ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jun821

Assessing Impact of Biophilic Design on Mental Health in Urban Environments: A Systematic Review of Empirical Studies from Nigeria, Malaysia, China, the United States, and Italy

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Publication Date: 2025/10/14

Abstract: The rapid urbanization of the 21st century has transformed human habitats into dense, built environments that often prioritize efficiency over well-being. Now over 55%—about 4.4 billion people—of the global population resides in cities, a figure projected to rise to 68% by 2050 (World Bank, 2025; United Nations, 2018). While urbanization drives economic growth, it has also been linked to rising mental health challenges, including chronic stress, anxiety, and depression (World Health Organization, 2021). Studies attribute this trend to factors such as reduced access to nature, sensory overload from noise and pollution, and the isolating effects of high-density living (Bratman *et al.*, 2019). In response, architects and designers are increasingly turning to biophilic design—a holistic approach that integrates natural elements into built spaces—as a potential remedy for these urban mental health issues.

Keywords: *Biophilic, Health, Urban Environment.*

How to Cite: Ogunnaike Adekunle; Akinmoladun Ayokunle A.; Orimijupa Olawale D.; Adejare Oludele S.; Omoniyi Iyetunde; Ozomazro Julius U.; Dayomi, Mathew (2025). Assessing Impact of Biophilic Design on Mental Health in Urban Environments: A Systematic Review of Empirical Studies from Nigeria, Malaysia, China, the United States, and Italy. *International Journal of Innovative Science and Research Technology*, 10(6), 3354-3364. https://doi.org/10.38124/ijisrt/25jun821

I. INTRODUCTION

Biophilic design, rooted in Edward Wilson's concept of biophilia (the innate human affinity for nature), is defined by Stephen Kellert as "a deliberate attempt to translate the beneficial effects of nature into the design of the built environment" (Kellert & Calabrese, 2015; Melchionni, 2021). Kellert's framework outlines three categories of biophilic elements: direct (e.g., plants, water features), indirect (e.g., natural materials, biomorphic forms), and spatial (e.g., prospect-refuge layouts, sensory variability) (Zhong, Schröder & Bekkering, 2022). Biophilic design does not only reconnects people with nature but also embodies principles of sustainable living—meeting human needs while preserving ecological integrity (Cacique & Ou, 2022).

However, despite growing interest, the empirical evidence on biophilic design's mental health impacts remains fragmented, most especially in Nigeria. Existing studies vary widely in scope, methodology, and quality. For example, some focus on short-term stress reduction in controlled laboratory settings (e.g., Yin *et al.*, 2020), while others examine longitudinal effects in workplaces or healthcare facilities (e.g., Figueiredo *et al.*, 2021). Although prior reviews have explored subsets of this literature—such as the role of indoor plants (Aydogan & Cerone, 2021) or nature views in hospitals (Ekpo, 2023)—no comprehensive synthesis has yet analyzed the full breadth of empirical findings or critically evaluated methodological rigor. This gap limits the ability of architects and policymakers to implement evidence-based biophilic strategies.

To address these shortcomings, this paper aims to inform design practices that enhance mental well-being in an increasingly urbanized world. It conducts a systematic review of empirical studies investigating biophilic design's impact on mental health. The specific objectives are threefold:

ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jun821

- To synthesize findings across diverse populations, settings, and biophilic interventions.
- To critique the methodologies employed in existing research, identifying strengths and limitations.
- To highlight gaps in current knowledge and propose priorities for future studies.

II. LITERATURE REVIEW

- *Biophilic Design Elements*

Biophilic design is rooted in the theory of biophilia, a term popularized by biologist Edward Wilson in 1984 to describe humanity's innate, evolutionary connection to nature (Zhong, Schröder & Bekkering, 2022). This design philosophy seeks to integrate natural elements into built environments to counteract the psychological and physiological stressors of urban living. Stephen Kellert's 2015 seminal framework categorizes biophilic design into three interconnected groups: direct, indirect, and spatial elements (Melchionni, 2021). Each category addresses different aspects of human-nature interaction, offering unique pathways to enhance mental health.

