Malaysian Journal of Sustainable Environment
Vol.11.No.2 (2024) 297-325
doi: 10.24191/myse.v11i2.1616

BIOPHILIC ARCHITECTURE AND SPATIAL PERCEPTION: THE CASE OF GEOFFREY BAWA'S KEY WORKS AND THE PAM CENTRE, A COMPARATIVE ANALYSIS

Ahmad Zharif Ahmad Zahir*[1] & Farah Shahira Azmi[2]
***Corresponding Author**
[1]College of Built Environment, MARA University of Technology,
[2]Studies of Architecture, College of Built Environment,
MARA University of Technology
UiTM Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor

ahmadzharif@uitm.edu.my[1],
2023122449@uitm.edu.my[2]
Received: 08 June 2024
Accepted: 13 July 2024
Published: 31 August 2024

ABSTRACT

The three main design parameters noted in the applications of biophilic architecture, Nature in the Space, Natural Analogues, and Nature of the Space are key design principles that focus on the integral relationship between the natural and the built environment. This study explores the application of these primary Biophilic design principles in Geoffrey Bawa's architecture focusing on the indispensable aspects of both; architectural design (the craft) and user experience (the psychological and the social well-being), measured through aspect of spatial perception. As this study aims to benefit the discourse of Malaysian Architecture, it will bring forth the corollaries between Geoffrey Bawa's architecture and the newly retrofitted Centre of Malaysian Institute of Architects (PAM). Geoffrey Bawa is noted as the internationally recognised leading architect practicing Biophilic design. In this research there are three key questions that have been addressed; (1) What roles do these three primary Biophilic design principles play in architecture? (2) How do they then engender a concrete sense of a cohesive and natural-feeling environment to the general user in the PAM Centre? (3) How effective is the Biophilic design applied in the PAM Centre in nurturing close-knit connection with Nature for its users, compared to

other architecture of equivalent typology, namely public building. This study is driven by qualitative methodologies, covering document analysis, precedent study, and a comprehensive case study of the PAM Centre. This case study involves a comparative analysis of the Biophilic design principles specifically drawn from architectures of Geoffrey Bawa and their applications in the PAM Centre. The findings reveal a deep understanding of three (3) main pillars of the Biophilic design and their effective integration as already manifested by Geoffrey Bawa, which enhances the natural ambiance and connectivity to nature within building and built environment. In conclusion, the research demonstrates Bawa's Biophilic design principles which is evident in the architecture of PAM Centre successfully creating environments that are both natural and supportive of human well-being

Keywords: *Biophilic Architecture, Geoffrey Bawa, PAM Centre, Environmental Design, Environmental Sustainability*

INTRODUCTION

Biophilia in Architecture: Geoffrey Bawa and the PAM Centre

Biophilia and biophilic design play a crucial role in contemporary design and architecture, driven by the biophilic theory proposed by E.O. Wilson; a leading scholar in sociobiology (1984). Wilson's interpretation of the Biophilia concept blends the ancient Greek words for "life" (bio) and "love" (philia), meaning "love of life" (Barbiero & Berto, 2021). This Biophilia thesis suggests that people have an inherent need to connect with nature, as they naturally seek beauty in their immediate surrounding, which in one way or the other leads to active mental stimulation, and, thus, spiritual fulfilment (Downton et al., 2017). In addition, according to Colman (2009), humans' deep-seated connection to nature is part of our genetic makeup.

Incorporating biophilic design principles has become essential for enhancing human well-being in built environments (Griffin, 2004). Geoffrey Bawa, a pioneering architect in the realm of Biophilic Architecture has significantly applied these design principles in his works. Geoffrey Bawa's architectural style is renowned for its harmony with nature and context-

sensitive design. His projects integrate natural elements, organic forms, and social interaction-promoting spaces (Hu, 2017). His major works are known for developing major theories, discussions and design applications of tropical and vernacular architectures, around which the general discourse of Malaysia's contemporary architecture revolves (Hettiarachchi & Moore, 2024). These design applications cover aspects of architectural design such as spatial design, system of relations between architectural elements, and the choice of materials.

This study investigates Bawa's application of biophilic design principles as design models in his practice of tropical and vernacular architecture that could be replicated elsewhere, particularly in Malaysia's new contemporary architectures. Here, the investigation involves verification of the universality of Biophilic design principles across contexts. Besides, the focus is to investigate the applications of the three main design parameters of biophilic architecture: Nature in the Space, Natural Analogues, and Nature of the Space (Ryan et al., 2014).

In this study, Bawa's biophilic applications are contrasted against the newly minted Centre of Malaysian Institute of Architects (PAM), sited in Bangsar. Considering concerns over modern buildings' negative impacts on the environment, health and productivity, exploring alternative designs that focus on holistic well-being is urgent. The in-depth comparative analysis between Bawa's archetypal biophilic design applications in his major public architectures and the PAM Centre serves as an excellent measure on the standing of Malaysia's latest emblem of national architecture against its own self-prescribed sustainability mission regarding its long-term effects on the environment, as well as on the psychological and socio-cultural well-being of its occupants (Ibrahim, I., Khairuddin, R., Abdullah, A., Wahid, I. M. 2021).

Problem Statement

Existing research on Biophilic design key parameters often focuses on theoretical frameworks or general principles, yet there is limited empirical evidence regarding the effectiveness of these principles in real-world contexts (Zhong et al., 2021). While theoretical discussions provide an overview for understanding the potential benefits of Biophilic design,

practical insights derived from empirical studies are essential for validating these theories and informing evidence-based design decisions (Zhong et al., 2021). By conducting a detailed examination of the three pillars of Biophilic design frameworks, namely the mentioned design parameters of Nature in the Space, Natural Analogues, and Nature of the Space (Ryan et al., 2014), a list of design recommendations and its spatial perception outcomes can be derived.

