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Development of Biophilic Design Elements and Attributes for a Restorative Indoor Office Environment in Malaysia

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ABSTRACT

Workplace stress and reduced productivity remain persistent challenges in Malaysian indoor office environments, particularly within government buildings characterised by enclosed layouts and centrally conditioned interiors. This study aims to develop and validate a Malaysian-contextualised biophilic design framework for restorative indoor office environments. A two-phase approach was implemented: (i) desk synthesis of four major biophilic frameworks to shortlist office-relevant attributes, followed by (ii) expert validation through a Focus Group Discussion (FGD) with nine interdisciplinary specialists using confirmatory thematic analysis supported by Atlas.ti. The refinement process reduced the literature-derived pool from 72 to 57 shortlisted attributes and produced a final validated set of 34 attributes, consolidated into three operational domains: Natural Environment, Composition, and Personal Experience. The resulting framework provides a practical basis for designing, assessing, and prioritising biophilic strategies in Malaysian government office interiors to support stress reduction and productivity enhancement.

Keywords: Biophilic Design, Malaysian Offices, Productivity Enhancement, Restorative Indoor Environment, Stress Reduction,

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INTRODUCTION

Workplace stress and reduced productivity remain pressing concerns in Malaysian indoor office environments, particularly within government buildings where employees spend prolonged hours in enclosed and centrally conditioned interiors. These conditions highlight the need for practical workplace strategies that

support psychological restoration and demonstrate measurable benefits for employee wellbeing and performance.

Biophilic design offers a relevant pathway by integrating nature and nature-derived qualities into built environments to promote stress recovery, attentional restoration, and positive workplace experience (Kellert, 2008; Terrapin Bright Green et al., 2014). However, existing biophilic frameworks especially Kellert's six elements and 72 biophilic attributes were primarily developed in Western contexts and are not directly transferable to Malaysian government offices without refinement (Kellert, 2008; Kellert & Calabrese, 2015). In hot–humid institutional workplaces, implementation feasibility is shaped by indoor operational constraints such as reliance on mechanical cooling, thermal comfort and glare management, standardised workspace layouts, and maintenance limitations. In addition, the full 72-attribute inventory is often too broad for consistent assessment and prioritisation in office settings, which can reduce usability for practitioners and weaken measurement reliability for research applications.

Therefore, this study aims to develop and validate a Malaysian-context biophilic design framework for restorative indoor office environments by refining established attribute inventories into an operational and measurable set of attributes. The framework development employed a staged approach consisting of a desk review synthesis of key biophilic design frameworks, followed by expert validation through a Focus Group Discussion (FGD) and confirmatory qualitative coding. The outcome is a consolidated biophilic attribute framework tailored to Malaysian government office interiors, providing a structured basis for subsequent design guidance, assessment tools, and future empirical testing of stress reduction and productivity enhancement.

LITERATURE REVIEW

This section reviews the theoretical and empirical foundations supporting biophilic design as a restorative workplace strategy and explains why contextual refinement is necessary for Malaysian government offices. It first summarises the restorative theories linking nature exposure to stress recovery and attentional restoration, then critically reviews major biophilic design frameworks and their operational limitations for indoor workplaces. Finally, it synthesises global and recent office-oriented evidence to justify the literature-derived attribute shortlisting criteria used for the desk study stage. (Kellert et al., 2008; Ulrich et al., 1991; Tabassum & Park, 2024).

Biophilic Design and Restorative Workplace Outcomes

Biophilic design refers to the intentional incorporation of nature and nature-derived qualities into the built environment to support human wellbeing, restoration, and performance. In office settings, its relevance is strengthened by the need to manage daily

cognitive fatigue and stress response associated with prolonged indoor work. Evidence-based workplace research increasingly positions biophilic strategies as health-supportive interventions rather than decorative enhancements, making them relevant for occupational environments where wellbeing and productivity outcomes are closely linked. (Kellert et al., 2008; Sjövall & Spiers, 2024).

Restorative environmental psychology provides a robust mechanism-based explanation for these outcomes. Stress Recovery Theory (SRT) proposes that exposure to nature supports faster physiological and emotional recovery from stress, while Attention Restoration Theory (ART) explains that natural qualities restore directed attention through fascination, being away, and mental compatibility. These theories offer a strong scholarly basis for selecting biophilic strategies that can plausibly influence stress and performance-related outcomes in indoor workplaces. (Ulrich et al., 1991; Kaplan, 1995).

Recent evidence reinforces these theoretical foundations by linking nature exposure and greenery-related interventions to psychological wellbeing and stress-related outcomes within indoor environments. Research in urban greening and indoor nature exposure has shown that vegetation and nature contact contribute to mental health and restorative experience, supporting the broader argument that nature-based qualities remain beneficial even in highly built, institutional contexts. (Bratman et al., 2019; Bringslimark et al., 2009).

