



## *A Progressive Checklist to Create Design Solutions in Buildings Through Biophilia Design Post-Coronavirus*

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### **Abstract**

The current modern lifestyle increases separation from nature. It negatively affects human health, productivity, and well-being. The world is presently at a pivotal stage with this universal epidemic to recognize the relationship value between the built environment, nature, and man. Therefore, the research adopted the biophilic approach in design to bridge this gap, restore this relationship, and treat the harmful isolation effects of the coronavirus. Hence, the concept and role of biophilia in healing, increasing productivity, and reviving the built environment, were investigated. An urban and another architectural project, which adopted the biophilia design besides its latest measurements of influencing users in the classifications of projects and its reliance on the three sustainable bio-design levels, were presented and analyzed. The most significant features of environments that embrace activities were collected to evaluate and enhance them within any environment. This approach has categories and patterns and is measured and assessed by three rating systems. Accordingly, a checklist was established as a designer's guideline to accomplish the biophilic approach. Furthermore, a formulated progressive evaluation model was to execute this checklist, proceed, and sequence across its nine objectives and three levels for attaining this approach, thus connecting man with the natural environment.

**Keywords:** Natural Environment; Bio-design; Human; Biophilic; Rating Systems.

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## 1. Introduction

Belonging to nature and the rest of the living creatures distinguishes man; on the other hand, the philosophy of nature explains human existence [1], [2]. The earliest human buildings used natural patterns in animal formations, such as the Egyptian Sphinx, or plant formations, such as the capitals of Greek temples and the Rococo style. Also, using nature was in homes and public spaces. Famous examples are the garden courtyards of the Alhambra in Spain, papyrus basins in the homes of Egyptian nobles, porcelain aquariums in ancient China, and the medieval cottage garden in Germany; in addition, the nature-inspired Art Nouveau designs of the late nineteenth century and the designs of Sullivan, Frank Lloyd Wright, and Le Corbusier [3]. Hence, the concept of the biophilia design emerged.

Recently, research studies addressed connecting with the natural environment or using nature to increase people's connection with life in the fields of health care, the workplace, education, childcare, nurseries, prisons, and other places to discuss the primary benefits to physical and mental health [4], [5]. Existing evidence refers to the connection with nature and its colors, shapes, and patterns that have tangible and measurable effects on human health, cognitive function, and physical and emotional well-being. However, a few scholars and designers have proposed a viable and practical toolkit for designing a building using biophilic approach principles [6]–[8]. Before the corona pandemic, there were ongoing debates about how humans are happy in spaces of life and work; biophilia design was one of the few concepts considered due to its positive effects on human health and environmental responsibility [9].

Due to the global pandemic, the world is at a pivotal stage to be recognized the relationship value between the built environment, nature, and man, besides its reflection on health. The importance of integrating the biophilia design as bio-design has a basic philosophy to create a better reality for future living and working places to maintain man's health and well-being and the buildings' prosperity [4], [7]. So, this is the perfect time to exploit the natural power around us by reviving the balance between humans and nature [10]. After the coronavirus, there will be certain inevitable future transformations in the design of buildings that are lived, learned, and worked within.

Hence, the need to shift to new concepts for designing healthy buildings that combat diseases and enhance health, well-being, and a sense of safety for their occupants can be trusted. Also, these new concepts support connectivity and communication with nature and the human experience at all standards and levels of life to provide opportunities to live and work in healthy places. The designers have started to come up with thoughts and quick solutions to ensure the safety of users in all types of buildings and prevent the spread of disease [11]. Humans should design and construct buildings in a better way. They end up in better cities, so why not do it by embracing and contacting nature? The main driving force behind numerous new creations always is the search for solutions to keep pace with society's aspirations and current circumstances.

Undoubtedly, under these exceptional circumstances in which the world is living, users need new creative solutions to design where they live and work. A design that reconnects its occupants with nature becomes more important than ever to provide a work environment that enhances their health, well-being, and productivity that is affected by the quality of the internal environments lived and worked as a long period is spent in these environments. Adopting biophilia strategies is more than just applying techniques or scientific methodology. Effectively using it depends on adopting a new awareness of nature. The designer, in his design, proceeds from a thought that believes in the importance of focusing on physical and mental health and adopting it as a lifestyle, starting from the home to all the places visited and daily life activities practiced.

## **2. Research Problem**

The effect of the emerging coronavirus was not only restricted to human health but also affected all life forms. Social distancing was mandatory, so remotely doing everything became the predominant nature of work, meetings, education, delivering services, and contacting friends and relatives. Consequently, leaving the house decreased, and isolation and separation from the natural environment increased. The post-Corona era accompanied an increase in anxiety and stress. Therefore, the need for direct contact with real-life forms and nature appears, rather than the bleak alternatives that man sees today in many architectural works. Today, with increasing population density in cities compared to the countryside, most modern designs stay far from any connection with nature; accordingly, the importance of applying biophilia designs arises in future architecture [3]. This obligatory trend emerged in response to technological advancement, applications, diseases, and calls for globalization in future architectural projects that would separate man from his natural environment and create an imbalance between humans and nature.

## **3. The Aim of Research and Objectives**

The research aims to build, equip, prepare, and qualify the built environments utilizing the biophilia design approach so that the human being can communicate with nature and its various manifestations because of its strong positive effects on health, well-being, productivity, and virus resistance. The following objectives can achieve this aim:

1. To clarify the concept and role of biophilia and investigate the clinical evidence within societies and different classifications of buildings concerning recovering healthy and psychologically and raising productivity;
2. To emphasize the biophilia design approach has patterns and categories as a sustainable bio-design making unique environments, especially with the corona pandemic consequences, and to cite and be guided by the three rating systems focusing on the biophilic approach; and

3. To set and establish a checklist to generate design solutions and be the guideline for a designer, along with a proposed progressive evaluation model that comprehensively attains such a checklist.

