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**Review Article**

# A Systematic Review of Biophilic Design Patterns and Strategies in Residential Settings*

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Abstract | In a world that is increasingly confronted with environmental crises and public health challenges, biophilic design, as a bridge between humans and nature, has gained a strategic position in the process of enhancing the quality of life. Despite the widespread adoption of this approach in architecture, there has yet to be a systematic review dedicated specifically to biophilic design in residential settings. The present study is an attempt to identify and categorize biophilic design patterns and strategies within residential settings, focusing on interior, exterior, and intermediate spaces, and to assess their impact on users. The research employs a qualitative and applied methodology, with data collected through library and documentary studies. This systematic review was conducted by searching reputable academic databases and selecting 83 articles published from 2000 to 2025 that specifically focus on biophilic design and its patterns in residential settings. The findings indicate that 36% of the studies utilized the framework proposed by Browning, which includes three main categories: 'Nature in the Space,' 'Natural Analogues,' and 'Nature of the Space,' along with 14 sub-patterns. To analyze the distribution frequency of the patterns, a Chi-square test was employed ($\chi^2 = 165.24$, df = 2, $p < 0.001$), revealing a significant difference in the distribution. The results show that the 'Nature in the Space' category accounted for the largest share, with an average frequency of 60.3%, and patterns such as 'Visual Connection with Nature,' 'Connection with Natural Systems,' and 'Dynamic and Diffuse Light' were the most commonly applied within this category. Furthermore, the majority of proposed strategies were related to interior spaces, with a particular emphasis on the pattern of 'Visual Connection with Nature.' The present study identifies the enhancement of resident well-being as the central goal of biophilic design in residential settings.

Keywords | *Biophilic housing, Design patterns, Biophilic design, Systematic review, Resident well-being.*

**Introduction** | Biophilic design has emerged as an approach to integrating natural elements into built settings to enhance human health, well-being, and environmental sustainability. This approach refers to the intrinsic human connection to nature and can contribute to improving mental and physical health, reducing stress, and enhancing the sense of connection with nature (Lee & Park, 2021a; Asnani & Sharma, 2024; Shakhshir & Sheta, 2024). Despite the extensive literature on this topic, significant gaps remain in systematic reviews that focus specifically on residential applications. Previous studies have primarily focused on commercial and academic settings, with less attention given to residential ones (Lee & Park, 2022; Khanzadeh, 2024). This gap has made it difficult to identify effective patterns and formulate specialized strategies. The rapid growth of the population and urban sprawl has inevitably encroached upon natural habitats, leading to people living in steel and concrete cages without warmth, resulting in a disconnection between humans and nature. This exacerbates the internal isolation experienced in modern society, where individuals spend over 90% of their time in indoor spaces, particularly in poorly designed residential settings, with low-quality construction and a lack of emphasis on attachment of humans to nature (Gong et al., 2023; Kujundzic et al., 2023; Mojtabavi & Tafakkori, 2023). Furthermore, the COVID-19 pandemic, which was associated with social restrictions and increased time spent in enclosed residential spaces, has highlighted the fragility of urban ecosystems and underscored the need to reconsider

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factors such as space area, natural ventilation, natural light, and access to green spaces (Tokazhanov et al., 2020; González & Krarti, 2021). The significance of biophilic design in residential settings has grown in response to global challenges such as climate change and the COVID- 19 pandemic (Bahador & Mahmudi Zarandi, 2024), as these factors have amplified the need for environments that support mental and physical health (Al Sayyed & Al-Azhari, 2025). Integrating biophilic elements can create more comfortable spaces and encourage individuals to connect with natural elements within their homes (Karaman & Selçuk, 2022). Despite the fact that theoretical frameworks, such as Browning and Clert's biophilic patterns, have been around for a while, their practical application in residential settings remains limited (Lee & Park, 2022). While previous studies have pointed to the potential of biophilic design to enhance quality of life and create proper housing (Mojtabavi & Tafakkori, 2023; Pandita & Choudhary, 2024; Untaru et al., 2024), Significant gaps still exist in understanding how to design these elements and biophilic design frameworks within residential settings (Peters & D'Penna, 2020; Richardson & Butler, 2022; Song et al., 2022). The present study addresses these gaps by conducting a systematic review of biophilic design strategies and patterns in residential settings, aiming to identify and categorize effective strategies for interior, exterior, and intermediate spaces.

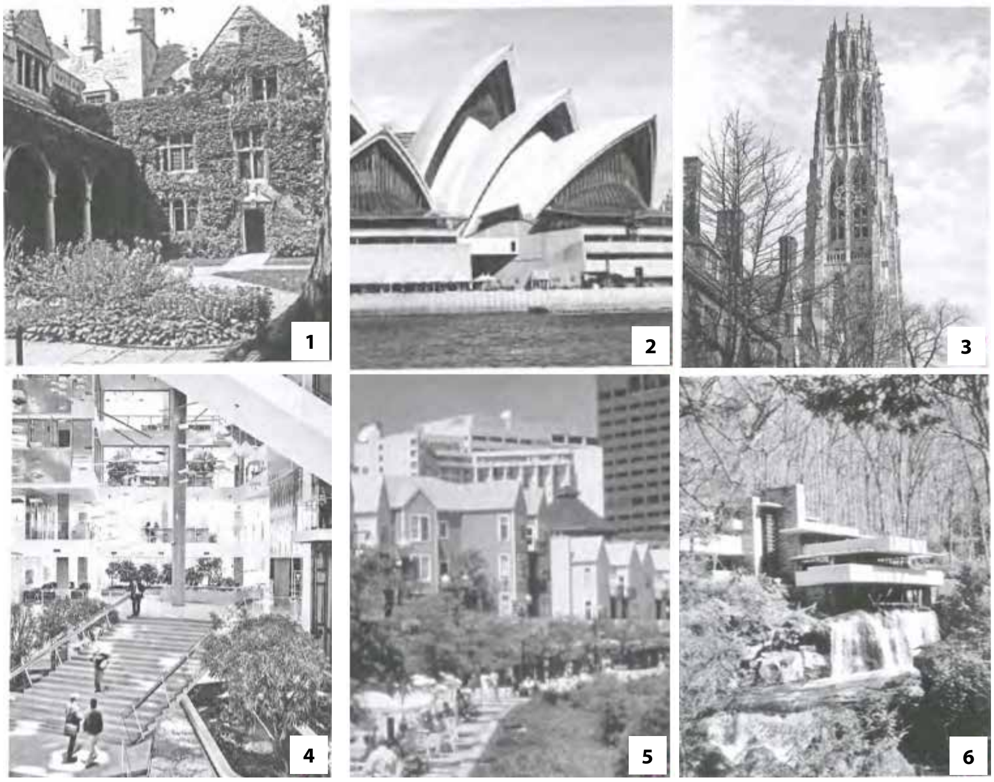
The present study, based on the analysis of 83 sources, seeks to identify the most commonly applied biophilic patterns and assess their impact on users. The motivation for this research stems from the need to address the challenges of urban living, where access to nature is limited (Zhong et al., 2022; Asojo & Hazazi, 2025). This approach not only reduces stress and anxiety and enhances creativity but also conforms with the United Nations' Sustainable Development Goals for 2030 (Bettaieb & Alsabban, 2023; Gong et al., 2023). The present study seeks to provide practical insights and commonly applied patterns for architects, designers, and urban planners to create healthier and more sustainable residential settings. The primary question is: What are the biophilic design patterns and strategies in residential settings, and how do they impact users?" The results of the present study can serve as a scientific reference for architects, designers, and researchers, paving the path for the development of standards and supportive policies in the housing sector.

## Review of Literature

This section introduces the viewpoints presented on biophilic design patterns in residential settings. One of the earliest viewpoints used in biophilic design for residential settings is that of Kellert (2005). In 2005, Kellert defined the concept of biophilic design along two main dimensions: organic design, which directly, indirectly, or symbolically elicits people's inherent affinity for the natural environment, and vernacular design, which is rooted in ecology, culture, history, and the avoidance of placelessness. In 2008, he expanded on this concept by introducing six key elements and 72 biophilic design attributes, including (1). environmental features, (2). natural shapes and forms (3). natural patterns, (4). light and space, (5). place-based relationships, and (5). the evolved human-nature relationships (Kellert, 2008) (Fig. 1).

At the Terrapin Bright Green Group, Browning et al. (2014) presented 14 biophilic design patterns, categorized into three groups: Nature in the Space (including visual and non-visual connections with nature, non-rhythmic sensory stimuli, thermal and airflow variability, dynamic light, presence of water, and connection with natural systems), Natural Analogues (biomorphic patterns, materials connection with nature, and complexity and order), and Nature of the Space (prospect, refuge, mystery, and risk/peril) (Fig. 2). In 2015, Kellert and Calabrese revised the previous 72 features and summarized them into 24 features across three categories: direct experience of nature, indirect experience of nature, and experience of space and place (Kellert & Calabrese, 2015) (Fig. 3). In 2018, Kellert retained this tripartite structure but introduced modifications, such as adding "prospect" to and removing "Evoking nature" from the direct experience of nature and adding "texture" to the indirect experience of nature (Kellert, 2018).

Drawing on Kellert's (2008) perspective, McGee et al. (2019) introduced a biophilic interior design matrix consisting of 6 elements and 54 attributes to facilitate the incorporation of biophilic components into interior space design. Coulthard (2020) defined biophilic design as an eco-friendly approach that emphasizes natural prospects, seasonal rhythms, thermal comfort, water presence, dynamic lighting, natural materials, natural sounds and scents, and fresh air. Browning & Ryan (2020) retained the previous structure and added the feature of "awe" to the "Nature of Space" category. Lee & Park (2021a) examined biophilic design for the renovation of sustainable housing at three scales: unit, building, and complex. Their study included three categories (supporting biodiversity, enhancing the experience of connection with nature, and collaborating with natural ecosystems) and 12 attributes, such as ecological parks, green rooftops, and daylighting. Nitu et al (2022), to increase energy efficiency in housing retrofitting, reviewed design strategies similar to Browning & Ryan 's (2020) categorization, but with a focus on four elements: plants, daylight, air, and water. These strategies include direct use of nature in space (such as skylights, passive ventilation, green walls and roofs, and constructed streams), biomimicry (lighting, geometric patterns, and mimicking plant and water geometrics), and enhancing the nature of space (lighting automation, details of building elements to ensure airflow, and visual access to plants and water bodies). In this approach, both physical connections

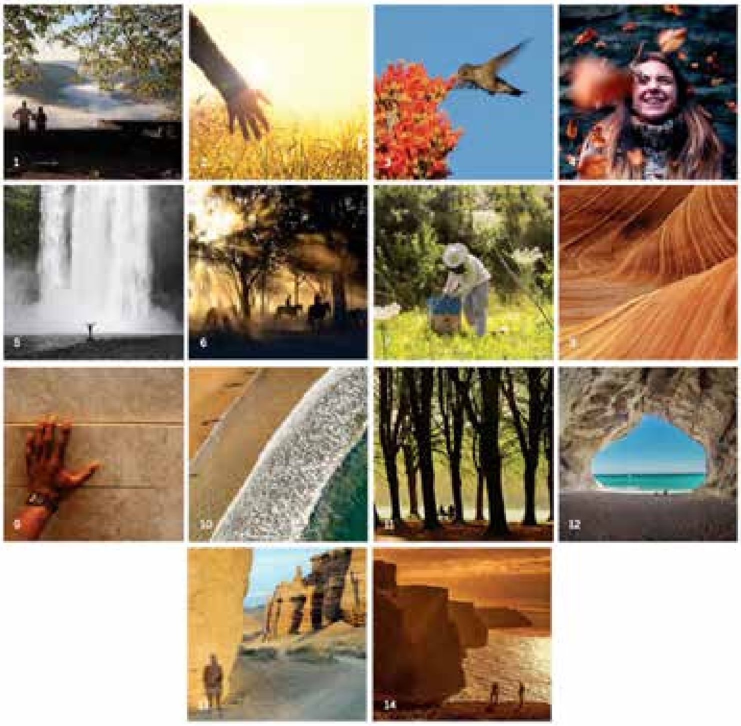



| 1. Environmental Features | 2. Natural Shapes and Forms | 3. Natural Patterns and Processes |
|---|---|---|
| 1. Color 2. Water 3. Air 4. Sunlight 5. Plants 6. Animals 7. Natural materials 8. Views and vistas 9. Façade greening 10. Geology and landscape 11. Habitats and ecosystems 12. Fire | 1. Botanical motifs 2. Tree and columnar supports 3. Animal (mainly vertebrate) motifs4. Shells and spirals 5. Egg, oval, and tubular forms 6. Arches, vaults, domes 7. Shapes resisting straight lines and right angles 8. Simulation of natural features 9. Biomorphy 10. Geomorphology 11. Biomimicry | 1. Sensory variability 2. Information richness 3. Age, change, and the patina of time 4. Growth and efflorescence 5. Central focal point 6. Patterned wholes 7. Bounded spaces 8. Transitional spaces 9. Linked series and chains 10. Integration of parts into wholes 11. Complementary contrasts12. Dynamic balance and tension 13. Fractals 14. Hierarchically organized ratios and scales |
| **4. Light and Space** | **5. Place-based Relationships** | **6. Evolved Human–Nature Relationships** |
| 1. Natural light 2. Filtered and diffused light 3. Light and shadow 4. Reflected light 5. Light pools 6. Warm light 7. Light as shape and form 8. Spaciousness 9. Spatial variability 10. Space as shape and form 11. Spatial harmony 12. Inside–outside spaces | 1. Geographic connection to place 2. Historic connection to place 3. Ecological connection to place 4. Cultural connection to place 5. Indigenous materials 6. Landscape orientation 7. Landscape features that define building form 8. Landscape ecology 9. Integration of culture and ecology 10. Spirit of place 11. Avoiding placelessness | 1. Prospect and refuge 2. Order and complexity 3. Curiosity and enticement 4. Change and metamorphosis 5. Security and protection 6. Mastery and control 7. Affection and attachment8. Attraction and beauty 9. Exploration and discovery 10. Information and cognition 11. Fear and awe 12. Reverence and spirituality |

Fig. 1. Kellert's (2008) perspective on biophilic design patterns. Source: Kellert, 2008.

to natural elements and their representation in architectural design are employed.

