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# Bringing Biophilic Architecture into Business Parks Design towards enhancing Users Experience

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**Abstract:** Recently, most people have spent much of their time at work, often in indoor office buildings that are designed without regard to natural elements and workers' well-being. For these reasons, Business Parks are designed to improve the whole workplace environment. Bringing fresh air, green areas, and natural elements into workspaces could enhance the work environment and increase productivity by taking care of workers' physiological needs. On other hand, Biophilic design introduces some principles to create visually beautiful and spiritual places. By merging Architecture with nature and bringing outdoors greenery through indoor areas, a healthy workplace environment could be generated. Therefore, Biophilic design could be a solution towards more relaxed workspaces. Consequently, this study will elaborate a comprehensive framework towards combining principles, attributes, and elements of Biophilic design and design solutions of Business Parks. The study focuses on Business Park as a case study as the trend of Business Park can change the traditional concept of office buildings and reconnect the human with nature again, which lessens stress and negative impacts on health. So that, workers can get a work environment free from stress which will enhance the individuals' well-being. In this context, this paper will analyze international, local offices and Business Parks that were designed upon Biophilic design concepts. Eventually, the novelty aim of this manuscript is to create a contemporary tendency which concerns about blending the Biophilic design concept with Business Parks interior and exterior design spaces to create an efficient and healthy work environment, also to improve the whole users' experience.

**Keywords:** *Biophilic design, Business Parks, Workspaces, Indoor-Outdoor areas*

## I. INTRODUCTION

### 1. Purpose

Modern indoor lifestyles lead to isolation and detachment from nature without exploiting its beneficial effects. Today's lifestyle negatively affects people's physical and mental health, performance, and overall well-being. It has become an important concern to find a new tendency towards linking workers with the surrounding natural environment, Business Parks have appeared to solve this issue. The use of biophilia in workplaces of Business Parks can be seen as an approach to bridge the gap between users and nature, to reconnect people with the environment, and recapture its beneficial effects.

### 2. Research Background

In modern cities, the development of societies depends on their economy [1]. The demand for convenient workplaces becomes a crucial concern [2]. Hence, the appropriate workplaces are the core of advancement in modern

municipalities. As, people spend most of their time at work, approximately one-third of the day [3]. More than 200 years ago, office buildings were firstly appeared, then tall buildings (or skyscrapers) were spreading and increasing quickly [4]. The massive expanding of those buildings causes negatives influences on the psychological health of people and the ecological balance of the environment [2]. Moreover, the current lifestyle and municipal living keep people, especially during working hours, away from the natural world that is supposed to surround them [5].

Since the beginning, humans were always connected to nature in various ways, but the current modern life has detached us from nature. Concurrently, technological advancements have diminished the connection with nature particularly in the indoor spaces. So, by decreasing the natural surroundings of people, the negative impacts on human-being have increased regarding physical, mental health and wellbeing thus affecting the overall daily performance [6]. Nowadays, people spend most of their instance surrounded by walls, concrete, and steel with less connection to greenery and nature, so that the typical office buildings lack the natural spirit [3]. Furthermore, in the Middle East, the results of surveys according to World Green Building Council stated that 42% of workers felt un-productive while 37% felt un-comfort because of office design [3].

Taking the environmental aspects into consideration, become a global demand to mitigate the climate changes that we are facing nowadays. In this context, most of the previous studies ensured that connecting employees with nature and taking environmental factors into design considerations, thus helps to increase productivity and get the best possible results [7]. Therefore, Business Parks have recently occurred all over the world to eliminate the negative impacts of high-rise buildings on employees and the environment. Business Parks can improve workers' wellbeing as they create comfort and relaxation mood, save effort, and make an encouraging place for work.

Re-establishing the natural surroundings in the current society could be a considerable assist to re-join the humans with nature again [6]. Lately, many trials have been done to integrate buildings with nature. Hence, Architects attempted to combine interior workspaces with the outdoor nature through biophilic design concepts. Biophilic design approaches aim to eliminate the gap between urbanization and human needs [5]. The interior environment that fulfils various biophilia elements, which

improve the connection between the human-beings and nature, will enhance the mental, wellbeing, and performance of the targeted users of place [6]. Biophilic design follows some principles to establish beautiful and spiritually healthful places. The biophilia theory depends on the human requirement for correlation with nature and that can contribute to human's wellbeing and better performance [5]. According to Kellert and Calabrese (2015), the successful application of biophilic design enhances comfort, balances blood pressure, ameliorates motivation, improves health, decreases sick building syndrome, and increases productivity [8]. Biophilic architecture has proven its advantages towards helping workers in being more efficient, healthy, and productive [3]. Thus, it becomes crucial to implement biophilic design strategies within the built environment because it can aid to improve the whole in work atmosphere [5].

### 3. Literature Review

This review starts by introducing the term of biophilia, biophilic design and its 14 patterns. Then it considers the application of biophilic design in workspaces. Finally, it focuses on the connection between biophilic design and business parks and merging between them to create healthy and productive workplaces.

