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Activating biophilic design patterns as a sustainable landscape approach

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Abstract

Biophilic design elements are found around us in many landscape elements while we do not perceive them as biophilic design patterns. By developing our understanding of biophilic design as a phenomenon, we could discover simple ways to utilize landscape elements and transform them into a good biophilic design that might have positive impacts on a user's health and well-being. Activating existing biophilic elements as an approach to a sustainable landscape has not been studied yet. Therefore, we rather analyse some international case studies in order to understand how biophilic design patterns can be implemented and see their different forms. Later, we will also go through an Egyptian biophilic design pattern case study and implement it to reach a sustainable landscape model. To summarize, the purpose of this study is to present a new sustainable landscape approach by activating biophilic design patterns in order to increase landscape efficiency.

Keywords: Biophilic design, Sustainable landscape, Biophilic design patterns, Biophilic design elements, Landscape efficiency

Introduction

A “love of life or living systems” is biophilia (Aristotle). It is our intrinsic human connection to the natural world. This simple relationship may often seem comprehensive but unfortunately has been lost through the urban world of technology and industrial architecture. In order to get a natural environment for us to live, function, and learn, we should consider biophilic design for this matter. We are unconsciously reconnecting by integrating nature into interior or architectural design, integrating the great nature into our environment. An environment without nature can badly impact health, efficiency, and well-being.

Biophilic design can incorporate nature into our environment and designs places of inspiration and regeneration that bind humans with their environment. Although it is hard to find a space that can accommodate all biophilic design elements, many contributory elements can enhance the space and well-being. It is more than just adding a plant or two to the space! [10]. A positive effect can be generated by filtered sunlight, planting, green walls, water features, natural textures and materials, and views of



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nature. If simply looking at nature can inspire you, imagine how living in an environment integrated with elements from nature can do? As a result, an important question comes up “Could we use the biophilic design patterns to increase the landscape efficiency?” And if so, how could it be implemented in existing landscapes to set up a sustainable approach in the Egyptian cases.

It is imperative to apply the concept of biophilic design not only in new designs but also within existing landscape sites. To our knowledge, no study has introduced biophilic design patterns as an approach to increase the efficiency of an existing site and create a sustainable landscape. Therefore, we will explore what is *biophilia* and *biophilic design* on a broad scale, then narrowing them into different biophilic design patterns with different landscape design forms. Then, we will study different international case studies and analyse all forms of biophilic patterns. Then, finally, we will repeat the same scenario but to an Egyptian case study, to examine the presence of biophilic patterns and suggest modifications in the proposed design, so we can come out with an efficient, integrated, and sustainable approach using biophilic design.

Methods

In this study, the concept of biophilic design was further investigated and studied, concerning its positive contribution to health and well-being. Based on profound theoretical and analytical studies, the principles of biophilic landscape design patterns were concluded. Furthermore, the efficiency of the concluded patterns was tested in a practical case study in the Egyptian urban context.

Sustainable landscape, biophilia, and biophilic design

Themes from nature had been always seen in early human structures, such as cave paintings and statues, which shows that biophilic design is not a new phenomenon. In 1865, the landscape architect Frederick Law Olmsted argued that nature scenery influences the human mind over the body and refreshes the whole system. Later, in the nineteenth century, there was a campaign to create large public parks in order to help in stress reduction and improve health [10].

The beginning of the term “Biophilia” was in 1964 by the social psychologist Eric Fromm who defined it as “Biophilia is the passionate love of life and of all that is alive” [22]. Later, in 1984, the biologist Edward Wilson contributed in making the term Biophilia more common [28].

A conference was conducted in 2004 to discuss translating the biophilia into the built environment design; a book was then released sequentially (Eds., [1]). The book discussed the ways of creating a biophilic experience and summed up the user experience into three main categories: nature in the space, natural analogues, and nature of the space.

The recent decade has shown an increase in the research and practice of biophilic design that it has been included in the green building standards. Some of the most popular texts that have been published on this topic are mentioned hereinafter: Last Child in the Woods [23], Healing Spaces [24], The Shape of Green [25], Your Brain on Nature [26], The Economics of Biophilia [27], and, 14 Patterns of Biophilic Design [10].

