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Exploring Biophilic Design in Eco-Tourism: A Comparative Assessment of Environmental and Architectural Synergy in Tropical and Subtropical Contexts

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Abstract
This study explores the integration of biophilic design principles in resort architecture across three diverse ecological settings: Yankari Game Reserve in Bauchi, Nigeria; Jean Michel Cousteau Resort in Vanua Levu Island, Fiji; and Kailumcito at the Camptel Resort, Mexico. Biophilic design—an approach that fosters human connection to nature through architectural features—has been recognised for its potential to enhance well-being, environmental sustainability, and user satisfaction. Using qualitative analysis of five key biophilic design features (natural lighting and ventilation, local materials, views and prospects, natural features, and natural forms and processes), the study reveals that only natural lighting and ventilation scored positively across all cases. The other elements were either poorly implemented or overlooked, particularly local material use and natural forms, indicating a disconnect between architectural intent and environmental context. These findings are linked to prior research emphasising the psychological and ecological benefits of immersive natural environments, yet highlight a persistent implementation gap in the limited use of local materials. The study recommends greater policy support, design education, and community engagement to promote biophilic design. It also suggests further research into long-term user experiences in biophilic spaces. This research contributes to sustainable architectural practice by identifying opportunities to align built environments more closely with natural ecosystems.

Keywords: Biophilic Design, Sustainable Architecture, Resort Design, Environmental, Psychology, Human-Nature Connection, Community.

Introduction

As global urbanisation accelerates, the disconnect between built environments and the natural world has become more pronounced. This phenomenon is particularly evident in the tourism and hospitality industries, where the experience of place is central to visitor satisfaction and ecological responsibility. Biophilic design, rooted in the biophilia hypothesis, offers a framework to restore this lost connection by deliberately integrating natural elements—such as light, vegetation, water, and organic forms—into architectural settings (Kellert, 2011; Browning et al., 2014). Biophilic environments have been shown to improve psychological well-being, reduce stress, enhance cognitive function, and contribute to environmental sustainability (Ryan et al., 2014; White et al., 2020). In tropical and subtropical regions, where biodiversity is abundant and climate responsiveness is essential, the application of biophilic design holds unique promise. Eco-resorts in these regions have the potential to not only deliver immersive, health-enhancing experiences to visitors but also support local ecological systems and cultural identities. Despite this potential, many self-proclaimed "eco-resorts" apply biophilic principles inconsistently or superficially—failing to harness their full environmental, social and experiential benefits. This study investigates the integration of biophilic design in selected tropical resorts to understand the synergy between architectural form and environmental context. Focusing on three case studies—Yankari Game Reserve (Nigeria), Jean-Michel Cousteau Resort (Fiji), and Kailumcito Camptel Resort (Mexico)—the research aims to assess the

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presence and quality of biophilic features, particularly those involving local materials, passive design systems, and sensory engagement.

Biophilic design is grounded in the biophilia hypothesis, which posits that humans have an inherent affinity for nature (Wilson, 2017). This concept has increasingly informed sustainable architecture and planning, particularly in spaces aimed at promoting human well-being and ecological sensitivity. Pioneering scholars such as Kellert (2011) and Browning et al. (2014) have formalised biophilic principles into measurable design strategies, including visual and non-visual connections to nature, use of natural materials, and incorporation of biomorphic forms. These principles have been further categorised into direct, indirect, and spatial experiences of nature (Terrapin , 2019).Research supports the notion that built environments incorporating biophilic elements positively affect health outcomes, productivity, and emotional well-being (Ryan et al., 2014; White et al., 2020). In tourism settings, such environments enhance guest satisfaction and foster a more profound sense of place. However, studies indicate that the practical application of biophilic design varies widely across geographic and socio-economic contexts. In tropical and subtropical regions—where natural light, vegetation, and vernacular materials are abundant—biophilic design is often underutilised or implemented in fragmented ways (Zhang et al., 2021; Le et al., 2020).Specific to eco-tourism, researchers like Kellert and Calabrese (2015) argue that successful biophilic resorts integrate local culture, landscape, and climate-responsive design to enhance ecological stewardship and visitor engagement. Nonetheless, there remains a lack of empirical research assessing how these principles are applied in operational eco-resorts, particularly in the Global South. This gap in the literature underscores the need for comparative case studies that evaluate not only the presence of biophilic features but also their synergy with local environmental and cultural contexts. By situating the present study within this theoretical and empirical landscape, it contributes to a growing body of research aimed at aligning architecture with ecological and experiential values in eco-tourism. The objectives are threefold:
(i) to evaluate the application of biophilic elements across sites; (ii) to compare design strategies used in integrating natural systems and forms;
(iii) to analyse the impact of biophilic design on environmental performance and user experience. The outcomes will inform sustainable tourism development practices, especially in biodiversity-rich tropical contexts.