#### ▪ From Biophilia Theory to Biophilic Design

The term 'biophilia' was initially conceived by psychologist Erich Fromm in 1973 and biophilia is a tendency to commune with nature. It is the human inclination to associate with nature, even in the recent world, it is crucial to individuals' mental health and wellbeing to affiliate with nature. The theory of biophilia initiates from an understanding of human progression, e.g., more than 99% of nature species that were developed biologically had responded adaptively to natural forces not human-made or artificial ones [8].

Unfortunately, the modern community has constructed many difficulties to the beneficial experience of nature. It is still critical to people's health to contact with the beneficial nature. Despite that, the recent building design considers nature as an obstacle to today's-built environment. So that, it becomes a great gap between persons and nature in the built environment, which is returned in insufficient connection with natural light, vegetation, ventilation, and the general beneficial connection with the nature [8].

Human beings need to have a strong bond with the nature elements in the surrounding environment. In case it is not existing, designers can create it into our daily lives by simulating its elements such as colors, forms, and patterns in designs, this is the main concept of biophilia in design [6]. Biophilic design is the actual application of biophilia theory through green design ideas which meets the human needs of mental health and wellbeing [6].

#### ▪ Biophilic design patterns and experiences

Biophilic design is ordered into three categories – Nature in space, Natural analogues, and Nature of the space. The three categories consist of 14 patterns, as shown in TABLE I, which provide a framework for understanding an effective integration of an intense assortment of strategies into the built environment [9].

#### 1- Nature in Space

Nature in space statements the direct, physical, and transient existence of nature in a place or space [10]. This comprises water, animals, and plant lives plus sounds, smells, breezes, and other elements in nature. The greatest 'Nature in Space' experiences is reached by the formation of direct relationships with the natural elements, especially through diversity and multi-sensory interactions [9]. Most popular examples are the plants in pots, flower patches, birdfeeders, butterfly parks, water features, fountains, aquariums, courtyards, vegetated walls, and green roofs.

TABLE I The 3 categories and 14 patterns of Biophilic design (classified by Kellert, S. and Calabrese, E.)

14 Patterns of Biophilic design		
1- Nature in space	2- Natural analogues	3- Nature of the space
(P1) Visual connection with nature	(P8) Biomorphic Forms and Patterns	(P11) Prospect
(P2) Non-visual connection with nature	(P9) Material Connection with Nature	(P12) Refuge
(P3) Non-rhythmic sensory stimuli	(P10) Complexity and Order	(P13) Mystery
(P4) Thermal & airflow variability		(P14) Risk/Peril
(P5) Presence of water		
(P6) Dynamic & diffuse light		
(P7) Connection with natural systems		

Nature in Space includes seven biophilic design patterns:

(P1) Visual connection with nature

It is meant to concern with viewing elements of nature, living systems, and natural processes [9], [11], as shown in Fig. 1.



Figure 1. Wide, tall windows, and natural colors to achieve visual connection with nature (P1) - IT'S Biophilia Office, Brazil [12]

**(P2) Non-visual connection with nature**

It can be noted in the form of sensory stimuli other than eyes (visual) such as hearing (auditory), touch (tactile), smell (olfactive) and taste (gustative) that are deliberately found to refer to living systems, natural processes, and create a positive retort [9], [11], as shown in Fig. 2.

**(P3) Non-rhythmic sensory stimuli**

Random and transitory links with nature can be statistically examined as clouds, shadows, nature sounds, and water reflections but cannot be precisely expected [9], [11], as shown in Fig. 3.

**(P4) Thermal & airflow variability**

It can be described as the slight change in relative humidity, air temperature, air flow across the skin, and the superficial temperatures that simulate natural environments as shown in Fig. 4. The advantage of this space leads to have a feel of recovery, activity, vitality, and comfort as well as a sense of flexibility and control [9], [11].



Figure 4. Thermal materials that mimic being in nature make variable air flow and thermal comfort [14].

**(P5) Presence of water**

It is a condition of enhancing the experience of a place through seeing, hearing, or touching the water element [9], as shown in Fig.5. A place that is characterized by a good occurrence of water results in a calm and refreshing space with a sense of magic and significance. A small water element can be sufficient to provide us with a sense of interest all the time. For instance, the sound of water flowing from a small fountain and our power to touch water can improve the health response of the multi-sensory experience [11].



Figure 5. The presence of water features includes the experience of seeing, hearing, and touching senses [15].

**(P6) Dynamic & diffuse light**

It is the effect of changing the intensities of light and shade over time to generate similar situations that happen in nature [9], as shown in Fig. 6. This supports a sense of drama, calm, and good isolation which provides users with the capability to control light in a technique that activates the vision and attracts attention [11].



Figure 2. Bringing artificial vegetation in indoor places to stimulate nature, IT'S Biophilia Office, Brazil [12].