#### **4. Methodology**

The research employed the inductive-analytical approach to study and examine the biophilia concept, its genesis, and its role in societies for healthy and psychological recovery and productivity. Also, it analyzed two examples: an urban example and another architectural example adopting biophilia design. Accordingly, the actual examples of its effects on users were highlighted and explained according to the clinical evidence within different classifications of projects, such as housing, hospital, school, hotel, and administrative buildings. These classifications illustrated that biophilia develops and grows through the three sustainable bio-design levels. As a result, the significant measurable advantages to physical and psychological health were demonstrated and verified by limiting the harmful effects of coronavirus and long-term isolation in such environments.

The study used the analytical approach to investigate and interpret the biophilia design approach as the third level of sustainable bio-design, besides collecting and inventorying the most significant features and elements of the environments embracing life activities. The roles of three building rating systems that integrate biophilia design into their classification systems were clarified and explained: LEED, WELL Building Certification, and Living Building Challenge (LBC) through benchmarks, procedures, and nine significant mutual objectives. They focus on man's health, well-being, productivity in the built environment, and reconnecting him with the natural environment.

The research utilized the deductive approach to create a checklist for implementing and integrating the principles and patterns of biophilia design in projects. It includes a group of design strategies and mechanisms to illustrate and present examples around the fourteen patterns and the three categories of the biophilic approach as a guideline for a designer through examining and analyzing previous studies. Accordingly, the study proposed the progressive evaluation model to implement, proceed, and sequence this checklist across the nine significant mutual objectives of the three rating systems for advancing and appraising step by step. Thus, fulfilling and enhancing the biophilia design through the three fundamental levels of sustainable bio-design reaches the biophilic approach at the third level. Hence, a design reconnecting its occupants to nature and providing an environment that supports health, well-being, productivity, and prosperity becomes more significant, accredited, and reliable than earlier.

##### **4.1. The Concept of Biophilia**

The term "biophilia" means the desired inborn communication with nature. "Bio" is a prefix indicating life or living in the ancient Greek language; "philia" is a suffix indicating familiarity, friendly feeling or attitude toward, or inclination [12]. Biophilia means

reconnecting humans with nature within the built environment, and biophilia design plays a fundamental role in ensuring a healthy place to live and work [1], [5]. The Babylonians are considered the first to have embodied it in the architecture of the Hanging Gardens [8]. However, the biophilia theory was put forward for the first time in the 20th century by the American biologist Edward Wilson who talked about human being biologically predisposed to connect with nature. Firstly, Social psychologist Eric Fromm introduced biophilia in his 1964 book, *The Heart of the Man* [6]. Eric meant the human tendency toward nature and landscapes. This term was subsequently published by biologist Edward O. Wilson in 1984 and included in his book *The Biophilia Hypothesis* in 1993. Wilson's hypothesis confirmed that humans need this connection just as much as their need nutrients and oxygen for their metabolism [4], [7]. The biophilia hypothesis explains why a view of a natural garden can enhance creativity, why shadows and heights give a sense of fascination, and why there are therapeutic benefits to accompanying animals and strolling in the garden. Also, why do humans prefer urban parks and buildings to others? Diverse evidence has evolved from biology and psychology to neuroscience, endocrinology, and architecture; they all relate to the desire to connect with nature and natural systems [3].

When trying to understand the meaning of biophilia design, it is biological design, bio-design, or a particularly flourishing natural experience of being encompassed by living things. It is certainly not only regarding using plants but also more complicated when various elements are employed to create a biophilic approach that represents nature without depending on plants [13]. Man evolves in nature due to the recognition ease with which its components. Biophilic strategies are, in some ways, simple to implement, even for retrofit and rehabilitation [6]. Nowadays, our connection to nature is becoming more evident and desirable. Considered recommendations by researchers are a model to make spaces healthier. For example, to avoid the spread of the coronavirus, cities like New York encourage restaurants to use outdoor dining spaces. It remains to be seen whether this is a permanent change or a temporary repair. However, natural ventilation mitigates the effect of existing viruses in the air. Exposure to outdoor air and daylight is the way to communicate with nature; they provide timely signals concerning transformations in the climate and the diversity of smells and ecological systems. An important question arises: how does biophilia design help humans psychologically and healthily?

#### **4.2. The Role of Biophilia in Societies to Heal and Raise Productivity**

During looking at any community, for example, if its occupants live next to open green spaces. They possess fewer social and health crises regardless of the circumstances of wealth and education, whether it is an urban or rural area [14]. Higher-quality societies also have a more positive evaluation of nature, a higher quality of life, and a strong sense of belonging. Among the urban examples in which the biophilia design was the Punggol Residential Neighborhood, as in **Fig. 1**, which uses a series of lush terraced gardens oriented

toward the watercourse that integrate living nature, wide openings to communicate with nature, daylight, air, colors, plants, and green rooftops.



**Fig. 1.** Residential neighborhood design in Punggol [15].

These help people conserve, restore space fast, and reduce and treat environmental degradation [16]. Because of the measurable physical and psychological benefits to human health, it is more important than ever to incorporate natural elements into the workplace and avoid isolating the indoor environment from nature.

#### **4.3. Measuring the Biophilia Design Effects on Users within Different Classifications of Projects**

According to numerous clinical evidence, living in such an environment, emotionally and biologically, can strengthen the internal nervous system and the immune system, especially in people suffering from diseases and health disorders [7]. Inside a room with a window overlooking a green area aids in the recovery process of hospitalized patients [6]. Also, plants and other manifestations of nature that are thoughtfully in the same room can play the same role and more. Thus, the biophilic bio-design can reduce stress and fatigue, lower systolic blood pressure and pulse rate, improve overall immune functions, cognitive and creativity, and regulate emotion and mood [8]. One of the architectural applying examples of the biophilia design was the hidden garden behind the concrete wall in office spaces, as in **Fig. 2**, to permeate and integrate living nature, curved offices, daylight, air, plants, daylight, materials, and colors that flow into the interior design.