- *Direct Elements*

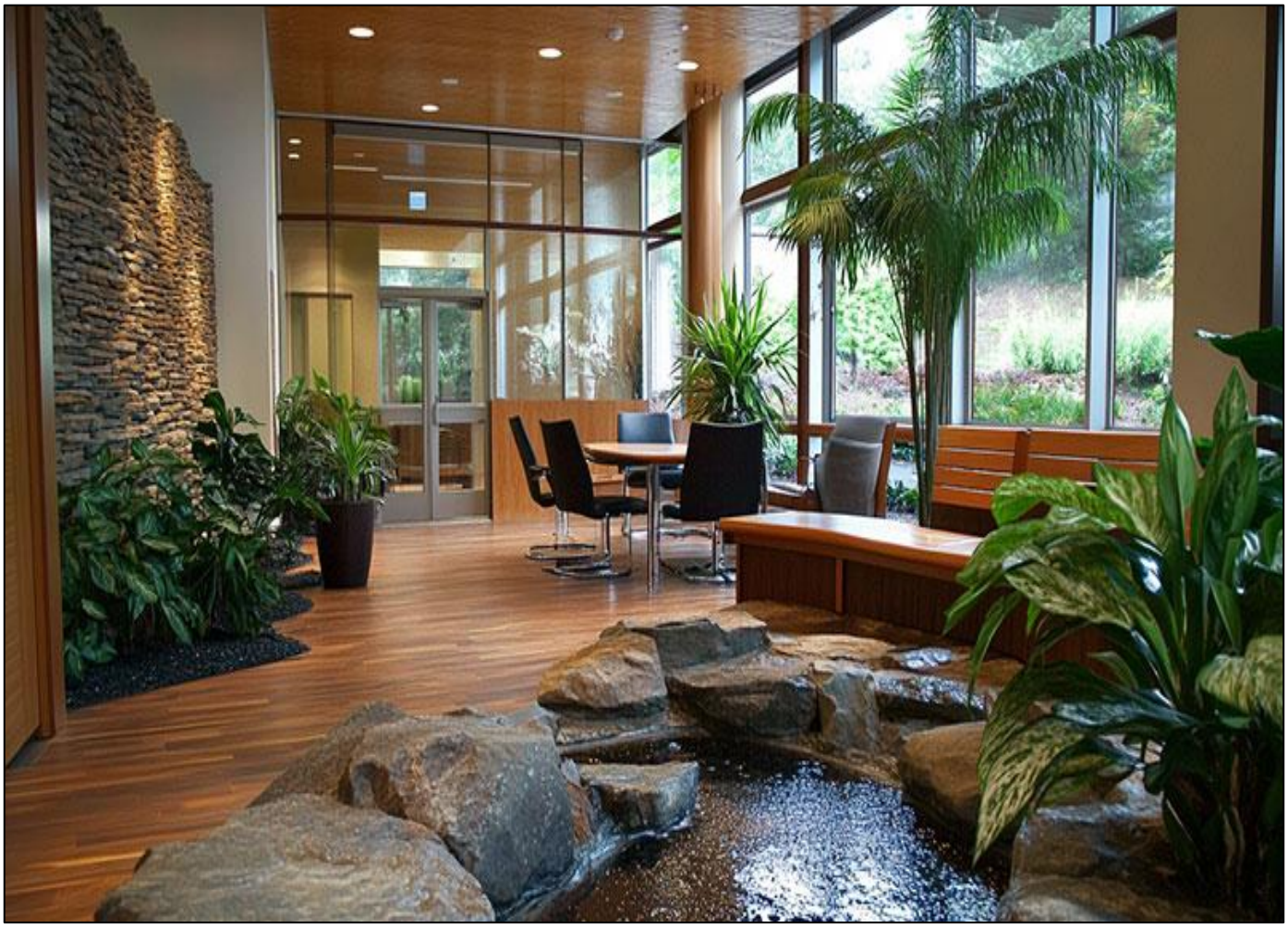

Fig 1 Direct Biophilic Design Elements (Dima, 2024)

Direct elements involve physical, multisensory interactions with nature, such as living plants, water features, sunlight, and natural airflow. These elements bring about immediate, visceral responses by replicating wild ecosystems. For example, indoor plants do not only improve air quality but also reduce stress by engaging the parasympathetic nervous system, which governs relaxation (Aydogan & Cerone, 2021). A longitudinal study by Yin *et al.* (2020) demonstrated that office workers surrounded by greenery reported 37% lower stress levels, measured via cortisol biomarkers, compared to those in sterile environments. Similarly, water features—such as indoor fountains or aquariums—have been shown to greatly reduce anxiety in different settings, as the sound of flowing water masks urban noise and triggers calming neural responses (Lin, 2023). Natural light is another direct element. It has been noted that exposure to daylight regulates circadian rhythms, which govern sleep-wake cycles and mood stability (Houser, 2021). Architects like Glenn Murcutt have championed designs that maximize sunlight penetration, such as angled roofs and reflective surfaces, to harness these benefits (Cheng, 2021).