Figure 3. Links with nature in Dockside Green, Ellen Moorhouse, Toronto [13].



Figure 6. Dynamic patterns diffuse natural light into spaces which reinforces the connection with nature [16].

#### (P7) Connection with natural systems

It is the awareness of natural systems, especially seasonal and chronological changes in the healthy ecosystem [9], as shown in Fig. 7. The space with this characteristic can provide the person with the awareness of life cycle and seasons results in feeling of comfort and nostalgia [11].

#### 2- Natural Analogues

Natural Analogues address organic, non-living, and indirect traces of nature [9]. They exist in the built environment in the form of materials, colors, objects, shapes, textiles, and patterns, that covered in nature, are present in any artwork [10]. The strongest 'Natural Analogue' capabilities are reached by presenting information richness in an ordered manner [9]. Seashell and leaf imitations, organic shaped furniture, and natural materials that have been significantly modified such as wood floorboards, granite tabletops, etc., each establish an implied correlation with nature. They are real, but objects are only naturally similar in the way of its natural state [9].



Figure 7. Open patio in Khoo Teck Puat Hospital in Singapore that allows feeling of different seasons in surrounding environment [17].

Natural Analogues includes three biophilic design patterns: (P8) Biomorphic Forms and Patterns

It is described as patterns, textures, and models that are borrowed from nature [9], as shown in Fig. 8. When it is applied to a certain space, it gives a sense of excitement, attraction, and comfort [11].



Figure 8. Biomorphic forms in the spheres Amazon biophilic workspace in Seattle [18].

#### (P9) Material Connection with Nature

It depends on using materials and elements from nature with minimum operations that reflect the local ecology of a place [9], as shown in Fig. 9. This process creates a discrete sense of place, richness of nature, and motivating the user to involve with the surrounding environment [11].

#### (P10) Complexity and Order

Abundant sensory information that follows a spatial hierarchy like the natural world [9], as shown in Fig. 10. Complexity and systems are a wealth of sensory information associated with time sequences, much like what happens in nature. The space in this property exudes charm and attention to detail, creating an interesting balance between boredom and detail. [11].



Figure 9. Selection of wooden material in ceiling in an Outdoor Recreation Center at Clemson University [17].



Figure 10. Patterns used in floors and partitions create a spatial hierarchy in an office space by Oliver Heath Design [19].

### 3- Nature of the Space

Nature of the Space directs to spatial compositions in nature [9]. The convincing experiences of 'Nature of the Space' are completed through the fabrication of obscured views, significant moments, and combatting spatial configurations; co-mingled with patterns of Nature in the Space and Natural Analogues [10]. These include an innate and realized appeal to perceive beyond our current surroundings, our captivation with the marginally dangerous and the unknown. Veiled views and insightful minutes. In some cases, they even have phobic properties if they contain reliable safety factors [9].

Nature of the Space includes four biophilic design patterns:

#### (P11) Prospect

It describes the free long-range view for monitoring and planning [9]. A prospect is a landscape without obstacles as shown in Fig. 11. With good horizontality, the space provides comfort and openness to nature, giving a sense of security and control, especially when a single user is in an unfamiliar location or environment [11].



Figure 11. Wide openings give panoramic views to the surrounding nature in Limehouse cottage, Ireland [20].

#### (P12) Refuge

A place where individuals are protected from behind and above, away from environmental conditions and the mainstream

of activity [9]. A shelter is a place to escape from the elements or a place where a person can hide in it so that they can participate in various activities as shown in Fig. 12. Places with good protective properties provide individuals or small groups with a sense of security, seclusion, and isolation in activities such as work, rest, housing, and hospitalization [11].



Figure 12. A private workspace at Ikea's indoor sphere garden design Wundr Studio Office [21].

#### (P13) Mystery

The imply of more information is reached through partially obscured vision and other sensory apparatus that entice individuals to explore their environment more deeply [9]. A room with a high Mystery Score has a distinct sense of expectation or teasing, providing the senses with a sort of reward that compels them to inspect the room further [11], as shown in Fig. 13.

#### (P14) Risk/Peril

It describes the combination of detectable threats with reliable protection [9]. This is an unspecified threat combined with reliable protection as shown in Fig.14. A place enjoying this state conveys a sense of excitement and joy, with implicit threat and perhaps even a small anxiety that the individual is in danger yet joyful [11].



Figure 13. Mystery patterns are intended to promote spatial navigation and exploration, reduce stress, and promote cognitive recovery [14].



Figure 14. The Risk/Peril pattern triggers the rush of living on the edge of safety is shown in glass wall, glass terrace, and glass cantilever in Kojimachi terrace [22].

- *Biophilic design in workplaces of business parks*

Nature plays an important role in giving office workers a positive impact on their physical environment. Combining nature into the workspace can impact employee and organizational performance, including member's satisfaction, organizational costs, and productivity [5]. So, researchers have recently begun to explore how biophilia is reflected in the workplace and what benefits can be gained by encompassing biophilia design elements into office environments.