Biophilia definitions

Biophilia as a concept promoted the idea that connection with nature plays an essential role in physical and mental health, and this has been proven in many studies [16, 29]. In modern society, it also plays a significant role in social and family relationships [30]. It is also useful in highly dense urban areas office workers [31] and helps in stress reduction for university students and staff [32]. Furthermore, a study proved the inherent psychological and physiological link between humans and nature and evaluated the research supporting the social, environmental, and economic benefits of biophilia [33].

The term biophilia was defined as “The inherent human inclination to affiliate with nature that even in the modern world continues to be critical to people’s physical and mental health and well-being [34, 35, 36, 37].

Terrapin also defined the term biophilia as “Humankind’s innate biological connection with nature” [10]. He also added: “It helps explain why crackling fires and crashing waves captivate us; why a garden view can enhance our creativity; why shadows and heights instil fascination and fear; and why animal companionship and strolling through a park have restorative, healing effects.” [10].

Biophilia was lastly defined as “The innate, genetically determined affiliation of human beings to nature and other living organisms.” (Biophilic Design Guidebook, June 2018).

Elements, principles, and experience of biophilic design

Biophilic design dimensions were first introduced in the book ‘Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life’ [1]. According to the book, there are two basic dimensions of biophilic design; the first dimension is the organic or naturalistic dimension, which represents the shapes and forms. The second basic dimension is the place-based or vernacular dimension, which represents the buildings and landscapes connected to the culture and ecology of the local environment [21].

These two basic dimensions of biophilic design were then related to six biophilic design elements. Environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved human-nature relationships are the main biophilic design elements [1]. **Table 1 shows the different attributes of each element.**

Later, in 2015, the principles of biophilic design were introduced in the book ‘The Practice of Biophilic Design’ [38]. These principles were repeated engagement with nature, focusing on human adaptations to the natural world, encouraging emotional attachment to specific places, promoting positive interactions between people and nature, and encouraging interconnected and incorporated architecture solutions. Also, the experience of nature was grouped into three types: direct experience of nature, indirect experience of nature, and the experience of space and place [38].

Categories and patterns of biophilic design

Biophilic design could be summed up into 3 main categories; each category encompasses some patterns. The main categories are as follows: nature in the space, natural analogues, and nature of the space [10].

Table 1 Six main biophilic design elements and their attributes

Environmental features	Natural shapes and forms	Natural patterns and processes
<ul style="list-style-type: none"> • Colour • Water • Air • Sunlight • Plants • Animals • Natural materials • Views and vistas • Façade greening • Geology and landscape • Habitats and ecosystems 	<ul style="list-style-type: none"> • Botanical motifs • Tree and columnar supports • Animal (mainly vertebrate) motifs • Shells and spirals • Egg, oval, and tubular forms • Arches, vaults, domes • Shapes resisting. Straight lines and right angles • Simulation of natural features • Biomorphy • Geomorphology • Biomimicry 	<ul style="list-style-type: none"> • Sensory variability • Information richness • Age, change, and the patina of time • Growth and efflorescence • Central focal point • Patterned wholes • Bounded spaces • Transitional spaces • Linked series and chains • Integration of parts to wholes • Complementary contrasts • Dynamic balance and tension • Fractals • Hierarchically organized
Light and space	Place-based relationships	Evolved human-nature relationships
<ul style="list-style-type: none"> • Natural light • Filtered and diffused light • Light and shadow • Reflected light • Light pools • Warm light • Light as shape and form • Spaciousness • Spatial variability • Space as shape and form • Spatial harmony • Inside-outside spaces 	<ul style="list-style-type: none"> • Geographic connection to place • Historic connection to place • Ecological connection to place • Cultural connection to place • Indigenous materials • Landscape orientation • Landscape features that define building form • Landscape ecology • Integration of culture and ecology • Spirit of place • Avoiding placelessness 	<ul style="list-style-type: none"> • Prospect and refuge • Order and complexity • Curiosity and enticement • Change and metamorphosis • Security and protection • Mastery and control • Affection and attachment • Attraction and beauty • Exploration and discovery • Information and cognition • Fear and awe • Reverence and spirituality

Source: Kellert, et al. [1]

The first category *Nature in the Space* includes all the direct, physical, and ephemeral existence of nature in a place. The influence of the nature in the space experience can be achieved through three main factors which are diversity, movement, and multi-sensory interactions, for instance *Some flowerbeds* and *bird feeders*; this category consists of seven biophilic design patterns and they are visual connection with nature, non-visual connection with nature, non-rhythmic sensory stimuli, thermal & airflow variability, presence of water, dynamic & diffuse light, and connection with natural systems [10]

The second category *Natural Analogues* includes indirect and non-living nature evocation. A strong result can be gotten if we can have accurate information, common examples are wooden furniture and granite table tops, they are real if they only represent analogous of the natural state of the objects. This category consists of three patterns of biophilic design and they are biomorphic forms & patterns, material connection with nature, and complexity & order [10].

