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Healthy Dwelling: The Perspective of Biophilic Design in the Design of the Living Space

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Abstract: As urbanization continues to advance rapidly, the emergence of biophilic design offers a positive perspective to address the alienation between humans and nature, becoming a hot research topic in areas related to human living environments. Biophilic design, as a design concept inspired by nature, has positive significance in promoting the development of ecological diversity and improving human physical and mental health. This paper makes a comparative analysis of two of China's residential communities in the same high-density environment through the main influencing factors of plot ratio, greening rate, external facades environments, and internal living space. Starting from the five senses of the human body, namely, sight, hearing, touch, smell, and taste, this paper aims to investigate the design of living spaces through the lens of biophilic design, and proposes a biophilic design model, along with strategies and recommendations tailored to high-density urban environments, in the hope of serving as a valuable reference and source of inspiration for future healthy dwelling design.

Keywords: biophilic design; healthy dwelling; living space; five human senses; high-density housing; interior space

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1. Introduction

According to the National Human Activity Pattern Survey (NHAPS), people spend 90% of their time indoors [1], so human-centered design is critical to consider the changing needs of occupants and the comfort of the built environment affecting living spaces. As an environmental design philosophy that promotes public health through the healing effects of nature, biophilic design interprets the relationship among nature, the space environment, and human health from the perspectives of biology and psychology [2]. For this reason, academics like Edward Wilson and Stephen Kellett [3,4] have proposed design concepts and strategies that use nature as a basis and aim at establishing a balance between humans and the natural world. Then, biophilic design is currently an established and widely adopted method of design in the field of architecture. In order to promote buildings that have a positive impact on the environment, the 2014 International Building Performance Standard incorporates biophilic design into its rating system. The evaluation process includes an initial audit and an assessment of occupancy performance over a one-year period, both of which together meet the criteria for being recognized as a 'living building' [5].

High-density collective housing seems to have become a widely accepted solution for solving the contemporary housing need, in the context of rapid urbanization and increasing population density [6]. But high-density housing causes many concerns; millions of people came to be living in overcrowded, high-density, poorly ventilated, damp, unclean housing [7], which directly affects the quality of the living environment and the health of residents. Urban development inevitably encroaches on natural habitats, leading to

people living in steel and concrete cages without warmth, resulting in a disconnection between humans and nature. The proposal of biophilic design provides a fresh perspective to solve the conflict between people and the urban environment in today's society. As a contemporary vision, the vision of placing greenery in the built environment is becoming increasingly clear. The combination of "green" and "architecture", and even "interior space", is the hope that architecture can also have some functions similar to those of green plants, so that architecture and the environment can coexist in harmony. In addition, starting from the perspective of the physical and mental health of residents, the novelty of this research is searching for a healthy dwelling standard based on the concept of biophilic design in the current environment of high-density housing development.

2. Literature Review

2.1. Biophilic Design: The Proposal, Development, and Elements

In 1964, the German social psychologist Erich Fromm first introduced the concept of "Biophilia" and used the term biophilia to describe people's innate need to be in close contact with nature [8]. In 1984, following the publication of *Biophilia* by biologist Edward Wilson, the concept of "Biophilia" began to spread and become popular [9]. He makes compelling arguments from the viewpoint of biological evolution: Wilson focuses on how people adapt to their changing environment and emphasizes the emotional attachment of humans to nature. In 1993, Edward Wilson and Yale environmental psychologist Stephen Kellett jointly proposed the <The Biophilia Hypothesis>, which envisioned and extrapolated a series of positive responses exhibited by humans in contact with nature [3]. This has motivated academics to investigate and use the value of a transdisciplinary combination of natural surroundings and the working, living, learning, and residential environments. From 2008, Stephen Kellett, together with other research scholars, jointly published *Biological Design: The Theory, Science and Practice of Bringing Buildings to Life* and *The Practice of Biophilic Design*, a relatively comprehensive account of the application of biophilic design in the field of architectural design, as well as environmental design.

In generalizing the concept of biophilic design according to these theories, biophilic design encourages the use of natural elements and processes in the built environment as inspiration for design [4]. In 2015, the biophilic design methods from Stephen Kellert and Elizabeth Calabrese mentioned that the design approach is divided into three categories: Direct experience of nature, Indirect experience of nature, and Experience of space and places, which contain 24 design elements (see Table 1).

Table 1. The biophilic design methods from Stephen Kellert in 2015 [4].