Comparing the perspectives of Kellert, Browning, and the Living Building Challenge (LBC), Lee & Park (2022) proposed a hybrid model for biophilic design in residential settings. This model includes three categories of experience: direct experience of nature (sunlight, air and thermal, weather and view, biodiversity and prospects, water and fire, image and video), indirect experience of nature (color and materials, shapes and structures, artificial lighting and HVAC, and biomimicry), and experience of space and place (transitional refuge, mobility and wayfinding, complexity and integration space, place and community, biophilia and education). Continuing their research in 2023, they developed this model further to improve the quality of life for the seniors, outlining 26 physical and digital features such as lightwell courtyards, digital walls, and smart glass, categorized into three groups (Lee & Park, 2023). Utilizing a biophilic approach, Shaliha et al. (2023) examined the quality of architectural spaces in traditional and modern housing by adding dimensions of culture, economy, and environmental psychology to the 14 patterns of Browning. Afifian et al. (2023a) proposed 46 biophilic features for outdoor spaces designed for elderly residents in Iranian residential complexes, categorizing them into six groups: environmental factors, natural forms, place orientation, the nature of space, diversity of environmental components, and biophilic activities. Combining the theories of Kellert, Browning, and Ulrich, Khanzadeh (2023) proposed 15 features in five categories (Nature in the Space, Nature



| Nature in the Space Patterns | Natural Analogue Patterns | Nature of the Space Patterns |
|---|---|---|
| 1. Visual Connection with Nature, 2. Non-Visual Connection with Nature, 3. Non-Rhythmic Sensory Stimuli, 4. Thermal and Airflow Variability, 5. Presence of Water, 6. Dynamic and Diffuse Light, 7. Connection with Natural Systems | 8. Biomorphic Forms and Patterns, 9. Material Connection with Nature, 10. Complexity and Order | 11. Prospect, 12. Refuge, 13. Mystery, 14. Risk/Peril |

Fig. 2. Browning's perspective on biophilic design patterns. Source: Browning et al., 2014.

| Direct Experience of Nature | Indirect Experience of Nature | Experience of Space and Place |
|---|---|---|
| 1. Light, 2. Air, 3. Water, 4. Plants, 5. Animals, 6. Landscapes, and Views, 7. Weather, 8. Fire | 1. Images, 2. Materials, 3. Texture, 4. Color, 5. Shapes and Forms, 6. Information Richness, 7. Change, Age, and the Patina of Time, 8. Natural Geometries, 9. Simulated Natural Light and Air, 10. Biomimicry | 1. Prospect and Refuge, 2. Organized Complexity, 3. Mobility, 4. Transitional Spaces, 5. Place, 6. Integrating Parts to Create Wholes |

Fig. 3. Kellert and Calabrese's perspective on biophilic design patterns. Source: Kellert & Calabrese, 2015.

of the Space, Natural Analogues, Nature of the Mind, and Human-Nature link) to enhance user experience in interior architecture (Khanzadeh, 2024). Saraf et al. (2023) introduced 16 features in three categories, direct involvement of nature, indirect involvement of nature, and involvement of space and place, for designing home workspaces during the Covid- 19 quarantine. Mousapour (2024) investigated the impact of biophilic design on residential satisfaction and the promotion of pro-environmental behaviors at four scales: building, street, neighborhood, and region, with 12 key features such as green facades, water features, natural materials, and access to natural water. Yue et al. (2024) presented an environmental assessment scale for high-rise residential areas, consisting of 18 items and five dimensions, divided into two categories: environmental factors (natural prospect, cultural identity) and behavioral factors (natural interaction, personal space, neighborhood interaction). Finally, Wil & Ismail (2025) investigated six biophilic elements (natural light, green spaces, indoor plants, Access to nature, communal areas, and Sustainable materials) for multigenerational housing across three designs: single-house sharing design, strata design, and community design (Table 1).

The review of literature reveals diverse perspectives on biophilic design patterns in residential settings, which exhibit both commonalities and distinctions. The research gap highlights the need to offer design strategies for implementing these patterns in residential settings (interior, intermediate, and exterior). The objective of the present study is to identify key patterns and offer design strategies for these settings. The research methodology involves the following steps: 1. reviewing the relevant literature, 2. Identifying the perspectives, 3. Rating the perspectives, 4. Identifying the objectives, 5. Rating the objectives, 6. Proposing patterns and design strategies, and 7. Rating the patterns (Fig. 4).

## Theoretical Foundations of the Study

Biophilia is defined as people's innate affinity to the natural world, and it has been explored in psychology and sociology since the 1980s (Peters & D'Penna, 2020). This concept reflects a fundamental human need to engage with the natural world, which is essential for achieving both psychological and physiological well-being. Such an inherent affinity has laid the groundwork for the emergence of biophilic design. Biophilic design is one of the new approaches in the design of spaces where people live, work, and receive training and treatment. This design employs nature and natural patterns in the design of interior and exterior spaces and promotes mental and physical well-being (Dami & Esmaeeldokht, 2024). In recent years, various scholars have proposed multiple frameworks and classifications for biophilic design. Browning et al. (2014) were among the first who introduced the term 'patterns' to describe the defining characteristics of biophilic design in an attempt to provide a clear and standardized terminology, reduce confusion with multiple terms, and enhance accessibility to the general public by upholding familiar terminology (Asim et al., 2021). In residential settings, spaces are typically categorized into three groups: 1. Indoor spaces, such as bedrooms, living rooms, and kitchens; 2. Transitional or intermediate spaces, which act as a bridge between indoors and outdoors and include balconies, terraces, atriums, corridors, and courtyards; 3. Outdoor spaces, such as gardens, parks, landscaped areas, cul-de-sacs, and alleys (Yazdanirostam et al., 2023) Each of these spaces possesses unique capacities for implementing biophilic patterns, which can in turn enhance residents' well-being while extending across various scales, from the micro to the macro, to make spatial design more effective and more responsive to human needs.

## Research Method

The present research falls into the category of qualitative

Table 1. A comparison of perspectives on biophilic design patterns in residential Settings. Source: Authors.

| First Perspective | Second Perspective | Third Perspective | Fourth Perspective | Fifth Perspective |
|---|---|---|---|---|
| Kellert (2008), McGee et al. (2019), Saraf et al. (2023), Afifian et al. (2023b) | Browning et al. (2014), Browning & Ryan (2020), Nitu et al. (2022), Shaliha et al. (2023), Khanzadeh (2024) | Kellert (2018), Kellert & Calabrese (2015), Lee & Park (2022), Lee & Park (2023) | Kellert (2005), Yue et al. (2024) | Lee & Park (2021a), Mousapour (2024), Wil & Ismail (2025) |
| 6 Elements: Environmental Features, Natural Shapes and Forms, Natural Patterns and Processes, light and space, Place-based Relationships, Evolved Human–Nature Relationships | 3 Patterns: Nature in the space, natural analogues, nature of the space | 3 Patterns: Direct experience of nature, indirect experience of nature, and experience of space | Dimension: Organic design, vernacular / Environmental factors, behavioral | Scale: Unit, building, and complex / Building, street, neighborhood, and district |

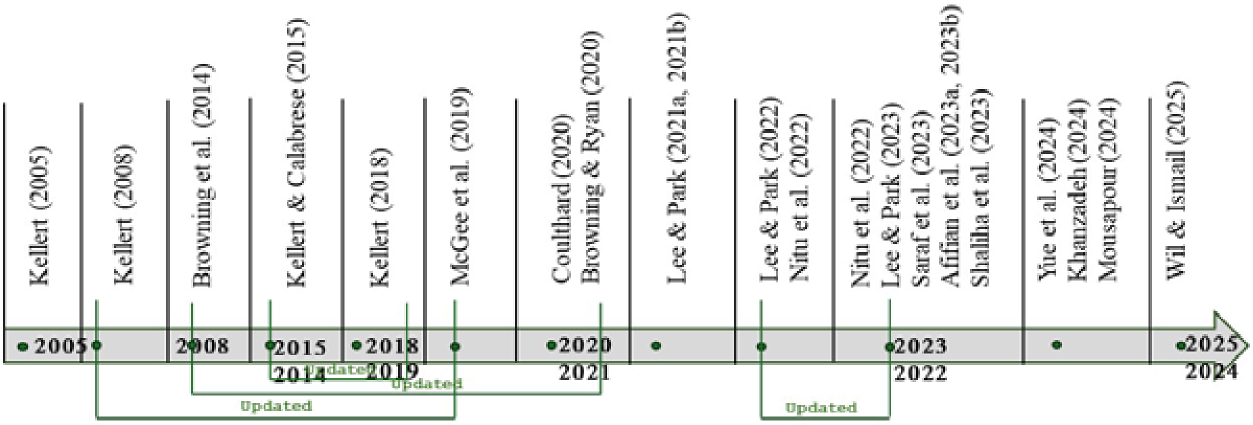



Fig. 4. Timeline of different perspectives on biophilic design patterns in the residential settings. Source: Authors.

studies in terms of nature and applied studies in terms of objective, and employs qualitative content analysis as the primary method. Data were collected through library and documentary sources, and a systematic review method was adopted to examine biophilic design patterns in residential settings. The aim of the study was to identify perspectives on biophilic design, determine key patterns, and offer design strategies for residential spaces. Relevant literature on biophilic design in residential settings was retrieved using keywords such as "biophilic," "biophilic design," and "residential setting" in reputable international databases-including Google Scholar, Scopus, Web of Science, PubMed, and ScienceDirect-as well as domestic databases such as SID (Jahad-e Daneshgahi) and Noormags (Table 1). From an initial pool of 1,596 sources-including review papers, research articles, books, and theses-redundant and irrelevant sources were removed, and a total of 890 sources were selected for screening. The inclusion criteria and quality assessment standards were defined based on the researcher's experiences as well as reputable studies such as Zhong et al. (2022). These criteria included: (1). direct relevance to biophilic housing, requiring explicit reference to the application of biophilic design in residential settings within the full text (sources focused on non-residential settings were excluded to maintain the study's focus on residential settings alone); (2). scientific credibility of the source (e.g., publication in reputable journals, well-recognized books, or valid academic theses); (3). manual assessment by the researcher (including confirmation of non-redundancy and consistency between the abstract and full text); (4). institutional affiliation of at least one author with the fields of architecture or prospect architecture; (5). publication window being restricted to 2000–2025 for international sources and to 2011-2025 for domestic sources (as earlier studies may not be consistent with recent developments-such as the impacts of the COVID-[19] pandemic-and biophilic design in architecture emerged in the early 21st century); (6). inclusion of the term "biophilic" in the title to ensure explicit focus on thematic design ; (7). thematic emphasis on the fields of architecture and prospect; (8). direct application of patterns within the full text; and (9). a search language restriction to English and Persian was applied, however non-English sources such as Arabic, Korean, and Indonesian publications were also reviewed to maintain geographic diversity and avoid the risk of bias. After applying these criteria during the screening process, 604 sources were excluded due to non-compliance, leaving 286 sources for further review. After reviewing the full text of articles, 203 sources were removed due to a lack of relevance to the research topic or the absence of biophilic design patterns and strategies. Ultimately, 83 sources were selected for the final analysis (Fig. 5). In the analysis phase, the biophilic design perspectives were reviewed, and due to the widespread use of Browning et al.'s 14 Patterns of Biophilic Design (2014) in the reviewed studies, these patterns were adopted as a basis for analysis. Browning's 14 patterns are categorized into three groups: Nature in the Space, Natural Analogues, and Nature of the Space.