Despite increasing recognition of Biophilic design's importance in enhancing architecture and spatial perception, there is limited understanding of Geoffrey Bawa's model applications of these principles. This gap exists due to a lack of empirical studies directly investigating Bawa's major works of public buildings against the architecture-wide Biophilic design parameters. Informal evidence suggests Biophilic design positively impacts well-being, but the specific design strategies and instruments applied through Bawa's architectures that contribute to occupant well-being remain unclear (Hu, 2017) (Owen, C., 2008). This research aims to address this gap through a comprehensive analysis of Bawa's designs, contributing to empirical evidence on Biophilic design's impact on architecture, as both built objects and design processes, as well as the resulting spatial perceptions.

These archetypal design strategies and instruments systematically derived from Bawa's major works will then be tested against the new PAM Centre. The comparative analyses between the two functions as an indicative measure to verify the major claims of Biophilic design present in the building (Ibrahim, I., Khairuddin, R., Abdullah, A., Wahid, I. M. 2021). This is noted as the original contribution of this paper considering existing studies on the new building of PAM Centre hardly outlines its Biophilic design applications.

Research Aim and Questions

This research aims to advance Malaysia's architecture as imperative to the scientific investigations in the realm of sustainable design and built environment. By positioning Geoffrey Bawa's major works as archetypal applications of key Biophilic design parameters, which then become the measure of Biophilic design strategies and instruments as applied in the PAM Centre. The resulting data will then be useful to offer recommendations on

the good design practice particularly regarding the applications of Biophilic key design parameters in Malaysia's architecture. It is also understood that successful implementation of Biophilic design will contribute to creating environments that improves occupant well-being.

Key research questions include verifying the applications of Biophilic design across contexts; time and place as well as examining the roles of the primary biophilic design principles in informing good design practice particularly in the context of Malaysia's architecture. In other words, how does the understanding on the mentioned design principles inform the framework of a set of systematic design practices that could work as strategic instruments to foster a cohesive and natural-feeling environment. Also, this study explores the effectiveness of biophilic design in forming a close connection with nature for its users compared to other public buildings – in this regard PAM Centre is chosen as a strategic case study to verify the appropriateness of Biophilic design in Malaysia's contemporary architecture.

Research Objectives

Objectives include studying the roles of biophilic design in architecture, analysing the environment's cohesiveness at the PAM Centre, and evaluating the biophilic design's effectiveness in connecting users with nature. Qualitative methodologies, including document analysis, precedent study, and a comprehensive case study of the PAM Centre, drive this research.

Here is the outline of the three main objectives of this research:

1. Analyse Biophilic Design Principles through its specified Design Parameters: Study Geoffrey Bawa's foundational biophilic design principles that is applicable across time, place and socio-cultural contexts.
2. Verify Applications of Biophilic Design Practices at the PAM Centre: Examine how do these principles are strategically applied in a modernist building that is an architype to Malaysia's contemporary architecture.
3. Evaluate Effectiveness of Nature-led Design Strategies: Assess the influence of these design elements on Spatial Perceptions, which translates into occupants' well-being.

Significance of Study

This study explores biophilic design principles in Geoffrey Bawa's architecture, contributing to the understanding and advancement of biophilic design knowledge, practical applications, and providing real-world examples. It aims to inspire future projects incorporating these principles for healthier and more sustainable built environments.

Significance of Study

This study explores biophilic design principles in Geoffrey Bawa's architecture, contributing to the understanding and advancement of biophilic design knowledge, practical applications, and providing real-world examples. It aims to inspire future projects incorporating these principles for healthier and more sustainable built environments.

Limitations

This study acknowledges limitations such as data availability, temporal constraints, and a single-case focus, which may affect the findings' robustness and relevance to other contexts.

For instance, the study acknowledges that the psychological and social effects of the Biophilic applied design parameters, drawn from the mentioned case studies are context and people sensitive. The observed effects, in the form of human experience, should be treated as conditional and non-conclusive, since architecture design and the environmental behaviour that result from it do not occur in a closed system.

In conclusion, this research highlights the importance of biophilic design in enhancing occupant well-being and provides practical insights for future architectural projects. By focusing on Geoffrey Bawa's work and the PAM Centre, the study underscores the significance of integrating biophilic elements to create environments that support human well-being and connection to nature. This research fills gaps in empirical studies on biophilic design, offering valuable guidance for architects and designers aiming to promote healthier, more productive, and human-centric built environments.

LITERATURE REVIEW

The research delves into the significance and drawbacks of Biophilic Design key principles, examining Geoffrey Bawa's approach within a regional context. It provides a thorough investigation of existing knowledge, exploring the alignment between Biophilic design principles and Bawa's strategies.

The initial section discusses Biophilic design's theoretical framework, particularly the "Three Pillars" of Biophilic design. These pillars serve as essential strategies that enhance both architectural design and user experience, contributing to psychological and social well-being. This theoretical framework serves as a foundation for understanding its implementation in built environment, benefiting both architectural design (the craft), spatial quality and spatial perception (occupant comfort and well-being).

Biophilic Design in Architecture

Biophilic design is an innovative method in architecture that incorporates natural components into the construction of buildings to enhance well-being, cognitive function, and overall quality of life (Kellert & Calabrese, n.d.). This concept stems from our profound affinity with nature and its patterns, structures, and constituents. Biophilic design seeks to achieve a harmonious balance between man-made structures and the natural environment to enhance the human experience (Kellert & Calabrese, n.d.).

Biophilic design refers to the architectural approach that fosters a strong connection between people and the natural environment. The design incorporates natural elements and architectural concepts to achieve a harmonious integration of the built environment with nature. This design philosophy is rooted in the Biophilia principle, which posits that individuals have an innate inclination towards nature. Biophilic design integrates elements of nature directly, such as plants, water features, and natural light, as well as indirectly using materials, textures, and colours that imitate nature (Browning, Ryan, & Clancy, 2014). The primary focus is on offering

perspectives, ensuring safety, and delivering diverse sensory encounters to construct settings that closely resemble natural habitats (Kellert et al., 2008). Biophilic design necessitates meticulous site selection and building orientation, incorporation of interior design elements such as green spaces and ample natural light, utilisation of sustainable materials, and integration of intelligent technologies (Browning et al., 2014).

The three (3) fundamental principles of Biophilic design in architecture, namely Nature in the space, Nature Analogue, and Nature of the place, work together to establish spaces that promote human well-being by fostering a connection between building occupants and nature.