The World Health Organization (2008) WHO estimates that cardiovascular and psychiatric disorders will be the leading diseases worldwide by 2020. Work stress is the cause of both mental disorders and heart disease, but direct access to nature can help reduce stress [23]. People work 8-10 hours a day, sometimes more. The workplace can be a high-stress environment that negatively impacts users, requiring point-in-time tasks, peer-to-peer competencies, and many other management requirements [24]. Numerous studies have demonstrated the effectiveness of using biophilia to improve workspaces as some workers spend at least a third of their working hours in the office. In some cases, employees complain due to the lack of natural elements. In urban areas, some workplaces may offer closed office systems with no openings which cause negative impacts on workers well-being [23].

Witherspoon 2015 stated that renovating offices with biophilic design elements, such as extra windows with nature views, lowered absenteeism by 15% [25]. Other researchers studied the effect of biophilic design on workers' productivity, health, and well-being [26]. The World Green Building Council (WGBC) published a report in 2014 summarizing evidence from various studies showing how biophilic design foundations impact workplace health, well-being, and productivity. The data shows the measured productivity benefits and failures associated with indoor air quality and ventilation. The paper identified 15 studies that linked improved ventilation with productivity gains up to 11%. Other studies show that poor air quality can decrease

performance by 10%. CO<sub>2</sub> levels had a measurable impact on employee fatigue, performance, and absenteeism. Adjusting indoor air quality through ventilation and air supply type has a positive impact on worker performance [25]. It has been shown that employees are more productive in an environment that meets the biophilic needs of humans. A Cardiff University study reports on the relationship between nature and productivity in European work environments. When the study compared productivity in two offices, one with natural elements and one without, they discovered that in the office with natural elements, employee's performance improved by 15% after three months of application [27].

However, based on responses to a global survey on biophilic design published by Human Spaces, 33% said office design influenced their decision to work for a particular company [27]. Elzeyadi 2011, accomplished a statistical analysis that was utilized to analyze the relationship between expert ratings of lighting and visibility quality and sick leave taken by employees was investigated. As the study prophesied, poorer lighting and vision quality predicted longer disease duration. For example, we can assume that people who have a good view of nature from their workplace take only 57 hours of sick departure per year. However, visually impaired workers are considered absent 68 hours a year [25].

The research on biophilia proves that exposure to nature reduces stress and, shows that natural elements can impart a high level of visual tranquility to the viewer [23]. Another study was conducted measuring the effects of plants on employees in office spaces. Nieuwenhuis et al. 2014 designed three different on-site experiments to determine the impact of lean and green offices on employees. Results from three field experiments show that employees want a greener office environment. There were few statistically significant changes (and in some cases even negative changes) in employee satisfaction, concentration, perceived air quality, and workplace productivity in lean office types. However, in green offices, employees conveyed clear positive improvements in all the surveyed categories. A third field study measured productivity on specific tasks and found that factory office workers were able to complete those tasks faster without increasing error rates. "Green" office workers were 15% more productive than lean office workers. Admittedly, this study provided verification that aspects of biophilic design, especially natural vegetation within offices, can lead to expressive improvements in job performance and cognitive performance [25].

Interestingly, in similar experiments different results were observed depending on the type of biophilic element examined. One office worker may be more productive with the involvement of vegetation, while another office worker may respond better to increased exposure to natural light. Interviews with people occupying spaces under renovation can inform facility operatives of their preferences for design improvements (more daylight and views, lighting and ventilation control, more

vegetation, etc.) [28]. A green work environment increases positive emotions and decreases negative ones. Psychological factors like stress, boredom, and anxiety can all delay performance and lead to less productivity through absenteeism and presenteeism [25].

Having nature in the workplace increases employee happiness. Additionally, job performance and productivity can depend on job satisfaction. This suggests that a positive relationship is developing between well-being and performance. Well-being is a broader concept than contentment or comfort, as it relates to general satisfaction, happiness, and quality of life. A good work environment means that people feel happy and satisfied when they do their job and have the best potential in terms of work productivity [23]. A global study shows that looking at a good green view through a window can affect the mental state of workers positively. Less frustrated, more patient, happier and healthier than workers who are naturally visually inaccessible. An experiment was conducted in an office on commercial land use, the results show that adding natural elements, such as natural plants and decorative elements, increases creativity and well-being [23].

There is a big differentiation between an office environment that is not toxic and a positive environment that supports health and well-being and promotes productivity [29]. Designing inclusive and mixed-use communities with adequate approach to employment, education, shopping, recreation, and health care will demote travel and promote healthier and more active lifestyles [30]. Business parks are a logical expansion of green buildings design. These parks naturally help to guard the quality of life of the local community [31]. Contact with nature can add benefits to human physical and mental health [30]. In addition to minimal rates of heart and respiratory disease due to reduced air pollution, another hypothetical benefit is a more active lifestyle and way of working. Indirect health paybacks include shorter commutes, less stress, less noise, lower costs, increased income, and less social isolation [31]. Business parks can alleviate what is often seen as a “conflict” between the market and the environment [32].