**Fig. 2.** Interior perspective (right) and plan (left) of office spaces [15].

If biophilia is used wrong, it can cause a problem. Mainly, if people look at the patterns constructed by the group of buildings, it was linked to increased headache risk. The more straight lines there are, the more people complain of headaches [17]. The following are the most significant manifestations of biophilia within the various classifications of buildings to conserve and develop it continuously and encourage adding the rest of the categories and patterns of biophilia due to its positive effects and the great benefits are measurable on the physical and psychological health of users:

- Hospitals: studying health care facilities takes a significant interest. Since the eighties of the last century, daylight benefits and the quality of views in hospitals have appeared after surgery [5]. Using fewer painkillers and employing landscapes can reduce stress levels, so imagine these benefits within a hospital or school context. In the context of the coronavirus, some hospitals are investing in biophilia design to provide their employees with a recharge room; thus, they can recover from their long and stressful shifts. Employees can get away from the noise and anxiety in the workplace in the recharge rooms as a space to relax, stretch, and meditate[11].
- Schools: biophilic schools can promote healthy development throughout childhood. Students exposed to nature during learning showed higher concentration and stronger memory [18]. According to the biophilic approach, it is easy for the human brain to process physical features and sensory patterns. In 2019, the performance appraisal of students was in the third through sixth grades [8]. The following observations were in daylight: the annual performance was 20% higher in mathematics and reading tests; the students scored better on the tests when exposed to good natural scenes; and the quality of the scenes is to make a direct line to the outdoors, that is, to check existing the light of day, noticing that time passes, seeing the movement of people, and how life goes on outside. One might associate only high-quality scenery with a pleasant-looking green environment, but sometimes the high-quality scenes are views of the city itself. Wherever the windows, furniture, partitions, or curtains did not distort the admirable perception of colors, daylight, and time.
- Hospitality "hotels": the comparison is between a room overlooking another building or a room overlooking nature, but it will cost 10% more. Generally, utilizing the economic advantage of nature can be in real estate, not only in hospitality, but its increase ranges from 10% to 20% next to natural areas such as parks [19].
- Administrative buildings: in testing the occupants of offices and call centers in the work environment, 201 participants, the daylight and views experiment resulted in larger memory capacity and fewer health complaints. Productivity raised from 10% to 25%; this study of 101 call center workers discovered that the speed of their work increased from 7% to 12%. So, by biophilia design, views, landscapes, daylight, and natural ventilation lead to better performance, lower stress, and higher stimulation. Also, it is associated with less absenteeism from work [4]. Major companies employ biophilia design in their headquarters and offices as Amazon. Its headquarters in Washington is one of the most beautiful applications of such a design approach. It consists of three balls with giant glass

domes and a private garden for gatherings, waterfalls, birds, and 400 categories of plants indoors and outdoors to provide a quiet and appropriate work environment to solve problems and boost productivity. At the same time, companies waste billions each year, hoping to restore lost productivity caused by stress-related illnesses. Biophilia design is reconnecting users with nature and providing opportunities to live and work in places and spaces that are healthier, less stressful, and have better overall health and well-being. So, as revealed, the biophilia design has usefulness for workers' health and performance and the company and work entirely. Most significantly, economic benefits to real estate, hospitality, and marketing.

Based on the concept of biophilia, its role in societies to heal and raise productivity, and its effects on users within different classifications of projects for the biophilic approach to be realized and activated through homogeneity and connection with nature and all its manifestations correctly and not cause harm to either nature or human. The biophilic design approach must develop and grow through the three levels of sustainable bio-design, as in **Table 1**.

**Table 1.** The three levels of sustainable bio-design to attain the biophilic design approach [8], [16], [20].

No.	Level	Concept	Result
<b>First</b>	Environmental preservation	Minimizing the harmful impact on surrounding ecosystems	Preserving energy and materials, paying attention to the health values of the environment, saving resources, and gaining economic vitality and biodiversity
<b>Second</b>	Human health design	Minimizing harmful impacts on health, well-being, and productivity	Improving the work and living environment and maintaining overall health and comfort through temperature, sight, hearing, and smell
<b>Third</b>	Biophilia design approach	Increasing the positive impact of the environment and its manifestations on humans	Paying attention to consolidating the positive relationship of man with nature in the built environment to achieve health, well-being, and productivity

#### 4.4. Biophilia Design Approach

From **Table 1**, many define biophilia design as an approach that can provide a connection to life and its vital processes for our innate needs. It depends on integrating nature and its elements into the indoors and outdoors of urban areas. It creates a permanent connection between architectural projects and nature, leading to the necessary link between humans and the natural environment, besides the innate inclination to search for ways to connect with living systems as life's form [6]. Nature is a powerful tool in architecture; it has

tangible impacts on the human condition, improving physical and psychological health, promoting positive emotions, and reducing negative emotions [8]. In addition, humans spend most of their waking time in living or working environments. There are many opportunities for architects and designers to improve these future environments and their characteristics, as in **Table 2**, by integrating the biophilia design approach principles and incorporating natural elements into buildings to enhance health and well-being, improve worker performance and increase productivity.

**Table 2.** The most significant features of environments that contain life activities [4], [5].

No.	Features	Elements
1	Indoor Air Quality	Pollutants include volatile organic compounds (VOCs), carbon dioxide (CO <sub>2</sub> ), ventilation rate, fresh air, and moisture content.
2	Thermal Comfort	Indoor air temperature, average temperature, air velocity, relative humidity, and their activity and personal preferences
3	Visual Comfort	Lighting type, quantity, quality, glare, and daylight
4	Auditory Comfort	Background noise, privacy & interference, and vibration
5	Active Interior	Workstation density, existing spaces, work environment, relaxation areas, and social features
6	Look and feel	Design ethos and branding include color, shape, texture, and a design that considers culture, gender, and age.
7	Location and Accessibility	Transportation and the general atmosphere quality
8	Scenery and Biophilia	Connecting to nature and outside Views