Categories	Key Elements
Direct Experience of Nature	(1) Light; (2) Air; (3) Water; (4) Plants; (5) Animals; (6) Landscape; (7) Weather; (8) Views; (9) Fire
Indirect Experience of Nature	(10) Image; (11) Materials; (12) Texture; (13) Color; (14) Shapes and forms; (15) Information richness; (16) Change, age, and the patina time; (17) Natural geometries; (18) Simulated natural light and air; (19) Bionicology
Experience of Space and Place	(20) Prospect and refuge; (21) Organized complexity; (22) Mobility; (23) Transitional spaces; (24) Integrating parts to create wholes

2.2. The Value of Biophilic Design—Experimental Analysis

Biophilic design encourages the use of natural elements and processes as design inspiration in the built environment [4]. The idea behind this is that exposure to natural environments and features has positive effects on human health and well-being, which has been supported in a wealth of research [10]. Contact with nature has five main benefits: physical health, mental emotion, behavioral cognition, economic value, and environment optimization.

For physical health, psychological studies have demonstrated the health and well-being benefits of placing plants inside. Bringslimark et al. [11] conducted a review of this evidence and concluded that plants have a beneficial effect on stress reduction and pain tolerance. A major study by Ulrich was on the benefits of green views; when recovering in a room with views of green trees, patients recovered faster and required less pain medication than patients whose view was of a brick wall [12]. In subsequent studies, the positive effects of nature on physical health were also confirmed from tests of physiological indicators showing it calms the heart rate and lowers blood pressure and stress hormones, such as adrenal hormones. This means that biophilic design use can bring relief from physiological stress, such as reducing the probability of heart disease and cardiovascular disease [13–15].

For mental emotion, Roger Ulrich's <Stress Recovery Theory> suggests that interaction with nature can relieve psychological stress and promote positive emotions [16]. On this basis, the positive effects of nature on mental health are manifested in a deeper way: promotes dopamine secretion, induces intense feelings of pleasure, and enhances subjective comfort [17]; emotional development that enhances a sense of multiple security, perception of well-being, and a sense of tranquility [18]; improves emotions, such as burnout, boredom, frustration, and anxiety [15].

For behavioral cognition, preliminary data indicate a strong positive effect from incorporating aspects of biophilic design to boost productivity, ameliorate stress, enhance well-being, foster a collaborative work environment, and promote workplace satisfaction, thus contributing towards a high-performance workplace [19]. A study by the Center for Health and the Global Environment at Harvard University showed that 'green' buildings contribute to increased productivity and can improve staff cognition by up to 101%. Stephen Kaplan, an environmental psychologist at the University of Michigan, proposed the <Attention Restoration Theory>, which states: contact with the natural environment restores directed attention consumed in cognitive tasks, which prevents mental fatigue and provides a constant source of motivation for cognitive activity [20].

For economic value, socio-economist Bill Browning suggests that a study of New York City, based on the effects of nature on physiological recovery, indicates it could reduce the average length of stay of individuals by 0.41 day, resulting in annual savings of USD 93 million in health care costs; saving USD 162,000 per year in correctional spending based on natural reductions in crime and violence; and it also, based on natural for the efficiency of the work, can increase the annual output of USD 470 million [21]. So, nature promotes the physical, psychological, and behavioral effects of people and has a positive economic value for them.

For environment optimization, biophilic design can repair the fracture between contemporary cities and nature, and build a living environment in which humans and nature coexist in harmony [22]. Biophilic derivation is the optimization of green plants in the built environment and urban environment, which has multiple ecological effects on the living environment, including improving the thermal environment and energy saving, storing rainwater, purifying the air, reducing noise, and increasing biodiversity.

The results of these experimental studies show that biophilic design, an environmental philosophy intervention design that promotes public health through nature's beneficial effects, explains the relationship among nature, the built environment, and human health from a biological point of view and can offer basic arguments and guiding principles for the creation of healthy and environmentally friendly human living spaces. In addition, in the face of the rapid development of urbanization and stress caused by fast-paced life and work,

human health is seriously affected, and the natural environment has a healing effect on the human body, which can effectively relieve stress and improve health conditions. Based on this, the architects are encouraged to think about the future urban living environment and healthy dwelling design under the concept of biophilic design.

2.3. Healthy Dwelling: The Application of Biophilic Design in Residential Building

The challenges posed by urbanization in terms of social and environmental pollution significantly impact our way of life, and in some instances, result in profound transformations, such as the recent COVID-19 pandemic. One of the objectives in United Nations Agenda 21, especially Chapter 7 on promoting sustainable human settlement development, is "Providing adequate shelter for all" (United Nations, 1992). This implies the right for everybody to live in good-quality housing that ensures health, safety, and happiness in their everyday life [7]. Therefore, residential spaces are essential environments for human existence, as they directly impact people's daily lives and have a significant influence on their overall well-being and health.

