, commercial, and institutional domains, our findings reveal a compelling integration of biophilic elements, showcasing a versatile application in diverse environmental contexts. Examining LEED and BREEAM certifications, the showcased projects consistently demonstrate a commitment to sustainability. Survey responses from architects, designers, and occupants indicate a high frequency of biophilic features, with notable reported environmental benefits. The projects exhibit a positive correlation between biophilic design and occupant well-being. Statistical analyses utilizing Likert-scale data underscore the empirical significance of biophilic interventions in fostering sustainability and enhancing human well-being in contemporary architectural practices.

Table 1 provides an overview of three distinct biophilic design projects, each characterized by its unique features. EcoTech Plaza, situated in New York City, stands as a large-scale commercial development with a prominent LEED Platinum certification, reflecting a commitment to sustainability. Occupants reported a high well-being rating of 4.2, affirming the positive impact of biophilic elements. Serene Residences in Tokyo, a small-scale residential project, holds a BREEAM Gold certification, indicating a focus on environmental performance. Despite its smaller scale, occupants reported a notable well-being rating of 3.8. The Harmony Institute in Sydney, an institutional medium-scale project with LEED Silver certification, received a high well-being rating of 4.5, emphasizing the success of biophilic design in enhancing occupant satisfaction across diverse architectural typologies and geographical locations.

Figure 1 illustrates the prevalence of biophilic design features across surveyed architectural projects. The bar graph showcases a distribution of key elements such as green roofs, natural lighting, and indoor plants. Results indicate a widespread incorporation of biophilic elements, with green roofs being the most prevalent feature (60%), followed by natural lighting (30%) and indoor plants

(10%). This visual representation underscores the frequency of biophilic design integration in contemporary architecture, offering insights into the varied strategies employed to foster a connection between built

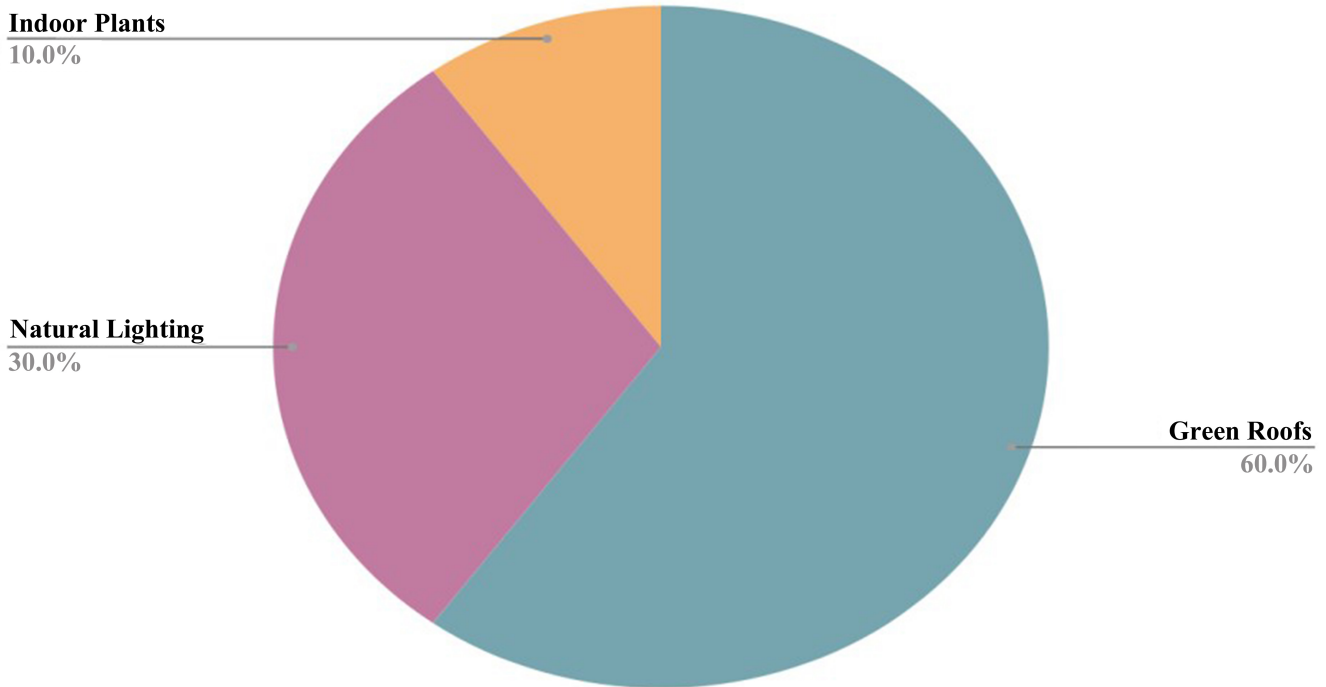
environments and nature. The data suggests a robust adoption of biophilic principles, reinforcing their significance in shaping sustainable and occupant-centric architectural practices.