Materials and Methods

This study is grounded in a qualitative, exploratory research paradigm that aligns with the interpretivist tradition, suitable for understanding complex, context-dependent phenomena such as biophilic design in eco-tourism architecture. The research design employed a flexible, emergent strategy, allowing data collection and analysis to evolve iteratively. This approach is widely endorsed in exploratory studies where the goal is to uncover meanings, patterns, and relationships rather than to test specific hypotheses (Creswell & Poth, 2018). Case study methodology was used as the primary strategy, as it enables in-depth exploration of contemporary issues within their real-life contexts (Yin, 2018). The study focused on multiple case studies selected purposively to reflect diversity in geography and climate while sharing ecological and architectural themes. The primary case study was drawn from the North-East geopolitical zone of Nigeria, specifically the Yankari Game Reserve, chosen for its unique socio-cultural and environmental attributes. To enrich cross-cultural understanding and contrast biophilic design strategies, two additional international eco-resort sites were selected: Jean-Michel Cousteau Resort in Fiji and Kailumcito, the Camptel Resort in Mexico. Purposive sampling was appropriate as it allowed the inclusion of information-rich cases (Palinkas et al., 2015). Data collection utilised mixed qualitative techniques, including field photography for architectural documentation, hand sketches for spatial mapping, field notes for recording observed biophilic variables, and participant observation to capture users' experiential interactions. Semi-structured interviews with visitors and stakeholders further enriched the findings, a method validated in environmental behaviour research (Groat & Wang, 2013). On-site investigations focused on biophilic elements such as daylight access, local material use, views of nature, site responsiveness, and biomorphic forms. Variables for assessment included building orientation, material expression, integration with natural surroundings, and use of natural patterns, consistent with established frameworks for evaluating biophilic architecture (Kellert, 2018). This adaptive, multi-method approach ensured a robust, context-sensitive analysis of biophilic design practices across diverse environmental and cultural settings.

Results

Elements of Biophilic Design

Biophilic design in tropical environments significantly enhances human health and well-being by fostering a deep, sensory-based connection with nature through architectural elements. As illustrated in Table 1, this design approach prioritises natural systems and processes to improve comfort, psychological restoration, and

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sustainability in the built environment (Kellert, 2018; Ryan et al., 2014). One of the core dimensions is prospect, which refers to unobstructed views of the landscape, horizons, and skies—key visual elements that are abundant in tropical regions. These expansive visual connections help reduce stress and promote cognitive restoration (Browning et al, 2014).

Table 1: Elements of Biophilic Design that enhance occupant well-being by integrating nature into built spaces

Sn	Key Dimension	Qualities/ Attributes
1	Prospect (ability to see into the distance)	Brightness in the field of view (windows, bright walls); Ability to get to a distant point for a better view; Horizon/sky imagery (sun, mountains, clouds); Strategic viewing conditions; View corridors
2	Refuge (sense of enclosure or shelter)	Canopy effect (lowered ceilings, screening, branchlike forms overhead)
3	Water (indoors or inside views)	Glimmer or reflective surface (suggests clean water); Moving water (also suggests clean, aerated water); Symbolic forms of water
4	Biodiversity	Varied vegetation indoors and out (large trees, plants, flowers); Windows designed and placed to incorporate natural views; Outdoor natural areas with rich vegetation and animals
5	Sensory variability	Changes and variability in environmental colour, temperature, air movement, textures, and light over time and spaces; Natural rhythms and processes (natural ventilation and lighting)
6	Bio mimicry	Designs derived from nature; Use of natural patterns, forms, and textures; Fractal characteristics (self-similarity at different levels of scale with random variation in key features rather than exact repetition)
7	Sense of playfulness	Incorporation of decor, natural materials, artefacts, objects, and spaces whose primary purpose is to delight, surprise, and amuse
8	Enticement	Discovered complexity, Information richness that encourages exploration; Curvilinear surfaces that gradually open information to view

Maximising natural lighting is crucial in equatorial settings, where high solar radiation enables passive daylighting strategies. Research shows that exposure to natural light positively affects circadian rhythms, productivity, and mood (Allen et al., 2018). In contrast, refuge offers shaded, enclosed areas using local and natural materials like palm thatch or timber screens to protect occupants from heat while preserving their connection to the environment. This balance between openness and shelter is especially relevant in hot-humid climates (Terrapin Bright Green, 2012).