All the previous literature studies have led us to a deduction. Through connecting and linking the biophilic design elements in interior workspaces with the exterior spaces of business parks, we can reach successful results in workers satisfaction afterwards getting high rates of performance and productivity. The previous researchers had studied the application of biophilic design on offices designed by international companies and designers especially in USA and Europe, a few studies have been conducted on the Middle-East. There are some cases for applying biophilic design concepts in workplaces. On contrary in Egypt, there is still a shortage in the available data regarding applying biophilic design strategies on workplaces, particularly for business parks although there is an obvious direction in Egypt towards replacing the traditional offices into business parks. Most of the recent research in Egypt studies biophilic

design application on schools, universities, hospitals, and workplaces of high-rise office buildings. It was observed that there is a lack in data regarding business parks in Egypt, there is no previous research connecting between biophilic design and business parks in Egypt although there is a serious connection between the two terms. Therefore, our study will take the privilege to be the original work which will link biophilic design strategies in interior design elements as well as the exterior spaces of business parks.

## II. METHODOLOGY

Towards achieving the aim that by linking the interior and exterior spaces together via applying the principles of both biophilic design and business parks, the rates of user's performance, mental health, wellbeing, and productivity will be enhanced and improved. The methodology of our manuscript has started by a theoretical study to biophilia concept, biophilic design elements, and its patterns, passing by introducing a literature review to the previous international and Egyptian researchers that have studied biophilic design in various fields. Consequently, our study proceeds with a framework that connects the interior design elements of workplaces with the biophilic design attributes & elements and their achieved patterns in biophilic categories. This original framework shown in TABLE II illustrates the relation between interior design elements and biophilic design elements in workplaces of business parks, can be beneficial to international and local upcoming projects. Afterwards, an analytical study will be conducted on two selected business parks as cases study which are “The Polygon Business Park and Galleria-40 Business Park/Hub”. The analysis depends on field-visits, documenting by taking on-site notes and photos, observing users' experience, and doing on-site surveys to the users. The criteria of case study selection rely on their location, accessibility, occupancy, popularity, data-availability, establishment, and various activities. Then, we established an evaluation framework and guidelines to workplaces of business parks that merges and links interior design elements, biophilic design attributes & elements, with the exterior spaces of business parks.

The Polygon Business Park is located in Al-Shiekh Zayed city, Giza governorate, a part of the greater Cairo in Egypt. It is designed based on a winning design award by UK-architects. The BP covers an area of approximately 90,000 sqm of office spaces, most of the buildings have direct views with the green spaces. Galleria 40 Business Hub is considered as a business park and an entertainment hub, a kind of a mixed-use property and non-residential. It is located in Al-Shiekh Zayed city with an area of approximately 41.687 sqm. The hub contains a green wall that is 100 meters wide and 12 meters high.

### III. ANALYTICAL STUDY

The analytical study is done on two of the most popular business parks in Egypt which are the Polygon Business Park and Galleria-40 Business Park/Hub. The study includes the analysis of the existence of the 14 patterns of biophilic design through their application on exterior and interior spaces of the selected cases-study. Firstly, the study starts with a field visit to the exterior open spaces of the Polygon Business Park and Galleria-40 Business Hub, which figures out the achievement of biophilic design attributes & elements as shown in TABLES III and IV. Then a field study to the interior workplaces of the two business parks to reveal the achievement of biophilic design elements as shown in TABLES V and VI, which show the manifestation of biophilic design concepts on the architectural elements e.g., ceilings, walls, openings, floors, furniture, and accessories. The analysis will connect those architectural elements and their achievement to the 14 patterns of biophilic design according to the previous framework in TABLE II. The analysis reveals the hypothesis that business parks were designed with respect to the biophilic design theory. Also, business parks can serve as an effective alternative to the traditional office buildings because business parks compromise the beneficial aspects of biophilic design application on workspaces. Therefore, business parks can enhance the efficiency and performance of workers, improve wellbeing, and increase productivity.

### IV. RESULTS AND DISCUSSION

The field-visits to the Polygon Business Park and Galleria-40 Business Hub reveal that the biophilic design attributes and elements have been achieved in the exterior open spaces of both parks. The well-designed open spaces with vegetation and water features like ponds or fountains improve natural ventilation. The nature materials and colors create a sense of natural spirituality of the spaces. The well-designed combination enhances views and vistas. The geometric and organic shapes in office buildings and landscape create dynamic features and engage a sense mystery. The successful application of those elements results in achievement of the biophilic design attributes and elements in both cases study, which has a positive impact on the users' experiences of place.