To assess the distribution of pattern frequencies across the three groups, a chi-square test was employed. This test determines whether the observed frequency distribution

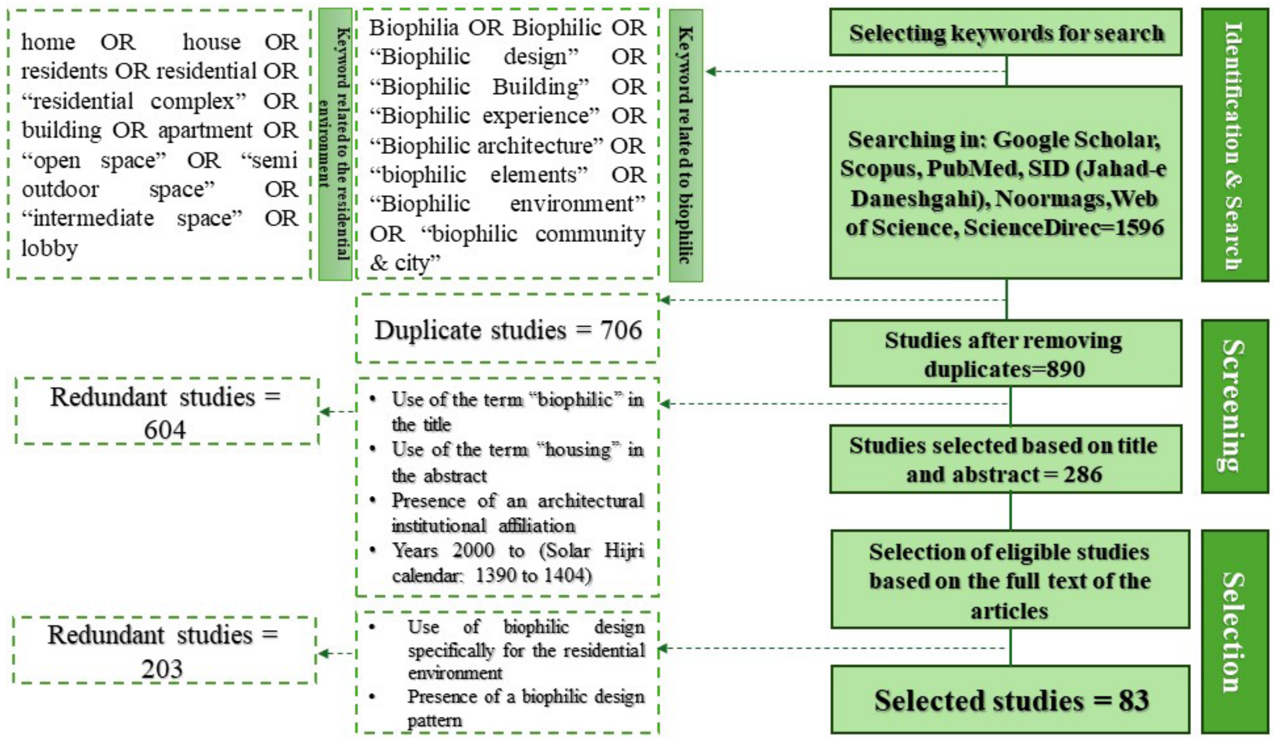


Fig. 5. Flowchart of the literature analysis process for the systematic review. Source: Authors.

conforms to the expected distribution under the null hypothesis (a uniform distribution). Any pattern with a frequency higher than the mean value within its respective group was identified as a key pattern.

The extracted design strategies were classified into interior, exterior, and intermediate spaces, and the impacts of biophilic design on users were also evaluated. This research addressed the primary question: What are the predominant perspectives and key patterns in biophilic design, what design strategies are applicable in residential settings, and how do they influence users? The present study is limited to sources with specific publication windows and specific databases, and its exclusive focus on residential settings may restrict the generalizability of the findings to other settings.

## Discussion and Analysis of Findings

The relevant literature on biophilic design has largely focused on broad patterns, such as those proposed by Kellert (2005) and Browning et al. (2014). These patterns have been widely adopted as reference frameworks across numerous studies. However, since 2021, researchers have developed more specialized patterns tailored to residential settings, building upon these theoretical foundations. For example, Lee & Park (2021a) proposed biophilic patterns tailored to various spatial scales within residential settings, with a particular emphasis on the needs of seniors. According to the analysis results, among the 83 reviewed studies, 30 cited Browning et al.'s (2014) pattern framework, and 16 cited Kellert's (2008) framework, highlighting the central role of these two frameworks in shaping the theoretical foundation of biophilic design. Nevertheless, the number of studies specifically focused on biophilic design patterns within residential settings remains very limited. The emergence of newer researchers such as Wil & Ismail (2025) reflect the dynamism of this field and the introduction of new perspectives into this domain. However, the patterns proposed by these newer researchers have received fewer citations, largely due to their emerging nature and the established credibility of the frameworks developed by Kellert and Browning. In the present study, Browning's pattern framework was selected as the primary framework, based on frequency of citations rather than prior judgments (Fig. 6).

### • Analysis of design patterns and strategies

To examine the frequency distribution of patterns across the three main categories-Nature in the Space, Natural Analogues, and Nature of the Space-a chi-square goodness-of-fit test was conducted. This test evaluates whether the observed frequencies conform to the expected frequencies under the null hypothesis (uniform distribution). The null hypothesis (H□) posits that the frequencies are evenly distributed (i.e., each category ≈ one-third of the total frequency), whereas the alternative hypothesis (H□) posits that the distribution is not even.

The observed data (O) for the three categories: O = [169, 174, 423]

The total frequ ency: $N = \Sigma O_i = 423 + 174 + 169 = 766$

The expected frequency (the null hypothesis) of distribution, for each category:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} = 165.24$$

The significance level (p-value), based on the chi-square distribution table, is less than 0.001 ($\chi^2 = 165.24$, df = 2; calculated $\chi^2 > 13.816$ at $\alpha = 0.001$). Therefore, the null hypothesis is rejected, indicating that the frequencies are not evenly distributed. This result confirms the significant predominance of the "Nature in the Space" category and

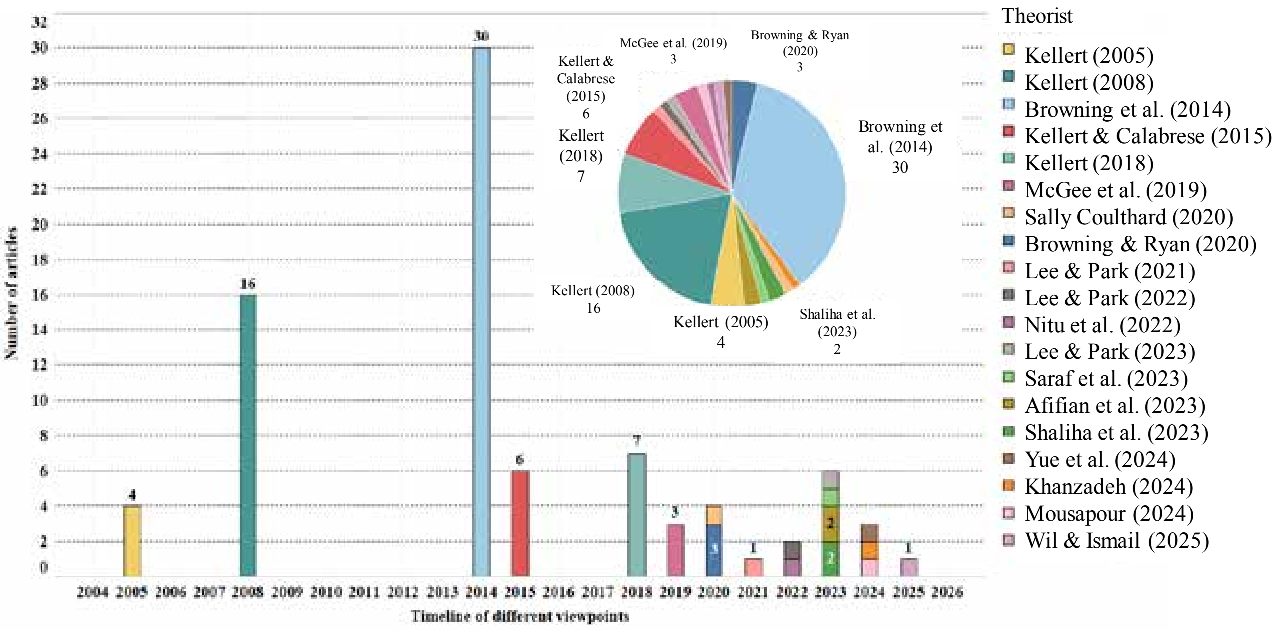



Fig. 6. Distribution of the identified perspectives over the years. Source: Authors.

suggests that patterns directly derived from nature hold a higher priority in biophilic design within residential settings. Such a finding can serve as a basis for sustainable and healthy architectural policy-making. To identify the dominant patterns in biophilic design of residential settings, the frequencies of all patterns were extracted, and a frequency table was compiled. Patterns with frequencies above the mean level were classified as the key biophilic design patterns for residential settings. The results indicated that the "Nature in the Space" category, with a mean frequency of 60.3, is the most significant category in the design of residential settings (Fig. 7). Within this category, visual connection with nature (frequency = 79), connection with natural systems (frequency = 68), and dynamic and diffuse light (frequency = 66) were identified as the key patterns. In the Natural Analogues category, which had an average frequency of 58, the patterns of material connection with nature (frequency = 64) and biomorphic forms and patterns (frequency = 56) were the most prominent. In the Nature of the Space category, with an average frequency of 42.25, the patterns of prospect (frequency = 71) and refuge (frequency = 47) were found to be the most significant (Fig. 8). To identify applicable biophilic design strategies across different residential settings, data extracted from the 83 selected scientific sources were used as a guide (Fig. 9). These strategies, corresponding to the 14 key patterns, were organized into three main categories: interior, exterior, and intermediate spaces (Table 2). While previous studies have primarily focused on commercial or academic environments (Lee & Park, 2022), the present study specifically focuses on residential settings and proposes distinct strategies, such as house plants (for interior spaces), ecological parks (for exterior spaces), and green balconies (for intermediate spaces). This distinction highlights the significant contribution of the present research in addressing existing gaps related to the practical application of biophilic design patterns within residential settings. Studies indicate that biophilic principles are embedded in traditional Iranian culture and architecture, where elements such as central courtyards, four-season gardens, and the integration of water and vegetation are naturally aligned with nature and can enhance residents' comfort and well-being. Incorporating traditional and vernacular architectural features not only strengthens environmental sustainability but also helps mitigate the impacts of global warming in arid regions,

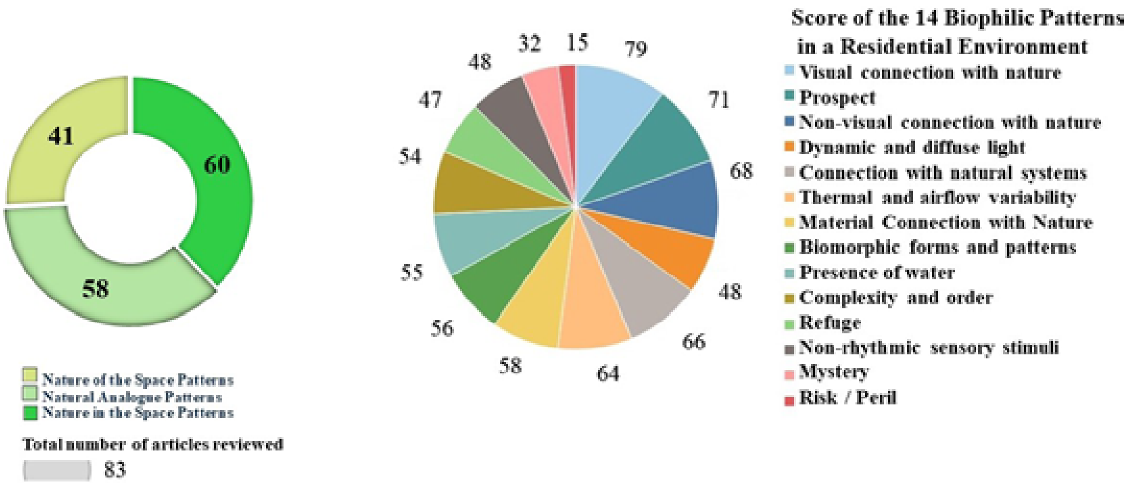



Fig. 7. Average frequencies of the three selected categories of perspectives and the frequencies of 14 biophilic design patterns in residential settings based on 83 sources. Source: Authors.