After the "biophilia" concept emerged, its supporting evidence increased; also, hundreds of publications revealed distinctive and proper patterns in building design. Biophilia design comprises fourteen patterns classified into three main categories, as in **Table 3**, to achieve a similar connection to nature and create it in architectural spaces [4], [21], [22]. Implementing them across multiple scales and climates demonstrates positive health reactions. So, dynamic spaces can employ more than one pattern and are the most successful in achieving the desired effect [7]. It is worth noting that applying some of these patterns is intuitive; however, others require careful planning and follow-up [2], as will be derived and proposed later in **Table 4** and **Fig. 4**. Thus, biophilia design becomes more common in contemporary architectural projects. As shown in **Fig. 1**, the building incorporates green facades and roofs, glass partitions separating internal and external natural spaces, and natural plant elements [15]. Attempting to provide a suitable habitat for humans as living beings in a natural environment brings many benefits; furthermore, applying bio-design strategies and connecting humans with nature improves the habitability of spaces. It can be converted into renewable and

inspiring places to improve health, productivity, and learning ability, optimize relationships and enhance psychological comfort sense, happiness, and harmony [7]. As shown in **Fig. 2**, adapting to interior spaces in biophilia design is another point reinforced by the epidemic to ensure suitable working spaces and proper study. Thus, social isolation and intense internet activity have affected everyone's well-being, while daylight and colors that are abundant in nature help humans relax and focus [3]. Therefore, biophilia design should become a core strategy to evaluate and assess design for any designer who seeks to make people and their surroundings healthier, happier, prosperous, and more productive during their daily activities.

#### **4.5. Rating Systems for Biophilia Design**

Three rating systems (LEED, WELL Building Certification, and Living Building Challenge (LBC)) have been developed to assess, support, and evaluate biophilia design inside buildings. They are innovative green building certifications focusing on human health and wellness in the built environment. Using scientific data supports biophilia where the results were consistent and valuable even before including the biophilic approach; they all cite benchmarks and procedures regarding sustainable construction and the inherent tendency to associate with nature:

- LEED has a trial credit that addresses strategies that combine people and nature; it is the building's certificate of sustainability and luxury;
- The credit for WELL certification requires a qualitative assessment of the design to guarantee a vital life in a predetermined condition. The WELL consists of ten indicators: air, water, nutrition, light, movement, thermal comfort, sound, materials, mind, and society. That means designers should at least describe how to add biophilia features to the project. Three certification levels are silver, gold, and platinum, which vary in fulfilling the criteria. The actual level is specified during the performance verification process that all projects must pass before getting the certification. The certification includes biophilia on two scales: one and two. Biophilia one is a more qualitative approach to biophilia design, while Biophilia two is on a quantitative scale; and
- The International Living Future Institute (ILFI) awards the Living Building Challenge Certificate (LBC). It is the most stringent green building standard in the world. LBC has a set of performance criteria, namely site, water, energy, health, happiness, materials, justice, and beauty; all are divided into several prerequisites and incorporate the biophilia design to promote productivity and well-being within the built environment.

All three of these certificates focus on the biophilia design requirements in its three categories and the fourteen patterns of the biophilia design through nine significant objectives as in **Fig. 3**. Thus, in this regard, the LBC is the most comprehensive certification.

<b>The significant objectives of the three rating systems aim to integrate the biophilic approach into them.</b>	To employ the ecosystem concept.
	To follow the concept of green design and set it as standards of LEED, WELL, and LBC.
	To achieve health, well-being, productivity, and harmony with nature.
	To support and improve residential and work areas toward interaction with nature.
	To take advantage of natural light and air movement.
	To utilize plants in planning and design.
	To care for planting roofs and landscaping.
	To interest in natural materials.
	To avoid away from sources of electromagnetic pollution, carbon emissions, volatile substances, and radioactive materials.

**Fig. 3.** The nine significant objectives enhancing the biophilic approach within the three rating systems.

The Living Building Institute promotes biophilia not with LBC certification, LEED, or WELL; but by advancing knowledge and supporting designers to make knowledge and understanding of the sustainable biophilic approach easier to apply to all cases all over the world. Such that encourages and pushes designers to find or formulate mechanisms, strategies, checklists, or models to activate and utilize the biophilia around us.

#### **4.6. A Checklist for Implementing Biophilic Approach in Buildings and Projects**

From the above, it is possible to set and establish a checklist that includes a set of strategies, mechanisms, and design considerations by examining and analyzing previous studies. This checklist aims to explain and provide design considerations, implementation strategies, and examples of the fourteen patterns and the three categories for achieving and activating the biophilic approach. Also, generating design solutions and guiding a designer to assess and review; as shown in **Table 3**, this checklist has the following aims:

1. To ensure the achievement of biophilia design approach patterns and to encourage their implementation in various buildings and projects;
2. To support and enhance the three biophilia categories in designing and equipping built environments by connecting them to the natural environment, whether inside or around them. For a man to connect to nature and all its various manifestations within these advanced built environments to optimize health, well-being, users' comfort, productivity, and mood;
3. To decrease and treat the harmful effects of living in such environments for long periods, like what happened during periods of home isolation in the emerging corona pandemic;

4. To reconnect, coexist with the nature around him once again, and improve the spatial experience to eliminate depression, boredom, monotony, narrowness, and disunity; and
5. To provide sustainable, healthy, safe environments that resist viruses, diseases, and epidemics and enhance the users' health, well-being, and productivity.

**Table 3.** The checklist to achieve and activate the biophilic approach [4]–[7], [23].

Category	Pattern	Design Considerations	Implementation Strategies
<b>Biomorphic shapes and patterns by using symbolism and mimicking natural formations</b>	Shapes and patterns borrowed from nature - symbolic signs of arrangements: contour, inscriptions, decorations, numerical.	Borrowing nature and design elements that mimic nature in a way: To bring users into contact with nature; To create a visually favorable work environment that enhances cognitive performance; and To help reduce stress while avoiding overdoing it.	To utilize lines, shapes, and living and organic simulation in landscaping the site and designing functional elements such as fences and gates that have the forms of nature; To design the outer cover, openings, and balconies with shapes and blocks inspired by nature; and To innovate forms that simulate nature in the interior design elements.
	Physical connection with nature, such as materials and elements of nature that reflect, through minimal processing, the local environment or geology and create a distinct sense of place	To investigate the properties of natural materials and treatments for use in structures or as decorative elements in spaces where the user feels more comfortable and calmer than when using manufactured materials; and To utilize the golden ratio originally comes from nature and achieves optimum visual pleasure.	To use natural materials such as wood and stones in coordination with the external environment; To utilize natural materials in the facades, with minimal processing to reflect the surrounding environment of a building; and To employ natural materials and colors while considering their variety in interior space and furniture design.
	Complexity and order, rich sensory information related to	To magnify sensory information about the sequence and formation that mimics nature by relying on	To use parametric organic and geometric shapes in the elements of the external environment;