The last category *Nature of the Space* includes all spatial aspects which can be found in nature and it expresses our desire to see things above and beyond our instant surroundings, and explore the unknown in a safe manner. A strong experience is achieved by: deliberate and engaging spatial arrangements, combined with patterns from the two other categories: *Nature in the Space* and *Natural Analogues*. This category consists of four biophilic design patterns, they are prospect, refuge, mystery, and risk/peril [10].

Since Wilson published *The Biophilia Hypothesis* almost two decades ago; the biophilia term has expanded considerably and the final biophilic patterns were analysed to disclose emotional connections mentioned by Wilson.

The term “pattern” is not only related to the natural environment through psycho-physiological and cognitive relationships, but it can be an independent description for three main reasons: set up clear and standardized terminology, avoid confusion, and maximize accessibility across other disciplines. Table 2 gives a brief explanation of each biophilic pattern [10].

Biophilic design application

Good biophilic design is usually drawn based on the user’s influential perspectives which can be impacted by health conditions, sociocultural norms, past experiences, and frequency and duration of experience are some of the most common examples [10].

Understanding the project’s design intent is one of the vital steps for a designer; the user’s performance needs must be precisely set up to identify the design strategies and interventions; to apply this scenario, two approaches can be used: *first is to ask*: What is the most biophilic space we could possibly design? *Another query is to ask*: How can biophilic design boost efficiency indicators that are already used by the client? [10]. Reducing stress and improving overall mood is one of the many biological responses that may occur to the design, besides other unlimited combinations of design interventions and patterns. A biophilic design’s impact on health represents great importance to managers, planners, and policy makers [10].

There is no appropriate duration when it comes to the time of exposure to a pattern; ideal duration depends upon the user and the required effect; it has been verified that health benefits could occur in a time of 5 to 20 min [39, 40, 41]. When a little duration

Table 2 Brief of the 14 biophilic patterns

Category	Pattern	Brief
Nature in the space	Visual connection with nature	Vision of natural elements
	Non-visual connection with nature	Sense something referring to nature
	Non-rhythmic sensory stimuli	Spontaneous relation to nature
	Thermal & airflow variability	Slight shifts in climate that simulates nature
	Presence of water	Boost the involvement by using water
	Dynamic & diffuse light	Varying light concentrations that differ with time
	Connection with natural systems	Knowledge of nature’s mechanism
Natural analogues	Biomorphic forms & patterns	Arrangements that symbolizes nature
	Material connection with nature	Using local materials from the environment
	Complexity & order	Rich sensual messages
Nature of the space	Prospect	Perspective free from obstacles, for observing & planning
	Refuge	Area for disengagement, protected from above & behind
	Mystery	Attracting to travel deeper to discover more scenes
	Risk/peril	Detectable risk accompanied with dependable security

Source: Terrapin [10]

of exposure is required, a pattern is usually located along paths with high foot traffic; this helps in improving access frequency [10].