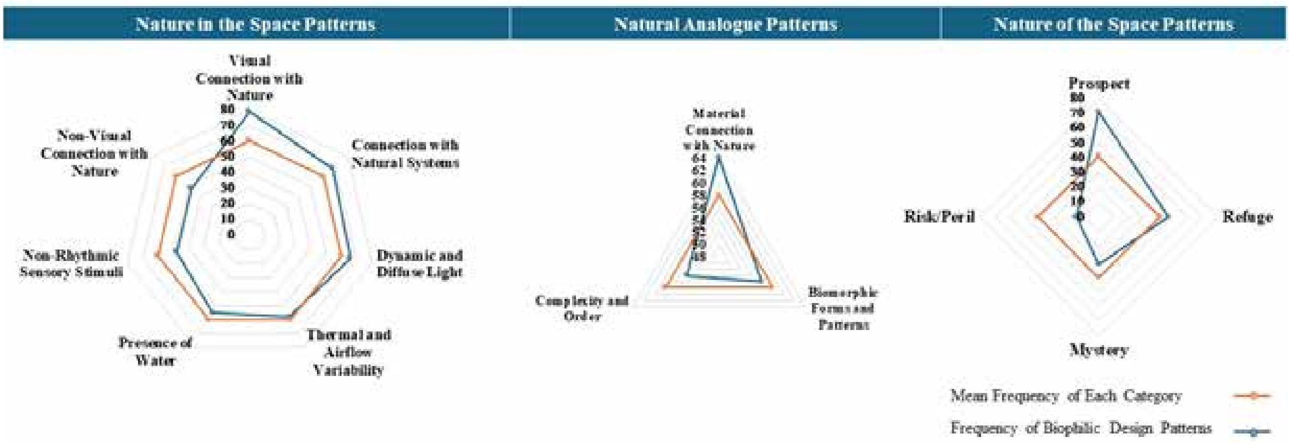



Fig. 8. Frequencies of biophilic design patterns across the three categories proposed by Browning et al. (2014) and the average frequency of each category. Source: Authors.

Fig. 9. Frequencies of applicable design strategies in residential settings based on 83 selected sources. Source: Authors.

reduces energy consumption, and enhances a sense of belonging and psychological well-being. Therefore, the present study suggests that future research explore the practical application of patterns by incorporating Iranian traditional elements into a biophilic framework.

In addition, assessments of the impacts of biophilic design on users indicate that these patterns can contribute to enhancing quality of life and well-being in residential settings. The findings also highlight the predominance of psychological objectives-such as well-being (reported in 20 studies), quality of life, and stress reduction-which is consistent with recent works such as Bahador & Mahmoudi Zarandi (2024). However, the systematic analysis conducted in the present study offers a more comprehensive framework for the practical application of these patterns. Although a wide range of objectives is illustrated in Fig. 10, many of them are directly or indirectly associated with the concept of human mental well-being in different settings, underscoring the high priority of enhancing human experience in residential settings, which remains a central focus within this field. In contrast, objectives such as indigenous identity, human-centered architecture, and visual preferences-while occurring less frequently-reflect the emergence of new interdisciplinary approaches in this field and may shape future research trajectories (Fig. 10). For future research, it is suggested that empirical studies employing quantitative methods (such as resident surveys) be conducted to evaluate the impact of biophilic patterns on occupants' well-being. Furthermore, focusing on specific groups-such as children or individuals with special needs-and integrating emerging technologies such as virtual reality into biophilic design may open new avenues in this field.

## Conclusion

The present study, through a systematic review of 83 academic sources, has identified and classified the key biophilic design patterns and strategies in residential settings. The analysis results show that the category of "Nature in The Space", with an average frequency of 60.3, is recognized as the dominant category. Patterns such as "visual connection with nature", "connection with natural systems", and "dynamic and diffuse light" not only have the highest frequencies, but also play a central role in achieving the main objectives identified in biophilic design for residential settings, such as enhancing well-being and quality of life for residents. These findings, by corroborating and expanding well-known theoretical frameworks, play a significant role in addressing the research gaps in the field of biophilic design for residential settings. The major contribution of the present study is the provision of a practical framework for designers, which can lead to the development of more sustainable and healthier housing. From a practical standpoint, these results help architects, designers, and urban planners create more sustainable and healthier environments that are better aligned with human needs and well-being by thoughtfully selecting and integrating biophilic patterns across interior, intermediate, and exterior spaces. Furthermore, taking cultural aspects into account and localizing these patterns can enhance their acceptance and effectiveness. Ultimately, the findings of the present study highlight the importance of biophilic design as an effective tool for addressing urbanization challenges, bridging the gap between humans and nature, and improving quality of life. It also lays the groundwork for future research, the development of new standards, and related policy-making. Practical suggestions include the development of design guidelines for architects, such as integrating indoor plants and natural light to reduce stress, as well as localizing patterns in accordance with traditional Iranian architecture (such as central courtyards and four-season gardens). This not only enhances environmental sustainability but also strengthens cultural attachment. For future research, it is suggested that quantitative experimental studies using instruments such as questionnaires and resident surveys, or virtual reality (VR), be conducted to assess the impact of these patterns on specific groups (such as the elderly or children).

## Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

Table 2. Design strategies for the selected patterns (the 14 biophilic design patterns introduced by Browning et al., 2014). Source: Authors.

| Category | Biophilic design pattern | Empirical evidence | Biophilic design strategies for residential settings | | |
|---|---|---|---|---|---|
| | | | Interior spaces | Intermediate spaces | Exterior spaces |
| Nature in the space | Visual connection with nature | - Relieving anxiety (Bratman et al., 2015)<br>- Enhancing concentration (Li & Sullivan, 2016) | - Indoor plants (houseplants, wall-mounted planters, green walls) (Bahador & Mahmudi Zarandi, 2024; Hudson, 2013)<br>- Natural scenery and décor (images, paintings, natural sculptures, virtual nature) (Maulina & Susanto, 2023)<br>- Natural color palettes (earth tones, greens, turquoise, neutrals) (Lee & Park, 2021a)<br>- Visual access to greenery (layout configuration offering a view of nature, large windows) (Maharani & Fitriyanto, 2022)<br>Natural elements (water, fire, fireplaces) (Lee & Park, 2022) | - Green walls and roofs (living walls, green façades, green roofs) (Orman, 2017)<br>- Green balconies and terraces (planting on balconies, terraces, patios) (Browning & Ryan, 2020)<br>- Interior courtyards and green atriums (Lee & Park, 2025)<br>- Openings and windows overlooking nature (Sadanand et al., 2022)<br>- Presence of water (natural/ artificial water flow, aquariums, small ponds) (Sadanand et al., 2022) | - Green spaces (urban parks, gardens, lawn areas, dense vegetation, green and blue carpets) (Kahveci, 2017)<br>- Presence of animals, birds, insects, and fossils (Chen, 2017)<br>- Natural prospects (unimpeded views, fruit trees/ vegetables) (Mari et al., 2023) |
| | Non-visual connection with nature | - Improved immune system function (Li et al., 2023) | – Multisensory diversity (sound, scent, touch, and taste): Incorporating natural sensory cues such as the sound of flowing water and birdsong, plant fragrances, and tactile natural textures (Asim & Shree, 2019).<br>– Digital simulation of sounds: including water, animal sounds, and thunder (Lee & Park, 2020)<br>– Aromatherapy and scented candles (Huntsman & Bulaj, 2022).<br>– Textured materials and wooden sculpture (Clark-Havron, 2023)<br>– Indoor vertical farming and houseplants (Khanzadeh, 2024)<br>– Water- and fire-based sensory stimulation: touching water, dynamic show (Abouelela, 2023)<br>– Acoustic control and ergonomic adjustments (Bettaieb & Alsabban, 2023) | – Open multisensory environments: (water and wind sound, or the scent of vegetation) (Peters & Verderber, 2022)<br>- Interior courtyards that integrate sensory cues (e.g., sound and scent) (Shbaita et al., 2024) | – Outdoor recreational activities: such as walking and gardening, (Shakhshir, 2022)<br>– Sensory diversity (sound, scent, touch): birdsong, breeze, flowing water, and the fragrance of flowers (Gong et al., 2023)<br>– Multisensory landscape design: diverse plant species, tall trees, and the presence of wildlife (Macovei, 2023) |
| | Non-rhythmic sensory stimuli | Increased dwelling time and enhanced behavioral markers of attention and exploratory engagement (Windhager et al., 2011) | – Variation in color, texture, and light (e.g., vibrant color palettes, diverse patterns, and light–dark contrast) (Ghorbani Param et al., 2020b)<br>– Spiral staircases and naturally occurring vegetative growth (such as moss colonization) (Moniaga, 2021)<br>– Layered and dynamic artificial lighting<br>– Touch-responsive virtual natural elements<br>– Dynamic visual and auditory stimulation (e.g., in accordance with climatic conditions, birdsong)<br>– Multisensory diversity in interior garden spaces, | – Mobile or reconfigurable green walls (Gür & Kaprol, 2022)<br>– Dynamic and unexpected lighting schemes, including spot lighting and variable daylight intensities (Lee & Park, 2023)<br>– Variation in openings, featuring windows of diverse shapes and sizes<br>– Multisensory spaces incorporating unpredictable auditory and visual connections | - Diverse vegetation with non-rhythmic patterns (trees, seasonal changes in foliage, blossoms) (Mandasari & Gamal, 2017)<br>- Dynamic water feature and illumination of the historic stream (Liang, 2021)<br>- Sensory diversity (bird song, water, plant fragrances, sunlight/ moonlight/fire) |

Rest of Table 2.