Nature in the place brings plants, water features, and natural light into the constructed environment for immediate, physical experiences (Kellert, Heerwagen, & Mador, 2008). Environmental Features: Adding water features, sunlight, flora, and plants to the constructed environment to foster a connection to nature. Create harmony and balance with natural shapes and forms like columns, ovals, arches, and spirals. Use transitions and complementing contrasts such centre focal points, patterned holes, and clear borders to incorporate sensory experiences (Ryan et al., 2014).

Nature Analogue uses natural materials like wood and stone and organic design themes to resemble or convey natural aspects, even if they are not existent (Browning, Ryan, & Clancy, 2014). Light and Space: Creating exciting, dynamic, and sculptural forms that mirror natural environments using diverse lights and spatial interactions (Ryan et al., 2014). Place-based Relationships: To develop a sense of location and belonging, focus on ecology and major geographical characteristics such mountains, deserts, rivers, and flora (Zhong et al., 2021).

Nature of the space incorporates prospect and sanctuary, sensory variety, and natural rhythms and processes to create settings that seem like nature (Söderlund & Newman, 2015). Evolutionary Human-Nature Relationships: Stressing the connection between humans and nature, addressing our passion for nature, and encouraging environmental responsibility. These ideas can be utilised alone or jointly to connect non-natural environments to nature and ensure a balance between human-made structures and nature (Ryan et al., 2014).

Research shows that Biophilic design in architecture improves health and well-being. Wei Jie Zhong found that biophilic surroundings boost cognitive function, stress, and quality of life. Biophilic design also boosts productivity, attitude, and sleep (Mollazadeh & Zhu, 2021). Biophilic design encourages the use of natural materials and decreases the need for artificial lighting and ventilation, making buildings more sustainable (Zhong et al., 2021). Biophilic design may help achieve sustainable development goals (SDG) by fostering natural materials and biodiversity through green areas and living walls (Kellert, 2005). Biophilic design in building enhances sensory experience and promotes healthier, more sustainable human-environment interactions.

Spatial Perception in Biophilic Design

Spatial perception is the ability to understand and interpret environmental spatial relationships and dimensions. It is essential to human cognition and affects how we navigate and interact with the world. Perception is essential for everyday tasks like walking in a room to driving or playing sports (Loomis, Klatzky, & Giudice, 2013). Deep perception, distance estimation, and object placement and orientation identification are all part of spatial perception. Wolbers & Hegarty (2010) found that spatial perception is shaped by innate brain mechanisms and learnt experiences and is modified by visual and proprioceptive sensory inputs. The design of physical spaces can significantly affect spatial perception; open and well-lit environments improve distance judgement and navigation, while cluttered or dimly lit areas can impair spatial awareness and increase accident risk (Franz & Wiener, 2008).

Spatial perception encompasses:

1. Depth perception: Distance and three-dimensionality perception. Binocular and monocular perspective, shading, and texture gradients determine depth.
2. Distance estimation: Measures distances between things and oneself. Driving, sports, and navigation demand precise distances.
3. Spatial orientation: Direction and environment awareness. This includes landmarks, spatial relationships, and navigation.
4. Spatial memory: Location and feature storage and retrieval. Spatial

memory recalls location and directions.
5.Object localisation: Placement of objects relative to oneself and others. This skill is needed for object manipulation.

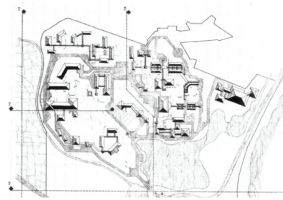
Biophilic design enhances spatial awareness by linking individuals to their surroundings. The Biophilia concept says humans are drawn to nature. Biophilic design creates quiet, connected rooms with natural light, plants, water features, and organic materials (Kellert, Heerwagen, & Mador, 2008). Browning, Ryan, & Clancy (2014) found that natural interior elements reduce stress, improve cognition, and raise well-being. Natural surroundings can boost happiness and focus (Söderlund & Newman, 2022). Biophilic design improves spatial orientation, wayfinding, and productivity by increasing sensory experiences and place. This strategy is becoming more popular for boosting health and well-being in healthcare, education, and the workplace.

Geoffrey Bawa's Architectural Philosophy

In the 20th century, Sri Lankan architect Geoffrey Bawa transformed architecture. Bawa, born in 1919, emphasised site and context in his architecture. Space manipulation and light and shade were crucial to understanding a building, which he believed could only be understood by moving through it. He was a key player in tropical modernism because to his regard for indigenous culture, heritage, and sustainability. Bawa uses courtyards, verandas, and lush landscaping to blend architecture and nature (Hettiarachchi & Moore, 2024).

His philosophy is that architecture should adapt to its climate and topography to create beautiful and effective buildings. Bawa's private mansions, hotels, and public structures combine contemporary concepts with traditional Sri Lankan design components to create unique and profoundly rooted environments (Geoffrey Bawa | PPT, 2014). Geoffrey Bawa's architecture celebrates site, blends modern and vernacular, and showcases the beauty of combining constructed spaces with nature, which aligns to the mentioned Biophilic design principles.

Table 1. Geoffrey Bawa's Public Building

Building Code	Building	Location / Year	Building Typology	Design Language
GB01	Lunuganga Estate  Image 1: Hallway Corridor of Lunuganga Estate. Source: Re-Thinking the Future. (www.re-thinkingthefuture.com)	Bentota, Sri Lanka/ 1940	Residence	Landscape architecture integrating garden design with architecture
GB02	University of Ruhuna  Image 2: Site Plan of Ruhuna University. Source: Re-Thinking the Future. (www.re-thinkingthefuture.com)	Matara, Sri Lanka/ 1978	Educational Institution	Modernist approach adapted for institutional needs
GB03	Heritance Ahungalla  Image 3: Aerial View of Heritance Ahungalla. Source: Daily Mirror. (www.dailymirror.lk)	Ahungalla, Sri Lanka/ 1981	Hotel	Organic architecture, blending with the natural surroundings
GB04	Sri Lankan Parliament  Image 4: Aerial View of Sri Lankan Parliament. Source: World Architecture. (worldarchitecture.org)	Kotte, Sri Jayewardenepura, Sri Lanka/ 1982	Government Building	Tropical modernism, emphasizing local materials and climatic responsiveness