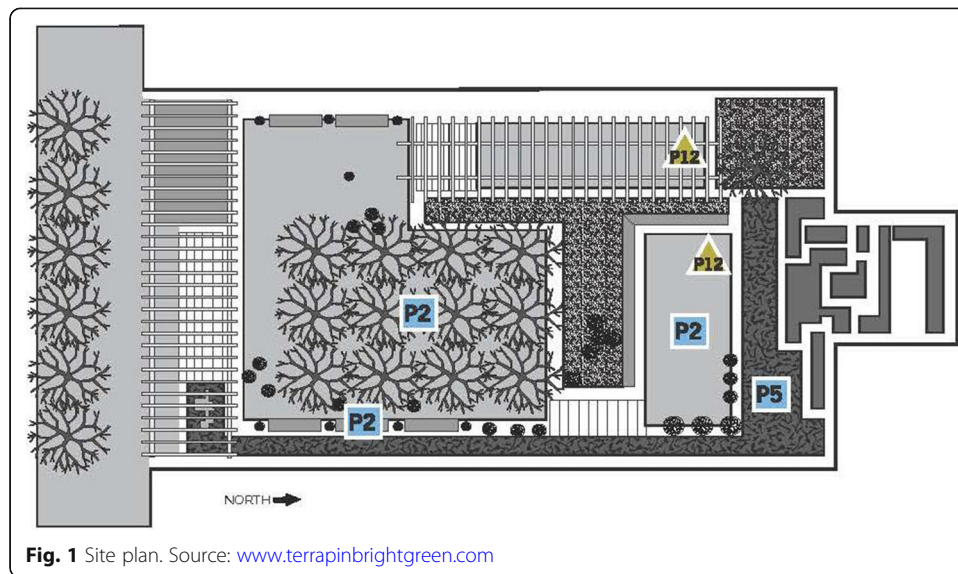
Biophilic design impact on health

Evidence of the impact of biophilia on health was shown mainly in three mind-body systems: *cognitive, psychological, and physiological systems*; the impact on these systems was tested and explored in various ways to understand how the environment could impact a user's health and well-being [10]. The results showed how each pattern can

Table 3 Biophilic patterns framework

Categories	Pattern	Experience	Objective	Examples	
Nature in the space	Visual Connection with Nature	Stimulating & calming	Change the focus to provide relaxation	Natural Animals	Simulated Green Wall
	Non- Visual Connection with Nature	Recognizable & comforting	Engagement to reduce stress	Flowing water	Digital simulations of nature sounds
	Non-Rhythmic Sensory Stimuli	Engaging & energizing	Catch attention to refresh mind	Breezes	Water reflections on a surface
	Thermal & Airflow Variability	Alive & refreshing	Sense airflow and thermal variability	Shadow & shade	Cross ventilation
	Presence Of Water	Stimulating & calming	Enhance the experience and prompts contemplation	Visual access to rainfall	Aquarium
	Dynamic & Diffuse Light	Drama, intrigue & calmness	Hold attention & maintain circadian rhythm	Direct sunlight	Light distribution
	Connection With Natural Systems	Nostalgic, thoughtful & relaxing	To increase awareness & management of the ecosystems	Geology	Exposure of water infrastructure
Nature analogues	Biomorphic Forms & Patterns	Interesting , comfortable & meditative	Connect with nature	Decor Furniture details	Form/function Furniture form
	Material Connection With Nature	Rich, warm & authentic	Explore the optimum natural materials	Natural colour palette, particularly greens	Footpaths, bridges
	Complexity & Order	Engaging & information-rich	To create a visually nourishing environment	Plant selection variety and placement	Building skyline
Nature of the space	Prospect	Open, safe & controlled	Allowing visual survey to surrounding	Spatial attributes Focal lengths ≥ 6 m	Common features Elevated planes
	Refuge	Contemplative, embracing & protective	Contribute effortlessly reachable & protective surroundings	Modular refuge: Small protection	Spaces reserved for reflection/ meditation
	Mystery	Anticipation	Encourage exploration	Auditory stimulation from an imperceptible source	Scent
	Risk/Peril	Thrilling with implied risk	To stimulate attention, curiosity, memory & problem-solving skills	Gravity	Transparent railing or floor plane

Source: Researcher



affect three main categories: *stress reduction*, *cognitive performance*, and *emotion, mood, and preference*. All patterns had an impact on at least one category but most of them impacted two to three categories.