	spatial sequences like those found in nature, give a sense of attractiveness and immersion in the details.	geometric patterns while achieving a balance between complexity and order; and To use algorithms based on computer design applications to create organizational designs quickly and accurately.	To employ broken geometric shapes in facades and hierarchical openings; and To use the vivid, organic, and geometric shapes in the spaces and the functional elements, such as the structural columns and the geometric pattern repeated in a rhythmic system, and the decorative elements.
<b>Using materials derived from nature evokes the local environment .</b>	Visual contact with nature.	To promote natural views and consider the elements of nature, living systems, and processes.	To give priority to real nature and biodiversity over simulated nature; and To employ windows that can open to allow visual and non-visual communication.
	Non-visual contact with nature.	It is caused by other senses, such as auditory, tactile, or olfactory stimuli, which generate positive signals to nature, living systems, or natural processes.	To be a design in harmony with the natural terrain of the land; and To be layout spaces to reinforce view lines desired for visual access to nature.
	Irregular and transient sensory contact with nature can happen randomly and unexpectedly.	Unexpected movements that occur in nature help: To maintain focus; To regain attention; and To stimulate clarity, vitality, and dynamism.	To cultivate as many plants and trees as possible on the site; and To enhance the connection between the inside and outside through efficient building envelope design to create a multi-sensory experience.
Thermal changes and airflow.	To mimic natural environments by simulating and making slight changes in air temperature, relative humidity, airflow across the building	To support users' ability to control and modify the thermal conditions of their environment; To be the responsive design of the envelope to enhance daylight and attract fresh air; and	

	<p>envelope, and surface temperatures; and To design the environment with what allows users to experience changes in temperature and airflow to control temperature, lighting, and airflow settings to realize thermal comfort and thus improve the spatial experience.</p>	<p>Incorporating light, natural ventilation, and water into the spaces of daily activities is essential to support the unseen experience.</p>
<p>The presence of water is a state that enhances the experience of a place through seeing, hearing, or touching the water.</p>	<p>Designers can control the feel of water in space by: Adjust liquidity and volume; Sound and turbulence; and Users can access it.</p>	<p>To use natural or artificial fountains, waterfalls, and pools on the site; and To provide green internal courtyards, water bodies, and dynamic natural lighting.</p>
<p>Moving and scattered light creates constantly changing shadows over time, like what happens in nature.</p>	<p>The dense penetration of sunlight is not preferred. A balance must be struck between regular and dynamic light distribution through shading facades and using an indoor courtyard to allow light with variable levels to scatter.</p>	<p>To increase the surface area of treated glass in facades (self-shading); and To shade the openings with intelligent methods to activate techniques for tracking the sun's path.</p>
<p>Connecting with the natural system is a healthy ecosystem through awareness of the seasonal</p>	<p>To integrate with the natural systems through natural scenes; and Within the envelope, incorporate a design that is responsive to changes in the outdoor environment.</p>	<p>To plant the facades and roofs of buildings as an ecosystem and not just a decorative garden; and To be the activity areas next to the windows to see the natural elements outside.</p>

	natural processes.		
<b>The complexity and hierarchy in the spaces mimic those found in nature.</b>	A landscape or an unobstructed landscape is at a sufficient distance for observation and planning.	Looking at a distant view of the horizon from where daily activities enable: To lower the level of stress and boredom; To provide a feeling of comfort and liberation; and To enhance focus and awareness among employees.	To be the design linked to or around an ecosystem that helps to enrich the information about the horizon; To make the plans more accessible by removing visual barriers when designing workstations and spaces and using partitions at a height that allows the seated person to extend their vision; To orient the buildings to help improve visual access to external views where the glass facades, external and internal walls, and staircases provide a good double vision of the horizon; and To provide some windows with low and wide seating to sit on.
	A place to withdraw from environmental conditions as a shelter, to practice activities like work, rest, or recovery, either alone or with a small group of people.	To provide separate and safe spaces for living, resting, or contemplating through some design considerations: To cover the work area from behind, where people tend to feel safe and protected, and To feel covering from above is the second priority to reaching this feeling.	Providing seating areas, covered walkways, kiosks, pergolas, and umbrellas are safe places to feel contained and provide privacy, isolation, and protection from the climate. Separate workspaces with low ceilings are used as safe havens to meet various needs; and Its dimensions differ according to the use way of it, and its lighting is different compared to the adjacent open spaces for the user to control over them.
	Mystery and suspense by partially obscured	Ambiguity involves movement and analysis and requires:	To hide outdoor scene parts to prompt the user to expect the actual scene and explore the

views or other sensory devices encourage immersion in the environment.	To travel from one location to another to explore it; To comprehend space to provide an environment that encourages exploration in a way that supports stress reduction and cognitive recovery; and To employ this style in motion paths, driveways, and interior courtyards.	elements of the external environment; To vary shades and shadows to enhance a constantly changing work environment and a sense of mystery; also, paths and corridors are more effective in stimulating movement; and The windows that overlook public areas where the activity is constantly changing; will be more effective in creating a sense of ambiguity in the workplace, as it includes fresh content or information.
Risk is the presence of an implicit threat coupled with a trusted guarantee that one feels might be dangerous but exciting and worth exploring.	A sense of danger combined with an element of safety helps to: Arouse attention and curiosity, and update memory and problem-solving skills; and It is possible to incorporate different degrees of risk into the design depending on the user and the available spaces, such as the employed elements that inspire falling, the risk of moistening, or losing control.	The winding paths and slopes are safe across plants, rocks, and ponds, allowing an exciting experience of intentional hazards; To provide a sense of risk, interest, and excitement through columns, balconies, and transparent facades to explore; and The inner courtyards are double-height, with terraces and movement corridors on different levels overlooking them.