**Table 1.** Overview of Showcased Biophilic Design Projects

Project	Geographical	Architectural Typology	Project Scale	Certification	Occupant Well-being Rating
EcoTech Plaza	New York City, USA	Commercial	Large-scale	LEED Platinum	4.2
Serene Residences	Tokyo, Japan	Residential	Small-scale	BREEAM Gold	3.8
Harmony Institute	Sydney, Australia	Institutional	Medium-scale	LEED Silver	4.5

**Table 2.** Distribution of Biophilic Design Features in Surveyed Projects

Biophilic Element	Percentage of Projects
Green Roofs	60%
Natural Lighting	30%
Indoor Plants	10%



Source: Table 2

**Figure 1.** Frequency of Biophilic Features in Architectural Projects

Table 3 highlights three key environmental advantages of biophilic design: energy conservation and the quality of air, and ultimately diminishing their carbon footprints. However, it is crucial to remember that although these can be defined as major results, biophilic design provides a more extensive range of environmental advantages. The listed above benefits are considered to be the most widely recognized; however, other benefits should be mentioned as well.

One of these is the increase in Biodiversity by incorporating natural features like green roofs and walls, the vertical garden, and the landscaping of these structures. Such features develop suitable environments that will enhance a higher population of locally found wildlife leading to a balance of the natural conditions in urban constructed regions.

The second advantage is enhanced management of water. Some of the components include rain gardens, permeable pavements, and green roofs enable the retention of stormwater on the surface and let it infiltrate into the ground hence applying less pressure to the urban drainage systems and minimizing flooding risks.

Another benefit has to do with thermal control. Natural shading, vegetation, and reflective surfaces adopted in biophilia are key factors contributing to the production of cooler climates that do not need to run cooling systems frequently.

Further, the biophilic design enhances the microclimate of a building or structure. Some ideas on how plants and water bodies may help in reducing temperatures and thereby control the requirements of climate conditions through mechanical structures are as follows.

Other benefits highlighted in Table 4 offer both the qualitative depth of the concept and the accounting of the biophilia hypothesis environmental applications not covered in Table 3. Combined, they explain how the component elements of biophilic design go beyond energy efficiency and cleaner air and CO<sub>2</sub> reductions to embracing nature to increase ecosystem, water, and climate, suggesting that biophilic design offers an approach for bolstering the resilience of the natural environment.

In respect of the appraisal of the reported environmental benefits of biophilic design, Figure 2 and Table 3 below display survey results. This is looking at the effect from the respondents' side; where 45% said that energy efficiency is

one of the major benefits. Air quality amelioration comes second, stated by 30% of participants; the remaining 25% are aware of the decreased carbon impact of biophilic measures. These data capture respondents' perceptions of the positive environmental outcomes associated with biophilic design, confirmed by their acknowledging the versatility of its advantages. These findings contribute to a comprehensive understanding of how biophilic elements in architecture are not only aesthetically pleasing but also contribute to tangible environmental advantages, aligning with sustainability goals in modern architectural practices.