The analytical study of the Polygon Business Park shows that most of the biophilic design patterns have been achieved in interior spaces like halls, offices, corridors, and other workplaces. The stripped sky lights, natural materials, and colors used in ceilings, walls, doors, floors, and furniture enhance the visual connection with nature pattern (P1). The sky light and natural materials evolve the patterns of non-rhythmic sensory stimuli (P3), connection with natural systems (P7), and create a kind of mystery (P13). Moreover, the skylight can create access to thermal and airflow variability (P4), dynamic and diffuse light (P6), complexity and order (P10), and generates the

feeling of risk (P14). In addition to the used natural materials in most of the park's spaces generate the sensation of non-visual connection with nature (P2). The natural colors like white, blue, green, and brown which are used in most design elements in ceilings, walls, furniture, and accessories in the business park's different areas improve the connection with natural systems pattern (P7). The green walls in different areas of the park create material connection with nature (P9), a sense of prospect (P11) and refuge (P12). The natural textures and patterns that appear in floors, furniture, and accessories can achieve the patterns of biomorphic forms and patterns (P8), material connection with nature (P9), and complexity and order (P10). Finally, the water elements like fountains and artificial lakes enhance the visual connection with nature (P1), achieve the presence of water pattern (P5), and connection with natural systems pattern (P7). Therefore, by connecting all the design elements with biophilic design patterns, we conclude that the design of The Polygon Business Park achieves the 14 patterns of biophilic design.

Regarding Galleria-40 Business Park/Hub, the analytical study results show the successful application of the biophilic design patterns. It is obvious that visual connection with nature (P1) has been achieved at green and waterfall walls, the wide, tall, glass, and operable windows, the glass and transparent walls, doors, and partitions, natural materials and colors in ceilings, walls, openings, floors, and furniture. Moreover, the water elements like waterfall walls and fountains can enhance the visual connection with nature (P1), achieve the presence of water pattern (P5), and connection with natural systems pattern (P7). The distinct vegetated walls in the hub create non-rhythmic sensory stimuli (P3), connection with natural systems (P7), material connection with nature (P9), and a sense of prospect (P11) and refuge (P12). The diverse openings of the hub allow access to thermal and air flow variability (P4), dynamic and diffuse light (P6), complexity and order (P10), a sense of mystery (P13) and risk (P14).

The pattern non-visual connection with nature (P2) has been achieved by using natural materials in ceilings, walls, doors, partitions, furniture, and floors. Finally, biomorphic forms and patterns (P8) appear in patterns of floors, furniture, and some decoration elements. So, by analyzing all the design elements, we reach the point that Galleria-40 Business Park/Hub design has achieved the 14 patterns of biophilic design in workplaces.

While studying the two cases study, we notice that both have a lack in the vegetated ceilings, it is almost disappeared in them, although its importance to enhance the visual connection with nature pattern (P1). Also, the manifestation of skylight did not appear obviously in Galleria-40 Hub and waterfall walls do not occur in the Polygon Business Park, which mitigate their direct visual connection with nature.

The analytical study shows that business parks can achieve biophilic design concepts.

**TABLE II A comprehensive framework to merge the relation between interior design elements in Business Parks` offices and the attributes & elements of Biophilic design corresponding to the 3 categories and 14 patterns of Biophilic design according to Terrapin and Kellert framework. (by authors)**

Categories of Biophilic	Achieved patterns of Biophilic design	Biophilic design attributes & elements		Interior design elements	
1- Nature in space (P1, P2, P3, P4, P5, P6, P7)	P4, P7	Environmental features	Natural ventilation	Ceilings	Sky light
	P1, P5, P7		Water features		Natural materials
	P1, P3, P7		Vegetation		Natural colors
	P2, P3		Materials		Vegetated ceiling
	P1, P7	Light + Space	Colors	Walls	Green walls
	P1, P3		Views & vistas		Coated glass walls
	P1, P6		Natural light		Glass louvers
	P3, P6		Diffused light		Natural colors
	P3, P7		Light & shadow		Natural materials
	P1, P3		Spatial harmony		Curved walls
	P1, P4	Place-based relationships	Inside-outside spaces		Transparent partitions
	P1, P7		Ecological connection to place		Waterfall walls
	P2		Indigenous materials	Openings	Wide/tall windows
	P1, P7		Landscape orientation		Glass windows
2- Natural analogues (P8, P9, P10)	P1, P7	Natural shapes & forms	Spirit of place		Operable windows
	P8, P9		Botanical motifs		Plants on windows
	P8, P10		Natural geometrics		Glass doors
	P9		Natural features simulation		Wooden doors
	P8, P10	Natural patterns & process	Biomimicry	Floors	Eco-friendly materials
	P10		Transitional spaces		Natural patterns
	P8, P10		Dynamic balance	Furniture	Natural colors
	P10		Organized ratios		Natural materials
3- Nature of the space (P11, P12, P13, P14)	P10	Evolved human nature relationship	Integration of parts & wholes		Natural textures
	P11, P12		Attraction & beauty		Natural patterns
	P13		Spirituality	Accessories	Fountains
	P13, P14		Exploration & discovery		Indoor plants
	P12		Security & protection		Natural colors