GB05	Heritance Kandalama  Image 5: Hallway Corridor of Kandalama Hotel. Source: Planning Design. (www.planningdesign.co.uk)  Image 6: Front of Kandalama Hotel. Source: Planning Design. (www.planningdesign.co.uk)	Dambulla Sri Lanka/ 1994	Hotel	Organic architecture, blending with the natural surroundings

Source: Author

RESEARCH METHODOLOGY

The study exclusively utilises qualitative methodologies for the collection of data and information. Collecting and analysing data includes reviewing past research on three fundamental aspects of Biophilic Design, examining Geoffrey Bawa's public buildings as example of Biophilic design applications, and then comparing it with the PAM Centre. Domains of investigation for the comparative analysis are spatial quality and spatial perception.

Stage 1: Literature Review Analysis

The initial research methodology employed for this study was to collect data from a variety of sources, including journals, papers, books, and magazines. All collected data included sources such as images, drawings, and quotes. To analyse data, all information is collected and filtered suitably. The literature review will draw on published sources from scholarly and academic journals (Rowley & Slack, 2004). Most of these published papers were written by researchers and professionals. These could contain a review

of the literature, an overview of the research methodologies employed, explanations of the findings, as well as conclusions and recommendations. According to Rowley & Slack (2004), these articles preserve and transmit thoroughly researched domains that are usually pre-refenced before publication.

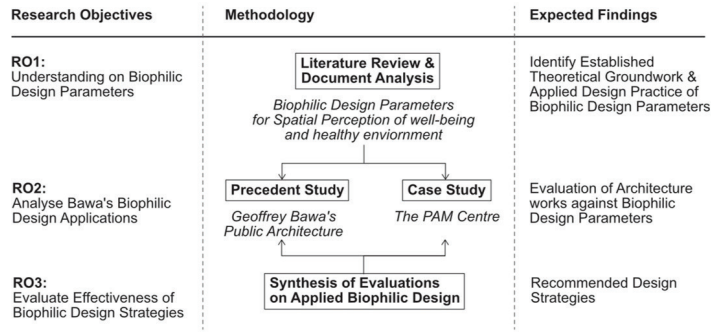
Stage 2: Analysing the Key Parameters of Biophilic Design in Spatial Quality and Spatial Perception based on five (5) precedents of Geoffrey Bawa's public buildings and the PAM Centre.

Stage 2 of the research is principally a systematic precedent study. It examines key aspects of biophilic design in relation to spatial quality and spatial perception. Five (5) key works of Geoffrey Bawa in the sector of public buildings are chosen as precedents. The research process takes a complete approach that begins with a literature assessment to lay theoretical groundwork and identify essential Biophilic design parameters. Based on recognition and verification of available recorded data such as architecture measured drawings and photos, the investigation is set to discover and evaluate biophilic characteristics in selected buildings' spatial quality and spatial perception. A detailed table of Biophilic design main parameters will summarise the findings.

Stage 3: Comparative Study and Case Study Analysis

The third stage entails comparative research that contrasts data from the precedent studies of Bawa's key works with the analysis of the PAM Centre, Bangsar. This technique seeks to find parallels and contrasts between Biophilic Design applications in broadly recognised architectures like Bawa's and the local setting. In conclusion, this holistic methodology guarantees a thorough understanding of Biophilic Design concepts and their implementation in public architectures. Synthesising the findings will demonstrate the effectiveness of Biophilic design, its implications for architectural practice, and future project recommendations. The results will be used to produce a comprehensive table of critical Biophilic design criteria.

Figure 1: Research Methodology Framework



Source: Author

FINDINGS & ANALYSIS

The data collected during the research process, focuses on three primary aspects:

1. The three primary Biophilic design principles in architecture.
2. The sense of cohesiveness and natural environment in the PAM Centre.
3. The effectiveness of the Biophilic design strategy in nurturing a connection with nature compared to other public architectures.

Data obtained from each section will be organised and presented in a comparative table. A full examination and synthesis of the data findings will be thoroughly described.

Literature Review Analysis: Understanding the Biophilic Design

Based on the data gathered, the three (3) pillars of Biophilic design are critical as a major design principle for using Biophilic design in architecture. As stated by Ryan et al. (2014), the three core principles of Biophilic design represent the connections between humans and nature. These principles serve as a framework for incorporating building elements and traits that address well-being demands and enhance the overall experience. Designing buildings with components that elicit positive emotions and prioritise the promotion of health, comfort, and happy experiences (Downton et al., 2017). Biophilic design parameters, while grounded in scientific study, are not rigid regulations. Instead, their purpose is to assist and direct designers in the

creation of environments. The purpose of these parameters is to elucidate the ways in which various aspects of architectures and environment interact, and how these interactions have a beneficial impact on individuals. They are just one of several strategies available to designers for enhancing human well-being in places (Ryan et al., 2014).

Kellert (2008)'s biophilic design concepts underpin the table below. Biophilic design incorporates health, comfort, and pleasurable experiences to improve human well-being. Designers use these design parameters to create spaces that connect people to nature.