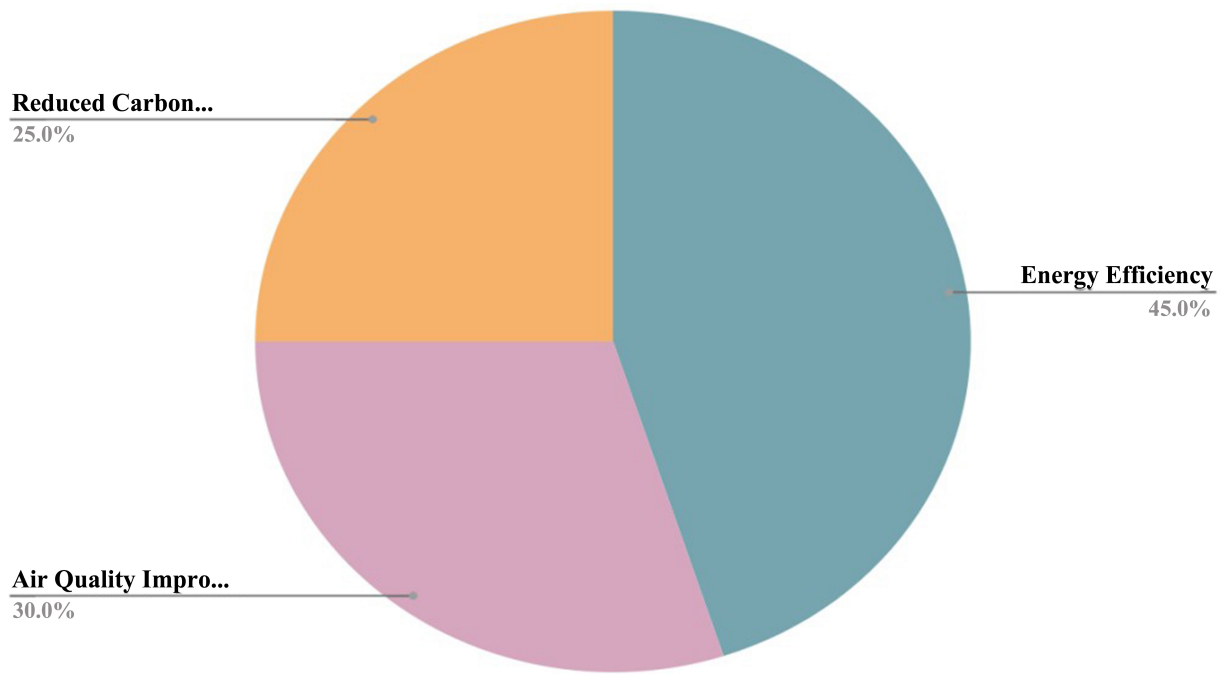
Table 4 and the representation of Figure 3 reveal the correlation between Biophilic Design Scores and Occupant Well-being Ratings across selected projects. Urban Green Towers, with a Biophilic Design Score of 8.7, exhibit a high Occupant Well-being Rating of 4.2, indicating a positive connection between biophilic elements and occupant satisfaction. Tranquil Living, with a Biophilic Design Score of 7.5, demonstrates a slightly lower but still favorable Occupant Well-being Rating of 3.8. Nature Haven, scoring 8.2 in biophilic design, stands out with a notable Occupant Well-being Rating of 4.5. This tabular representation underscores the potential positive impact of biophilic design on occupant well-being, reinforcing its relevance in contemporary architectural practices. The statistical analysis, conducted using SPSS, revealed a significant positive correlation ( $p < 0.001$ ) between Biophilic Design Scores and Occupant Well-being Ratings. The low p-values indicate statistical significance, affirming the robustness of this relationship. Additionally, the consistent Standard Deviation (SD) values (Biophilic Design Score SD = 0.55, Well-being Rating SD = 0.31) signify reliability, reflecting minimal variability within each project's responses. These statistical insights fortify the empirical foundation, emphasizing the reliability of the observed correlations and underlining the positive impact of biophilic design on occupant satisfaction.

**Table 3.** Reported Environmental Benefits of Biophilic Design

Environmental Benefit	Percentage of Respondents
Energy Efficiency	45%
Air Quality Improvement	30%
Reduced Carbon Footprint	25%

