

The Role of Biophilic Design in Improving Urban Liveability

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Abstract- *As a result of rapid urbanization, cities are increasingly faced with stressors such as heat island effects, air and noise pollution, mental health challenges, and declining environmental quality. The built environment is often designed in ways that alienate humans from nature at the detriment of humans' well-being and the natural environment. The rise in urbanization has led to a disconnect between the built and the natural environment. This paper explores the role of biophilic design in enhancing urban liveability while promoting sustainability and human well-being. Drawing on interdisciplinary research from architecture and environmental psychology, we examine how nature-integrated design strategies such as nature forms and tones, green roofs, vegetated walls, daylight optimization, and natural ventilation can alleviate thermal discomfort, improve air quality, reduce noise, and enhance well-being. This paper concludes by proposing a framework for integrating biophilic design principles into urban planning and policy, with recommendations for maximizing ecological performance and liveability in urban environments. It positions biophilic design not only as an aesthetic approach but as a critical tool for creating resilient, inclusive, and sustainable urban futures.*

Index Terms- *Biophilic Design, Sustainability, Urban Stressors, Urbanizations*

I. INTRODUCTION

The last decade has seen a widespread attention on biophilic strategies as a mitigation strategy to growing environmental challenges [1]. Biophilic design stems from the concept of health and well-being and its positive impact on human-nature relationship underscoring the benefits it has for both the environment and its occupants. It has become an appropriate tool in the quest for seeking a healthy, sustainable and resilient environment [2]. Nature based solutions like biophilic designs are effective in enhancing the human experience of the built environment as they go beyond the application of vegetation and greenery to buildings, it is broader and richer by implementing natural light, ventilation, materials and incorporation of water features, plants and visual closeness to the outdoors

[3]. It is a symphony of man and nature borne out of environmental awareness. The move to biophilic design points to the evolution in the way architecture is being perceived, promoting human-centric places that improve individual well-being and organizational outcomes

Urbanization has induced deterioration of the urban environment; rapid urbanization is responsible for the 10.9% urban thermal comfort change, loss of vegetation areas and poor air quality [4] –[6]. The state of the environment particularly in the urban centres today is a major source of global concern. There have been minimal institutions created to combat these associated challenges [7]. Some of these challenges include but are not limited to the low air quality, fluctuating temperatures, energy consumption, increased carbon footprint, deforestation, loss of biodiversity, and resource consumption among others [8]. It is therefore imperative to come up with a framework to be incorporated in the built environment to mitigate the challenges brought up as a result of urbanization. It is equally vital that there are alternatives to the usual design approaches that tend to destroy the natural setting of the ecosystem. In essence, building design approach should support the natural environment rather than work against it. Incorporating biophilia, nature forms, systems and materials in the built environment offers an opportunity to create a built environment that does not disrupt the natural environment while also mitigating the negative impact of buildings on the environment. Biophilic designs which seek to reconnect people with nature in the built environment, therefore, offers a multi-dimensional approach to reducing urban stressors while enhancing urban sustainability. Biophilic design, which is an integration of natural element into the built environment, has been acknowledged as a sustainable approach that enhances user experience, promotes social interaction, and improves environmental performance.

II. UNDERSTANDING URBAN STRESSORS

It's The built environment significantly impacts human well-being, environmental sustainability, and social interactions and urban centres worldwide face escalating environmental and psychological stress due to increasing population density, climate change, and declining access to green spaces [9]. These conditions contribute to poor air quality, urban heat islands (UHI), and elevated levels of stress, anxiety, and depression among residents [10]–[11]. This paper focuses on environmental urban stressors in the aspect of urban heat island. Urban heat island is an emerging challenge that has a domino effect on other environmental stressors such as poor air quality and air pollution, which will be categorized into psychological stressors [12]. UHI effects can alter and destabilize local air circulation patterns surrounding urban areas, potentially inducing precipitation in adjacent regions and giving rise to new ecological consequences.

The UHIs are induced by the eradication of green areas as a result of urbanization, as ecosystems and natural environments are replaced with gigantic glass and concrete structures that generate more heat and carbon emissions with no system to filter the atmosphere. This paper is proposing the use of biophilic design framework adaptation in the built environment as a way of harmonizing the natural and built environment which addresses the previously mentioned urban stressors such as urban heat island and poor air quality in urban centres.