Table 2. Parameters of Biophilic Design

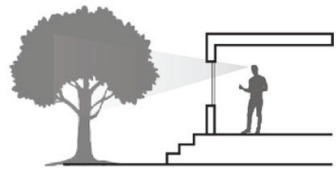
Design Parameters	Description	Elements/Features
Nature in the Space		
Visual Connection with Nature	Observation of natural environments and functioning ecosystems (real or simulated)	-Plants -Animals -Water -Fire -Habitats and ecosystems -Image of nature -Views and Vistas
Non-Visual Connection with Nature	Non-visual sensory inputs that have a good association with living systems or nature.	-Smell of plants -Animal sounds -Waterfall sound -Fireplace sound
Light	Different degrees of actual or simulated lighting and shadow casting that resemble natural lighting conditions	-Natural light and shadow -Filtered light -Warm light -Reflected light
Thermal and airflow variability	Different levels of actual or artificial light and shadow like those seen in nature (real of stimulated)	-Surface temperature airflow (e.g. wind, breeze) -Humidity
Natural Analogues		
Natural material	Materials and elements derived from nature	-Natural materials
Natural Shapes and Forms	A symbolic parallel to the forms and shapes that are found in the natural environment	-Natural geometries -Natural colours -Biomimicry -Biomorphic

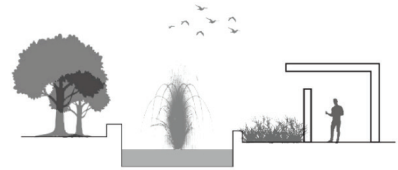
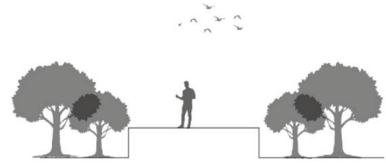
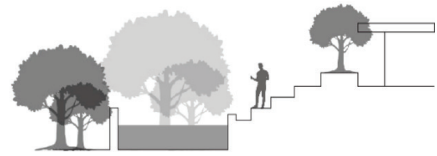
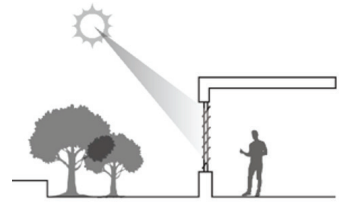
Natural patterns and processes	A symbolic parallel to patterns and processes observed in the natural world	-Growth -Change and age -pattern -Integration of parts to whole -Fractals -Central Focal point -Transition spaces -Bounded spaces
Nature of the space (Experience of place and space)		
Evolved Human-Nature Relationship	Natural arrangements of space. It includes the natural desire that all people have	-Refuge and prospect -Discovery and exploration -Mastery -Curiosity -Protection and security -Order and complexity
Place-Based Relationship	Place attachment and people's normal desire to be in familiar places	-Historical, cultural, geographic or ecological connection to place -Culture and ecology integration -Landscape orientation -Landscape features and ecology -Indigenous materials -Spirit of place

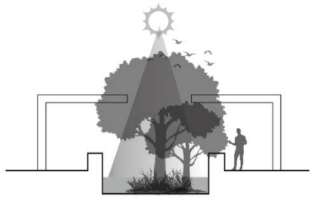
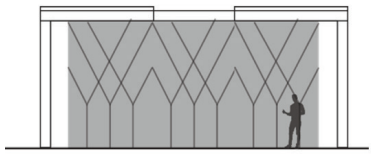
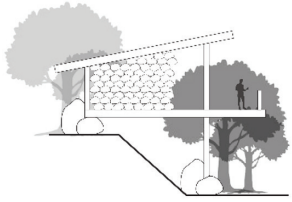
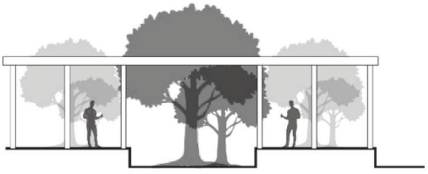
Source: Mollazadeh & Zhu, (2021)

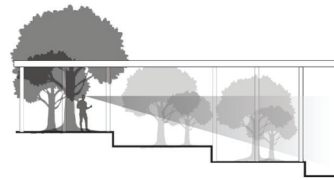
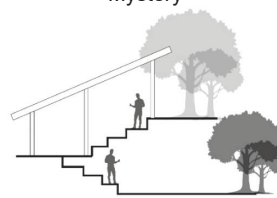
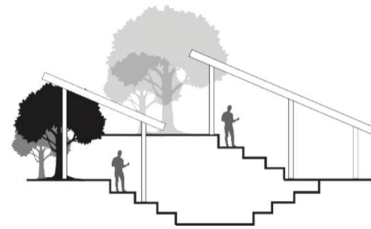
Browning et al. (2014) proposed 14 Parameters of Biophilic Design to integrate people's biology and nature in the built world. Downton et al. (2017) employ the 14 Parameters of Biophilic Design to construct a practical framework. The framework helps plan and and identify design opportunities that improve places and the built environment, creating healthy spaces for humans and living things (Downton et al., 2017). This method shows that Biophilic design is more than just adding plants—it's about creating a full experience that integrates nature and architecture in healthy ways.

Table 3. 14 Parameters of Biophilic Design

Contexts	14 Parameters of Biophilic Design
Nature in the Space	
[P1] Visual Connection With Nature A view to elements of nature, Living systems and natural processes	Visual Connection with nature  Figure 3.1: Visual Connection with nature. Source (Author, 2024)

[P2] Non-Visual Connection with Nature Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes	Non-Visual Connection with nature  Figure 3.2: Non-visual connection with nature. Source (Author, 2024)
[P3] Non-Rhythmic Sensory Stimuli Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely	Non-Rhythmic Sensory stimuli  Figure 3.3: Non-Rhythmic Sensory stimuli. Source (Author, 2024)
[P4] Thermal and Airflow Variability Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments	Thermal and airflow Variability  Figure 3.4: Thermal and airflow Variability Source (Author, 2024)
[P5] Presence of Water A condition that enhances the experience of a place through seeing, hearing or touching water	Presence of Water  Figure 3.5: Presence of Water. Source (Author, 2024)
[P6] Dynamic and Diffuse Light Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature	Dynamic and diffuse light  Figure 3.6: Dynamic and diffuse light Source (Author, 2024)

[P7] Connection with Natural System Understanding environmental phenomena, especially cyclical and time-related fluctuations that indicate a healthy ecology	Connection with natural system  Figure 3.7: Connection with natural system Source (Author, 2024)
Natural Analogues	
[P8] Biomorphic Forms and Patterns Symbols of natural patterns like consistency, structure, texture, or numbers	Biomorphic Forms and Patterns  Figure 3.8: Biomorphic Forms and patterns. Source (Author, 2024)
[P9] Material Connection with Nature Natural materials that are minimally processed to reflect the local environment or geology create a unique and true feeling of locality	Material connection with Nature  Figure 3.9: Materials connection with nature. Source (Author, 2024)
[P10] Complexity and Order Rich sensory information with a natural spatial hierarchy	Complexity and order  Figure 3.10: Complexity and order Source (Author, 2024)
Nature of the Space	