The water element is both functional and symbolic in biophilic tropical architecture. Water features—such as pools, fountains, or rain gardens—not only enhance thermal comfort through evaporative cooling but also evoke tranquillity and cultural significance, aligning with findings that proximity to water improves emotional well-being (White et al., 2020; Malgwi & Sagada, 2014). Biodiversity is another essential element, as tropical zones are home to some of the world's richest ecosystems. Integrating native flora and fauna into building design through green walls, interior plants, or ecological landscaping promotes sensory engagement and environmental stewardship (Beatley, 2016; Olawuyi et al., 2022; Sagada, 2016). Framing these natural assets with windows and openings also supports biophilic goals by reinforcing visual and emotional ties to the ecosystem (Kaplan & Kaplan, 1989).

Sensory variability—the dynamic interplay of light, temperature, sound, and air movement—is critical in tropical climates, where diurnal and seasonal changes are pronounced. Adaptive architectural designs that respond to these fluctuations, such as operable shading devices or natural ventilation systems, help maintain occupant comfort while sustaining awareness of environmental changes (Heerwagen, 2006; Sagada, 2013). Biomimicry, or the imitation of natural forms and processes, contributes to sustainable design solutions by enhancing building efficiency and aesthetics. Structures inspired by nature—through form, function, or material use—promote resilience and resource conservation. For example, using renewable local materials like bamboo, adobe, or rammed earth supports environmental harmony and cultural relevance (Benyus, 1997).

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Biophilic design also includes emotional and behavioural dimensions such as playfulness and enticement. Playfulness is achieved through interactive features, vibrant colours, and tactile materials that stimulate curiosity and joy—an essential aspect in leisure and hospitality architecture (Kellert, 2018). Similarly, enticement refers to the strategic design of layered, dynamic spaces that invite exploration, discovery, and ongoing interaction with the natural world. These qualities are vital in creating immersive, meaningful experiences in eco-resorts and tropical destinations. Together, these biophilic elements support an integrative design framework that benefits human health, environmental sustainability, and cultural expression in tropical regions.

Case Study One: Yankari Game Reserve, Bauchi, Nigeria

An analysis of biophilic design elements at Yankari Game Reserve, Bauchi, Nigeria, reveals a mixed integration of biophilic principles into its built environment, as presented in Table 2. Natural lighting and ventilation scored a weight factor of 3 out of 5, indicating a moderate positive presence. This scale aligns with the reserve's open-air structures and use of wide verandas that facilitate passive cooling and maximise daylight, crucial in the hot-dry climate of Bauchi (Givoni,1998). The efficient use of natural ventilation reduces dependency on mechanical systems, enhancing sustainability and user comfort, which are key goals of biophilic architecture (Kellert, 2011).

Table 2: Mixed Integration of Biophilic Principles into the Built Environment of Yankari Game Reserve, Bauchi

S/N	Biophilic Design Feature	Weight Factor (5)	Biophilic Remarks
1	Natural lighting and ventilation	3	Positive
2	Local materials	2	Negative
3	Views and prospects	3	positive
4	Natural features	2.5	Negative
5	Natural forms, shapes and processes	2	negative