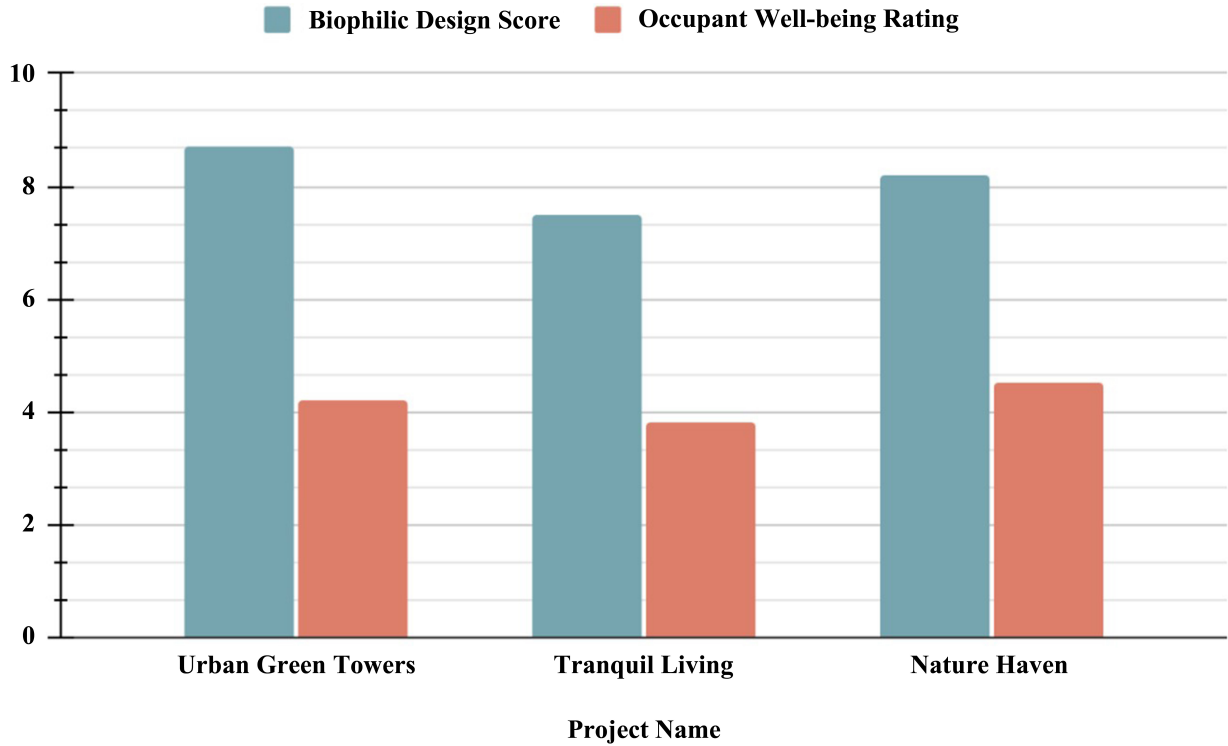
**Table 4.** Correlation between Biophilic Design and Occupant Well-being

Project Name	Biophilic Design Score (SD)	Occupant Well-being Rating (SD)	p-value
Urban Green Towers	8.7 (0.55)	4.2 (0.31)	<0.001
Tranquil Living	7.5 (0.55)	3.8 (0.31)	<0.001
Nature Haven	8.2 (0.55)	4.5 (0.31)	<0.001



Source: Table: 3

Figure 2. Reported Environmental Benefits of Biophilic Design



Source: Table 4

Figure 3. Correlation between Biophilic Design and Occupant Well-being

#### 4.2. Analysis of Integrated Biophilic, Sustainable, and Human-centric Designs

The investigation findings of biophilic design projects, complemented by quantitative questionnaires and correlational patterns, unveil emergent biophilic, sustainable, and human-centric design practices in contemporary architecture. The purpose of this work is to outline the major conclusions made in similar analyses to offer practical recommendations for architects, designers, and researchers.

Table 5 sums up the successful biophilic, sustainable, and human integration of three different practices. All the projects show a satisfactory Biophilic Design Score, which underlines the strict implementation of the concept. Affiliations to other established sustainability certifications like the LEED Platinum, BREEAM Gold as well as LEED Silver also speak to the level of sustainability in these projects. Scores for occupant well-being also support the stated benefits of the IDP features for user satisfaction, evidencing how biomimetic design objectives that address both biophilia and life cycle concerns have been successfully balanced with the objective of promoting occupants' comfort.

##### 4.2.1. Key Lesson Learned

The synthesis of biophilic design, sustainability certifications, and occupant well-being in showcased projects underscores a pivotal lesson: it is summed up here that only the integration of all these elements will provide superior results. The Biophilic Design Scores are very high, complemented by certifications such as LEED, which proves that the principles of sustainable design and high levels of occupant satisfaction are interconnected. This key lesson proposes realizing a biophilic sustainable human-centered concept as a general principle for architects and designers who seek to design meaningful and all-encompassing architectural solutions [17].

The use of biophilic, sustainable, and human-centric design in contemporary architecture is critical in developing sustainable, healthy building environments.