#### 4.7. A Proposed Progressive Evaluation Model to Achieve Biophilia Design at The Third Level of The Sustainable Bio-Design

To be executed the previous checklist, as shown in **Table 3**, for achieving and activating the fourteen types and three categories of the biophilic approach as the guideline for a designer to generate design proposals of built environments and spaces. By sequencing across the basic levels of the sustainable bio-design toward the biophilic approach in the third level:

1. The first level reduces or treats the harmful effects on the environment to preserve and develop it;

2. The second level minimizes and treats the harmful effects of the environment on human health; and
3. The third level enhances the positive effects of the environment on man, which is the stage of the authentic realization of the biophilic approach by reconnecting man to the natural environment and making full use of nature.

Consequently, to achieve the sustainable design concept that harmonizes with nature is by progressing and sequencing the nine significant mutual objectives of the three rating systems. These objectives enhance the biophilic approach, as shown previously in **Fig. 3**. Then, advancing, proceeding across realizing the three levels, as in **Table 4**, and optimizing human health, well-being, and productivity. All of that was incorporated and structured in the following progressive evaluation model, in **Fig. 4**, to achieve the biophilic approach at the third level of sustainable bio-design.

**Table 4.** The sustainable bio-design levels and the biophilia design approach at the third level.

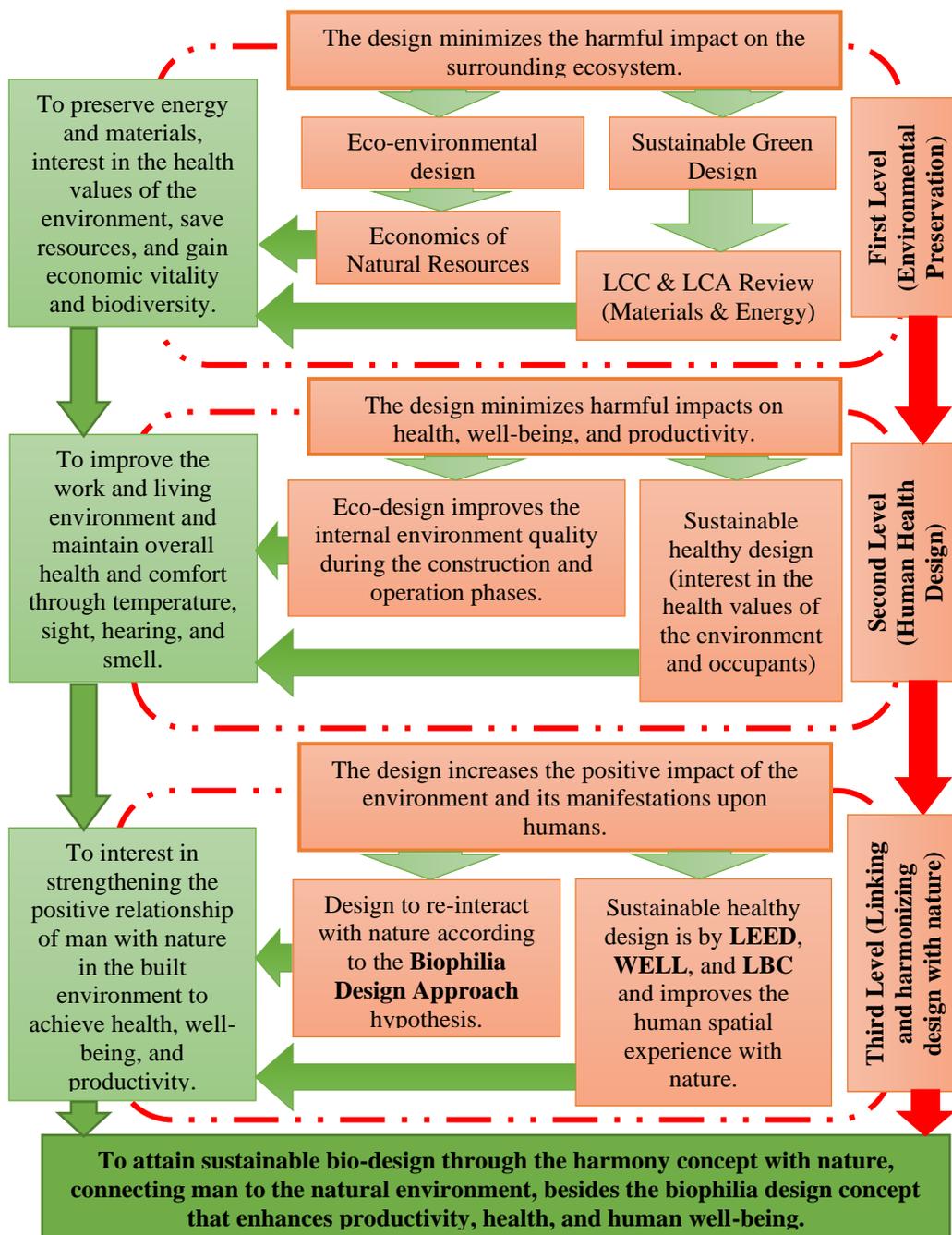
<b>The mutual objective of the three rating systems</b>	<b>The three levels of sustainable bio-design</b>		
	<b>First Level</b>	<b>Second Level</b>	<b>Third Level</b>
<b>Employ the ecosystem concept.</b>	To minimize the negative impact on the environment by simulating ecosystems during recycling materials and energies without pollution or waste.	To seek to reduce or treat the negative impact on human health by studying the mutual influence between human activities and the structure, which is called the ecology of the building.	To strive to achieve a positive environmental impact on human health and well-being by studying the relationship between humans, the environment, and nature, as the elements and the human ecological label.