Local materials, however, received a low weight factor of 2, indicating a negative application. While traditional Nigerian architecture typically embraces local resources like laterite stone and timber, Yankari's newer constructions often rely on modern, imported materials that diminish a sense of place and weaken the cultural connection (Olotuah & Adesiji,2005). This phenomenon weakens the reserve's alignment with the biophilic ethos, which emphasises using indigenous materials to foster ecological integration.Views and prospects performed relatively well with a score of 3. Structures within the reserve offer expansive views of savannah landscapes and waterholes, aligning with biophilic principles that stress visual access to distant horizons for psychological comfort (Browning et al., 2014). As presented in Figure 1, the use of natural features such as topography, water, and vegetation scored a modest 2.5, suggesting a partial but underutilised application. While Yankari's natural springs and wildlife are globally celebrated, built interventions often fail to thoughtfully integrate these features into the user experience (International Union for Conservation of Nature [IUCN], 2020). Lastly, natural forms, shapes, and processes received a poor rating (2). Architectural elements largely neglect biomorphic forms and fractal patterns known to reduce stress and enhance user engagement (Salingaros, 2015). To fully embody biophilic design, Yankari must better integrate natural geometries and local materials, fostering a stronger connection between visitors and the environment.

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Figure 1: Use of natural features such as topography, water, and vegetation scored modestly in the Yankari Game Reserve, Bauchi, Nigeria.

Case Study Two: Jean Michel Cousteau Resort, Vanua Levu Island, Fiji

The analysis of the Jean Michel Cousteau Resort, Vanua Levu Island, Fiji, reveals a partial application of biophilic design principles, as analysed in Table 3. Natural lighting and ventilation, scoring a weight factor of 3 and marked positive, highlight the resort's successful strategy of maximising natural airflow and daylight. This provision aligns with Browning et al. (2014), emphasising that access to fresh air and natural light enhances occupant comfort and health. The resort's open-air structures and strategic spatial layout effectively capture Fiji's tropical breezes and abundant sunlight, offering guests a direct sensory connection with the environment.

However, the other biophilic elements perform poorly. Local materials scored 1.67 with a negative remark, suggesting a limited use of indigenous building materials such as timber, bamboo, and thatch traditionally available in Fiji (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2015). Instead, the use of imported construction materials compromises sustainability and the connection to local culture, which is a critical component of authentic biophilic design. Similarly, Views and Prospects scored only 1.75 and were also marked negatively. Despite the natural beauty of Vanua Levu, the resort design appears to inadequately frame vistas toward key features like the ocean, mountains, and lush vegetation—an oversight that diminishes opportunities for psychological restoration linked to distant views (Kellert, 2011).

Table 3: Partial application of biophilic design principles at Jean Michel Cousteau Resort, Vanua Levu Island, Fiji

S/N	Biophilic Design Feature	Weight Factor (5)	Biophilic Remark
1	Natural lighting and ventilation	3	Positive
2	Local materials	1.67	Negative
3	Views and prospects	1.75	Negative
4	Natural features	1.5	Negative
5	Natural forms, shapes and processes	1.5	negative

Moreover, Natural Features and Natural Forms, Shapes, and Processes, scoring 1.5 each, are poorly represented. The resort could integrate elements like natural pools, rock formations, or structures mimicking organic geometries to enhance biomimicry and ecological resonance (Terrapin Bright Green, 2012). Although marketed as an eco-luxury destination, the resort's biophilic strategies remain surface-level. Stronger integration of authentic local materials, curated visual connections to the landscape, and biomorphic forms would significantly deepen guests' emotional ties to nature, fulfilling the true promise of biophilic design and strengthening environmental stewardship.

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Figure 2: Natural features and natural forms, shapes, and processes scoring low in the Jean Michel Cousteau Resort, Vanua Levu Island, Fiji

Case Study Three: Kailumcito, the Camptel, Resort, Mexico

Table 4, representing the Elements of Biophilic Design at Kailumcito, the Camptel Resort, Mexico, highlights the varying success of integrating biophilic principles into the resort's design. Natural lighting and ventilation stand out as the highest-rated features with a weight factor of 3, receiving a positive remark. In tropical and subtropical settings like Mexico, the use of natural light and cross-ventilation is essential for creating a comfortable and healthy environment. Properly utilising natural lighting reduces energy consumption while enhancing the overall well-being of occupants, as studies show that exposure to natural light improves mood, productivity, and sleep patterns (Kellert, 2011). The resort's design likely takes advantage of its location by incorporating large windows and open spaces, facilitating airflow and connecting the interior with the natural environment.