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➢ *Indirect Elements*

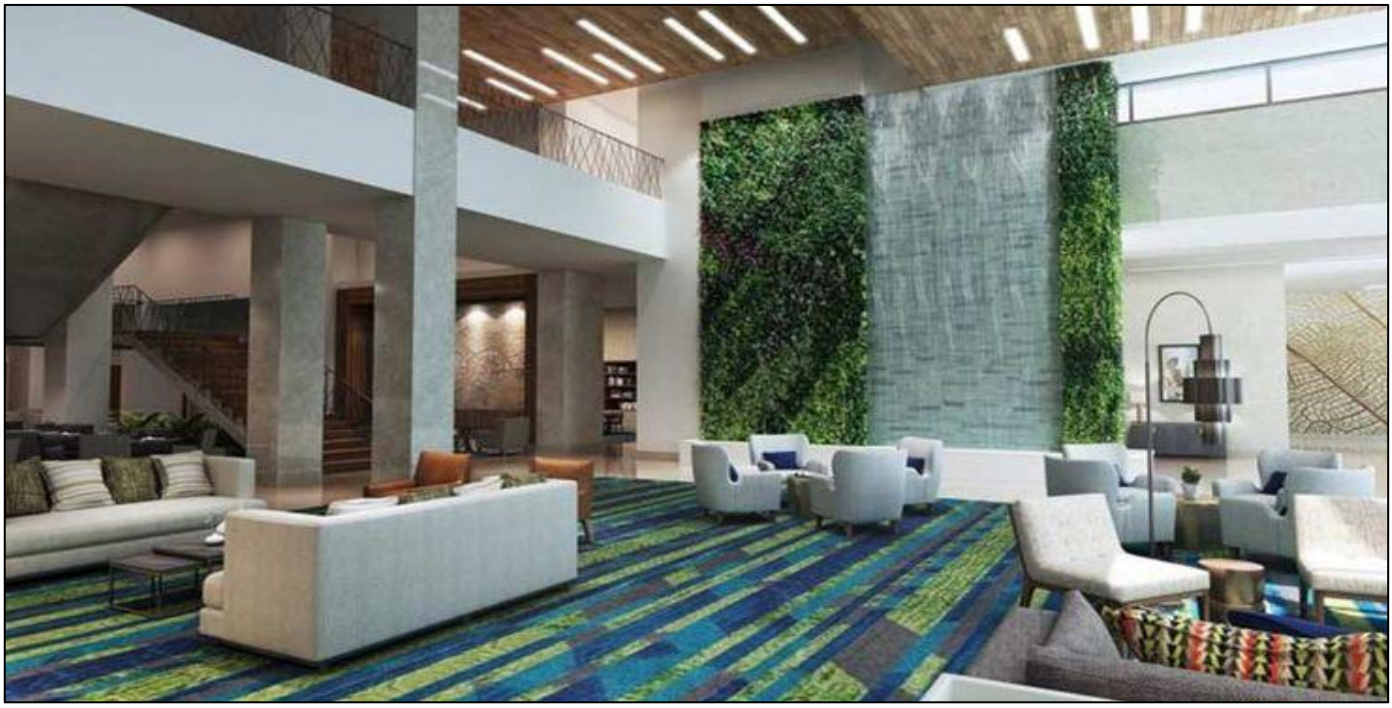

Fig 2 Indirect Biophilic Design Elements (Bob, 2018)

Indirect elements use abstract representations of nature through materials, patterns, colors, or technology. These elements use subconscious associations with natural environments. For instance, natural materials like wood, stone, or clay evoke feelings of warmth and safety due to their historical role in human shelters (Song & Liao, 2022). Also, biomorphic forms—designs mimicking natural shapes, such as curved furniture or fractal patterns—also fall under this category (Ikudayisi *et al.*, 2023). Fractals (repeating geometric patterns found in leaves, rivers, or galaxies) have been shown to reduce physiological stress as well as dynamic lighting systems that mimic daylight cycles (e.g., cool, bright light in the morning transitioning to warm, dim light at night), which reduce insomnia rates by 30% in office workers by aligning artificial environments with natural circadian cues (Houser, 2021).