[P11] Prospect An unimpeded view over a distance for surveillance and planning	Prospect  Figure 3.11 Prospect Source (Author, 2024)
[P12] Refuge A secure refuge that provides protection from both the immediate environment and the predominant movement of people, shielded from the rear and above	Refuge  Figure 3.12 Refuge Source (Author, 2024)
[P13] Mystery The possibility of learning more, aided by partially obscured views or other sensory devices that encourage exploration	Mystery  Figure 3.13 Mystery Source (Author, 2024)
[P14] Risk/Peril An identifiable threat coupled with a reliable safeguard	Risk/Peril  Figure 3.14 Risk/Peril Source (Author, 2024)

Source:Browning et.al(2014)

Although there is an increasing amount of study conducted by academics and experts on Biophilic design, there is still a notable misunderstanding among the media, the general public, and practitioners

in the field of built environment. This myth suggests that Biophilic design is only about including plants, such as green roofs, green walls, and water-sensitive urban design components (Downton et al., 2017). Nevertheless, this limited perspective fails to include the wider range of Biophilic reactions that might be evoked by the holistic encounter with the constructed surroundings. The 14 Parameters of Biophilic Design illustrate that the effects of Biophilia can be achieved without direct physical links to nature or living systems (Downton et al., 2017). Nature in the Space: Bawa's designs blend indoor and outdoor spaces, like Lunuganga Estate and Heritance Kandalama, creating immersive nature experiences.

The 14 Parameters of Biophilic Design (Downton et al., 2017) are used to create a practical and successful framework. This framework guides and evaluates place-making and built environment projects. The goal is to create areas that benefit humans and the environment (Downton et al., 2017). This method shows how Biophilic design goes beyond merely adding plants to provide a holistic experience that integrates nature and architecture in healthy ways.

Precedent Studies and Case Study Analysis: Evaluation of the Biophilic Key Design Parameters in Bawa's Public Architectures and the PAM Centre

The final examination of spatial perceptions in different architectural designs demonstrates a unified focus on using natural elements and maximising lighting to improve the user's experience. The Lunuganga Estate, Heritance Kandalama, and architectural projects by Geoffrey Bawa demonstrate this method by employing a deliberate arrangement of open and enclosed areas, corridors, and expansive apertures to effectively disperse and manipulate natural light in a dynamic manner. These features not only allow natural light to enter but also include shade to ensure a well-balanced and comfortable environment. Similarly, the Sri Lankan Parliament utilises shading devices to regulate the dynamics of light, showcasing a consistent architectural approach that emphasises alignment with nature and efficient light regulation. The amalgamation of design principles from many projects emphasises the significance of deliberate spatial organisation and the incorporation of natural elements in the creation of visually appealing and highly functional places.

Table 4. Geoffrey Bawa's Public Building and the PAM Centre against the 14 Parameters of Biophilic Key Design Parameters

Code/ Name	Nature in the Space							Nature Analogues			Nature of the Space				Total Score
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	
GB01 Lunuganga Estate	/	/	/	/	/	/	/	/	/	/	-	/	/	-	11/14
GB02 University of Ruhuna	/	/	/	/	/	/	/	-	/	/	-	-	/	-	10/14
GB03 Heritance Ahungalla	/	/	/	/	/	/	/	/	/	-	/	-	-	-	10/14
GB04 Sri Lankan Parliament Building	/	/	/	/	/	/	/	/	/	-	-	-	-	-	9/14
GB05 Kandalama Hotel	/	/	/	/	/	/	/	/	/	/	/	/	/	-	13/14
CS01 PAM Centre	/	/	/	/	/	/	/	/	/	/	/	/	/	-	13/14

Source: Author (2024)

P1Visual connection With Nature
P2Non-Visual Connection with Nature
P3Non-Rhythmic Sensory Stimuli
P4Thermal and Airflow Variability
P5Presence of Water
P6Dynamic and Diffuse Light
P7Connection with Natural System
P8Biomorphic Forms and Patterns
P9Material Connection with Nature
P10Complexity and Order
P11Prospect
P12Refuge
P13Mystery
P14Risk/Peril

According to the previous analysis of Geoffrey Bawa's public buildings, it can be observed that most of his public works align closely with the 3 main principles and 14 key characteristics of Biophilic design. GB05 and CS01 achieve the greatest scores, both earning 13 points. GB01 follows closely with 11 points, while GB02 and GB03 both score 10 points. The lowest score is obtained by GB04, with 9 points. The ratings demonstrate that Geoffrey Bawa's approach to tropical environments and vernacular architecture align directly with the three fundamental elements of biophilic design.

Synthesis of Applications of Biophilic Design: Guideline on Biophilic design strategies in Architecture design and spatial perception

A comparative evaluation of biophilic principles in Geoffrey Bawa's

architecture and PAM Centre shows different yet effective applications of nature in built environments:

1.Nature in the Space: Bawa's open courtyards and lush gardens vs. PAM's integrated plants and open spaces.
2.Non-Visual Connection with Nature: Bawa's serene water features vs. PAM's outdoor spaces promoting social interactions.
3.Thermal and Airflow Variability: Bawa's natural ventilation and high ceilings vs. PAM's ventilated lounges and open space.
4.Dynamic and Diffuse Light: Both Bawa's and PAM's use of natural light enhance the environment's aesthetics and occupant satisfaction.
5.Material Connection with Nature: Bawa employed local materials for authenticity, while PAM used materials like red brick to blend traditional and modern elements.
6.Complexity and Order: Visually pleasing spaces that balance stimulation and relaxation.
7.Prospect and Refuge: Spatial designs offering openness and secure, tranquil spots enhance occupants' engagement and comfort.

The following are the guidelines for implementing Biophilic design methods in Architecture design and spatial perception. These principles are derived from the examination and assessment of 14 Biophilic Design Parameters in relation to five previous studies, specifically the public buildings designed by Geoffrey Bawa and the PAM Centre in Bangsar. The study aims to identify both common and distinctive Biophilic features, assess their application in Architectural design, and analyse their impact on spatial perception.