In 1988, the World Health Organization (WHO) proposed the construction of healthy dwellings, and residential health began to become a key topic of international attention [23]. In 1995, under the influence of academician Wu Liangyong, China embarked on research in the field of healthy dwelling, emphasizing the harmonious integration of human health and the design environment. In 1999, the Healthy Living Environment Research Center of China initiated an interdisciplinary approach, incorporating architecture, sports medicine, psychology, and nutrition, to investigate the impact of variables, such as sunlight, temperature and humidity, density, and greenery, on human health. Their research culminated in the release of the pioneering "Technical Essentials of Healthy Housing Construction" in 2001, providing valuable insights into the optimization of health-oriented housing design. From 2002 to 2017, China made continuous advancements in the development of the theoretical framework for healthy housing. The implementation of the "Health Housing Evaluation Standard" (T/CECS462-2017) marked a significant milestone during this period. The standards focused on six key aspects of residential health evaluation, namely, spatial quality, air quality, water quality, environmental factors, lighting conditions, and overall health considerations (refer to Figure 1) [24].

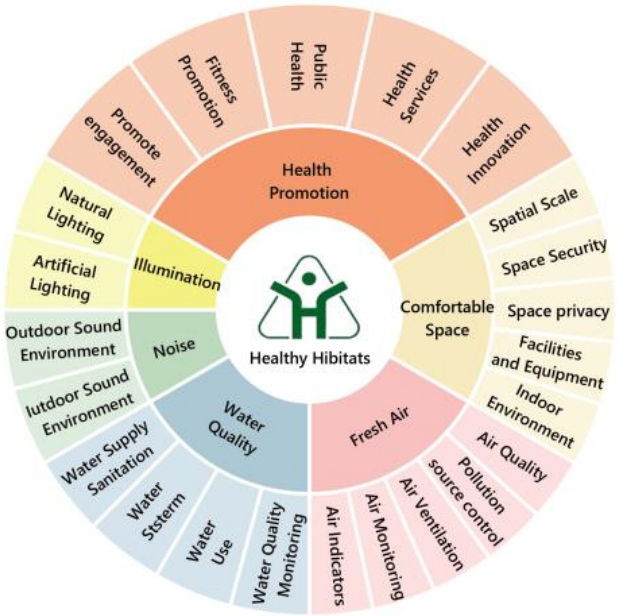

Figure 1. "HIH" Heathy Housing Evaluation Standard (T/CECS462-2017) [24].

The research on biophilic design methods has evolved towards typification, presenting different approaches tailored to diverse architectural environments. A notable example occurred at the prestigious World Architecture Festival (WAF) in Singapore, where the Royal Children's Hospital in Melbourne was awarded the "2012 World Health Building" accolade. The hospital's design incorporated innovative architectural elements, such as courtyards, a two-story coral reef aquarium, large-scale artworks, and a miniature zoo, all aimed at optimizing the connection with nature. Inspired by biophilic principles, the application of "restorative healing environments" in both outdoor landscapes and indoor architectural spaces has been extensively supported by empirical evidence. Numerous studies have shown that biophilic design elements, including natural light, greenery, scenic views, social spaces, natural sounds, aromas, water features, animals, and visual control, have a positive impact on promoting emotional well-being and facilitating the healing process for patients [25]. Biophilic design in the teaching environment can help improve student productivity [26]. The University of Melbourne's joint project with the Australian Research Council "School for the Future" states that having natural ventilation, natural light, and good acoustics and indoor air quality has a positive impact on students. Providing open space and connection to the outdoors can increase mental stimulation, energy, and physical comfort, which in turn increases cognition, attention, and memory [27]. Biophilic design in office environments establishes a connection between productivity and spatial surroundings, fostering employees' subjective satisfaction with their work environment and subsequently enhancing work efficiency [19]. The use of biophilic design in commercial environments has positive effects, such as enhancing environmental attractiveness, promoting consumer behavior, and eliciting favorable customer feedback [28].

Therefore, biophilic design is an innovative approach to designing our living, working, and learning spaces, aiming to address the inherent conflict between humans and the urban environment in the context of rapid urbanization. Biophilic design lays a solid foundation for the development of healthy dwelling by employing artificial environmental design methods that harness the beneficial effects of nature, thereby creating a healthier and more natural living environment.