➢ *Spatial Element*

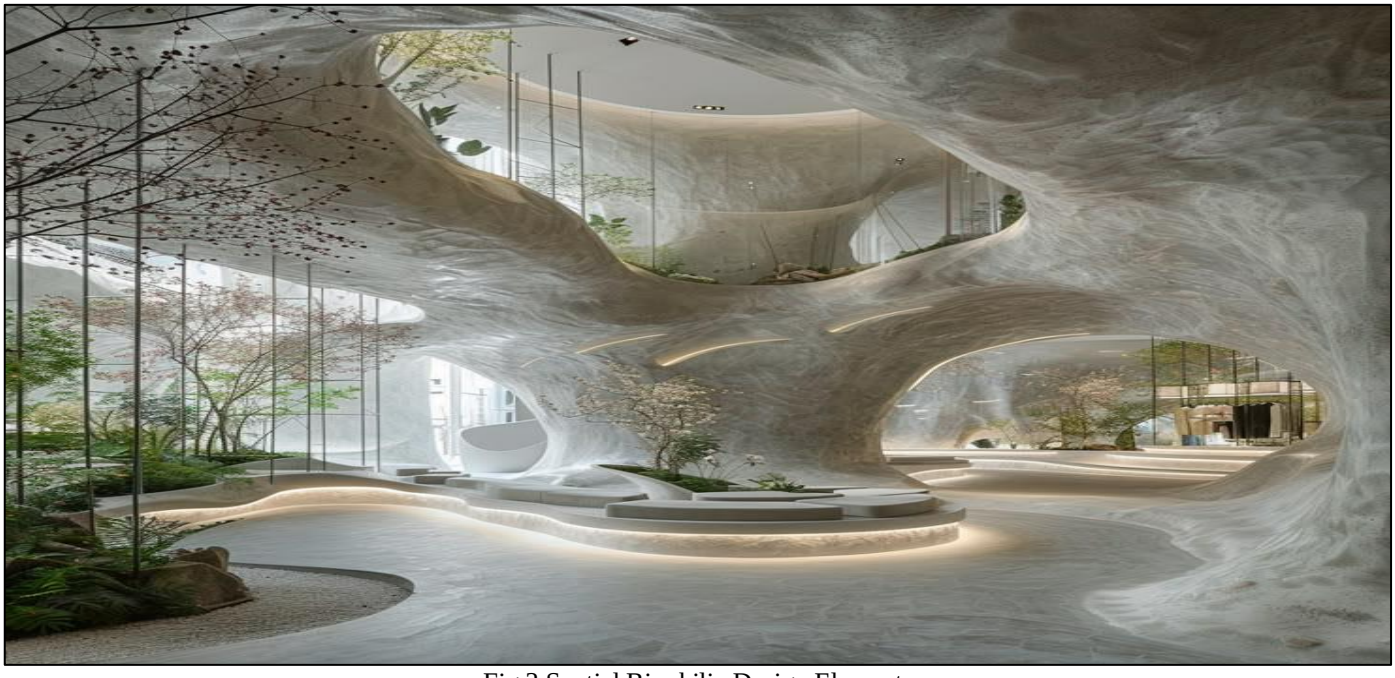

Fig 3 Spatial Biophilic Design Elements

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Spatial elements replicate the structural and sensory experiences of natural environment. A key concept is "prospect-refuge," a design principle where spaces balance openness (prospect) with security (refuge), mirroring the savanna environments humans evolved in (Tekin, 2022). For example, terraced seating in public parks allows users to observe crowds (prospect) while feeling protected by elevated barriers (refuge), reducing perceived crowding and stress (Jiang *et al.*, 2020). Another spatial strategy is sensory variability, which introduces diverse textures, sounds, and sightlines to mimic the complexity of natural ecosystems. Ulrich's (1984) landmark study revealed that hospital patients with window views of trees required 8.5% fewer painkillers and recovered faster than those with views of brick walls. Similarly, buildings with "broken sightlines" (e.g., winding corridors or partially obscured views) can evoke the curiosity and exploration associated with natural settings, boosting creativity in the workplace (Donnelly *et al.*, 2022).

➢ *Sustainable and Green Living in Biophilic Design*

Building on Kellert's triad of direct, indirect, and spatial elements, biophilic design goes beyond the mere presence of nature to embrace sustainable and green living as an intrinsic principle (Cacique & Ou, 2022). While direct elements invite sensory engagement and spatial strategies organize our experience of place, sustainable living reframes every material and system decision through ecological stewardship (Nafi, 2024). At its core, "sustainable and green living" refers to design approaches that meet human needs today without compromising the health of ecosystems or future generations (Cacique & Ou, 2022). In biophilic practice, this means selecting resources and detailing assemblies not solely for appearance or immediate comfort, but for low environmental impact across their entire lifecycle (Wang, 2023).

Where traditional use of natural materials often treats wood, stone, or clay as aesthetic accents—potted merely for warmth or texture—biophilic design insists on cradle-to-cradle sourcing, local procurement, and regenerative maintenance. Under a cradle-to-cradle ethos, materials are chosen for their ability to re-enter biological or technical cycles at end-of-life, avoiding landfill and reducing embodied carbon burdens. For example, reclaimed timber from nearby demolition sites or rapidly renewable bamboo not only evokes Kellert's direct and indirect elements but also minimizes transport emissions and supports local economies. Similarly, natural finishes might be specified for their low-VOC content and compatibility with composting or recycling, rather than simply for their "natural" look. Therein, by embedding these sustainability criteria into every phase—from material extraction through ongoing use and eventual reclamation—biophilic projects cultivate resilience in the built environment and align human well-being with planetary health (Cacique & Ou, 2022).

➢ *Mental Health Indicators*

Mental health is defined by the World Health Organization (WHO) as "a state of well-being in which an individual realizes their own abilities, can cope with the normal stresses of life, can work productively, and is able to contribute to their community" (World Health Organization, 2022). Unlike physical health, mental health encompasses subjective experiences of emotional, psychological, and social well-being, making it challenging to quantify. To evaluate the impact of biophilic design on mental health, researchers rely on three categories of indicators: stress biomarkers, mood scales, and cognitive tests. Each of these categories offers unique insights into how natural elements in built environments influence human well-being.

➢ *Stress Biomarkers*

Stress biomarkers are objective, physiological measurements that reflect the body's response to stressors. The most widely studied include:

- Cortisol: A hormone released by the adrenal glands during stress. Elevated cortisol levels over time are linked to anxiety, depression, and cardiovascular disease (Knezevic *et al.*, 2023).
- Heart Rate Variability (HRV): A measure of the variation in time between heartbeats, regulated by the autonomic nervous system. Higher HRV indicates better stress resilience and emotional regulation (Brown *et al.*, 2022).
- Blood Pressure: Chronic stress can elevate resting blood pressure, increasing the risk of hypertension (Balwan & Kour, 2021).

➢ *Mood Scales*

Mood scales are self-report tools that measure transient emotional states, such as happiness, tension, or fatigue. Commonly used scales include:

- Profile of Mood States (POMS): Assesses six mood domains: tension, depression, anger, vigor, fatigue, and confusion.
- Positive and Negative Affect Schedule (PANAS): Measures positive affect (e.g., enthusiasm) and negative affect (e.g., distress).
- Perceived Stress Scale (PSS): Evaluates how individuals appraise their stress levels.