**TABLE III Manifestation of biophilic design attributes and the corresponding achieved patterns in the exterior/outdoor spaces of the Polygon Business Park. (by authors)**

(1) Nature in Space					
(1-1) Environmental features					
Natural ventilation	Water features	Vegetation	Materials	Colors	Views & vistas
					
Patterns achieved		P1, P2, P3, P4, P5, P7			
Notes		Well- designed open spaces create natural ventilation – Artificial ponds and fountains – Trees, plants, green areas – Wooden hardscape elements – Natural colors of building and hardscape elements – Well-designed landscapes creates good views and vistas			

(1-2) Light + space				
Natural light	Diffused light	Light & shadow	Spatial harmony	Inside-outside spaces
				
Patterns achieved	P1, P3, P4, P6, P7			
Notes	Open spaces promote natural light – Stripped skylights create diffused light and shadows – Green areas and blue glass windows evokes spatial harmony and connect inside with outside spaces			

(1-3) Place-based relationships			
Ecological connection to place	Indigenous materials	Landscape orientation	Spirit of place
			
Patterns achieved	P1, P2, P7		
Notes	Using indigenous plants and natural materials in landscape create ecological connection and spirit of place		

(2) Natural Analogues			
(2-1) Natural shapes and forms		(2-2) Natural Patterns and processes	
			
Patterns achieved	P8, P9, P10		
Notes	Geometric forms, dynamic, and organized ratios create natural analogues		

(3) Nature of Space	
(3-1) Evolved human-nature relationship	
	
Patterns Achieved	P11, P12, P13, P14
Notes	Trees, palm trees, and water features achieve attraction & beauty, and spirituality

**TABLE IV** Manifestation of biophilic design attributes and the corresponding achieved patterns in the exterior/outdoor spaces of Galleria-40 Business Park/Hub (by authors)

(1) Nature in Space					
(1-1) Environmental features					
Natural ventilation	Water features	Vegetation	Materials	Colors	Views & vistas
					
Patterns achieved		P1, P2, P3, P4, P5, P7			
Notes		Well- designed open spaces create natural ventilation – Artificial ponds and fountains – Trees, plants, flowers, and green areas – Natural colors of building and hardscape elements – Well-designed landscape creates good views and vistas			
(1-2) Light + space					
Natural light	Diffused light	Light & shadow	Spatial harmony	Inside-outside spaces	
					
Patterns achieved		P1, P3, P4, P6, P7			
Notes		Open spaces promote natural light, diffused light, and shadows – Green areas and blue glass windows evokes spatial harmony and connect inside with outside spaces			
(1-3) Place-based relationships					
Ecological connection to place	Indigenous materials	Landscape orientation	Spirit of place		
					
Patterns achieved		P1, P2, P7			
Notes		Using indigenous plants and natural materials in landscape create ecological connection and spirit of place			
(2) Natural Analogues					

(2-1) Natural shapes and forms		(2-2) Natural Patterns and processes	
			
Patterns achieved		P8, P9, P10	
Notes		Geometric forms, dynamic balance, and organized ratios create natural analogues	

(3) Nature of Space	
(3-1) Evolved human-nature relationship	
	
Patterns Achieved	P11, P12, P13, P14
Notes	Trees, palm trees, plants, flowers, and water features achieve attraction & beauty, and create nature spirituality

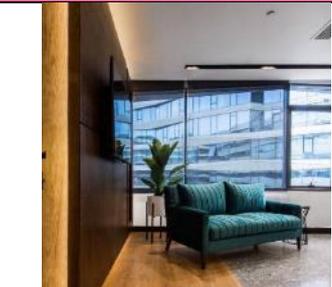
TABLE V Manifestation of biophilic design elements and the corresponding achieved patterns in the Polygon Business Park (Ceilings, walls, openings, floors, furniture, and accessories) (by authors)

(1) Ceilings			
Sky Light	Natural materials	Natural colors	Vegetated ceiling
			No
Patterns achieved	P1, P2, P3, P4, P6, P7, P10, P13, P14		
Notes	Ceilings with sky lights – Wooden ceilings – Shades of natural green color in offices' ceilings		
(2) Walls			
Green walls	Coated glass walls	Glass louvers	Natural colors

			
<b>Natural materials</b>	<b>Curved walls</b>	<b>Transparent partitions</b>	<b>Waterfall walls</b>
	No		No
Patterns achieved	P1, P2, P3, P7, P9, P10, P11, P12		
Notes	Vegetation on walls – Offices with glass and transparent walls – Glass louvers on windows – Various shades of green and brown colors – Wooden tables - Transparent partitions between offices		

<b>(3) Openings</b>		
<b>Wide/tall windows</b>	<b>Glass windows</b>	<b>Operable windows</b>
		