<b>Follow the concept of green design and set it as standards of LEED, WELL, and LBC.</b>	To design using green energies, such as wind and solar energies, and materials, which have little impact on the environment, such as natural materials, permanent harvested materials, and materials that emit low gases, and use energy in a manner that meets all (LEED-WELL- LBC).	To employ the healthy green concept for the occupants by paying attention to the indoor environment quality and the air quality affecting the occupants' health. Directing (LEED- WELL- LBC) standards toward air quality, ionization rates, and the air is free of volatile organic compounds when providing comfort factors and reducing exposure to electromagnetic radiation.	To use the concept of "beyond the green" to establish fundamental values of nature in human comfort and well-being by imparting these values directly, indirectly, or symbolically to enhance the human relationship with nature and consider it standard within (LEED-WELL-LBC).
<b>Achieve health, well-being, productivity, and harmony with nature.</b>	To pay attention to the economy of resources and energies, their conservation and recycling, and the preservation of nature.	To improve the work and home environment and maintain human health and well-being.	To interact with nature and combat stress and anxiety.
<b>Support and improve residential and work areas toward interaction with nature.</b>	To develop places and spaces in a way that preserves the biodiversity and natural features in the region while employing means of self-sufficiency in sustainable energies and resources.	To develop places and spaces on open sites in a free, loose, and intertwined manner with green spaces sufficient to provide oxygen and the ionic level necessary for human health and well-being. One of the most comfortable design procedures is to put the residential areas away from the industrial centers and the main roads to minimize the noise.	To provide open spaces and views of the natural landmarks to consolidate the relationship with nature. To design places in the external environments for people to resort to after periods of stress and anxiety.

<b>Take advantage of natural light and air movement.</b>	To employ sunlight and air movement to generate energy as inexhaustible sources with zero pollution impact on the environment.	To use natural light and ventilation as important bases in healthy design. The effect of natural light upon melatonin is required to balance metabolic processes. To increase activity with the importance of air movement in restoring the proportions of air containment of gases O <sub>2</sub> , CO <sub>2</sub> , and the ratios of ions necessary for human health and well-being.	To use and employ natural lighting and ventilation as essential foundations in design due to the inherent human nature in interaction and closeness to the values of nature and their significant impact on the sense of well-being and improving performance.
<b>Employ plants in planning and design.</b>	To preserve the indigenous plants of the area and forests, conserve biological diversity, and employ them as essential elements in the design.	To preserve an area's indigenous plants and forests, conserve biological diversity, and use them as essential design elements.	In a design, employing plants strengthens relationships between man and nature and reduces exhaustion and stress.
<b>Care for planting roofs and landscaping.</b>	They contribute to reducing the energy consumed due to their role in lowering the surface temperature.	To contribute to preventing and absorbing sound and absorbing toxic gases.	To contribute to promoting the human relationship with the environment.
<b>Pay attention to natural materials.</b>	To preserve natural materials and work to recycle them.	To employ natural materials, such as wood, clay, straw, and finish materials for maintaining the balance of moisture and heat and release negative ions into the environment that are important for human health and comfort.	To employ natural materials such as wood, clay, and stone within the design to strengthen the relationship of humans with the environment and nature.

<b>Avoid sources of electromagnetic pollution, carbon emissions, volatile substances, and radioactive materials.</b>	To keep away from sources of pollution, emissions, and radioactive as much as possible.	To keep away from pollution sources during the housing planning process and choose them away from mobile phone towers. Take an interest in investigating electromagnetic pollution and emissions from their origins to avoid its harmful effects on human health.	Bio-electromagnetic balance and global warming treatment are essential in the human sense of harmony, comfort, and well-being in the surroundings and are significant in environmental parameters to reduce stress and diseases.
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Sustainable bio-design seeks to harmonize with nature through its proposals, concepts, and directions to meet sustainability aspects. At level one, sustainable bio-design propositions relied on ecology conceptions, sustainability, and green. The emphasis was on reducing energy consumption and recycling resources through life cycle cost (LCC) and life cycle assessment (LCA) to preserve the environment. Then at level two, sustainable bio-design is interested in design values seeking to care for human health and the performance of a building, especially after diagnosing the manifestations of ill buildings. Finally, at level three, sustainable design proposals seek to activate the positive impact of the environment on human productivity, welfare, and health by studying natural systems and their effects. Thus, sophisticating sustainable green design concepts to more values toward fundamental human values take another name, represented by bio and biophilia design.



**Fig. 4.** The proposed progressive evaluation model attaining the biophilic approach at the third level.

## 5. Results and discussion

Biophilia design is one of the most important future directions for designing places to live and work during daily-life activities in a post-coronavirus world. Its influential role causes it to improve the building's defense against diseases, provide a safe and healthy work environment, achieve future flexibility and adaptability, and integrate it into future workplaces. Biophilia will be the key to achieving high-quality, safe work environments that face risks, enhance health, well-being, and productivity, and increase user satisfaction. Thus, strategies stand out in creating natural environments around us and integrating them with health procedures to support our immune and respiratory systems. Furthermore, introducing habits promotes the ability to recover as a vital factor and an urgent need in a health crisis world [11], [24].

The study established a checklist, as in **Table 3**, which works to incorporate the principles and patterns and the fourteen patterns of biophilia design into buildings and spaces by developing and making a set of design considerations and implementation strategies necessary to achieve each of them. Thus, a human recovers his lost relationship with nature and improves his spatial experiment within it by activating the proposed progressive evaluation model, as in **Fig. 4**, to sequence toward a comprehensive biophilia design. Built environments become eligible for long-term living and enhance health, well-being, and productivity. Depending on the nine significant mutual objectives drawn from the three rating systems and the progressive levels to achieve them, as in **Table 4**, by sequencing across the three fundamental levels of the sustainable bio-design toward biophilia as the connecting and harmonious design with nature; in the third level.

This epidemic demonstrated the importance of connecting with nature and integrating natural elements into all built environments having the most significant features to embrace life activities, as shown in **Table 2**. The study classified the basic sustainable bio-design ideas into three levels, as shown in **Table 1**. The first level treats the harmful effects on the environment to preserve it and the potential for developing it. The second level reduces dangerous consequences on human health. The third level improves the positive effects of the environment on humans. As shown in **Fig. 3**, these three levels represent the basis for comprehensively accomplishing all nine mutual objectives of the three rating systems (LBC – WELL - LEED). These objectives focus on biophilia so that utilizing the three categories and fourteen patterns is not random but in a way that fulfills green architecture and sustainability. These objectives support and guide a designer and make biophilia in different classifications of projects approved and consistent with the most significant international rating systems.