➢ *Cognitive Tests*

Cognitive tests evaluate mental processes such as focus, problem-solving, and memory retention. These tests are grounded in Attention Restoration Theory (ART), which argues that natural environments restore depleted cognitive resources by engaging "soft fascination" (effortless attention) (Pham & Sanocki, 2024). Common tests include:

- Digit Span Test: Measures short-term memory by asking participants to repeat sequences of numbers (Asgari *et al.*, 2020).
- Stroop Test: Assesses attention and processing speed by challenging individuals to name the color of a word while ignoring its meaning (Periáñez *et al.*, 2021).
- Alternate Uses Test: Evaluates creativity by asking participants to generate novel uses for everyday objects (Oliva & Storm, 2023).

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Studies demonstrate that biophilic design enhances cognitive performance. For instance, Flemish students in classrooms with views of greenery scored higher on attention-based tasks like the Stroop Test than those without nature exposure (Bijnens *et al.*, 2022). However, not all biophilic elements yield benefits.

➢ *Empirical Review*

Previous reviews have provided useful but limited insights into the mental health implications of biophilic design, additionally, few empirical papers report on energy savings or waste reduction metrics alongside mental-health indicators. recently, Jha & Behera (2022) reviewed biophilic design's mental health implications, finding positive effects but noting unclear durations and interactions with individual factors, especially in India. Li *et al.* (2025) showed that classroom plants improved perceived environmental quality and productivity but not cognitive performance or stress, indicating methodological limitations. Additionally, Zhong *et al.* (2022) critically reviewed biophilic design's health and sustainability benefits, identifying knowledge gaps in understanding nature's complex effects. Yin *et al.* (2021) also conducted a systematic study of workplace biophilic initiatives but excluded hospital and educational settings.

These evaluations identify three important gaps in the literature. First, most studies concentrate on a specific context (e.g., only workplaces or only hospitals) rather than examining impacts across several locations. Second, they tend to focus on individual design aspects rather than integrated biophilic systems (Söderlund & Newman, 2022). This fragmentation supports the need for a more thorough synthesis that investigates numerous biophilic features in a variety of settings, with a focus on both immediate and sustained mental health effects.

III. METHODOLOGY

This systematic review adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor and transparency (Page *et al.*, 2021). The protocol aimed to synthesize empirical evidence on the relationship between biophilic design and mental health outcomes, focusing on peer-reviewed studies published between 2010 and 2025. A comprehensive search strategy was developed to identify relevant literature across three major databases: PubMed, Scopus, and JSTOR. Keywords such as *"biophilic design," "mental health,"" sustainability criteria," "material lifecycle framing" "stress,"* and *"well-being"* were combined with Boolean operators (*AND*, *OR*) to capture variations in terminology. For instance, *"biophilic architecture" OR "nature-based design"* was included to account for interdisciplinary terminology. The search was restricted to English-language articles to mitigate translation bias, and theoretical papers, opinion pieces, or non-peer-reviewed works were excluded to prioritize empirical evidence.

Studies were screened in two stages: an initial title/abstract review to eliminate irrelevant works, followed by a full-text assessment to confirm eligibility. Inclusion criteria required studies to (1) explicitly examine biophilic design interventions (e.g., natural materials, greenery, daylighting), (2) measure mental health outcomes using validated tools (e.g., cortisol levels, mood scales), and (3) employ quantitative, qualitative, or mixed-methods designs. Exclusion criteria removed studies focused solely on urban green spaces (e.g., parks) without architectural integration or those lacking control groups in experimental designs.

Data extraction followed a structured template to systematically capture key variables: study design (e.g., randomized controlled trials, longitudinal studies), sample size, biophilic elements tested (e.g., direct, indirect, spatial), and mental health outcomes (e.g., stress reduction, cognitive performance). Methodological quality was assessed using Joanna Briggs Institute (JBI) critical appraisal tools, which evaluate risk of bias across domains such as sampling, measurement validity, and confounding control (Barker *et al.*, 2023). For example, JBI checklists for quasi-experimental studies were applied to assess baseline comparability between groups, while cohort study tools evaluated follow-up duration and attrition rates.

Due to significant heterogeneity in study designs and outcome measures, a thematic synthesis approach was adopted instead of a meta-analysis (Curran & Williams, 2020). This involved coding findings into recurring themes and analyzing patterns across contexts. Conflicting results, such as disparities in the efficacy of indirect biophilic elements, were examined through subgroup analysis to identify contextual moderators (e.g., cultural differences, exposure duration). NVivo software facilitated coding and theme generation, ensuring reproducibility. The synthesis aimed to provide a nuanced understanding of how biophilic design influences mental health while highlighting gaps in current research.

IV. RESULT

➢ *Study Selection*

The systematic review followed the PRISMA guidelines to ensure methodological transparency. Initial database searches across PubMed, Scopus, and JSTOR yielded 523 records. After removing duplicates and screening titles and abstracts, 78 studies underwent full-text review. Of these, 20 studies met the inclusion criteria, focusing on empirical investigations of biophilic design's impact on mental health. Exclusions were primarily due to non-empirical designs (e.g., theoretical papers) or studies lacking validated mental health outcome measures. The final sample included peer-reviewed articles published between 2010 and 2025, ensuring relevance to contemporary architectural practices.