| Category | Biophilic design pattern | Empirical evidence | Biophilic design strategies for residential settings | | |
|---|---|---|---|---|---|
| | | | Interior spaces | Intermediate spaces | Exterior spaces |
| Nature in the space | Thermal and airflow variability | -Enhanced temporal and spatial pleasure perception (Parkinson et al., 2012) | - Natural and cross ventilation through adequate windows and openings (Al Sayyed & Al-Azhari, 2025) - Materials with thermal sensitivity (wood, totora, natural insulators) - Air-purification systems and shade-providing plants to improve air quality Fans and shading devices/louvers for temperature and light control (Coulthard, 2020) - Passive climatization and manual/digital ventilation control (Adank, 2025) - Roofed ground surfaces and proper opening layout to enhance air circulation (Ahmed & Shukur, 2022) | - Cross-ventilation through balconies and windows Permeable walls (folding doors, deep verandas) (Ghanbari Zadeh & Bina 2024) - Open atriums and courtyards to enhance air circulation (Azkiawati & Lissimia, 2020) - Automated thermal regulating window and opening | - Vegetation and water features for indirect cooling (Abdulkadir & Olagunju, 2023) - Facade orientation optimized for prevailing winds and solar exposure - Windcatchers, ventilators, and wind traps for passive ventilation (Shaliha et al., 2023) |
| | Presence of water | -Visual preferences and positive emotional responses (Haapakangas et al., 2011) | - Indoor water features such as aquariums, artificial waterfalls, water walls, fountains, rills, and pools (Kim & Park, 2024) - Simulated water elements (wallpaper, color reflections) - Fish-breeding basins and minimalist water features (such as fish bowls, small basins, or sinks) | - Reflective water features (such as ponds, fountains, aquariums, and water streams) (Ardiani et al., 2020; MirzaMohammadi & Doozdoozani, 2021). - Central courtyards incorporating water elements (Shaliha et al., 2023) - Soft, low-intensity lighting combined with reflective surfaces and symbolic water-inspired forms (Barekat, 2024) | - Natural water bodies (rivers, seas, ponds, wetlands, and artificial lakes) - Dynamic water features and aquatic landscapes (ecological ponds and fish pools) - Integration of water as a design element (Gür & Kaprol, 2022) |
| | Dynamic and diffuse light | - Positive effect on circadian rhythms (Elzeyadi, 2011) - Improved cognitive and behavioral performance (Keis et al., 2014) | - Skylights, daylight atriums, and large windows (Nitu et al., 2022) - Dynamic lighting systems incorporating warm light bulbs, green LEDs, and natural-light simulations such as candles or fireplaces - Smart tinting glass with adjustable transparency and automated curtain systems - Variation in openings - shape, size, and orientation- and reflective illumination (Al Sayyed & Al-Azhari, 2025) - Layered and scheduled artificial lighting systems providing a minimum of 150 lux (Shakhshir & Sheta, 2024) - Glass walls and verandas to enhance daylight penetration - Light-colored surface materials and reflective finishes - Tall windows with tinted or colored glass to diversify the visual experiences of light - Open and uncluttered interior arrangements to maximize daylight access | - Glass entrances and walls for light and shadow variations - Reflective lighting in facades - Arabic mashrabiya and al-faraj for light control (Algamdi, 2020) - Wide, well-lit corridors and sun-drenched verandas - Verandas with horizontal planting for shading - Materials with light-reflective properties - Light control through sensors and rotating louvers (Moghadasi & et al., 2024) - Openings (windows, orsises, holes) and awnings for light regulation | - Orientation towards sunlight – Growing shading plants for light regulation (Lee & Park, 2021a) – Sunlight, moonlight, and digital simulations – Patterned louvers for light control – Spotlights or projectors for creating dynamic light and shadow effects (Lee & Park, 2023) |

Rest of Table 2.

| Category | Biophilic design pattern | Empirical evidence | Biophilic design strategies for residential settings | | |
|---|---|---|---|---|---|
| | | | Interior spaces | Intermediate spaces | Exterior spaces |
| Nature in the space | ‘Connection with Natural Systems | - Improved health outcomes and changes in environmental perception (Kellert et al., 2011) | Air-purifying indoor plants (e.g., bamboo, snake plant, areca palm, etc.) – Indoor fruit and vegetable gardens and growth of naturally occurring plants (e.g., moss) – Smart systems (e.g., microbial waste filtration, plant cultivation devices) – Simulation of seasonal environments and social robots (e.g., cats/dogs) – Passive solar systems and space-reshaping equipment – Weathered wood and patinated materials for time-awareness – Aquatic plants and aquariums with fish – Flexible living rooms and access to courtyards (Maharani & Fitriyanto, 2022). | Small cozy gardens and vertical green wall systems fed with rainwater – Seasonal verandas and cultivation of aboriginal edible plants – Courtyards and indoor gardens to enhance ecosystems – Green roofs and vegetation at the edges of spaces (Pamanto, 2023) – Birdhouses and dovecotes for birds (e.g., pigeons, sparrows) – Experience of cyclical changes with patinated materials – Skylights for connection between interior and exterior spaces (Susanto et al., 2025). | - Habitat and ecosystem diversity (ecological parks, community gardens, sustainable parks) – seasonally changing plant species and aboriginal trees – Sustainable systems (solar panels, water storage systems, microbial water treatment, biogas) – Walking paths in natural environments and large gardens – Animal accommodations and attraction of birds/insects – Sustainable agriculture and centralized parks (Wil & Ismail, 2025) |
| Natural analogues | Biomorphic forms and patterns | - Improved recovery from stress (Determan et al., 2019) - Improved learning outcomes (Determan et al., 2019) | - Organic and biomorphic forms in furniture, railings, chandeliers, and openings (spirals, curves, Fibonacci) (Bettaieb et al., 2024) - Natural patterns and motifs (botanical wallpapers, landscape paintings, natural woven fabrics) - Virtual simulations (virtual ceilings/windows, 3D holograms, natural objects such as birds/ butterflies) (Lee & Park, 2021b) - Fractal and geometric patterns (spirals, shells, beehives, golden ratio) - Visual decor and artwork inspired by nature - Branching shapes and biomimicry (biomimetic design) (Yassein & Ebrahiem, 2018) | - Curvilinear forms in façades and arches (non-90-degree angles, curves, ellipses) - Decorative elements with tree motifs and - plant/Islamic patterns - Al-Sharaf (arrow, triangle, square) and mashrabiya (Stefanovska, 2019) - Integrated indoor and outdoor spaces | - Organic and nature-inspired forms (vernacular forms, curves, protruding and recessed squares) (Bakti et al., 2022; Kalantari, 2016) - Green structures and corridors - Symbolic artworks representing nature (vernacular plant motifs, decorations without living creatures) (Mousapour, 2024) - Fibonacci geometry and natural proportions (Yazdanirostam et al., 2023a) Curved surfaces and branch-like façades (Bitaraf et al., 2018b) |
| | Material connection with nature | - Observation of preferred materials (Jiménez et al., 2016) | - Natural materials with textural diversity (wood, stone, bamboo, brick, cob, leather, wool, linen) (Nguyen, 2023) - Materials with minimal processing (weathered wood, stone, exposed aggregate concrete) - Permeable flooring and natural fabrics (linen, jute, wicker) - Natural colors (neutral, warm, white, gray, brown) (Cameron, 2025; Prawata, 2024) - Nature-mimicked patterns (shells, leaves, pudding plants) (Elsafty, 2024) - Wooden and stone finishes with diverse textures | - Natural materials with tactile interaction (wood, stone, concrete) - Wooden furniture and elements (lobby with wood grain textures, wooden pallets, concrete flower boxes) - Natural colors (blue, green, brown, red) (Kim & Park, 2025) - Glazed surfaces and natural flooring (e.g., amphitheater seating rows | - Vernacular and natural materials (stone, clay, wood, coral stone, reed, timber) (Afifian et al., 2023a) - Local tree species and natural topography - Recycled wood, bamboo, and natural stone (Moghimi Shahri & Vafamehr, 2024) |

Rest of Table 2.

| Category | Biophilic design pattern | Empirical evidence | Biophilic design strategies for residential settings | | |
|---|---|---|---|---|---|
| | | | Interior spaces | Intermediate spaces | Exterior spaces |
| Natural analogues | Complexity and order | - Brain waves indicative of relaxation (Hagerhall et al., 2008)<br>- Advanced environmental wayfinding (Juliani et al., 2016) | - Spatial hierarchy and gradual transitions (private to public)<br>- Open and flexible floor plans with fractal geometry<br>- Plants serving as partitioning elements and organized layouts (Wijaya, 2023)<br>- Visual order and symmetry (Marquetry, mosaic tiling)<br>- Complex decorations (stucco, Ayeneh-kari, tiling) (Ghorbani Param et al., 2020a)<br>- Short and safe paths with directional signage<br>- Movable partitions and connected rooms (Tondrosaleh et al., 2023)<br>Layouts facing openings with harmony and rhythm<br>- Minimized environmental complexity with visual clarity<br>- North-South orientation (Maharani & Fitriyanto, 2022) | - Passages and vestibules connecting the street to the house (Abyazi & Pourahmadi, 2021)<br>- Seamless connection between interior and exterior spaces<br>- Complexity through openings and the combination of windows<br>- Open and semi-open spaces (central courtyards, verandas) (Heidar Nattaj et al., 2021)<br>- Richly colored plants and layered landscapes (Yue et al., 2024)<br>- Diverse functional areas (play grounds, relaxation, sports) (Yazdanirostam et al., 2024)<br>- Flexible windows and uneven green space design (Moghadasi et al., 2024)<br>- Discoverable complexities with rich information (Bitaraf et al., 2018b) | - Habitat and ecological diversity (trees, shrubs, flowers)<br>- Coordination and coherence in design<br>- Progressive and cumulative complexities<br>- Organic forms and regular geometry (Law of plurality in Unity) (Shaliha et al., 2023) |
| Nature of the Space | Prospect | - Visual priority (Wiener et al., 2007) | - Unimpeded sightlines and open plans<br>- Large and numerous windows for panoramic views (Mojtabavi & Tafakori, 2023)<br>- Full-height glass walls and glass verandas<br>- Framed landscapes and virtual nature<br>- Striking a balance between prospect and refuge using high ceilings and cozy living rooms<br>- Open room corners for better sightlines<br>- - Large openings for visual transparency (Huntsman & Bulaj, 2022) | - Terraces and verandas with views (shaded trees, water features)<br>- Transparent partitions, wide landings, and large windows<br>- Facade walls with trellises for outward views<br>- Sky gardens with 360-degree views (Susilo et al., 2024)<br>- Expansive and layered vistas<br>- Open structures and transparent barriers (Yazdanirostam et al., 2023b) | - Preferred and natural landscapes (mountain, savannah)<br>- Diverse facades and scenic streets<br>- Retreating towards a hill for better views<br>- Glass materials in the outdoor spaces for visual transparency (Pamanto, 2023) |
| | Refuge | - Observed view preference (Grahn & Stigsdotter, 2010) | - Private and cozy spaces (Gloriette, fire pit table, alcoves in walls)<br>- Spiritual spaces in the bedroom and personal resting areas<br>- Small refuges (reading nook, under-stair compartment)<br>- Movable partitions and boundary spaces for privacy<br>- Protected plants and window awnings<br>- Unidirectional lighting in the bedroom and low-ceilinged alcoves (Ghanbari Zadeh & Bina 2024)<br>- Functionally separated spaces with natural surfaces | - Small, cozy gardens and central courtyards for conversation and relaxation<br>- Roofed verandas, Gazebos, and trellises for having an unobstructed view of the surroundings<br>- Nature-friendly communal spaces (atriums, courtyards)<br>- Carved spaces in facades for privacy<br>- Shading devices, low ceilings, and enclosed forms (vaulted/dome-shaped roofs) (Beigi Nejad & Ameri Sefat, 2016)<br>- Short, safe pathways with protective qualities | - Refuges and shelters for exploration (gazebos, under-tree seating)<br>- Organic forms for bird protection<br>- Transparent refuges and low-ceilinged walkways (arcades)<br>- Cozy spaces for physical activities (yoga) and meditation<br>- Safe playgrounds for children in streets and alleys |

Rest of Table 2.

| Category | Biophilic design pattern | Empirical evidence | Biophilic design strategies for residential settings | | |
|---|---|---|---|---|---|
| | | | Interior spaces | Intermediate spaces | Exterior spaces |
| Nature of the Space | Mystery | Results in strong dopamine or pleasure responses (Ikemi, 2005) | - Gradual transition from private to public spaces (Foidart, 2010)<br>- Spiritual and cozy spaces (bedrooms, recessed areas)<br>- Perforated latticed walls for partial visual obstruction.<br>- Sense of spatial openness in corridors and stairways with small openings<br>- Multiple pathways with diverse lighting and spatial contrasts (light/dark, open/closed)<br>- Interpretive patterns, ambiguous forms, and variations in height<br>- Clean pathways and variable topography<br>- Universal nature references and living/cosmic patterns<br>- Cultural attachment<br>(Saraf et al., 2023) | - Rhythmic and unexpected movement paths (opening and closing)<br>- Glass/ transparent doors and walls at entrances and verandas<br>- Labyrinthine pathways, green corridors, and unexpected recesses in facades<br>- Ambiguous facades (e.g., hanging vine branches) and sky garden pathways<br>- Sensory stimulation from unseen sources<br>(Yazdanirostam et al., 2023b) | - Hidden vistas with the potential for discovering deeper insights<br>- Legibility and conceptualism through cultural symbols<br>(Shaliha et al., 2023) |
| | Risk/peril | - Resulted in strong dopamine or pleasure responses (Kohno et al., 2015) | - Glass railings<br>- Small climbing walls<br>- Services given by pet-like robots<br>- Red and green colors for wayfinding<br>- Avoid bringing pets home<br>(Algamdi, 2020) | - Cantilevered balconies and patterned structures<br>- Glass flooring, walkways, and elevated pool walkways with glass fences<br>- Unpredictable water features<br>- Proximity to wildlife through bridges/elevated walkways<br>(Coulthard, 2020) | - Paths for wildlife Unpredictable connections with nature (cliff-edge sensation)<br>(Afifian et al., 2023b)<br>- Cliff-edge buildings with hidden access paths<br>- Speed bumps and green pedestrian pathways for children's play<br>- Glass walls facing outward (Prawata, 2024) |