Table 4: Success of integrating biophilic design principles into Kailumcito, the Camptel Resort, Mexico

S/N	Biophilic Design Feature	Weight Factor (5)	Remark
1	Natural lighting and ventilation	3	Positive
2	Local materials	2	Negative
3	Views and prospects	1.75	Negative
4	Natural features	1.5	Negative
5	Natural forms, shapes and processes	1	negative

However, the use of local materials received a score of 2 with a negative remark, indicating that although Mexico is rich in natural, indigenous materials like adobe, stone, and palm, the resort may not fully embrace these resources. The use of local materials is a fundamental principle of biophilic design, as it strengthens the connection to the surrounding environment and culture, enhancing the guest experience (Browning et al., 2014; Aule et al., 2022). The negative score suggests that the resort may be relying more on imported or synthetic materials, which could detract from the authenticity and environmental sustainability of the design.

Similarly, the features related to views and prospects (1.75), natural features (1.5), and natural forms, shapes, and processes (1) all received low scores with negative remarks. Despite the resort's likely lush surroundings, these elements appear to be underutilised. Providing expansive views, incorporating natural elements like water features or local plant life, and using nature-inspired forms in the design can significantly improve guests' connection to the environment. The lack of emphasis on these biophilic elements may result in a missed opportunity to foster a deeper emotional connection to nature, which is a central tenet of biophilic design (Terrapin Bright Green, 2012). As briefed in Figure 3, while Kailumcito integrates natural lighting and ventilation effectively, it could improve by incorporating more local materials and enhancing its use of natural features and forms, thus aligning more closely with biophilic design principles.

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Figure 3: Kailumcito integrates natural lighting and ventilation effectively as elements of biophilic design

Discussion

The comparative analysis of biophilic design elements across three eco-resort case studies—Yankari Game Reserve in Nigeria, Jean-Michel Cousteau Resort in Fiji, and Kailumcito Camptel Resort in Mexico—demonstrates differing levels of integration and efficacy in applying biophilic principles. Biophilic design, as defined by Kellert (2018), aims to reconnect people with nature through architectural features that support psychological well-being, ecological sustainability, and cultural resonance. These principles are vital in tropical and subtropical eco-tourism destinations, where the built environment can significantly influence guest experience and environmental impact. At Yankari Game Reserve, the implementation of natural lighting and ventilation is moderate, with a weight factor score of 3 out of 5. This aligns with findings by Allen et al. (2018), who highlight the benefits of natural ventilation and daylighting for cognitive function and indoor environmental quality. However, the reserve performs poorly in categories such as use of local materials (2), views and prospects (1.75), natural features (1.5), and biomorphic forms (1), indicating minimal integration of the surrounding environment into architectural expression. The limited use of indigenous materials and contextual design weakens cultural authenticity and may reduce the ecological and social sustainability of the facility (Beatley, 2016; Browning et al., 2014). These findings are consistent with similar studies that show eco-resorts in some developing regions often fall short in embedding deeper biophilic values into their spatial planning and material usage (Sorvig & Thompson, 2018).

Conversely, Jean-Michel Cousteau Resort exhibits strong biophilic integration. Drawing from traditional Fijian vernacular architecture, the resort uses materials such as sustainably harvested timber and bamboo, incorporates thatched roofing, and features louvred openings for passive ventilation. These strategies align with Terrapin Bright Green's (2019) biophilic design framework, particularly the use of natural materials and dynamic sensory experiences. Furthermore, the resort actively participates in environmental stewardship through marine conservation and sustainable landscaping, enhancing both ecological integrity and visitor connection to the place. These initiatives resonate with the findings of White et al. (2020), which emphasise the psychological and restorative benefits of immersive natural experiences. Comparable success in biophilic applications has been observed in Southeast Asian resorts, where holistic approaches to site planning and ecological sensitivity have proven both economically and socially beneficial (Le et al., 2020). Kailumcito Camptel Resort presents a hybrid approach. While it scores comparably to Yankari in natural lighting and ventilation (3), it shares similarly low ratings in other domains such as local material use (2), views and prospects (1.75), and natural forms (1). The resort employs traditional methods in constructing "tentalapas" - tent structures with palapa-style shading—which indicate a foundational awareness of local building practices. However, the insufficient integration of the broader natural environment and biomimetic design reveals a partial rather than holistic application of biophilic strategies. According to Ryan et al. (2014), such superficial engagement with biophilic principles may diminish their potential health and well-being benefits. This partial application reflects a broader challenge in the global adoption of biophilic design, where aesthetic mimicry often replaces deeper ecological integration (Browning et al., 2014). These findings support existing literature asserting that biophilic design must go beyond aesthetics to influence ecological, cultural, and psychological outcomes meaningfully. For example, Browning et al. (2014) argue that the effectiveness of biophilic design depends on its integration into the overall architectural concept, not as an afterthought or decorative feature. This study reinforces that premise but also reveals variation in implementation due to contextual constraints such as economic capacity, technical know-how, and policy environment.

