

SUSTAINABLE DEVELOPMENT AND BIOPHILIC DESIGN: INTEGRATING NATURAL ELEMENTS INTO THE CONTEMPORARY URBAN ENVIRONMENT

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Abstract. This article examines Biophilic Design (BD) as an interdisciplinary strategy for enhancing urban sustainability. Three categories of biophilic stimuli are analyzed, demonstrating how their systematic application contributes to achieving Sustainable Development Goals (SDGs) 11 and 3. It is emphasized that the integration of BD – from vertical greening to fractal patterns – optimizes environmental parameters and improves the psycho-physiological well-being of city dwellers.

Contemporary cities are major consumers of resources and generators of waste. In the context of climate change, exponential population growth, and urbanization, traditional, anthropocentric approaches to construction and territorial management are becoming unviable. Biophilic Design (BD) is not merely an aesthetic embellishment but a scientifically grounded, interdisciplinary strategy aimed at restoring the innate human connection with nature (a concept developed by Edward O. Wilson in 1984 as the "biophilia hypothesis") [4]. The objective of this article is to demonstrate how the multi-scale, systematic application of BD principles contributes to achieving specific Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 3 (Good Health and Well-being), through the optimization of the environmental and psycho-physiological parameters of the urban environment [1].

For effective integration, it is necessary to clearly understand and apply the three categories of biophilic stimuli proposed by Stephen R. Kellert: Direct Experience of Nature, Indirect Experience of Nature, and Experience of Space and Place [2]. Direct contact is realized through green roofs (providing thermoregulation and reducing surface runoff), vertical greening (serving as a biofilter for atmospheric pollutants), and the integration of water features such as rain gardens and bioswales for managing stormwater runoff (LID). Indirect experience includes the use of natural materials (wood, stone) while preserving their natural texture, the application of biomorphic forms and patterns, particularly fractal structures, and the use of natural color palettes. The Experience of Space and Place mimics human evolutionary needs for safety and exploration, achieved through creating zones of Prospect and Refuge and introducing elements of Complexity and Order that emulate natural landscapes. The integration of BD must be systemic and manifest at various scales: at the micro-scale (individual building), where greening reduces facade surface temperatures by 5–10 °C and saves up to 25 % on air conditioning energy; at the meso-scale (neighborhood), through the creation of green corridors for fauna migration and improved recreation; and at the macro-scale (city), through the development of a unified "blue-green framework" as climate adaptation infrastructure. The impact on health (SDG 3 [3]) is measurable: exposure to natural imagery reduces cortisol levels, improves cognitive functions (Attention Restoration Theory [1]), and accelerates patient recovery [2].

Despite the evident advantages, the implementation of Biophilic Design (BD) in the urban environment faces several significant barriers.

Firstly, there are high initial investment costs (CAPEX). The design and realization of complex "living" systems, such as multi-level green roofs, integrated rainwater harvesting systems, or actively vegetated facades, require substantial capital outlays that often exceed standard budgets for conventional construction.

Secondly, there is a lack of unified regulations and standards for the operation of these "living" systems. Existing building codes and regulations (SNiPs) do not always adequately address safety issues (e. g., wind loads on green facades), fire safety, and the durability of such elements. This creates legal uncertainty for developers and architects.

Thirdly, long-term maintenance (OPEX) presents a serious challenge. Operating biophilic elements necessitates specialized knowledge and regular care that differs from standard building maintenance. A shortage of qualified specialists to maintain vertical gardens or complex water features can lead to system degradation, loss of functionality, and consequently, the loss of the claimed ecological and recreational value [3].

Solutions to these problems require a comprehensive approach at the level of state policy and municipal management. This includes financial incentives: developing targeted subsidy programs and offering tax credits for projects incorporating BD, especially for small and medium-sized enterprises and the residential sector. Integrating BD principles into mandatory urban planning regulations (Land Use Plans, Zoning Rules) could involve setting minimum thresholds for the proportion of vegetated surfaces or mandating the use of fractal patterns in public space design. Furthermore, establishing centers of expertise and specialized educational programs for architects, engineers, landscape designers, and, critically, for management companies will ensure the necessary expertise for the high-quality, long-term maintenance of "living" infrastructural solutions. Systematically overcoming these barriers will allow biophilic design to transition from a niche practice to a standard component of sustainable urban development [4].

Biophilic Design (BD) acts not merely as an aesthetic trend but as a critically important methodological tool for achieving a fundamental shift in architecture and urban planning – a transition from the concept of "sustainability" to "regenerative architecture". This means moving from minimizing negative impact to actively restoring and improving urban ecosystems and resident well-being. This transition is closely linked to the Sustainable Development Goals (SDGs): BD directly addresses issues outlined in SDG 11 (Sustainable Cities) by integrating nature into the very structure of buildings and districts, thereby increasing biodiversity, mitigating the "urban heat island" effect, and improving water management. It also addresses SDG 3 (Health) by utilizing scientifically grounded principles of human connection to nature to reduce stress, improve cognitive function, and accelerate health recovery. The key difference between BD and simple greening lies in its systemic and multi-scalar approach: nature is integrated at the city level (green corridors), the building level (facades, lighting), and the interior level (textures, patterns), transforming natural elements from decoration into active functional infrastructure components (biofiltration, thermoregulation, water management). Consequently, biophilic design is the operationalization of regenerative architecture principles, offering concrete methods for designing environments that actively heal both the planet and its inhabitants.

References

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