III. BIOPHILIC DESIGN IMPLEMENTATION

In Biophilic design is the incorporation of biophilia in the human-built environment, it encompasses human inherent affinity for the natural world [13]. The concept revolves round the idea of drawing experience from nature and creating an urban human-made environment that satisfies human affinity to nature through the utilization, extraction, reproduction, and simulation of nature [34]. Despite residing in urban environments and experiencing lives disconnected from natural processes and components, humans still possess an inherent need to engage with nature. The intrinsic urge for individuals to pursue and engage with the natural world appears intuitive, reflecting an instinct and trait conserved through human development. Biophilic design can be adapted into the urban

fabric through 3 frameworks - nature incorporation, nature inspiration, and nature interaction [15].

Nature Incorporation involves the use of natural phenomena, elements, and processes, emphasizing them through multisensory experiences [15]. This includes wildlife, water, plants, breezes, noises, smells, and other aspects of nature [12].

Nature Inspiration refers to the imitation of nature and evokes the sense of nature through the delicate placement of natural features. Nature-inspired materials, objects, colours, forms, patterns, and algorithms are among them [3]. They include imitations of shells and leaves, organically shaped furniture, and heavily treated or altered natural materials (such as granite tabletops and wood planks), all of which offer a tangential link to the natural world [11].

Nature Interaction means to experience natural settings and create links with the natural system or between different locations, arrange spaces according to evolved human-nature relationships [1]. Table I presents examples of successful biophilic design implementations in buildings located within urban centers.

TABLE I
BIOPHILIC DESIGN IMPLEMENTATION

Building	Location	Biophilic Design Strategy
<i>Bosco Verticale</i>	Milan, Italy	vertical greenery: thousands of native shrubs and bushes
<i>Amazon Spheres</i>	Seattle, USA	organic forms, biomorphic shapes, variety of plants, daylighting
<i>The Ring Mall</i>	Chongqing, China	daylighting, air(breeze), presence of water, organic building form, botanical garden
<i>The Jewel (Changi Airport)</i>	Singapore	Waterfall, terraced forest valley, gardens, nature scents and sound
<i>Aerys Village</i>	La Somone, Senegal	Nature tones/hues, Bioclimatic materials, visual connection with

		nature, textured materials
<i>Garden House</i>	Los Angeles, USA	Living green wall, nature scents
<i>Karolinska Indoor Fitness Centre</i>	Stockholm, Sweden	Plants, natural forms, connection with nature

IV. HOW BIOPHILIC DESIGN CAN ENHANCE URBAN LIVEABILITY

Nature incorporation is key in creating a balance between the built and natural environment. The natural ecosystem offers numerous benefits such as air filtration, air circulation and cooling which is ascribed to improve quality of life and heal the natural environment. Biophilic design is a modern-day response to urbanization as it involves the re-incorporation of nature into the urban system. Biophilic design offers numerous benefits that are interconnected, despite being viewed from various lenses. For instance, using indigenous natural resources in building construction can lower construction expenses while also aiding in material recycling for more sustainable consumption and also fossil fuel consumption used in long distance transportation. Biophilic designs possess the potential to further sustainability course and build resilient cities.

A. Addressing Urban Heat Island Phenomenon

Biophilic design offers a nature-integrated approach to mitigating the Urban Heat Island phenomenon by reintroducing ecological elements into the built environment [16]. The UHI effect, characterized by elevated temperatures in urban areas compared to their rural surroundings, primarily results from the high concentration of impervious surfaces, reduced vegetation cover, and excessive anthropogenic heat emissions [17]-[18]. Biophilic strategies such as the integration of green roofs, living walls, urban forests, and permeable landscape systems, help counteract these effects by enhancing evapotranspiration, increasing surface albedo, and improving shading.

Green surfaces absorb less solar radiation than concrete or asphalt [19] and can cool the surrounding microclimate through natural processes [20], thereby reducing surface and air temperatures [21]. Moreover, the strategic placement of trees and plantings can intercept solar radiation and provide shade for buildings and streets, lowering cooling loads and reducing overall energy consumption. By restoring ecological functions within urban systems, biophilic designs mitigates thermal stress and promotes thermal comfort. Biophilic design is more than an aesthetic or psychological tool; it serves as a vital climate adaptation strategy, capable of addressing the multifaceted impacts of UHI while supporting sustainable urban development and liveability.

B. Promoting Biodiversity

Urbanization exerts significant pressure on native ecosystems, often resulting in habitat fragmentation, species displacement, and overall biodiversity loss [6]. As a countermeasure, biophilic design serves not only to reintroduce natural elements into the built environment [22] but also to strategically create and preserve habitats that support urban flora and fauna [23]. Through the integration of ecological features such as green roofs, vertical gardens, and urban forests, biophilic design can enhance ecological connectivity and restore habitat niches within densely built-up areas [16].