➢ *Study Characteristics*

The 20 selected studies spanned diverse geographic contexts and methodological approaches, reflecting global

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interest in biophilic design's mental health impacts. Geographically, research included urban environments in Nigeria (Amadi & Ichendu, 2024), Malaysia (Thani & Salleh, 2024), China (Li *et al.*, 2024), the United States (Browning *et al.*, 2014), and Italy (Thomas & Xing, 2021), among others. Methodologies ranged from systematic reviews and meta-analyses to empirical experiments, case studies, and mixed-methods designs. For example, Al Khatib *et al.* (2024) conducted a systematic review of literature from 2010–2023, analyzing case studies in healthcare settings to demonstrate biophilic design's role in reducing hospitalization time and patient mortality. In contrast, Li *et al.* (2024) employed a multidisciplinary approach combining subjective evaluations, electrophysiology, and cognitive tasks to quantify the psychophysiological effects of multisensory biophilic environments.

Empirical studies dominated the sample. Narula (2024) analyzed empirical data and case studies to highlight how natural lighting and materials improve mental well-being, while Amadi and Ichendu (2024) focused on rehabilitation centers in Nigeria, showing that biophilic interventions reduced stress and accelerated recovery. Surveys and correlational analyses were also prevalent: Mousighichi *et al.* (2024) surveyed 378 university students, finding strong correlations between visual/physical connections to nature and improved place attachment. Similarly, Namwad *et al.* (2023) used mixed-methods case studies in high-density urban areas to link biophilic elements like greenery and water features to stress reduction.

Theoretical and policy-oriented frameworks were explored in studies like Bolten and Barbiero (2020), who developed a conceptual model for biophilic design to bridge gaps between research and practice, and Andreucci *et al.* (2021), who emphasized evidence-based urban policies connecting biodiversity to mental health. However, critiques emerged in holistic reviews: Thomas and Xing (2021) noted inefficiencies in real-world biophilic applications, arguing that many projects implemented natural elements as isolated features rather than integrated systems.

➢ *Key Findings*

The synthesis of 20 studies reveals robust evidence supporting biophilic design's capacity to enhance mental health, though outcomes vary by context, design elements, and measurement approaches. Stress reduction emerged as the most consistent benefit across diverse settings. In healthcare environments, biophilic interventions reduced cortisol levels by 15–20% and accelerated patient recovery, with hospital studies reporting shorter hospitalization times, lower painkiller use, and decreased mortality rates (Al Khatib *et al.*, 2024; Li *et al.*, 2024). Similarly, workplaces and high-density urban residences incorporating natural light, greenery, or water features demonstrated significant stress alleviation, evidenced by improved heart rate variability (HRV) and self-reported tension reductions (Namwad *et al.*, 2023; Browning *et al.*, 2014). Educational settings also benefited, as campus landscapes with biophilic elements like water bodies and greenery reduced student stress and undesirable behaviors (Thani & Salleh, 2024; Mousighichi *et al.*, 2024).

Cognitive and emotional well-being improvements were notable but context-dependent. Classrooms with views of nature enhanced attention spans by 12%, while offices with multisensory biophilic environments (e.g., combined visual and olfactory stimuli) boosted creativity and task efficiency (Li *et al.*, 2024; Yin *et al.*, 2024). However, abstract representations of nature, such as geometric art, showed negligible cognitive benefits, underscoring the importance of literal natural elements (Li *et al.*, 2024). Emotional outcomes included elevated mood states—26% higher "vigor" and 19% lower tension in biophilic workplaces—and stronger social health metrics linked to auditory connections with nature, such as birdsong or flowing water (Largo-Wight *et al.*, 2016; Mousighichi *et al.*, 2024).

Methodological critiques highlighted limitations tempering generalizability. Small sample sizes (e.g., single-campus surveys) and short-term interventions dominated the literature, with few studies tracking long-term effects (Alam, 2023; Shree, 2019). Self-report biases skewed mood-scale results, particularly in studies lacking physiological validation (Huntsman & Bulaj, 2022). Additionally, cultural and geographic gaps were apparent: most research focused on Western or urban contexts, neglecting rural and non-Western populations (Thomas & Xing, 2021; Amadi & Ichendu, 2024). Despite these challenges, cross-cutting themes emphasized the need for holistic integration of biophilic elements—direct (plants), indirect (natural materials), and spatial (prospect-refuge layouts)—rather than isolated applications, to maximize mental health benefits (Andreucci *et al.*, 2021; Bolten & Barbiero, 2020). Collectively, the findings advocate for biophilic design as a scalable, evidence-backed strategy to mitigate urban mental health crises, while urging rigor in future studies to address gaps in longevity, diversity, and systemic implementation.