Table 5. Geoffrey Bawa's Public Building and the PAM Centre against the 14 Parameters of Biophilic Key Design Parameters

Biophilic Design Parameter	Architectural Design	Spatial Perception
[P1] Visual connection With Nature A view to elements of nature, Living systems and natural processes	-Courtyards -Openings -Balcony -Green walls -Landscape-facing Openings -Green pocket	-Integration with natural surrounding -Visual connection with nature

[P2] Non-Visual Connection with nature Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes	-Natural landscape -Artificial water features -Green Walls -Planter box -Natural materials, colour, and texture	-Use of Natural Elements -Enhancement of Ambiance
[P3] Non-Rhythmic Sensory stimuli Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely	-Courtyards -Water features -Planter box -Open courtyard -Natural plants -Pocket garden -Wide openings	-Presence of scents, sounds, light & shadow and Air/Water -Inside-out ambiance
[P4] Thermal and airflow variability Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments	-Courtyards -Corridor -Wide Opening -Green Walls -Shading devices -Louvres`	-Integrates building with nature -Enhancement of thermal and Airflow dynamic
[P5] Presence of water A condition that enhances the experience of a place through seeing, hearing or touching water	-Pool -Artificial water features -Pond -Lakes -River -Ocean	-Enhancing the visual and physical connection with nature. -Tranquil and immersive experience amidst nature
[P6] Dynamic and diffuse light Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature	-Wide opening -Corridor -Green Wall -Skylights	-Dynamic light diffusion -well-controlled lighting experience -Energy Efficiency
[P7] Connection with natural System Understanding environmental phenomena, especially cyclical and time-related fluctuations that indicate a healthy ecology	-Green spaces -Landscape -Close to water body -Integrates with nature elements to be as part of the building structure	-Integration with nature -Respecting site -Visual Connection to nature
[P8] Biomorphic Forms and Patterns Symbols of natural patterns like consistency, structure, texture, or numbers	-Exposed structure -Large and wide opening -Artificial nature element - Visual imitation of natural elements	-Natural materials and colours -Nature-Inspired Ambiance

[P9] Material connection with Nature Natural materials that are minimally processed to reflect the local environment or geology create a unique and true feeling of locality	-Timber as frame for opening and railing -Natural stone -Wide Glass -Timber flooring, wall and furniture -Artificial natural elements such as plants	-Transparency & light -Connection with nature -Warmth & Comfort -Aesthetic Harmony
[P10] Complexity and order Rich sensory information with a natural spatial hierarchy	-Dynamic sequence of courtyard and veranda -Open Atrium Framing landscape -Open space and pocket garden	-Dynamic & Engaging -Visually and physically connected to nature- Enhanced wayfinding
[P11] Prospect An unimpeded view over a distance for surveillance and planning	-Open plan layout -Vertical levelling with atrium -Internal balcony and mezzanine floor	-Sense of openness -Connection to nature -Transparency
[P12] Refuge A secure refuge that provides protection from both the immediate environment and the predominant movement of people, shielded from the rear and above	-Courtyards -Balcony -common spaces	-Sense of Containment -Separate & Unique -Exclusive -Seamless connection to nature
[P13] Mystery The possibility of learning more, aided by partially obscured views or other sensory devices that encourage exploration	-Flow of connecting staircase to courtyard or balcony -Dynamic sequence of courtyards and verandas	-Connection with nature -Dynamic spatial sequence -Nature integration
[P14] Risk/Peril An identifiable threat coupled with a reliable safeguard	*All precedent studies and case study were observed to not have this final patterns.	*All precedent studies and case study were observed to not have this final patterns.

Source (Author 2024)

CONCLUSION

The study stresses how Biophilic design concepts effect architectural practices and occupant well-being. An analysis of the PAM Centre and

Geoffrey Bawa's architecture shows how Biophilic design may create environments that nurture a deep connection to nature. This partnership enhances mental and physical health as well as appearance. Modern architecture uses biophilic design to improve residents' quality of life by using natural materials, facilitating airflow, and creating attractive spaces (Ryan et al., 2014)

The study examines the three Biophilic design concepts in architecture. Data are collected from journals, papers, books, and periodicals utilising literature review methodologies. The study emphasises the 14 Biophilic Design Parameters (Ryan et al., 2014). This comprehensive framework methodically incorporates Biophilic ideals into architectural design, promoting well-being through multiple applications. The design parameters help uncover design opportunities and implement solutions that improve human-nature relations (Mollazadeh & Zhu, 2021). The PAM Centre's architecture uses dynamic and diffuse light, natural mimics, and smooth airflow to produce a healthy environment (Ibrahim et al., 2021).

Continue to Research objective two, which examines the average PAM Centre user's perception of a coherent and organic environment. Comparing Bawa's architecture and the PAM Centre shows that both apply the three Biophilic design principles: inclusion of nature, use of natural analogues, and consideration of the space's inherent character. Lunuganga Estate and Heritance Kandalama are Bawa's faultless integration of natural elements with built surroundings. Open courtyards, extensive gardens, and natural materials create a multi-sensory experience that increases tenant well-being (Hu, 2017). The PAM Centre's multi-level atrium and the building's small open spaces, which are meticulously intended to contain plants and natural materials, create a coherent and nature-inspired experience for users.

Finally, study objective three (3) compares the PAM Centre's Biophilic design philosophy to comparable institutional buildings to see if it helps users connect with nature. Resolving Biophilic design myths is crucial. Despite common belief, Biophilic design includes more than just plants and a wider spectrum of design strategies that elicit Biophilic responses. These methods leverage natural light, ventilation, and natural equivalents to enhance the built environment. Biophilic design can generate healthy, comfortable, and enjoyable spaces (Downton et al., 2017).

Biophilic design concepts' successful use in the PAM Centre and Bawa's architecture shows their importance in modern architecture. Biophilic design connects people to nature, improving their mental and social health as well as the appearance and functionality of buildings (Ryan et al., 2014). This study suggests using natural materials and Biophilic principles to develop buildings that promote human well-being.