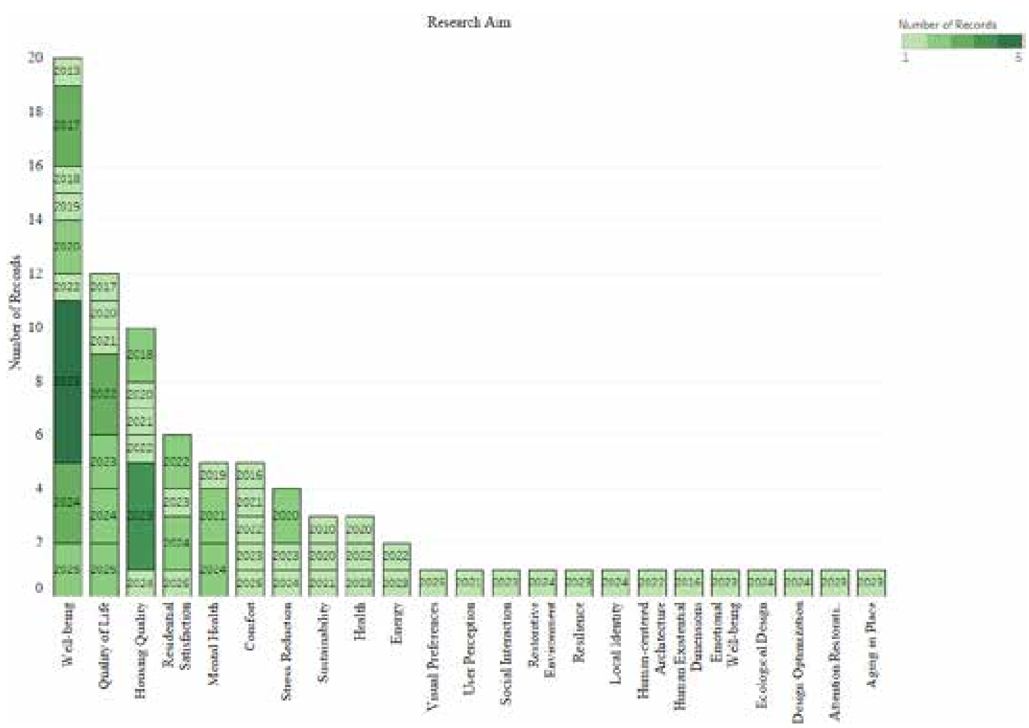



Fig. 10. Distribution of identified themes (impacts) related to biophilic design in residential settings over the years. Source: Authors.

## Endnotes

* This article is extracted from Ph.D. thesis of "Mahsa Mirheydarian" entitled "Principles of Biophilic Design in Residential Complexes with the Aim of Promoting Comfort and Subjective well-being" which has being in process under supervision of Dr. "Esmaeil Zarghami" at Shahid Rajaee Teacher Training University, Faculty of Architecture and Urban Planning, Tehran, Iran.

## References list


• Abdulkadir, J., & Olagunju, R. (2023). Biophilic design: Towards enhancing user's comfort via direct experience with nature in high-rise residential buildings, Abuja, Nigeria. *International Journal of Environmental Research & Earth Science, 27*(4), 107–118.

• Abouelela, A. (2023). Biophilic design as an approach towards integrating nature into the design of residential units to improve human mental health and well-being. *Eur. Chem. Bull, 12*(1), 1985–2006. https://doi.org/10.48047/ecb/2023.12.1.277

• Abyazi, S., & Pourahmadi, M. (2021). Effective factors on increasing students' sense of belonging in the design of student dormitories using biophilic architecture approach. *Journal of Engineering and Construction Management, 6*(2), 9–13. https://www.jecm.ir/article_156247.html?lang=en

• Adank, P. A. (2025). *Rooted: Future proof biophilic design for Dutch resettlement housing* [Master thesis, Delft University of Technology (TU Delft)]. TUDelft. https://repository.tudelft.nl/record/uuid:5442a75d-e1aa-4904-9e60-d913054c845d

• Afifian, M., Keshmiri, H., Moztarzadeh, H., & Ziari, K. (2023a). Evaluation of the relationship between biophilic outdoor elements of residential complexes and the elderly's residential satisfaction (Case study: Residential complexes of Shiraz). *Journal of Sustainable Architecture and Urban Design, 11*(1), 215–234. http://dx.doi.org http:/doi.org 10.22061/jsaud.2023.9041.2049

• Afifian, M., Keshmiri, H., Moztarzadeh, H., & Ziari, K. (2023b). Quality improvement of the elderly's outdoor environment in residential complexes of future cities emphasizing on elements of the biophilic approach. *Journal of Future Cities and Villages, 4*(2), 15–41. http://dx.doi.org/10.61186/jvfc.4.3.15

• Ahmed, A. N., & Shukur, S. M. (2022). Biophilic design patterns implementation in houses: A case study of residential villages in Erbil City. *Eurasian Journal of Science and Engineering, 8*(1), 1–19. https://doi.org/10.23918/eajse.v8i1p1

• Al Sayyed, H., & Al-Azhari, W. (2025). Investigating the role of biophilic design to enhance comfort in residential spaces: Human physiological response in immersive virtual environment. *Frontiers in Virtual Reality, 6,* 1411425. https://doi.org/10.3389/frvir.2025.1411425

• Algamdi, M. (2020). *Connecting elders to nature: A study on using biophilic design to foster successful aging at home in Saudi Arabia* [Master's thesis, University of North Carolina System]. NC DOCKS. https://libres.uncg.edu/ir/listing.aspx?id=32871

• Ardiani, Y. M., Prawata, A. G., & Sholihin, A. (2020). Application of biophilic architecture in apartment design. In *IOP Conference Series: Earth and environmental science* (Vol. 426, No. 1, p. 012105). IOP Publishing. https://doi.org/10.1088/1755-1315/426/1/012105

• Asim, F., & Shree, V. (2019). The impact of biophilic built environment on psychological restoration within student hostels. *Visions for Sustainability,* (12), 18–33. https://doi.org/10.13135/2384-8677/3534

• Asim, F., Rai, S., & Shree, V. (2021). Biophilic architecture for restoration and therapy within the built environment. *Visions for Sustainability,* (15), 53–79. https://doi.org/10.13135/2384-8677/5104

• Asnani, B., & Sharma, A. (2024). Biophilic spaces: The connection between green surroundings and human well-being: A review. *E-Planet, 22*(2), 119–130. https://www.researchgate.net/publication/389809090_Biophilic_spaces_the_connection_between_green_surroundings_and_human_well-being_A_review#fullTextFileContent

• Asojo, A., & Hazazi, F. (2025). Biophilic design strategies and indoor environmental quality: A case study. *Sustainability, 17*(5), 1816. https://doi.org/10.3390/su17051816

• Azkiawati, D., & Lissimia, F. (2020). Kajian konsep biophilic pada bangunan hunian vertikal [Study of the biophilic concept in vertical residential buildings]. *Jurnal Arsitektur Zonasi, 3*(2), 202–210. [in Indonesian] https://doi.org/10.17509/jaz.v3i2.24448

• Bahador, A., & Mahmudi Zarandi, M. (2024). Biophilic design: An effective design approach during pandemic and post-pandemic. *Facilities, 42*(1–2), 68–82. https://doi.org/10.1108/F-01-2023-0004

• Bakti, A. P., Atika, F. A., & Azizah, S. (2022, November). Implementasi pendekatan biophilic design pada rancang bentuk dan ruang bangunan apartment di kawasan CBD GEM City Gresik [Implementation of biophilic design approach in form and space design of apartment buildings in the CBD GEM City Gresik area]. *Prosiding Seminar Nasional Sains dan Teknologi Terapan* [Proceedings of the National Seminar on Applied Science and Technology]. [in Indonesian] https://ejurnal.itats.ac.id/sntekpan/article/view/3371/0

• Barekat, M. (2024). Principles of ecological and biophilic architecture in the design of Iranian residential complexes in order to improve their quality. *Современное строительство и архитектура,* *2*(45), 1–9. https://cyberleninka.ru/article/n/principles-of-ecological-and-biophilic-architecture-in-the-design-of-iranian-residential-complexes-in-order-to-improve-their

• Beigi Nejad, M. A., & Ameri Sefat, A. A. (2016). *بررسی ویژگی‌های معماری بیوفیلیک در بناهای بومی ایرانی (نمونه موردی: اقلیم گرم‌وخشک)* [Investigating biophilic architectural features in Iranian vernacular buildings (case study: hot and dry climate)]. International conference on Innovative Technologies in Engineering, Sciences and Technology. https://sid.ir/paper/853843/fa [in Persian]

• Bettaieb, D. M., & Alsabban, R. F. (2023). Users' role in applying biophilic attributes to the interiors of residential spaces. *Open House International, 48*(1), 163–184. https://doi.org/10.1108/OHI-02-2022-0040

• Bettaieb, D. M., Mohammed, W., & Khawaji, S. (2024). Exploring visual biophilic interior design features in homes: An experimental study through a virtual environment design. *International Journal of Architectonic, Spatial, and Environmental Design, 18*(1), 45–73. https://doi.org/10.18848/2325-1662/CGP/v18i01/45-73

• Bitaraf, E., Habib, F., & Zabihi, H. (2018a). Biophilic attitude toward improving the quality of the living environment of residential residences. *International Journal of Urban and Rural Management, 16*(49), 331–349. http://ijurm.imo.org.ir/article-1-2102-fa.html

• Bitaraf, E., Habib, F., & Zabihi, H. (2018b). Native ecological and ecological architecture principles in the design of residential complexes in Iran to improve their quality. *International Journal of Urban and Rural Management, 17*(52), 205–218. http://ijurm.imo.org.ir/article-1-2314-fa.html

• Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., & Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences, 112*(28), 8567–8572. https://doi.org/10.1073/pnas.1510459112

• Browning, W. D., & Ryan, C. O. (2020). *Nature inside: a biophilic design guide*. Routledge.

• Browning, W., Ryan, C., & Clancy, J. (2014). *14 patterns of biophilic design, Improving health & well-being in the built environment.* Terrapin Bright Green, LLC.

• Cameron, E. (2025). *Biophilic design in residential environments: exploring emotions, restorativeness, and satisfaction* [Master's thesis, Michigan State University]. MSU Libraries, Digital Repository. https://d.lib.msu.edu/etd/52387?__goaway_challenge=header-refresh&__goaway_id=b8345aea8dc5c06635f2723fa762052c&__goaway_referer=https%3A%2F%2Fd.lib.msu.edu%2F

• Chen, Y. (2017). *The impact of biophilic design on health and wellbeing of residents through raising environmental awareness and nature connectedness* [Doctoral dissertation, University of Georgia]. UGA Open Scholar. The impact of biophilic design on health and wellbeing of residents through raising environmental awareness and nature connectedness

• Clark-Havron, H. (2023). *Biophilic homes: Analyzing biophilic design in the residential setting* [Master's thesis, University of Cincinnati]. ProQuest. https://www.proquest.com/openview/3ef7e5c06570662e42b0ab8fc0ebfe70/1?pq-origsite=gscholar&cbl=18750&diss=y

• Coulthard, S. (2020). *Biophilia: You+ nature+ home*. Octopus Books.

• Dami, S., & Esmaeeldokht, M. (2024). An evaluation of the effectiveness of biophilic landscape patterns on the sensory integration of autistic children. *Manzar: The Scientific Journal of Landscape, 16* (66), 52–63. https://doi.org/10.22034/MANZAR.2024.408003.2254

• Determan, J., Akers, M. A., Albright, T., Browning, B., Martin-Dunlop, C., Archibald, P., & Caruolo, V. (2019). *The impact of biophilic learning spaces on student success*. BRIK, Building Research Information Knoeledgebase. Retrieved from https://www.brikbase.org/content/impact-biophilic-learning-spaces-student-success

• Elsafty, M. W. M. (2024). Biophilic design patterns and universal design principles application in the long-term residential care centers for the elderly. *International Design Journal, 14*(2), 405–415. https://doi.org/10.21608/idj.2024.339514

• Elzeyadi, I. (2011). Daylighting-bias and biophilia: Quantifying the impact of daylighting on occupants' health. In *Thought and leadership in green buildings research: Greenbuild 2011 proceedings.* USGBC Press. https://www.researchgate.net/publication/344361245_Daylighting-Bias_and_Biophilia_Quantifying_the_Impacts_of_Daylighting_and_Views_on_Occupants_Health

• Foidart, N. R. (2010). *The human-nature connection: Biophilic design in a mixed-use, multi-unit residential development* [Master's practicum, University of Manitoba]. University of Manitoba Institutional Repository.