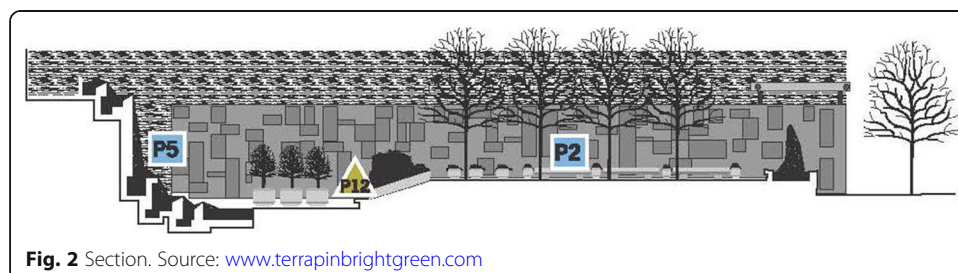
Framework of biophilic design patterns

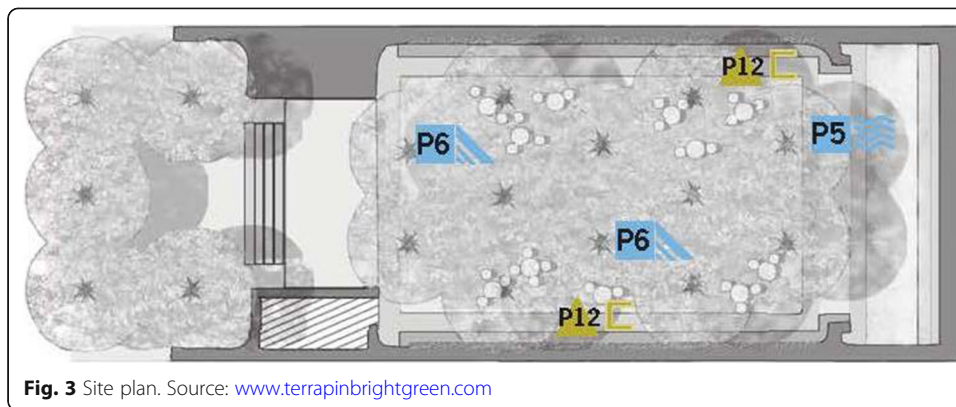
Biophilic design patterns have been defined to guide and assist in the design process and the main purpose was to explain the connection between the characteristics of built and natural environments [10]. Table 3 shows the summary of each pattern's experience, objective, design attributes, and examples.

Biophilic design patterns are very flexible and could be implemented in design using various shapes based on user-specific needs; the combination of patterns tends to increase the positive impact on health and also integrating design strategies could lead to a restorative environment for users from different cultures and demographics [10].

Case studies

When it comes to studying the different biophilic patterns in a landscape and their efficiency, we need to choose spaces that are accessible to the public and created for different types of users. In that order, we can understand if all different users receive the same experience or not.





Case 1 (Greenacre Park)

Greenacre Park is a small park that is located between tall towers in Manhattan; it consists of three different levels offering users various environmental conditions; the excellent implementation of the biophilic design patterns creates a quiet and peaceful space, which is rare in the city centre.

The site plan is divided into three different spaces using plants, water, and trellises (Fig. 1). A T-shaped flower bed acts as a physical divider, the water bordering the lower level and a steel trellis demarcating the raised platform. This section highlights the elevation change between the street and space levels (Fig. 1).

Case 2 (Paley Park)

Paley Park was the first of its kind when initially opened back in 1967; it was created right after designing the concept of very small accessible parks that are open to the general public; today, it is one of the most common parks in New York City (Fig. 2).

The way this park was designed makes it a unique space for office workers and Museum of Modern Art patrons during short breaks.

This site plan shows the honey locust trees arranged loosely to assure the casualness of the space (Fig. 3). A tall waterfall acts as a focal point and dominates the space. Also, the movable site furniture allows flexible seating throughout the space, which creates a dynamic series of layouts (Fig. 4).