3. Case Study

A key premise of this study is that there is a close link between biophilia or a biophilic design residential community and high-density healthy dwelling, where, especially, the former helps develop the latter. The concept of design thinking has evolved from addressing the challenges of enclosed spaces in high-rise residential buildings and community environments in the context of rapid urbanization to encompass the quality of living and design issues in existing residences. The discussion will start with the basic consideration of biophilic aspects in architecture, especially in the high-density residential community, then analysis of two examples of a representative high-density residential community in China by using the four main basic aspects of plot ratio, greening rate, external façade environment, and internal living space. This study aims to explore the overall living environment of high-rise residential buildings in China, using Chinese residential communities as a case study. The objective is to establish residential environmental space design standards based on the principles of biophilic design in the current Chinese context. The following is a detailed description of the research method and scope: Firstly, a discussion of the literature is utilized to provide an overview of the concepts and components of biophilic design, as well as the beneficial effects of nature on human health. Secondly, the limitations of Chinese residential environments in terms of the living space and public space that needs to be improved are integrated through a comparative examination of two typical high-density residential communities, Huaguoyuan community in Guiyang and Baiziwan community in Beijing. Thirdly, we utilize the comprehensive framework of the WELL Building Standard in the United States, which encompasses key aspects, such as air quality, water quality, nourishment, lighting, movement, thermal comfort, acoustics, materials, mental well-being, community, and innovation. Building upon this foundation, we integrate the principles

of biophilic design, emphasizing the innate connection between humans and nature. By considering the sensory experiences of sight, hearing, touch, smell, and taste, we identify and summarize the essential design principles of biophilic design in the realm of residential architecture. By incorporating design strategies to meet these requirements, it is possible to achieve a well-balanced living environment in the future. This approach can improve both housing and environmental quality while enhancing the overall satisfaction of residents, particularly in high-density conditions.

3.1. Research Setting and Samples

China's high-rise residential buildings are an efficient way for city dwellers with low and middle incomes and those who live in shantytowns in older cities to quickly improve their living conditions and enjoy a modern urban lifestyle on a large-scale, low-cost basis. High-density residential buildings have, therefore, become a mainstream product in China's residential market in response to rapid urbanization and rising population density, but with a number of issues appearing, including: overcrowding; high density; inadequate ventilation; damp, unclean housing; etc. The current high-density residential construction in China is uniform (similar to the Huaguoyuan Residential Community in Guiyang), blindly pursuing a large amount of housing demand, while neglecting the quality of its living environment. Baiziwan Residential Community adopts a three-dimensional public space network composed of aerial streets and a multi-level three-dimensional green courtyard system, making the community public space a complete and rich public place. In this paper, two typical residential area cases are selected for comparative analysis: Huaguoyuan Residential Community in Guiyang and Baiziwan Residential Community in Beijing (refer to Figure 2). Both are residential areas in high-density urban environments in China. However, Huaguoyuan Residential Community has been rated as the "most crowded residential area" in China, while Baiziwan Residential Community has been recognized as the "most beautiful residential area." These evaluations can be derived from observations and comparisons of the overall environment, public spaces, traffic pressure, community greening rates, and residential spaces in these neighborhoods. From Figure 2, it is evident that Huaguoyuan Residential Community exhibits a high building density and relatively small spaces. Moreover, there is a lack of sufficient public spaces, such as parks, recreational areas, or green spaces, which limits residents' opportunities for outdoor activities, relaxation, and social interactions. In contrast, Baiziwan Residential Community has enhanced its living quality through design interventions. The buildings in this area feature staggered floors and semi-open gray spaces, while the rooftops are designed with diverse scales of green landscape. These design elements provide residents with more comfortable and aesthetically pleasing spaces.

Figure 2. Visualization of Huaguoyuan Residential Community (**left**) and Master plan of Baiziwan Residential Community (**right**) and the green public space (**middle**).

3.1.1. Analysis of Plot Ratio and Greening Rate

By comparing the building density and greenery rate of Huaguoyuan Residential Community and Baiziwan Residential Community (see Table 2), the following conclusions can be drawn. From the analysis of the plot ratio, although Huaguoyuan Residential Community meets the demand for a large number of housing units, it neglects the moderate and environmental quality of residents' living conditions. Each residential building exceeds 30 floors in height, while the distance between buildings is only about 30 m, which results in residents not obtaining sufficient privacy and sunlight. Secondly, the high-density environment leads to issues of noise and environmental pollution. The convergence of traffic, community activities, and a large number of vehicles in close proximity to residents increases the risk of environmental pollution. Lastly, in high-density neighborhoods, parking spaces are insufficient, leading to difficulties for residents in finding parking spots and increasing their traffic and parking pressures.