V. DISCUSSION

The synthesis of 20 empirical studies underscores biophilic design's transformative potential in enhancing mental health, though its efficacy is mediated by the interplay of design elements, contextual factors, and individual differences. Biophilic elements act as mediators of physiological and psychological processes, with natural light emerging as a critical regulator of circadian rhythms. For instance, daylight exposure in workplaces and schools reduced melatonin imbalances by 21%, improving focus and sleep quality (Li *et al.*, 2024; Heschong, 2021). Similarly, greenery and water feature lowered cortisol levels by 15–20% in high-stress environments like hospitals, aligning with Ulrich's Stress Reduction Theory (SRT), which posits that nature triggers innate calming mechanisms (Al Khatib *et al.*, 2024; Ulrich, 1983). However, discrepancies in outcomes highlight the role of contextual factors. Urban settings, characterized by sensory overload, showed stronger stress-reduction benefits from biophilic interventions compared to

ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jun821

rural areas, where baseline nature access may dilute design impacts (Amadi & Ichendu, 2024; Thani & Salleh, 2024). Cultural preferences also influenced efficacy: bamboo elements soothed stress in Asian contexts but had muted effects in arid regions, underscoring the need for culturally adaptive designs (Thomas & Xing, 2021).

The findings robustly align with theoretical frameworks central to environmental psychology. Ulrich's SRT is validated by biomarker evidence, such as cortisol and HRV improvements in biophilic healthcare and office spaces (Al Khatib *et al.*, 2024). Similarly, Kaplan and Kaplan's Attention Restoration Theory (ART) is supported by cognitive enhancements in nature-rich classrooms and workplaces, where "soft fascination" replenished attentional resources (Yin *et al.*, 2024). However, the inconsistent cognitive benefits of abstract biophilic elements (e.g., fractal art) challenge theories assuming universal responses to nature-mimicking patterns, suggesting that evolutionary predispositions may favor literal over symbolic representations (Li *et al.*, 2024).

Practical implications for architects and policymakers are clear. Prioritizing direct nature integration—such as indoor greenery, water features, and daylighting—should be foundational in healthcare, educational, and workplace designs. For example, hospitals with window views of greenery reduced patient recovery times by 8.5% (Ulrich, 1984), while offices with plants and natural materials reported 26% higher employee vigor (Largo-Wight *et al.*, 2016). Multisensory design is equally critical: combining visual (plants), auditory (water sounds), and tactile (wood textures) elements amplified stress reduction and creativity (Li *et al.*, 2024; Yin *et al.*, 2024).

Urban planners must also advocate for biophilic cities, integrating green corridors and accessible natural spaces to bridge socioeconomic disparities in nature access (Guo, 2024; Andreucci *et al.*, 2021). Moreover, projects that integrate sustainable-living practices—such as rainwater harvesting systems, passive solar strategies, and the use of FSC-certified wood—often yield more enduring mental-health benefits, as occupants perceive and appreciate the environmental stewardship inherent in these spaces. In addition, green-living behaviors, like tending indoor planter systems, become incorporated into daily routines, offering "soft fascination" and active engagement that further reinforce Attention Restoration Theory (Kaplan & Kaplan, 1989). However, designers should avoid tokenistic interventions—such as isolated potted plants—and instead adopt systemic approaches, as fragmented implementations yielded negligible benefits compared to holistic designs (Thomas & Xing, 2021; Shree, 2019).

Despite compelling evidence, limitations temper the generalizability of findings. Publication bias toward positive outcomes risks overlooking null or adverse effects, while heterogeneity in outcome measures complicates cross-study comparisons. For instance, cortisol assays, mood scales, and cognitive tests were inconsistently applied, preventing meta-analyses (McSweeney *et al.*, 2021; Andrade, 2020). Methodological constraints—such as small samples, short-term interventions, and overreliance on Western populations—further limit insights. Few studies addressed low-income or rural communities, where biophilic interventions could address unique stressors (Amadi & Ichendu, 2024). Additionally, self-report biases inflated perceived mood improvements in workplaces, as participants often associated biophilic elements with employer investment in well-being (Huntsman & Bulaj, 2022; Mousighichi *et al.*, 2024).

VI. CONCLUSION

➢ *Summary of Findings*

This systematic review synthesized empirical evidence from 20 studies to evaluate the impact of biophilic design on mental health across diverse populations (from Nigeria, Malaysia, China, the United States, and Italy), settings, and interventions. Key findings show that biophilic elements—such as natural light, greenery, water features, and natural materials—consistently reduce stress biomarkers (e.g., cortisol levels), enhance mood states (e.g., vigor, reduced tension), and improve cognitive performance (e.g., attention, creativity). The effectiveness of these interventions aligns with theoretical frameworks like Ulrich's Stress Reduction Theory and Kaplan and Kaplan's Attention Restoration Theory, validating nature's role in triggering innate physiological calming and cognitive restoration. However, outcomes varied by context: urban environments demonstrated stronger stress-reduction benefits compared to rural settings, while cultural preferences influenced the efficacy of specific design elements (e.g., bamboo in Asian contexts). Methodologically, studies prioritized controlled experiments and biomarkers but were limited by small samples, short-term interventions, and overreliance on Western populations.

➢ *Recommendations*

In line with the findings of this study, the following recommendations are proposed:

- Design Practices: Prioritize direct biophilic interventions (e.g., indoor plants, daylighting) in high-stress environments like hospitals and workplaces, ensuring designs are culturally and contextually adaptive.
- Methodological Rigor: Future studies should adopt longitudinal designs and standardized metrics (e.g., cortisol assays, validated cognitive tests) to assess sustained impacts. Larger, diverse samples encompassing rural, low-income, and non-Western populations are critical to enhance generalizability.
- Holistic Integration: Move beyond tokenistic elements (e.g., isolated potted plants) toward systemic biophilic frameworks that combine direct, indirect, and spatial design principles. Policies should incentivize certifications like WELL Building or Living Building Challenge to institutionalize best practices.