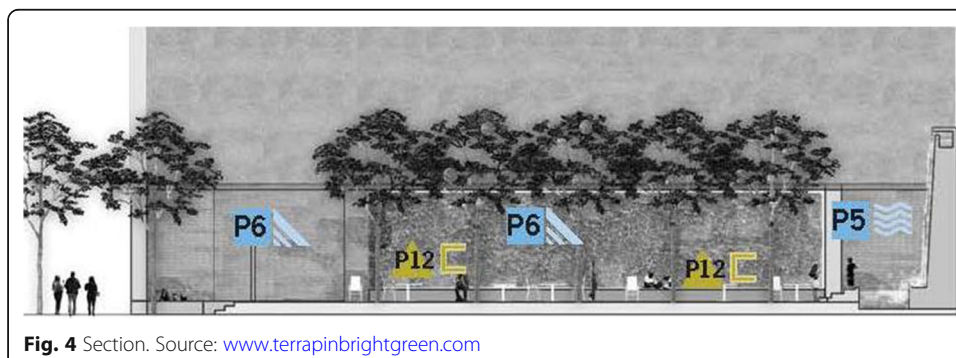


Table 4 Biophilic design patterns in the case studies

Categories	Biophilic design patterns	Case 1 Greenacre Park	Case 2 Paley Park
Nature in the space	Visual connection with nature	Ivy covering west wall	Locust trees and ivy
		Different planting throughout space	Waterfall
	Non-visual connection with nature	Sound of water	Sound of splashing waterfall
		Smell of plants	
		Cool air flowing of the water	
	Non-rhythmic sensory stimuli	Water features	Waterfall
		Rustling ivy & tree canopy above	Rustling canopy leaves
		Birds flit in & out of space	Ivy covered walls
	Thermal & airflow variability	Cool air from water features	Cooling effect from waterfall spray
		Shading provided by trees	Different levels of shading from locust trees
		Movable furniture to ensure preferred conditions	Movable furniture to ensure preferred conditions
	Presence of water	Water flowing through stone sculpture	20 ft. waterfall
		25 ft. tall waterfall	
Nature of the space	Dynamic & diffuse light	Light filters through tree canopy	Dappled light filtering through tree canopy
		Different levels experience different light infiltration	Different levels of light penetration through ivy covered wall
	Connection with natural systems	Observing birds, insects and plant life interactions	Seasonal changes in canopy cover
		Seasonal changes in canopy densities and colours	
	Natural analogues	Biomorphic forms & patterns	Not represented in design
		Material connection with nature	Ivy-covered walls
		Complexity & order	Not represented in design
	Prospect	Upper level elevated above street	Raised entrance and seating, providing views to busy street beyond
		Refuge	Limited visual access to street
	Mystery	Lower level veiled by plantings	Inward faced and protected benches
		Waterfall sounds	Waterfall sounds
		Lower level not visible from the entryway	Not represented in design
	Risk/peril	Not represented in design	Not represented in design

Source: Researcher

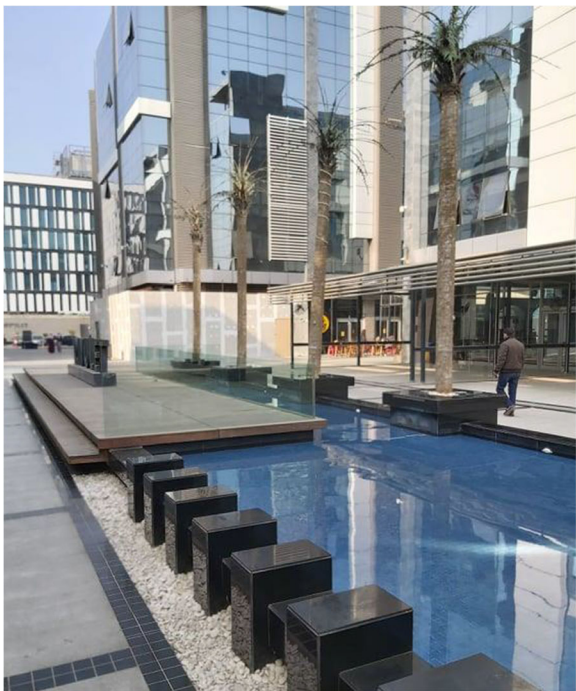


Fig. 5 Green wall. Source: Researcher



Fig. 6 Reflecting pool. Source: Researcher

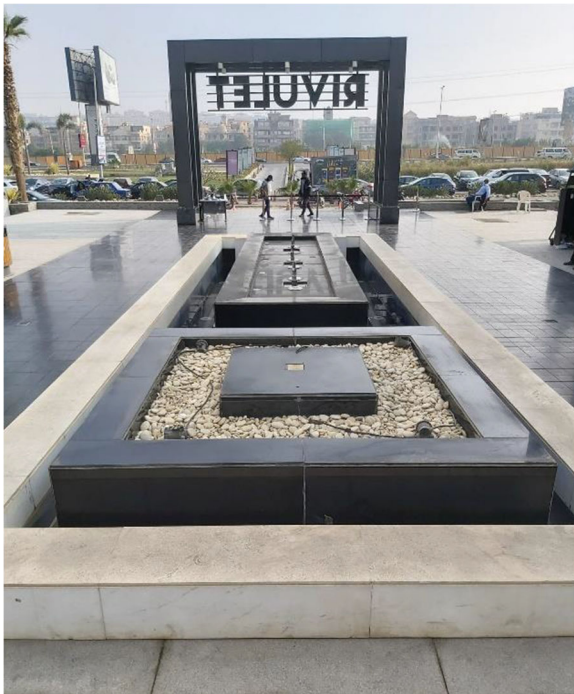


Fig. 7 Water fountain. Source: Researcher

Biophilic design patterns implemented in case studies

Table 4 shows biophilic design patterns in the case studies.