Table 2. Information about the Huaguoyuan Residential Community and Baiziwan Residential Community.

	Huaguoyuan RC	**Baiziwan RC**
Location	Guiyang, China	Beijing, China
Building Area	18.3 million m^2	4.733 million m^2
Plot Ratio	6.8	3.5
Greening Rate	15%	47% + 100% Roof Garden

The analysis of the greening rate leads to the following conclusions. Due to the high building density in Huaguoyuan Residential Community, the available green space is relatively limited, resulting in a restricted area of greenery that fails to meet residents' needs for a natural environment and leisure spaces. In contrast, Baiziwan Residential Community boasts a remarkable greening rate of 47%. Worth learning from, the greening landscape is distributed across different areas, allowing residents to enjoy plant life on the ground, platforms, rooftops, and walls, achieving an almost 100% natural greening rate. In areas where the urban environment is the limiting factor towards viewing green nature, the availability of green plant forms and roofs have been found to be restorative [29]. Consequently, residents generally exhibit higher satisfaction with living in Baiziwan Residential Community, as the addition of natural green spaces in outdoor areas proves to be an essential measure in enhancing residential quality.

3.1.2. Analysis of the External Façade Environment

In analyzing the external façade environment, it was observed that both residential complexes have balcony designs, but the presence of natural elements is scarce. This issue is not limited to these two projects, but is a common problem in residential areas across China. The design of rooftop gardens provides a direct opportunity for urban residents to connect with nature, fostering diverse interaction and communication between people and the natural environment. However, in current residential designs in China, there are challenges and deficiencies in fully utilizing balcony spaces. To address this situation, it is crucial to prioritize the functionality and aesthetics of balconies during the design process, creating spaces that meet the residents' needs while integrating harmoniously with nature.

Studies have shown that the presence of green plants and natural light is beneficial to the physical and mental well-being of residents [30]. As a result, planting green plants is considered a convenient and efficient way to improve the living environment. The topic of "5.9-square-meter balcony garden for family vegetable and fruit supply" has gained popularity on social media platforms, with search volumes reaching billions of times. The balcony is a common architectural element closely related to the daily lifestyle and quality

of life, providing an opportunity to reconsider how to establish a connection between landscape design and residential patterns.

3.1.3. Analysis of Internal Living Space

The spread of the COVID-19 virus has disrupted people's usual routines and social order, altering their daily lives and lifestyles. The experience of living at home has also been strongly affected, especially during mandatory quarantine periods [31]. During this pandemic, various narratives about the meaning of "home" have emerged, some positive (as a safe and healthy place, characterized by peace and tranquility, with more time to spend with family), and some negative (as an isolated, lonely, threatening, oppressive, and confining place) [32]. However, "home" is not just a physical living space; it is an organic space that provides relief from stress and improves psychological well-being. The changes in lifestyle brought about by the COVID-19 lockdown have compelled us to contemplate more deeply about living spaces and residential environments. The composition of "home" extends beyond the essential functional rooms, like the living room, kitchen, bedroom, and bathroom. It becomes particularly crucial to intervene in design to create spaces and perceptions that alleviate negative emotions, such as boredom, suppression, and restlessness.

3.2. The Biophilic Design Connect with WELL Building Standard

The WELL Building Standard is an international building standard evaluating and enhancing the impact of the built environment on human health. It lays the foundation for investigating healthy homes by offering researchers reliable references and integrating health, comfort, and sustainability into all aspects of building design, construction, and operation. Human beings require daily contact with nature, and cities should not be barriers that isolate them from the natural environment, but rather unified entities that integrate with nature organically [33]. The WELL Building Standard, an architectural certification system in the United States, emphasizes the importance of biophilia in meeting psychological and spiritual needs, aiming to create healthy spaces through design interventions that promote pleasant environments for both the body and mind [34]. The website of the certification system explores the connection between indoor layouts and nature from various aspects, including air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, community, and innovation. The introduction of the WELL Building Standard provides valuable theoretical guidance and a practical framework, promoting research and practices on the interrelationship between built environments and human health. By focusing on these aspects, designers and architects can create healthier and more livable architectural spaces that meet people's needs for a connection with nature, thus enhancing the quality of life and well-being of the occupants.