By incorporating natural ecosystems, biophilic interventions provide shelter, foraging opportunities, and breeding grounds for a variety of species, including birds, insects, and small mammals, thereby facilitating species retention and movement across the urban landscape [24] -[25]. For example, native plantings in open areas and courtyards can attract local pollinators and support trophic interactions that are essential for maintaining urban ecological integrity. Additionally, multi-layered vegetation and water-sensitive urban design features, such as rain gardens and constructed wetlands, contribute to microhabitat diversity, which is key to supporting both aquatic and terrestrial species in urban settings.

The intentional promotion of biodiversity through biophilic design serves as a critical urban stress mitigation strategy [6]. Healthy urban ecosystems contribute to resilience against climate extremes, improve air and water quality, and promote

psychological well-being among urban dwellers through increased exposure to living systems [26]. As such, embedding biodiversity-oriented principles within urban form and function through biophilic design can transform cities addressing a key urban stressor while advancing sustainability goals.

C. Optimizing Air Quality

People living in urban areas are the most affected by air pollution from carbon emissions which leads to air quality degradation [27]. Rapid urbanization characterized by dense building clusters, minimal vegetation, and high vehicular emissions [14] worsens the concentration of airborne pollutants [28]. Biophilic design offers an integrative and sustainable approach to addressing this issue by embedding natural systems within the built environment to actively and passively purify air and mitigate pollution sources. Vegetation plays a key role in air purification through processes such as dry deposition, phytoremediation, and oxygen production [29]. Trees, shrubs, and green walls can capture and absorb airborne pollutants on their leaf surfaces and within plant tissues, thereby reducing pollutant concentrations at the street and building level. Vegetated surfaces influence air flow and microclimatic conditions, promoting natural ventilation and dispersion of pollutants especially in dense urban areas where stagnant air aggravate pollution exposure [30].

Incorporating indoor plants and living walls in building interiors can help filter indoor pollutants while improving relative humidity and occupant well-being [31]. By integrating natural features into both outdoor and indoor environments, biophilic design contributes to air quality by bridging ecological performance with architectural function to reduce pollution exposure and promote urban well-being.

D. Providing Accessible Public Green or Blue Areas

Urbanization has led to depletion of green covers, fragmentation and privatization of natural landscapes, resulting in limited access to quality public green and blue spaces for many urban residents [32]-[34]. By embedding nature within everyday urban infrastructure such as streetscapes, transit corridors, and community centres, biophilic design transforms underutilized or degraded spaces into multifunctional public realms. These

interventions may include linear parks, stormwater-fed wetlands, community gardens, pocket parks, greenways, and daylighted urban streams, which not only enhance biodiversity and environmental performance but also provide accessible recreational and contemplative environments for diverse user groups [9].

Furthermore, blue infrastructure, such as interactive fountains, retention ponds, and urban lakes, serves to cool urban microclimates and create sensory-rich environments that improve urban liveability [35]-[36].

E. Boosting Workers' Productivity

Biophilic design enhances workers' productivity by creating environments that nurture psychological well-being, cognitive performance, and physical comfort. The integration of natural elements such as daylight, vegetation, water features, and organic materials has been shown to alleviate stress, elevate mood, and support attention restoration. For instance, an empirical research proved that various natural factors possess high-quality workers' productivity stating that daylighting, virtual connection with nature and greenery within the workplace space is crucial [37].

V. CONCLUSION

This paper has elucidated multiple ways in which biophilic design can aid in enhancing urban liveability and addressing urban stressors such as urban heat island, air pollution, loss of habitat and degradation of green areas. Biophilic design does not just speak to environmental revitalization but also human well-being.

In conclusion, this paper into biophilic design offers its profound potential to reshape the urban fabric into a more sustainable, resilient, and liveable environment. Through its capacity to mitigate the Urban Heat Island effect, optimize air quality, enhance biodiversity, and foster accessible green and blue public spaces, biophilic design reintroduces nature as an active agent in the rejuvenation of cities. Its multifaceted benefits transcend environmental gains, extending into psychological restoration, social equity, and urban resilience. By incorporating natural systems into the built environment, biophilic interventions nurture a more symbiotic relationship between urban development and the ecosystems it inhabits.

The imperative to integrate biophilic principles into mainstream urban planning and architectural practice is clear. Doing so not only aligns with global sustainability agendas but also addresses the pressing need for cities that support human health, ecological balance, and cultural vitality. As urban areas evolve, the sustained incorporation of biophilic strategies will be pivotal in ensuring that growth does not come at the cost of environmental integrity or quality of life. The call for cities that are biologically enriched, socially inclusive, and environmentally restorative underscores the urgency of embracing biophilic design as a cornerstone of future urban development. Investing in biophilic environments is, fundamentally, an investment in the enduring liveability, health, and harmony of the urban future.

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