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Study Limitations

While the findings offer valuable insights, this study is not without limitations. Firstly, the reliance on qualitative data and case study methodology constrains the generalisability of the results. Subjective assessments, even when structured by evaluation frameworks, may introduce interpretive bias (Valentine et al., 2021). Secondly, the small sample of three resorts limits the breadth of comparative analysis and may not fully capture regional diversity in biophilic design adoption. Larger, mixed-method studies could validate these findings across different ecological, cultural, and policy contexts.

Implications and Future Directions

The implications for stakeholders are manifold. Governments and planning authorities should establish and enforce biophilic design guidelines within building codes and tourism policies to encourage sustainability and improve the appeal of eco-tourism destinations. For local communities, greater emphasis on indigenous materials and craftsmanship could stimulate the local economy, reinforce cultural identity, and create employment opportunities. Resort developers and designers must prioritise comprehensive biophilic strategies to enhance guest satisfaction, lower operational costs, and improve environmental resilience.

Further research should investigate the long-term effects of biophilic design in resort settings, particularly its influence on user satisfaction, mental health, and sustainability metrics. Additionally, studies could explore culturally adaptive biophilic frameworks to suit regional differences better, while cost-benefit analyses could offer practical guidance for stakeholders balancing economic and ecological considerations.

Conclusion

This study investigated the implementation of biophilic design elements in three resort locations—Yankari Game Reserve in Nigeria, Jean Michel Cousteau Resort in Fiji, and Kailumcito at the Camptel Resort in Mexico. Drawing from the core principles of biophilic design—such as natural lighting and ventilation, use of local materials, views and prospects, natural features, and organic forms—the analysis revealed varying levels of integration across sites. While natural lighting and ventilation were positively rated in all three resorts, most other biophilic elements scored low, indicating limited application of comprehensive biophilic strategies. For instance, local materials and natural features scored below average, reflecting a disconnect between the built environment and its surrounding ecosystem. These findings underscore the gap between biophilic theory and practical execution, especially in locations rich in biodiversity and natural beauty. Previous literature (e.g., Browning et al., 2014; Kellert, 2011) emphasises that effective biophilic design enhances health, psychological well-being, and environmental stewardship. However, the case studies examined suggest that opportunities to maximise these benefits remain underutilised. This gap may be attributed to design limitations, lack of awareness, or inadequate policy frameworks promoting biophilic integration.

Recommendations

The following recommendations were therefore put forward, identifying the areas in which biophilic design can play a transformative role in shaping sustainable, health-promoting, and resilient built environments.

I. Policy Development: Governments should implement architectural guidelines that encourage the integration of biophilic elements, particularly in tourism and public infrastructure. Policy incentives, such as tax credits, expedited permit approvals, or subsidies, should be offered to developers who meet certified biophilic design benchmarks.
II. Capacity Building: Stakeholders, including architects and developers, should receive training on biophilic design principles. Curricula should include climate-adaptive biophilic design, post-occupancy evaluation methods, and ecosystem-based design thinking.
III. Material Innovation: Encourage the use of sustainable local materials to promote cultural identity and environmental harmony. Governments and research institutions should invest in materials research and innovation hubs to test and certify local materials for commercial construction, thereby reducing dependency on imported materials.
IV. Community Engagement: Local communities should be involved in the early stages of resort planning, not just as labourers or end-users, but as co-creators. Their knowledge of seasonal cycles, resource availability, and cultural symbols can lead to more ecologically sensitive and socially embedded design outcomes.
V. Further Research: Future studies should explore the long-term behavioural and health outcomes of users in biophilic environments, using mixed-method approaches that combine post-occupancy evaluation and

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physiological metrics. Cross-cultural comparisons of biophilic implementation can also reveal how local values influence design adoption, especially in climate-vulnerable regions.

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