• Gareca Apaza, M. L. (2022). Biofilia: La naturaleza como factor de tendencia en el diseño de una vivienda [Biophilia: Nature as a trend factor in the design of a home]. *Revista Ciencia, Tecnología e Innovación, 20* (26), 137–160. https://doi.org/10.56469/rcti.v20i26.711

• Ghanbari Zadeh, M., & Bina, M. (2024). Investigating the art of biophilic design in the visual aspect of Dezful architecture. *Paykareh, 13*(38), 89–110. https://doi.org/10.22055/pyk.2024.19685

• Ghorbani Param, M. R., Bavar, C., & Mahmoudinejad, H. (2020a). مطالعهٔ تطبیقی تأثیر معماری بیوفلیک در طراحی خانه‌های سنتی و مدرن (مطالعه موردی: شهر گرگان) [Comparative study of the effect of biophilic architecture on design of traditional and modern houses (case study: Gorgan city)]. *Journal of Regional Planning, 10*(40), 535–555 [in Persian]

• Ghorbani Param, M. R., Bavar, C., & Mahmoudinejad, H. (2020b). ارزیابی تأثیر اصول معماری بیوفیلیک در کیفیت طراحی مسکن در اقلیم شمال ایران (مطالعه موردی: شهر گرگان) [Evaluating the impact of biophilic architecture principles on the quality of residential design in northern Iran (case study: Gorgan city)]. *Journal of Human Geography, 12*(2), 405–424. https://sid.ir/paper/519781/fa [in Persian]

• Gong, Y., Zoltán, E. S., & János, G. (2023). Healthy dwelling: The perspective of biophilic design in the design of the living space. *Buildings, 13* (8), 2020. https://doi.org/10.3390/buildings13082020

• González, J. E., & Krarti, M. (2021). Reflecting on impacts of COVID-19 on sustainable buildings and cities. *Journal of Engineering for Sustainable Buildings and Cities, 2*(1), 010201. https://doi.org/10.1115/1.4050374

• Grahn, P., & Stigsdotter, U. K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. *Landscape and Urban Planning, 94*(3–4), 264–275. https://doi.

org/10.1016/j.landurbplan.2009.10.012
• Gür, M., & Kaprol, T. (2022). The participation of biophilic design in the design of the post-pandemic living space. In E. G. Özdamar & O. Tandogan (Eds.), *Emerging approaches in design and new connections with nature* (pp. 75–106). IGI Global. https://doi.org/10.4018/978-1-7998-6725-8.ch004
• Haapakangas, A., Kankkunen, E., Hongisto, V., Virjonen, P., Oliva, D., & Keskinen, E. (2011). Effects of five speech masking sounds on performance and acoustic satisfaction: Implications for open-plan offices. *Acta Acustica United with Acustica, 97*(4), 641–655. https://doi.org/10.3813/AAA.918428
• Hagerhall, C. M., Laike, T., Taylor, R. P., Küller, M., Küller, R., & Martin, T. P. (2008). Investigations of human EEG response to viewing fractal patterns. *Perception, 37*(10), 1488–1494. https://doi.org/10.1068/p5918
• Heidar Nattaj, V., Hatami, N., & Ahmadi, F. (2021). Determination of effective criteria on the improvement of seniors' mental health using biophilic design: A case study on district 1 of Tehran Municipality. *Urban Structure and Function Studies, 8*(28), 243–274. https://doi.org/10.22080/usfs.2021.20613.2097
• Hudson, K. (2013). *Holistic dwelling: Integrating biophilic design, environmental psychology, and feng shui* [Doctoral dissertation, University of Hawai'i]. Research Gate. https://www.researchgate.net/publication/319624122_Holistic_Dwelling_integrating_biophilic_design_environmental_psychology_and_feng_shui
• Huntsman, D. D., & Bulaj, G. (2022). Healthy dwelling: Design of biophilic interior environments fostering self-care practices for people living with migraines, chronic pain, and depression. *International Journal of Environmental Research and Public Health, 19*(4), 2248. https://doi.org/10.3390/ijerph19042248
• Ikemi, M. (2005). The effects of mystery on preference for residential facades. *Journal of Environmental Psychology, 25*(2), 167–173. https://doi.org/10.1016/j.jenvp.2005.04.001
• Jiménez, P., Dunkl, A., Eibel, K., Denk, E., Grote, V., Kelz, C., & Moser, M. (2016). Wood or laminate?—Psychological research of customer expectations. *Forests, 7*(11), 275. https://doi.org/10.3390/f7110275
• Juliani, A. W., Bies, A. J., Boydston, C. R., Taylor, R. P., & Sereno, M. E. (2016). Navigation performance in virtual environments varies with fractal dimension of landscape. *Journal of Environmental Psychology, 47*, 155–165. https://doi.org/10.1016/j.jenvp.2016.05.011
• Kahveci, H. G. P. (2017). Evolution of biophilic approach in the design of residential sites: Case of Sinpas Altinoran Ankara, Turkey. *International Journal on Emerging Technologies, 8*(1), 628–634. https://hdl.handle.net/11552/1320
• Kalantari, Z. (2016). بررسی تأثیر استفاده از اصول معماری بیوفیلیک بر ابعاد وجودی انسان در طراحی بناها (نمونه موردی: فرح‌آباد شهر ساری) [Investigating the impact of biophilic architecture principles on human existential dimensions in building design (case study: Farahabad, Sari)]. *International International Conference on New Research in Civil Engineering, Architecture and Urban Planning*. https://sid.ir/paper/868087/fa [in Persian]
• Karaman, G. D., & Selçuk, S. A. (2022). Transferring biophilic and universal design theory to practice with learning from green buildings: Restorative design parameters according to three certified green building case studies. In *Emerging approaches in design and new connections with nature* (pp. 225–252). IGI Global. https://doi.org/10.4018/978-1-7998-6725-8.ch010
• Keis, O., Helbig, H., Streb, J., & Hille, K. (2014). Influence of blue-enriched classroom lighting on students' cognitive performance. *Trends in Neuroscience and Education, 3*(3–4), 86–92. https://doi.org/10.1016/j.tine.2014.09.001
• Kellert, S. R. (2005). *Building for life: Designing and understanding the human-nature connection*. Island press.
• Kellert, S. R. (2008). Dimensions, elements, and attributes of biophilic design. In S. R. Kellert, J. Heerwagen, & M. Mador (Eds.), *Biophilic design: The theory, science, and practice of bringing buildings to life* (pp. 3–19). Wiley. https://www.researchgate.net/publication/284608721_Dimensions_elements_and_attributes_of_biophilic_design
• Kellert, S. R. (2018). *Nature by design: The practice of biophilic design*. Yale University Press. https://books.google.com/books/about/Nature_by_Design.html?id=maNUDwAAQBAJ
• Kellert, S. R., Heerwagen, J., & Mador, M. (2011). *Biophilic design: The theory, science and practice of bringing buildings to life*. John Wiley & Sons. https://books.google.com/books/about/Biophilic_Design.html?id=FyNer_nQrW4C
• Kellert, S., & Calabrese, E. (2015). The practice of biophilic design. *Terrapin Bright LLC, 3*(21), 2021–2009.
• Khanzadeh, M. (2024). Enhancing user experience in interior architecture through biophilic design: A case study of urban residential spaces. *New Design Ideas, 8*(1), 137–168. https://doi.org/10.62476/ndi81137
• Kim, J. Y., & Park, S. J. (2024). Visualizing biophilic design in residential spaces with generative AI: Focusing on water attributes for direct experience. *Journal of the Architectural Institute of Korea, 40*(7), 61–70. https://doi.org/10.5659/JAIK.2024.40.7.61
• Kim, J. Y., & Park, S.-J. (2025). AI-driven biophilic façade design for senior multi-family housing using LoRA and Stable Diffusion. *Buildings, 15*(9), 1546. https://doi.org/10.3390/buildings15091546
• Kohno, M., Ghahremani, D. G., Morales, A. M., Robertson, C. L., Ishibashi, K., Morgan, A. T., Mandelkern, M. A., & London, E. D. (2015). Risk-taking behavior: Dopamine D2/D3 receptors, feedback, and frontolimbic activity. *Cerebral Cortex, 25*(1), 236–245. https://doi.org/10.1093/cercor/bht218
• Kujundzic, K., Vuckovic, S. S., & Radivojevic, A. (2023). Toward regenerative sustainability: A passive design comfort assessment method of indoor environment. *Sustainability, 15*(1), 840. https://doi.org/10.3390/su15010840
• Lee, E. J., & Park, S. J. (2020). A framework of smart-home service for elderly's biophilic experience. *Sustainability, 12*(20), 8572. https://doi.org/10.3390/su12208572
• Lee, E., & Park, S. (2021a). Toward the biophilic residential regeneration for the Green New Deal. *International Journal of Environmental Research and Public Health, 18*(5), 2523. https://doi.org/10.3390/ijerph18052523
• Lee, E. J., & Park, S. J. (2021b). A preference-driven smart home

service for the elderly's biophilic experience. *Sensors, 21*(15), 5108. https://doi.org/10.3390/s21155108

• Lee, E. J., & Park, S. J. (2022). Biophilic experience-based residential hybrid framework. *International Journal of Environmental Research and Public Health, 19*(14), 8512. https://doi.org/10.3390/ijerph19148512

• Lee, E. J., & Park, S. J. (2023). Hybrid Residential Space Model Based on Biophilic Design for Older Adults. *Journal of the Korean Society of Interior Design Academic Conference, 25*(1), 172–177 https://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE11434423

• Lee, E. J., & Park, S. J. (2025). Strategic biophilic residential design based on seniors' health profiles: A HRQoL-driven approach. *Buildings, 15*(11), 1792. https://doi.org/10.3390/buildings15111792

• Lee, E., & Park, S. (2021a). Toward the biophilic residential regeneration for the Green New Deal. *International Journal of Environmental Research and Public Health, 18*(5), 2523. https://doi.org/10.3390/ijerph18052523

• Li, D., & Sullivan, W. C. (2016). Impact of views to school landscapes on recovery from stress and mental fatigue. *Landscape and Urban Planning, 148*, 149–158. https://doi.org/10.1016/j.landurbplan.2015.12.015

• Li, Q., Kobayashi, M., Inagaki, H., Wakayama, Y., Katsumata, M., Hirata, Y., Li, Y., Hirata, K., Shimizu, T., & Nakadai, A. (2013). Effect of phytoncides from forest environments on immune function. In *Forest medicine* (pp. 159–169). Nova Science Publishers, Inc. https://www.researchgate.net/publication/286556242_Effect_of_phytoncides_from_forest_environments_on_immune_function

• Liang, Z. (2021). *Biophilic design: A new exploration of residential design in China, Tianjin* [Doctoral dissertation, Politecnico di Torino]. Web thesis Libraries. https://webthesis.biblio.polito.it/19825/

• Macovei, I. (2023). *Paekawakawa's healing corridor: An architectural approach to help the integration of immigrants in residential communities through biophilic-placemaking* [Doctoral dissertation, Victoria University of Wellington]. Te Herenga Waka—Victoria University of Wellington. https://tewaharoa.victoria.ac.nz/discovery/fulldisplay/alma99179917485602386/64VUW_INST:VUWNUI

• Maharani, R. T., & Fitriyanto, D. A. (2022). Biophilic design to enhance residence comfort in COVID era. *Journal of Architectural and Engineering Research, 2,* 41–51. https://doi.org/10.54338/27382656-2022.2-007

• Mandasari, A., & Gamal, A. (2017). Biophilia as a factor of consumer preferences in choosing residential property product. In *ICCREM 2017: Real estate and urbanization* (pp. 15–26). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/9780784481073.003

• Mari, T., Hua, H. S. Y., Gunasagaran, S., Veronica, N., Srirangam, S., & Kuppusamy, S. (2023). Biophilic design for elderly homes in Malaysia for improved quality of life. J*ournal of Engineering Science and Technology, 18,* 96–112. https://www.researchgate.net/publication/373603063_BIOPHILIC_DESIGN_FOR_ELDERLY_HOMES_IN_MALAYSIA_FOR_IMPROVED_QUALITY_OF_LIFE