3.3. The Biophilic Design Connect with People's Five Senses

In the above statement, the present high-density residential buildings in China are analyzed mainly from four aspects: plot ratio, greening rate, external façade environment, and internal living space. Finding evidence of the effects of the rapidly urbanizing living environment is not difficult: (1) A lack of thoughtful consideration for the internal living space, which can be enhanced by the creation of a biophilic environment; (2) Low greening rate of the district, inability to meet residents' needs for natural environment and recreational space; (3) Uniform style of the façade—despite the design of balconies, reasonable use of the rate is not high; (4) High building density, insufficient building spacing to affect sunlight, ventilation issues. By establishing a biophilic environment, the living environment can be improved. The ecological and sustainable benefits of biophilic design in human habitats are undeniable, and researchers from various fields have conducted experiments on the methods of biophilic design. Notably, Soderlund Jana combined biophilic design principles with the specific requirements of prison architecture and proposed the incorporation of natural elements in prisons, which has the potential to reduce stress and improve the mental

health, cognitive function, and learning abilities of inmates [35]. Therefore, meeting these requirements through design can create balanced future living environments, improve housing and environmental quality, and enhance residents' satisfaction with housing in rapidly urbanized settings.

Through an analysis of previous studies on biophilic design methods and incorporating people's sensory experiences of sight, sound, touch, smell, and taste as feedback to the spatial environment, suggestions have been made to further refine biophilic design methods and create an interactive connection between humans and nature in the process of urbanization. Building upon the foundation of the WELL Building Standard, Table 3 establishes a linkage between biophilic design and residential design, with nature as the fundamental element. It further deepens the design of living spaces by considering people's sensory experiences of sight, sound, touch, smell, and taste. Nature is multisensory [29], including natural light, natural materials, etc. and all the human senses. So, this integrated approach enhances the quality of residential environments, creating more comfortable and healthy living experiences, while also strengthening the close connection between people and nature.

Table 3. Five Senses BIO Housing Design Standards.

Sense	Feature/WELL Building Standard	Elements/Application
BIO + Visual	Air	Fresh air, Air quality, Ventilation, Operable windows, Air condition, Fragrant herbs and flowers, Fragrance
	Water	Clean water, Flowing water, Audible/physically accessible water feature, Waterscape
BIO + Sound	Light	Sunlight, Moonlight, Firelight, Digital simulations of nature light, Light distribution
	Movement	Physical activity opportunities, Yoga, Physical exercise, Planting, Animal feeding
BIO + Touch	Thermal Comfort	Simulates the natural environment by changing the temperature, relative humidity, and wind speed perceived by the human body
	Sound	Sounds of singing birds, crisp breezes, and running water in the background
BIO + Smell	Materials	Natural decorative material—Wood, Stone, Wool, Cotton, Leather, Bamboo, Rattan
	Mind	Natural Images, Photographs, Paintings, Sculptures, Murals, Video, and Other representative things
BIO + Taste	Community	Biodiversity, Promote outdoor activities, Increase green infrastructure, Health services and benefits, Diversity and inclusion
	Innovation	Green building rating systems, Carbon disclosure and reduction, Gateways to well-being

Designing to meet these requirements can lead to a well-balanced future living environment, improving the quality of housing and the surrounding environment, and enhancing residential satisfaction, even in high-density conditions. The factors that support a positive outlook towards future healthy dwelling can be summarized as follows:

- BIO + Visual: Vision allows us to perceive light through our eyes and interpret visual information from the external world [36]. It provides us with a rich and varied sensory experience, encompassing aspects such as color, size, brightness, and motion. Vision also grants us spatial perception and navigation abilities, enabling us to perceive and understand the location, direction, and distance of our surroundings. In the context of architectural design, incorporating natural elements, such as green plants, natural materials, natural lighting, or representations of nature, we can evoke a sense of connection between humans and the natural world, creating a pleasant state of mind. Introducing these natural elements helps to cultivate a visually appealing environment that promotes comfort and relaxation, thereby enhancing the quality of the living experience.
- BIO + Sound: Hearing allows us to perceive and interpret external sounds, including language, music, natural sounds, and environmental noises. It not only conveys information and facilitates communication, but also triggers emotional and psychological responses, influencing our mood and overall experience [37]. However, urban living is often accompanied by various noises, which can lead to feelings of anxiety and stress. By incorporating plantings on balconies, the impact of noise can be effectively reduced. Pleasant sounds, such as melodic songs, crisp bird chirping, and the soothing flow of water, in landscapes can create a sense of tranquility and comfort. Therefore, by implementing well-designed and controlled sound environments, one can create an enjoyable and comfortable auditory experience, enhancing the quality of residential environments.
- BIO + Touch: The sense of touch allows us to perceive and interpret the contact and texture of objects through our skin [38]. It provides a rich array of sensory experiences, including the temperature, texture, pressure, vibration, and tactile feedback during touch. Through touch, we can perceive the hardness, softness, smoothness, and roughness of objects, thereby gaining important information about their properties and environmental conditions. Touch can also evoke emotional and affective responses, such as comfort and relaxation from a soft touch, or alertness and discomfort from a sharp or stimulating touch. In the context of architectural environments, the thoughtful integration of tactile elements can create a rich tactile experience for individuals, for example, selecting appropriate materials and textures that offer comfortable tactile sensations, designing ergonomic furniture and furnishings that provide comfortable seating and support, and considering temperature and humidity regulation to maintain pleasant tactile perceptions. Through these tactile presentations, people can enjoy a more diverse and comfortable living experience, thereby enhancing their quality of life and overall well-being.
- BIO + Smell: The sense of smell, or olfaction, allows us to perceive and interpret odors from the external environment through our nose. It provides a rich sensory experience encompassing aspects such as the intensity, types, texture, and complexity of different smells [39]. Olfaction plays a significant role in our perception of the surrounding environment, object recognition, and the triggering of emotions and memories. Smell can elicit strong emotional and sensory experiences. For example, the fragrance of flowers can bring about feelings of pleasure and relaxation, while the aroma of food can stimulate appetite and satisfaction. On the other hand, unpleasant odors can evoke discomfort and aversion. Olfaction is closely linked to memory and emotions, as specific scents can evoke past memories and emotional experiences. In the realm of architectural design, the judicious use of olfactory elements can create rich sensory experiences for individuals. For instance, selecting appropriate scents or incorporating aromatic plants can fill the air with pleasant fragrances. Controlling