FUNDING

There is no funding for this research.

AUTHOR CONTRIBUTIONS

All authors contributed to the design of the research, the questionnaire, and the write-up. The on-line survey, data cleaning and tabulation was undertaken by MARA University of Technology. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Barbiero, G., & Berto, R. (2021). Biophilia as Evolutionary Adaptation: An Onto- and Phylogenetic Framework or Biophilic Design. *Frontiers of Psychology, 12*(1). Retrieved April 26, 2024, from doi.org/10.3389/fpsyg.2021.700709.

Downton, P., Jones, D., Zeunert, J., & Roos, P. (2017). *Biophilic Design Applications: Putting Theory and Patterns into Built Environment Practice*, 2017, Retrieved April 26, 2024, from doi.org/10.18502/keg.v2i2.596.

Geoffrey Bawa | PPT. (2014). *SlideShare.* Retrieved July 1, 2024, from

slideshare.net/slideshow/geoffrey-bawa/39886357.

Griffin, C. (2004). *An Introduction to Biophilia and The Built Environment.* RMI Solutions, 20(1), pp. 7–11, Retrieved April 27, 2024, from archives.pdx.edu/ds/psu/17468.

Hettiarachchi, R., & Moore, C. (2024). *Tropical modern design strategies used by Geoffrey Bawa*. Sri Lanka: Sri Lanka Institute of Information Technology.

Hu, W. (2017, June). A Simple Analysis on The Combination of Modernism and Regional Culture in The Construction by Geoffrey Bawa. *Proceedings of the 2nd International Conference on Contemporary Education, Social Sciences and Humanities* (ICCESSH 2017), pp. 496–499, Retrieved April 27, 2024, from doi.org/10.2991/iccessh-17.2017.121.

Ibrahim, I., Khairuddin, R., Abdullah, A., & Wahid, I. M. (2021). Analysis of biophilic design in communal space of an office building. Case study: Pertubuhan Arkitek Malaysia (PAM) centre, *AIP Conference Proceedings, 2347*(1) Retrieved April 28, 2024, from doi.org/10.1063/5.0052824.

Kellert, S. R., & Calabrese, E. F. (N.D.). *The Practice of Biophilic Design.* Minnesota: UMN Press.

Kiang, T. B., & Robson, D. (2006). Bioclimatic Skyscraper – Learning from Bawa, PLEA-2006 – *The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland,* 6-8 September, Retrieved April 28, 2024, from api.semanticscholar.org/CorpusID:111334984.

Mollazadeh, M., & Zhu, Y. (2021). *Application of Virtual Environments for Biophilic Design: A Critical Review. Buildings*, Retrieved April 28, 2024, from doi.org/10.3390/buildings11040148.

Owen, C. (2008). Architecture Between the Culture-Nature Dualism: A Case Study of Geoffrey Bawa's Kandalama Hotel. *International Journal of Architectural Research: Archnet IJAR, 2*(1), pp. 40-56 Retrieved April 29, 2024, from archnet.org/.

Robson, David (2001). *"Genius of the Place: The Buildings and Landscapes*

of Geoffrey Bawa." In Modernity and Community: Architecture in the Islamic World, edited by Philippa Baker, pp.17-48. London: Thames & Hudson.

Ryan, C. O., Browning, W. D., Clancy, J. O., Andrews, S. L., & Kallianpurkar. (2014). Biophilic Design Patterns Emerging Nature-Based Parameters for Health and Well-Being in The Built Environment. *International Journal of Architectural Research: Archnet IJAR, 8*(2), pp. 62-75 Retrieved April 29, 2024, from archnet.org/.

Sperlich, B. W., Hoffmann, S., Salditt, A., Bipp, T., & Froboese, I. (2019). Moving To An "Active" Biophilic Design Office Workplace: A Pilot Study About the Effects on Sitting Time and Sitting Habits of Office-Based Workers. *Int J Environ Res Public Health, 16*(9), Retrieved April 30, 2024, from doi.org/10.3390/ijerph16091559.

Vimukthi, K.K. M., & Rajapaksha, U. (2015). Spatio-Visual Patterns in Respect to Visual Experience: An Exploration of Architecture of Geoffrey Bawa, *8th International Conference of Faculty of Architecture Research Unit* (FARU) - 2015, pp. 357-368, Retrieved April 30, 2024, from dl.lib.mrt.ac.lk/handle/123/12922.

Zhong, W., Schroder, T., & Bekkering, J. (2021). Biophilic Design in Architecture and Its Contributions to Health, Well-Being, And Sustainability: A Critical Review. *Frontiers of Architectural Research, 11*(1), pp. 114-141, Retrieved April 30, 2024, from doi.org/10.1016/j.foar.2021.07.006.

Wilson, E. O. (1984). *Biophilia. Harvard University Press,* Retrieved May 1, 2024, from archive.org/details/edward-o.-wilson-biophilia/page/61/.

Browning, W., Ryan, C.O., & Clancy, J. (2014). *14 Patterns of Biophilic Design: Improving Health and Well-Being in the Built Environment.*

Loomis, J. M., Klatzky, R. L., & Giudice, N. A. (2013). Representing 3D space in working memory: Spatial images from vision, hearing, touch, and language. In S. Lacey & R. Lawson (Eds.), Multisensory imagery (pp. 131–155). *Springer Science + Business Media., 16*(9), Retrieved May 1, 2024, from doi.org/10.1007/978-1-4614-5879-1_8.

TMD Studi Ltd. (2017). *Spatial Perception and Architecture,* Medium. Retrieved July 18, 2024, from medium.com/studiotmd/spatial-perception-and-architecture-4f8ab99eeb41.

Wolbers T, Hegarty M. (2010). What determines our navigational abilities? *Trends Cogn Sci.14*(3), pp. 138-46. Retrieved May 1, 2024, from doi.org/10.1016/j.tics.2010.01.001.

Söderlund, J., Newman, P. (2022). How the biophilic design social movement informs planning, policy and professional practice. *Sustain Earth 5*(4). Retrieved May 1, 2024, from https://doi.org/10.1186/s42055-022-00051-2.