Applied case study

As mentioned in the previous section, existing landscape spaces need to be accessible to the public and visited by different types of users; our case study is a commercial administrative complex that is sought by various user types; the space offers a pleasurable pedestrian experience and also a great haven during short breaks for different types of employees in the complex.

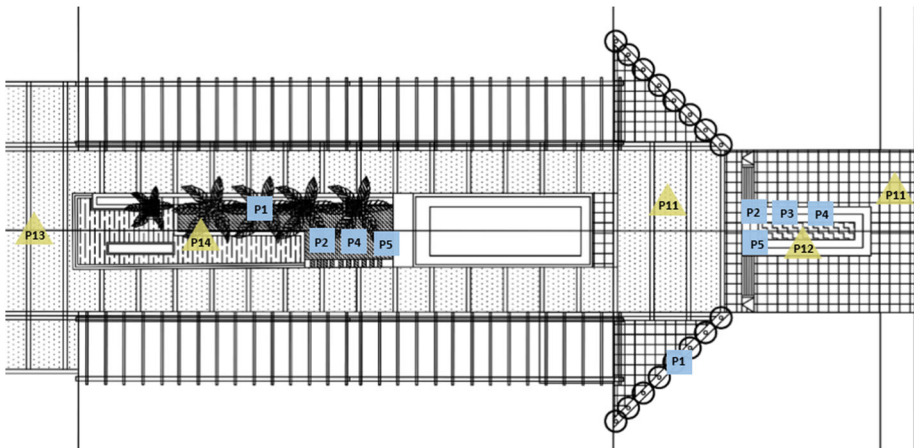
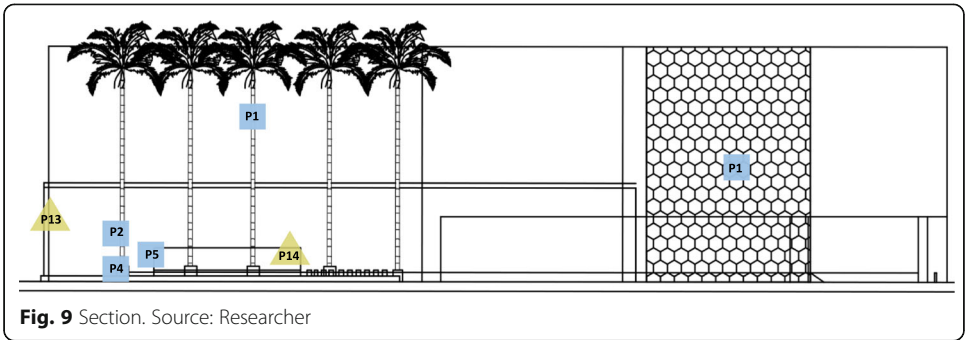


Fig. 8 Site Plan. Source: Researcher



Rivulet is a fully integrated complex that is located in El Sheikh Zayed City on the main 26th of July corridor combining different categories of attractions like restaurants, cafes, shops, and gyms and also has a business hub and medical centres; the space’s unique and simple design makes it a harbour for visitors and workers during short breaks (Figs. 5, 6, 7, and 8).