indoor air freshness and quality through air conditioning systems and ventilation designs can help avoid unpleasant odors. These olfactory presentations can significantly impact people's emotions and psychological states, fostering a pleasant and comfortable environment that enhances the quality of living experiences.

- BIO + Taste: While taste is not a primary sense in the context of architectural environments, it still has some influence on improving the residential experience, particularly in relation to factors such as air quality, food experiences, and ambiance creation [36]. In the design of residential spaces, the ventilation system in the kitchen should ensure timely removal of food odors and smoke, maintaining fresh and comfortable air. Adequate indoor air quality is crucial for the comfort and health of residents. Utilizing available spaces, like balconies, for cultivating edible plants, such as vegetables, herbs, and fruits, not only provides access to fresh food, but also enhances the overall residential environment.

The human experience of the five senses encompasses the connection between architectural elements and nature, the incorporation of natural textures in buildings, and the interaction between humans and nature. The addition of natural elements in living spaces induces changes in cognition and emotions, influencing individuals' stress levels, health, and well-being [39]. Whether it is the external environment of residential buildings or the interior spaces, people tend to seek contact with nature and establish a daily connection to compensate for the elements lost in the process of urbanization.

3.4. Biophilic Design Model in Residential Building Design

Applied research is creative research carried out to acquire new knowledge on the premise of a specific purpose or goal. The purpose of this section is that the application research of biophilic design in residential building is an extension of existing knowledge, and provides the functions and strategies for solving practical design problems. The housing environment in China has undergone tremendous changes, and China's urban housing and living styles are vast and diverse [40]. Therefore, creating the new housing patterns that are of high density under the concept of biophilic design meets the needs of resilient high-density urban housing.

This section selects the design works of the Vancouver Affordable Housing Challenge from the BUILDER Competition (see Figure 3) as a possibility of thinking about high-density housing from the perspective of a future biophilic model. The aim of this project is seeking to advance Vancouver's high-rise residential housing program through an integrated approach to create a cohesive new form of cohousing community. This project is a biophilic design application in residential community planning, through the creation of natural environments within the community. From the external environments, the green tower was divided into three–four parts, which have the independent community, and the communal landscaped terraces span the sunlit slot to stimulate impromptu social interactions between residents. Creating outdoor spaces, such as balconies, terraces, or gardens, allows residents to connect with nature, and consider incorporating plants, water features, and other natural elements into these spaces. From the internal environments, offering visual relationships and accessibility with qualitative green areas and support in various ways contact with nature, such as natural materials, ventilation, daylighting, and so on, presenting sustainable and ecological features in the design of the interior environments. For the concept of the green tower, the ambition is to relaunch an aesthetic, sustainable, design-based approach to improve dwelling conditions, trying to implement care into different well-being dimensions—mental, physical, and social.

Figure 3. Visualization of Green Tower from Vancouver Affordable Housing Challenge—BUILDER Competition.

4. Discussion

As we all know, the natural environment is preferred much more than the urban environment or built environment [41,42]. Therefore, the emergence of biophilic design has offered a positive perspective to address the existing conflicts between individuals and the urban environment, providing value and feasibility to urban and architectural design, as well as residential environments. The application of biophilic design enhances the connection between humans and nature by emphasizing biological features, ultimately promoting sustainable health and well-being among residents.