The third level is the stage of the factual realization of the biophilia design approach by reconnecting man with the natural environment and achieving maximum benefit. The sustainable bio-design concept rises toward harmonizing with nature by incorporating the three levels. Furthermore, proceeding across the comprehensiveness concept by the sustainability pillars and enhancing human health, well-being, and productivity in the

proposed progressive evaluation model, as in **Fig. 4**, to sequence toward the biophilia design at the third level.

The biophilia design depends on the potential to stimulate self-healing by employing restorative environments that recover the positive mood to maintain and boost health and reduce or treat stress and psychological pressures. The surrounding physical and social environment will support this in two ways:

To be interested in the physical and social requirements of the human being; and

To emphasize the qualities of the natural environment that promote a faster, more complete positive recovery process and allow people to relax and release their minds away from the usual stressful aspects of life. The four main aspects illustrate healthful, restorative environments [5], [6], [13], [18]:

1. Escape: refers to the ability to get away from some stressors and stresses to find an environment for mental and physical comfort without getting bored;
2. Connection and Extent: refer to the individual's association with the surrounding environment and its distinction by extending beyond that to communicate continuously;
3. Fascination: indirect attention stimulates fascination that requires no effort, as when something interesting happens, an individual looks at it and discovers what is going on. It is considered one of the most important factors; it enhances attention and perception without directing it and not feeling bored; and occurs through some natural features, such as natural lighting, water elements, and green spaces; and
4. Compatibility: it is creating environments that align with individuals' inclinations to foster a sense of fascination. As a result, the determination aspects of restorative environments are incorporated into their design considerations to construct their study framework. A new design approach for the built-environment spaces in the context of health and well-being is needed. Accordingly, some design methods emerged that conserve the restorative environmental design that supports health in a way that achieves serenity and psychological comfort for its occupants.

Numerous research findings confirmed that open external spaces have restorative possibilities and are more crucial today than before as a critical element in achieving a healthy environment. They have a psychological impact on the person who uses or visits them. Furthermore, studies and research have emphasized the importance of achieving a healthy envelope generated by the natural environment around humans because the natural environment has a wide range of benefits for human development and growth. Likewise, it

helps in mental relaxation and avoids stress and psychological pressure. So, the natural environment is valuable to man's mental health [6], [10], [18], [20], [25].

The biophilia design conception emanated from the idea that humanity has a contact syndrome with nature. It appears in the core six design elements: environmental features; natural forms, models, patterns, and processes; light; space; the primary relationship to place; and man's relationship with nature. It connects two fundamental dimensions of the nature-associating design: organic and surrounding local, through the six elements to codify the restorative ecological design as a necessary attempt [3], [4], [22].

Bio-design is a new sustainable scope in design studies that includes the realistic features of living or once-living creatures and their processes. Besides, when it comes to working with living organisms, reallocating them into new environments with new attributes is difficult. It can repeat more quickly and precisely. Similarly, devotees of bio-design see it as a way to build things and products that are more sustainable, in which living things grow, reproduce with little energy, replace toxic materials, and integrate with nature [2], [20], [21].

## **6. Conclusions**

The main conclusion was the progressive evaluation model proposed for implementing the checklist established to realize and activate the biophilia design approach in buildings and projects. Accordingly, attaining the sustainable design concept that harmonizes with nature is by progressing and sequencing the nine significant mutual objectives of the three rating systems that enhance the biophilic approach. At the same time, advancing and proceeding across the three levels of sustainable bio-design is toward the biophilia design at the third level. Consequently, the comprehensiveness sustainability concept will be achieved. Also, health, well-being, and human productivity will be optimized. These actions are by bridging the separation gap from nature, restoring this relationship, and treating the harmful isolation effects of the coronavirus. The study developed and formulated the proposed model and the checklist to implement the biophilia design depending on the outputs of the two used approaches to conduct the study. This checklist includes a set of design strategies and considerations, which explains and gives examples of its fourteen patterns and three categories to generate design solutions and be the guideline for a designer to design, build, improve, or equip the built environments through the proposed model from now on.

Accordingly, the study examined the concept, role, and origins of biophilia, which was not only associated with the coronavirus spread but also due to continuous conversations concerning how to make individuals happier in their places of life and work. The concepts of an urban and architectural project to employ biophilia in design, internally and externally, were presented and analyzed. Biophilia was investigated and interpreted as a sustainable bio-design approach. Subsequently, previous measurements of the biophilia design impacts on users were collected and analyzed according to the various classifications of projects.

Thus, biophilia design should become a core strategy for any designer. It has categories and patterns that must develop and grow through the three levels and can be measured and evaluated by the common objectives of the three evaluation systems to be easier in practical application and assessment. Also, entering restorative surroundings as an environment in all types of spaces, buildings, and existing, emerging, and future projects helps in reviving the built environment, mental relaxation, and away from stress and psychological anxieties. It is gradually transitioning toward the comprehensiveness concept in sustainable bio-design, which achieves green rating systems, comprehensive ecological and ecosystems, and resists viruses and epidemics. Now, the world is at a pivotal stage concerning the value of nature's relationship to human life and the built environment. In addition, future design proposals will depend on the significance of integrating the biophilic approach into buildings and design standards for all the diverse elements inside and outside projects, which will be a critical design philosophy to create a better reality currently and in the future.

## 7. List of abbreviations

VOCs: Volatile Organic Compounds

LEED: Leadership in Energy and Environmental Design

WELL: it is a performance-based system for measuring, certifying, and monitoring features of the built environment that impact human health and well-being through the air, water, nourishment, light, fitness, comfort, and mind.

LBC: Living Building Challenge is an international sustainable building certification program created in 2006 by the non-profit International Living Future Institute.

ILFI: International Living Future Institute.

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