• Maulina, W., & Susanto, D. (2023). Biophilic design: Virtual nature application in a windowless room. *Sinektika: Jurnal Arsitektur, 20*(1), 90–98. https://doi.org/10.23917/sinektika.v20i1.20484

• McGee, B., Park, N. K., Portillo, M., Bosch, S., & Swisher, M. (2019). DIY biophilia: Development of the biophilic interior design matrix as a design tool. *Journal of Interior Design, 44*(4), 201–221. https://doi.org/10.1111/joid.12159

• MirzaMohammadi, A., & Doozdoozani, Y. (2021). The Effect of Biophilic Architecture on Improving the Environmental Quality of Residential Complexes (Case Study: Aseman Tabriz Residential Complex). *Sustainability, Development & Environment, 2*(3), 85–102 https://sanad.iau.ir/en/Journal/jsde/Article/846632

• Moghadasi, N., Khanmohammadi, M., Saremi, H., & Haghighat Bin, M. (2024). The Effect of Biophilic Architecture on Physical-Environmental Resilience of Residential Complexes Case Example: Tehran International Residential Tower. *Iranian Islamic City Studies, 14*(53), 59–74. https://iic.ihss.ac.ir/en/Article/46884

• Moghimi Shahri, E., & Vafamehr, M. (2024). Evaluating and Ranking Biophilic Design Principles in the Residential Architecture of Mashhad. *Journal of Sustainable Architecture & Environment (JSAE), 2*(5), 79–92. https://www.sid.ir/paper/1501327/en

• Mojtabavi, S. M., & Tafakkori, F. (2023). Analyzing ways to improve health and well-being in the design of housing through the direct experience of biophilic architectural elements. *Rahpooye Memari-o Shahrsazi, 2*(1), 35–52. https://doi.org/10.22034/rau.2023.1999519.1036

• Moniaga, C. (2021). Arsitektur biophilic untuk mendukung pengembangan desain hunian di era kegiatan work from home (pandemic COVID-19) [Biophilic architecture to support residential design development in the work from home era (COVID-19 pandemic): Case study of Naraya BSB Housing, Semarang]. *Tesa Arsitektur, 19*(1), 35–50. [in Indonesian] https://journal.unika.ac.id/index.php/tesa/article/view/3404

• Mousapour, B. (2024). Assessment of biophilic design's impact on citizens' residential satisfaction to enhance pro-environmental behavior. *Architectural Engineering and Design Management, 20*(4), 761–775. https://doi.org/10.1080/17452007.2023.2209709

• Nguyen, V. T. (2023). Integrating the 14 patterns of biophilic design into the convenience and comfort of apartments in Ho Chi Minh City. In *E3S Web of Conferences* (Vol. 403, p. 03009). EDP Sciences. https://doi.org/10.1051/e3sconf/202340303009

• Nitu, M. A., Gocer, O., Wijesooriya, N., Vijapur, D., & Candido, C. (2022). A biophilic design approach for improved energy performance in retrofitting residential projects. *Sustainability, 14*(7), 3776. https://doi.org/10.3390/su14073776

• Orman, P. (2017). *Understanding the biophilia hypothesis through a comparative analysis of residential typologies in Phoenix, São Paulo, and Tokyo* [Master thesis, Arizona State University]. ProQuest. https://www.proquest.com/openview/7a80eff09f3e930e1ce03a01ac7ddbb8/1?pq-origsite=gscholar&cbl=18750

• Pamanto, N. R. (2023). *Apartemen Dengan Pendekatan Arsitektur Desain Biophilic di Kota Makassar [Apartment with a biophilic design architectural approach in Makassar City]* [Doctoral dissertation, Universitas Hasanuddin]. Repository, Hasanuddin Universitas. [in Indonesian] https://repository.unhas.ac.id/id/eprint/32536/index.html

• Pandita, D., & Choudhary, H. (2024). Biophilic designs: A solution for the psychological well-being and quality of life of older people. *Working with Older People, 28*(4), 417–427. https://doi.org/10.1108/WWOP-01-2024-0003

• Parkinson, T., De Dear, R., & Candido, C. (2012, April). Perception of transient thermal environments: Pleasure and alliesthesia. In *Proceedings of the 7th Windsor Conference*, Cumberland Lodge, Windsor, UK. https://www.researchgate.net/publication/268688166_Perception_of_Transient_Thermal_Environments_Pleasure_and_Alliesthesia

• Peters, T., & D'Penna, K. (2020). Biophilic design for restorative university learning environments: A critical review of literature and design recommendations. *Sustainability, 12*(17), 7064. https://doi.org/10.3390/su12177064

• Peters, T., & Verderber, S. (2022). Biophilic design strategies in long-term residential care environments for persons with dementia. *Journal of Aging and Environment, 36*(3), 227–255. https://doi.org/10.1080/26892618.2021.1918815

• Prawata, A. G. (2024). Apartment with biophilic architecture approach in West Jakarta. In *IOP Conference Series: Earth and environmental science* (Vol. 1324, No. 1, p. 012018). IOP Publishing. https://doi.org/10.1088/1755-1315/1324/1/012018

• Richardson, M., & Butler, C. W. (2022). Nature connectedness and biophilic design. *Building Research & Information, 50*(1–2), 36–42. https://doi.org/10.1080/09613218.2021.2006594

• Sadanand, A., Chander, S., & Devadas, M. (2022). A dialogue with nature through biophilic design: Focus on the façade wall in the architecture of Laurie Baker's houses. *International Journal of Design and Nature and Ecodynamics, 17*(1), 37–45. https://doi.org/10.18280/ijdne.170105

• Saraf, M. H. M., Tharim, A. H. A., & Ahmad, A. C. (2023). A systematic review on the biophilic designs for home workspace during the COVID-19 quarantine. In *World Sustainable Construction Conference Series 2021* (Vol. 2688, No. 1, p. 030007). AIP Publishing LLC. https://doi.org/10.1063/5.0111445

• Shakhshir, K. S. (2022). *Assessment of biophilic features in residential buildings in Dubai* [Doctoral dissertation, The British University in Dubai (BUiD)]. BSpace, The British University in Dubai (BUiD) Digital Repository. https://bspace.buid.ac.ae/items/56b36a38-7e2c-475b-85eb-a0a830859d88

• Shakhshir, K., & Sheta, W. (2024). The assessment of biophilic features in residential buildings: a case from Dubai. *Archnet-Ijar International Journal of Architectural Research, 18*(3), 247–267. https://doi.org/10.1108/ARCH-03-2023-0064

• Shaliha, P., Farajollahi Rad, A., Ahmadi, V., & Shoaei, H. R. (2023). Explanation of quality improvement indicators of conventional urban housing based on biophilic architecture in District One of Tehran. *Journal of Geography and Regional Development, 21*(1), 261–296. https://doi.org/10.22067/jgrd.2023.80640.1238

• Shaliha, P., Farajollahi Rad, A., Ahmadi, V., & Shoaei, H. R. (2023). Effective factors on increasing users' satisfaction with housing by biophilic approach. *Creative City Design, 6*(1), 1–15. https://journals.iau.ir/article_698496.html

• Shbaita, A. S., Denerel, S. B., & Asilsoy, B. (2024). An evidence-based assessment of biophilic interior design in a traditional context: The case of the Kingdom of Saudi Arabia. *Sustainability, 16*(18), 7979. https://doi.org/10.3390/su16187979

• Song, C., Ali, F., Cobanoglu, C., Nanu, L., & Lee, S. H. J. (2022). The effect of biophilic design on customer's subjective well-being in the hotel lobbies. *Journal of Hospitality and Tourism Management, 52*(2), 264–274. https://doi.org/https://doi.org/10.1016/j.jhtm.2022.07.008

• Stefanovska, D. (2019). *Health-promoting Multifamily House-A new biophilic house design in Gothenburg* [Master thesis, Chalmers University of Technology]. Communities & Collections. https://hdl.handle.net/20.500.12380/257093

• Susanto, F. A. C., Siwi, S. H., & Fatimah, T. (2025). The vertical residence based on biophilic architectural design concept (Case study: Taman Anggrek Residence Apartment West Jakarta). *Jurnal Asiimetrik: Jurnal Ilmiah Rekayasa & Inovasi,* 107–114. https://doi.org/10.35814/asiimetrik.v7i1.7934

• Susilo, K., Arifin, L. S., & Tulistyantoro, L. (2024). Evaluasi parameter biophilic desain menurut Terappin pada Skygarden Apartment Benson [Evaluation of biophilic design parameters according to Terappin at Skygarden Apartment Benson]. *Advances in Civil Engineering and Sustainable Architecture, 6*(1), 33–41. https://doi.org/10/C/C3/DT.05.00/2025

• Tokazhanov, G., Tleuken, A., Guney, M., Turkyilmaz, A., & Karaca, F. (2020). How is COVID-19 experience transforming sustainability requirements of residential buildings? A review. *Sustainability, 12*(20), 8732. https://doi.org/10.3390/su12208732

• Tondrosaleh, N., Hojjati, M., & Movahed, K. (2023). Recognizing the effective components of biophilic architecture to reduce the stress of housewives in residential complexes: Case study (Shiraz city). *Journal of Housing and Rural Environment, 42(184), 75–88. http:// doi.org/10.22034/42.184.75*

• *Untaru, E. N., Han, H., David, A., & Chi, X. T.* (2024). Biophilic design and its effectiveness in creating emotional well-being, green satisfaction, and workplace attachment among healthcare professionals: The hospice context. *HERD: Health Environments Research & Design Journal, 17*(1), 190–208. https://doi.org/10.1177/19375867231192087

• Wiener, J. M., Franz, G., Rossmanith, N., Reichelt, A., Mallot, H. A., & Bülthoff, H. H. (2007). Isovist analysis captures properties of space relevant for locomotion and experience. *Perception, 36*(7), 1066–1083. https://doi.org/10.1068/p5587

• Wijaya, I. B. A. (2023). Biophilic concept analysis in the interior of a post-new normal residential home. In *IOP Conference Series: Earth and environmental science* (Vol. 1169, No. 1, p. 012055). IOP Publishing. https://doi.org/10.1088/1755-1315/1169/1/012055

• Wil, C. M. H. C., & Ismail, H. (2025). Integrating biophilic design in multi-generational housing: A conceptual framework for enhancing well-being and quality of life. *Built Environment Journal, 22*(SI). https://doi.org/10.24191/bej.v22iSI.6498

• Windhager, S., Atzwanger, K., Bookstein, F. L., & Schaefer, K. (2011). Fish in a mall aquarium- An ethological investigation of biophilia. *Landscape and Urban Planning, 99*(1), 23–30. https://doi.org/10.1016/j.landurbplan.2010.08.008

• Yassein, G., & Ebrahiem, S. (2018). Biophilic design in the built environment to improve well-being: A systematic review of practices. *Journal of Urban Research, 30*(1), 128–146. https://doi.org/10.21608/jur.2018.88412

• Yazdanirostam, F., Saeideh Zarabadi, Z. S., & Habib, F. (2023a). Investigating the effect of spatial relationships connection pattern of passages with its block entrance in phase 1 of Ekbatan town using biophilic design strategy. *The Journal of Urban Futurology, 1*(3), 71–90. https://doi.org/10.30495/uf.2023.1981185.1104

• Yazdanirostam, F., Saeideh Zarabadi, S., & Habib, F. (2023b). Theoretical modeling of the relationship between biophilic components and the efficiency of spaces between residential complexes (In the context of previous researches). *Journal of Space and Place Studies, 2*(1), 31–48. https://doi.org/10.30495/jsps.2023.1993094.1058 [in Persian]

• Yazdanirostam, F. , Saeideh Zarabadi, Z. S., & Habib, F. (2024). Understanding the requirements of biophilic intersection design in residential complexes of Tehran, Case study: Phase 1 of Ekbatan Township. *Journal of Urban Ecology Researches, 14*(4), 103–120. https://doi.org/10.30473/grup.2023.68618.2800

• Yue, M., Zhang, X., & Zhang, J. (2024). Biophilic experience in high–rise residential areas in China: Factor structure and validity of a scale. *Sustainability, 16*(7), 2866. https://doi.org/10.3390/su16072866

• Zhong, W., Schröder, T., & Bekkering, J. (2022). Biophilic design in architecture and its contributions to health, well-being, and sustainability: A critical review. *Frontiers of Architectural Research, 11*(1), 114–141. https://doi.org/10.1016/j.foar.2021.07.006



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