In this paper, we focused on the quality issues of residential environments resulting from rapid urbanization and proposed the direction of biophilic design as an improvement approach for residential buildings, providing a new perspective for future healthy dwelling models. By conducting a comparative analysis between Huaguyuan Residential Community in Guiyang and Baiziwan Residential Community in Beijing, the following conclusions can be drawn: In high-density residential environments, people generally exhibit low satisfaction with their living conditions. This may be attributed to various issues associated with high-density environments, such as excessive plot ratio, inadequate greening rate, monotonous external facades environments, and limited internal living spaces. These factors restrict people's interaction and connection with nature, thereby negatively impacting the quality of the residential experience.

Based on the principles of biophilic design and the WELL Building Standard, taking into consideration the five sensory experiences of individuals in indoor and outdoor spaces, this conclusion focuses on the research of incorporating green elements and nature connection. Firstly, increasing the greenery coverage appropriately and creating diverse landscapes can provide residents with visual pleasure and a sense of relaxation. By utilizing natural features, such as colors, shapes, and textures of plants, an enjoyable visual environment can be created, enhancing the quality of the living experience. Secondly, the appropriate use of tactile elements and selection of suitable materials can offer residents a pleasant and comfortable touch and texture, providing tactile pleasure and comfort. Additionally, by regulating indoor air freshness and quality, unpleasant odors can be avoided, creating a pleasant olfactory environment and improving the quality of living. Moreover, proper interior lighting design that maximizes natural light can create a warm and bright space, meeting people's visual needs and enhancing residential comfort. Lastly, through

sound acoustic design, such as utilizing balcony spaces for planting vegetation to reduce urban noise pollution, a quiet and comfortable environment can be created to fulfill people's auditory perception needs.

According to previous literature, biophilic design has been receiving increasing attention in the global architecture industry [43]. Numerous studies have supported the positive impact of exposure to natural environmental features on human health and well-being [29]. The WELL Building Standard, an architectural rating system, has directly incorporated biophilic design and promoted its adoption worldwide. By enhancing the utilization of natural elements, we can effectively improve residents' satisfaction and comfort in high-density residential environments. Therefore, biophilic design holds significant importance in future residential architecture, providing a fresh perspective and approach to creating healthy and livable housing models.

However, it should be noted that biophilic design still faces some challenges in practical applications. For example, in terms of the external environment of buildings, there is a need for in-depth research and solutions on how to arrange green spaces in high-density urban areas and how to balance the relationship between the building density and greenery ratio. However, it is undeniable that biophilic design can effectively improve the indoor environment. By incorporating features such as natural ventilation, daylighting, courtyard landscapes, natural materials, and nature-inspired elements, it strengthens the connection between humans and nature, thereby enhancing the residents' sense of well-being. In addition, the implementation of biophilic design requires coordination and cooperation with various aspects of urban planning, architectural design, and policy development.

In summary, improving high-density residential environments through biophilic design is a promising and necessary direction. Future research and practice should further explore how to effectively integrate natural elements while considering social, economic, and environmental factors to create healthier and more sustainable living environments. Taking the human senses as a starting point offers a new perspective for understanding the development of future healthy homes and creating human-centered living spaces.

5. Conclusions

From the emergence of biophilic design to the development of urban housing, we are faced with limitations due to the demands of societal progress, preventing us from fully returning to a completely natural way of living or replicating nature within cities. However, we can employ artificial environmental design methods that harness the benefits of nature to create a healthier and more natural living environment. In the face of increasing urban population and housing density, as well as the challenges of a post-pandemic era, the regeneration and enhancement of nature have become perpetual topics. Biophilic design offers a hopeful direction for improving high-density environments, emphasizing the need for daily human interaction with nature. Cities should no longer be barriers that isolate us from nature, but should instead be integrated and harmonized with it.

This paper, guided by a people-centric design philosophy and centered on human sensory experiences, paves the way for the development of future healthy homes, creating spaces that enhance overall well-being and prioritize human needs. When confronted with the challenges of urbanization and population growth, we must integrate biophilic design principles with practical considerations to create solutions that are adaptable to diverse urban environments. Therefore, biophilic design is not only a powerful strategy for improving high-density urban living environments, but also a crucial direction for establishing a harmonious coexistence with nature in urban development. Future research and practice should further promote the application and development of biophilic design to create healthier, more sustainable living environments that enhance residents' quality of life and residential experiences.

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