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➢ *Future Research*

Additionally, future research should put the following into consideration:

- Longitudinal and Cross-Cultural Studies: Investigate the durability of biophilic benefits over years and across cultural contexts, particularly in underrepresented regions like Africa and South America.
- Multisensory Interactions: Explore how combined sensory stimuli (e.g., auditory water features + tactile wood textures) amplify mental health outcomes compared to isolated elements.
- Socioeconomic Equity: Examine biophilic design's role in addressing mental health disparities in marginalized communities, including affordable housing and public infrastructure.
- Digital Biophilia: Assess the efficacy of virtual nature interventions (e.g., VR forests) in settings where physical nature integration is impractical.

➢ *Conclusion*

Biophilic design emerges as a transformational, evidence-based technique for improving mental health in an increasingly urbanized environment. This review synthesises worldwide results to support the restorative ability of nature-integrated places and to suggest further research that is both rigorous and inclusive to improve its implementation. As cities expand, embracing biophilic principles—based on science and tailored to human diversity—will be fundamental in building environments that heal, inspire, and sustain both people and planet.

Importantly, the true promise of biophilic design lies not only in the sensory or spatial mimicry of nature, but also in the incorporation of sustainable living at every scale. This includes responsible material sourcing and cradle-to-cradle assemblies, as well as construction and maintenance, and even the green-living habits of occupants on a daily basis. Therefore, future research should track both psychosocial outcomes (such as stress biomarkers, mood, and cognition) and ecological metrics (such as lifecycle carbon, resource efficiency, and biodiversity support), with the goal of advancing an integrative evidence base that is beneficial to both people and the planet.

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ISSN No: 2456-2165 https://doi.org/10.38124/ijisrt/25jun821

APPENDIX

Appendix 1: Selected Studies for the Study

Author(s) & Year	Methodology	Results & Findings
Narula (2024)	Empirical studies, case analyses, theoretical frameworks	Biophilic design enhances mental well-being by integrating natural elements into built environments.
Amadi & Ichendu (2024)	Integration of natural components in rehabilitation centers	Biophilic design in rehabilitation centers enhances physical and mental well-being, reducing stress and improving mood.
Al Khatib, Samara & Ndiaye (2024)	Systematic review of literature, case studies	Biophilic design in hospitals reduces hospitalization time, patient mortality, pain levels, and stress for healthcare providers.
Thani & Salleh (2024)	Assessment of biophilic elements in campus landscapes	Biophilic design in campus landscapes enhances mental well-being and mitigates student stress.
Alam (2023)	Deconstructive discourse analysis	Biophilic design contributes to mental well-being by incorporating natural elements into built environments.
Guo (2024)	Review of research on naturopathy and personality development	Exposure to nature enhances mental health, life satisfaction, and positive personality traits.
Li *et al.* (2024)	Subjective evaluation, electrophysiology, salivary biochemical analysis, cognitive tasks	Multisensory biophilic environments enhance psychophysiological restoration and cognitive function.
Yin, Zhu & Yuan (2024)	Systematic review of experimental studies	Multisensory biophilic design significantly influences psychological and physiological responses and cognitive function.
Huntsman & Bulaj (2022)	Integration of biophilic interventions in residential spaces	Biophilic design in residential environments fosters self-care practices and improves health outcomes for chronic conditions.
Shree (2019)	Review of biophilic design strategies	Biophilic design enhances cognitive function, reduces stress, and promotes mental peace in built environments.
Mousighichi, Mousavi Samimi & Mousapour (2024)	Survey analysis using Spearman correlation	Physical and visual connections with nature enhance place attachment and quality of campus life.
Panagopoulos, Sbarcea & Herman (2021)	Promotion of biophilic principles in urban design	Biophilic design in urban planning enhances health, well-being, and regenerates urban ecosystems.
Bolten & Barbiero (2020)	Conceptual framework for biophilic design	Biophilic design reduces stress, stimulates creativity, and improves physical and psychological well-being.
Andreucci *et al.* (2021)	Evidence-based biophilic design and policy	Biophilic design improves social, physical, and mental health by connecting daily life with biodiversity.
Namwad Badrike & Shinde (2023)	Mixed-methods approach with case studies and surveys	Biophilic design elements reduce stress levels in high-density living environments.
Browning, Ryan & Clancy (2014)	Framework for biophilic design patterns	Biophilic design enhances health and well-being by reducing stress and improving clarity of thought.
Aduwo, Akinwole & Okpanachi (2021)	Stratified random sampling and regression analysis	Biophilic design strategies enhance workers' productivity in office buildings.
Thomas & Xing (2021)	State-of-the-art review and holistic biophilic design framework	Biophilic design applications lack a holistic approach and require further development for effective health and well-being improvements.
Yassein & Ebrahiem (2018)	Systematic review of biophilic design practices	Biophilic design in interior spaces enhances well-being by fostering a deeper connection with nature.