<b>Plants on windows</b>	<b>Glass doors</b>	<b>Wooden doors</b>
		
Patterns achieved	P1, P2, P3, P4, P6, P7, P11, P13, P14	
Notes	Large, wide, tall, and operable glass windows – Outdoor vegetation in front of large windows – Transparent glass doors facing outdoor plants – Treated natural wood doors and partitions	

(4) Floors	
Eco-Friendly materials	Natural patterns
	
Patterns achieved	P1, P2, P3, P7, P10, P13
Notes	Floors with minimally treated wood surfaces have natural textures and patterns

(5) Furniture			
Natural colors	Natural materials	Natural textures	Natural patterns
			
Patterns achieved	P1, P2, P3, P7, P8, P10, P13		
Notes	The used furniture has natural colors like blue and brown, with natural materials, textures, and patterns		

(6) Accessories		
Fountains	Indoor plants	Natural colors
		
Patterns achieved	P1, P3, P5, P7, P9, P11, P12	
Notes	Water elements like fountains – Indoor pots in offices and interior spaces – Wooden decoration elements	

**TABLE VI** Manifestation of biophilic design elements and the corresponding achieved patterns in Galleria-40 Business Park/Hub (Ceilings, walls, openings, floors, furniture, and accessories) (by authors)

(1) Ceilings			
Sky Light	Natural materials	Natural colors	Vegetated ceiling
No			No
Patterns achieved	P1, P2, P3, P7, P13		
Notes	Wooden ceilings – Natural white color shades in ceilings		
(2) Walls			
Green walls	Coated glass walls	Glass louvers	Natural colors
			
Natural materials	Curved walls	Transparent partitions	Waterfall walls
			
Patterns achieved	P1, P2, P3, P5, P7, P8, P9, P10, P11, P12, P13		
Notes	Elevated gardens (vegetation on walls) – Transparent glass walls and partitions in multipurpose halls, meeting, and office rooms – Organic curved walls with wooden natural materials – Water elements like waterfall walls		
(3) Openings			
Wide/tall windows	Glass windows	Operable windows	
			
Plants on windows	Glass doors	Wooden doors	

No		
Patterns achieved	P1, P2, P3, P4, P6, P7, P10, P12, P13, P14	
Notes	Large, wide, tall, and operable glass windows – Transparent glass doors – Treated natural wood doors and partitions	

(4) Floors	
Eco-Friendly materials	Natural patterns
	
Patterns achieved	P1, P2, P3, P7, P8, P9, P10, P13
Notes	Floors with minimally treated wood surfaces and others have natural textures and patterns

(5) Furniture			
Natural colors	Natural materials	Natural textures	Natural patterns
			
Patterns achieved	P1, P2, P3, P7, P8, P9, P10, P13		
Notes	The used furniture has natural colors like white, green, and brown, with natural materials, textures, and patterns		

(6) Accessories		
Fountains	Indoor plants	Natural colors
		
Patterns achieved	P1, P3, P5, P7, P9, P11, P12	
Notes	Water elements like fountains – Indoor pots in various spaces – Wooden and natural material decoration elements	

## V. CONCLUSIONS

It is a fact that workers have spent a lot of time at indoor closed offices which has negative impacts on their well-being and performance. It becomes a crucial issue to alter the way of designing the traditional offices, so business park's concept comes to change this. The business park's main aim is to link outdoor spaces with indoor workspaces, which means to reconnect the man with nature, that seems to be the same target of biophilic design theories. Many previous researchers have studied the biophilic design application on workspaces in traditional office buildings but there was a lack of studies on business parks, which opened new disciplines towards our way of thinking. The previous studies showed perfect results towards how biophilic design can improve workers' health, wellbeing, performance, and then productivity. Therefore, our research assumes a hypothesis that business parks can achieve biophilic design concepts and elements. So, a comprehensive framework has been developed upon the previous studies, books, examples, and experiences, to merge the biophilic design categories, attributes, elements, and the 14 patterns with the design elements of open spaces and indoor workspaces of business parks. By applying this comprehensive framework on two of the most popular business parks in Egypt, the Polygon Business Park, and Galleria-40 Business Park. We conclude that business parks have achieved the biophilic design concepts which means that the business park's direction is a successful experience towards altering the traditional office buildings. Besides that, business parks can improve the negative impacts of office buildings on environment and so far, this can mitigate the climate change and achieve sustainability by respecting the three main sustainability pillars (economic, social, and environment). Thus, our research can contribute effectively to Sustainable Development Goals (SDGs) vision and goals 2030. We recommend that the upcoming researchers and stakeholders can get benefit from our original novel results and the comprehensive framework as a documented guideline to merge the biophilic design concepts with business parks' design towards designing effective workplaces that encourage performance and improve human wellbeing, then increase productivity with minimal negative impacts on nature. Hence, we can highlight the main guidelines to the future workplaces such as adding appropriate vegetation and water elements to interior and exterior places. Designing with the spirit of opening to connect the interior spaces with the exterior landscapes and connect the ceilings with the sky. Using natural colors, textures, patterns, and natural local materials.

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