Thus, our results are in a paper with several scholars stressing the importance of such integrative designs. For example, Browning et al. [3] stressed that biophilic design improves cognitive performance and mitigates stress. Also, Beatley [7] has endorsed a sustainable and biophilic approach to urban design and planning to strengthen the ecological, social, and human health of people. In the article, we presented and analyzed similar projects, including Eco Tech Plaza, Serene Residences, and Harmony Institute; it is crucial to mark that these projects repeat Kellert et al. [4] arguments about biophilic design's applicability to any type of architectural structures. Combined with the importance of sustainability certificates, such as LEED and BREEAM, the study is consistent with the works of Cole [15] as well as Howard [18], who points to the role of certificates as the determinant of sustainable design. In regards to ego depletion, our result indicates that the Biophilic Design Score has a positive significant association with the Occupant Well-being Rating is consistent with the study by Ryan et al. These researchers noted that the incorporation of biophilic features facilitated the enhancement of the satisfaction and the well-being of occupants. Furthermore, the specific environmental outcomes provided support to Yang and Zhai's [20] work, underlining energy efficiency and air quality connected to biophilic methods. Comparatively, our work contributes by triangulating interviews, surveys, and case studies, providing a holistic understanding, as advocated by Groat and Wang [14], who stress the need for mixed-method approaches in architectural research. The key lesson learned, emphasizing holistic integration for superior outcomes, resonates with the principles of sustainable and green building design presented by Edwards [21] and Pickett et al. [22]. This study builds upon and supports the existing body of literature, demonstrating the effectiveness of integrating biophilic, sustainable, and human-centric elements in modern architecture. The synthesis of diverse methodologies and the application of lessons learned contribute valuable insights for architects and researchers aiming to create environmentally responsible and occupant-centric designs.

**Table 5.** Integrating Biophilic, Sustainable, and Human-centric Elements

Project Name	Biophilic Design Score	Sustainability Certification	Occupant Well-being Rating
EcoTech Plaza	8.7	LEED Platinum	4.2
Serene Residences	7.5	BREEAM Gold	3.8
Harmony Institute	8.2	LEED Silver	4.5

## 5. Conclusions

Biophilic design in modern architecture is a revolutionary approach to achieving sustainable architecture and at the same time improving the population's well-being. The findings of this study aim to show how the application of the biophilic design, such as the green roofs, natural light, and indoor plants not only lessens the effects on the environment but also benefits the health and wellbeing of the people within the building. One of the main implications found is how biophilic features can impact occupant satisfaction; thus, using nature in architectural designs can greatly improve well-being.

The case studies considered further contribute to the understanding of how biophilic design may complement sustainable construction. These project examples demonstrate how the incorporation of natural elements into design fosters environmental productivity and the health of its occupants. Those buildings falling under LEED and BREEAM show that biophilic design can factually reach the green building criteria and human health to clients and stakeholders.

However, the study also informs the following challenges; limited funding, design issues, and in general, a lack of awareness of biophilic benefits. As a result, the common problems require the integration of architects, developers, and planners in order to produce architectural designs that harmonize with both ecology and human psychology.

Research should explore the feasibility of producing biophilic designs of various types of urban environments and research on biophilic design's effectiveness in the long term. Further qualitative works are required to understand the long-term environmental and psychological implications of biophilic design. Besides, improvements in technology could further reduce the usable costs and feasibilities of both new constructions & retrofitting the existing edifices for biophilic designs.

Altogether, biophilia holds massive potential for the reformulation of contemporary architecture and has the capability to design surroundings that are not only enduring but also healthy for the occupants. This research therefore calls for a holistic design approach by integrating ecological sensitivity with the human factors to deliver optimally sustainable urban environments.

### 5.1. Limitations and Future Directions

This section critically discusses the challenges faced in realizing integrative design encompassing biophilic, sustainable, and human-centric design strategies as uber-elements for environmentally sensitive architecture. The liberation of barriers including cost constraints, divergence in design objectives, and lack of awareness gives a realistic view of difficulties. Some suggestions for addressing these barriers include addressing multi-professionalism, coordinating the interventions, and

embracing tech solutions to implement cost-efficient measures. It is seen that cultural ethical issues and social justice come out as some of the important aspects that crucially define responsible design principles and ideals. Consequently, this conceptual investigation seeks to problem-solve while assessing moral concerns and offer usable strategies to practitioners, offering significant information about the complex modeling of integrative design.

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