Table 5 Biophilic design patterns found in the applied case study

Category	Pattern	Rivulet complex space
Nature in the space	Visual connection with nature	Palm trees and other plants across the space
		Green wall
		Water fountain and reflecting pool
	Non-visual connection with nature	Cool air flowing from the water
		Sound of water fountain
	Non-rhythmic sensory stimuli	Birds flit in & out of space
		Water features
	Thermal & airflow variability	Cool air flowing from the water
	Presence of water	Water fountain and reflecting pool
	Dynamic & diffuse light	Not represented in design
Natural analogues	Connection with natural systems	Observing birds
	Biomorphic forms & patterns	Not represented in design
	Material connection with nature	Green walls
		Pebbles used around palm trees and reflecting pool
		Rough stones covering the walls of the fountain
		Wood used in the reflecting pool deck
Nature of the space	Complexity & order	Varying size of pebbles used around palm trees, water fountain and reflecting pool
	Prospect	The space is elevated above the street
		Raised entrance providing view to the busy street beyond
	Refuge	Limited visual access to street
		Sound of water fountain
	Mystery	Some zones of space are not visible from the entryway
	Risk/peril	Glass railings of the reflecting pool

Source: Researcher

The plan shows the green wall and water fountain that is located beside the entrance; the palm trees are arranged with fixed spaces between them; besides the reflecting pool that acts as a focal point in the space, some seat steps are provided by the water features.

The section cut through the centre of the plan showing the reflecting pool area with its deck, railings, and palm trees. It also shows the green wall (Fig. 9).

In order to evaluate this case study, we need to verify which patterns were achieved, and in which form and more over how we could increase its efficiency. Table 5 shows the patterns represented in the case study, with a brief on the form that was used to represent each pattern.

Results and discussion

The unrepresented patterns in the case study, lead to the absence of some important integrations of biophilic design patterns. This lowers the positive impact of design on health and reduces the effect of biophilic design overall. Table 6 shows the missing and achieved integrations between patterns in the previous case study.

The missing patterns could be implemented easily in order to achieve the integration between different patterns and increase the positive impact of the design. Referring to the case study, the missing patterns are dynamic and diffuse light and biomorphic forms and patterns.

Dynamic and diffuse light is an important pattern in order to elicit feelings of drama and mystery, time, and movement, buffered with a feeling of peace; the main goal of this pattern is to achieve an ununiformed distribution of light, but without extreme differences. This pattern could be achieved in many ways; some examples are creating shade structures, providing more shade using trees, or using simulated light distribution at night.

Table 6 Achievement of integrated biophilic design patterns in the case study

Relation to other patterns														
Biophilic design patterns	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	–	√	√		√			×			√			
2	√	–	√	√	√				√				√	
3	√	√	–	√	√					√			√	
4		√	√	–	√	×	√						√	
5	√	√	√	√	–		√				√			√
6				×		–	×	×					×	
7				√	√	×	–						√	
8	×					×		–		×				
9	√	√						×	–	√				
10	√	√						×	×	–				
11	√				√						–	√	√	√
12				√		×					√	–	√	
13	√	√	√			×	√			√	√	√	–	
14	√				√						√			–
Key	Missing integration			×	Integration achieved					√	No integration			

Source: Researcher after Terrapin [10]

The aim of biomorphic forms and patterns is to use biomorphic styles and patterns in a way that creates a more visually desired atmosphere that enhances cognitive performance while helping to alleviate tension. We are more attracted to organic and biomorphic shapes, but there is a hidden scientific reason that we need to figure out and address. While biomorphic forms and patterns are not living objects, our brain recognizes that they can be represented as symbolic representations of life; this pattern could be implemented in two ways, the decor elements and the form. Some examples in decor include golden mean in fabrics, carpets and wallpaper design, window glass colour and texture, and free-standing sculptures. While in form, examples include building and furniture form, columns shaped like trees, and pathway form.

Conclusions

As explored throughout the paper, biophilic design patterns can increase the efficiency of a landscape site experience; the more varieties of the patterns are used, the more efficiency we get. This takes us back to our main research question: "Could we use the biophilic design patterns to increase the landscape efficiency?"

The research aimed to introduce a new sustainable landscape approach by activating biophilic design patterns, to increase landscape efficiency; this approach was applied to an Egyptian case study, to analyse the possibilities and results and furthermore to suggest a proposed design that activates the biophilic landscape efficiency and achieves pattern integration.

All in all, biophilic design patterns are found around us in the landscape elements of any space, even if not intended or implemented in purpose. With little modifications, some landscape designs could be transformed into an integrated sustainable biophilic design that could generate positive impacts on the users and increase the landscape efficiency. Activating our perception of biophilic design patterns could be easily achieved by increasing the types of patterns and their different forms. This would also impact the user's health and well-being.

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Declaration

Competing interests

The author declares that there are no competing interests.

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