Global Frameworks and Office Operationalisation Needs

Kellert's biophilic taxonomy remains one of the most influential global references due to its comprehensive classification of biophilic design into six elements and 72 attributes, covering direct and indirect nature experience and experience of space and place. However, for workplace implementation and assessment, the full inventory can be difficult to operationalise consistently because some attributes overlap conceptually, vary in interpretability, or are challenging to measure in indoor office environments. (Kellert et al., 2008; Kellert & Calabrese, 2015).

Terrapin Bright Green's 14 Patterns of Biophilic Design offers an evidence-based bridge between biophilic attributes and restorative outcomes by explaining how design conditions trigger stress recovery and attentional restoration. By connecting strategies to mechanisms and user responses, this approach supports outcome-driven workplace evaluation and provides a clearer foundation for selecting office-relevant interventions. (Terrapin Bright Green, 2014; Gillis & Gatersleben, 2015).

Contemporary research trends increasingly emphasise measurable and assessment-oriented frameworks for indoor workplaces. Recent evaluation studies propose structured matrices and scoring approaches to assess biophilic quality in architecture, reflecting a

shift towards "tool-like" operationalisation that can support systematic assessment, comparison, and prioritisation of interventions. This strengthens the rationale for refining broad frameworks into measurable attribute sets for office applications. (McGee et al., 2019; Tabassum & Park, 2024).

Rationale for Contextual Refinement in Malaysian Government Offices

Despite their value, Western-derived biophilic frameworks require contextual refinement for Malaysian government offices due to climate, operational constraints, and institutional management realities. In hot–humid environments, indoor comfort is strongly influenced by thermal load, glare, humidity control, and ventilation conditions, and many offices rely heavily on mechanical cooling to maintain stable working conditions. This operational reality affects the feasibility of certain biophilic strategies and necessitates prioritisation of attributes that remain beneficial without compromising comfort and building performance. (Chen & Jim, 2020; Kellert & Calabrese, 2015).

In institutional workplaces, feasibility is also shaped by policy constraints, maintenance capacity, and standardisation requirements. Features such as large water installations, extensive planting maintenance, or complex spatial restructuring may be difficult to implement consistently across government offices. Therefore, localisation must focus on attributes that are measurable, maintainable, and scalable while preserving restorative outcomes supported by theory and evidence. (McGee et al., 2019; Sánchez et al., 2021).

The need for localisation is further supported by growing evidence that biophilic outcomes depend on both environmental features and how they are perceived and experienced by occupants within the specific socio-cultural and climatic context. As a result, a contextualised framework is required to translate global biophilic theory into an operational attribute set suitable for Malaysian government office interiors, supporting systematic assessment for stress reduction and productivity outcomes. (Wong & Subhi, 2022; Tabassum & Park, 2024).

Derivation of the Desk-Study Attribute Shortlist

To ensure traceability between theory and selection, this literature review was structured to directly inform the derivation of the desk-study attribute shortlist. Four established frameworks were compared to generate an initial inventory and shortlist relevant to indoor office environments: Kellert et al. (2008), Terrapin Bright Green (2014), Kellert and Calabrese (2015), and McGee et al. (2019). Cross-framework mapping supported consolidation of redundant concepts and prioritisation of office-relevant attributes aligned with restorative mechanisms and implementation feasibility. (Kellert et al., 2008; Terrapin Bright Green, 2014; McGee et al., 2019).

Attributes were prioritised when they met three key principles: (i) mechanism-based justification through SRT/ART (stress recovery and attention restoration), (ii) feasibility under centrally cooled and institutionally managed office constraints, and (iii) measurability for structured assessment tools such as observation checklists and occupant evaluation. Table 1 summarises the framework-based shortlisting criteria applied to translate global biophilic theories into an office-ready attribute list suitable for Malaysian government office contexts.

Table 1
Framework-based shortlisting criteria for the desk review

Shortlisting dimension	Key supporting framework(s)	Shortlisting criterion (decision rule)	Malaysian office relevance
Comprehensive attribute inventory	Kellert (2008)	Start from a complete baseline attribute pool before reduction	Prevents missing important biophilic qualities
Restorative mechanism relevance	Terrapin (2014)	Prioritise attributes linked to stress recovery / attention restoration mechanisms	Strengthens health–wellbeing justification
Indoor feasibility	Kellert & Calabrese (2015)	Retain attributes realistically implementable in indoor workplaces	Fits institutional and maintenance constraints
Measurability / clarity	McGee et al. (2019)	Retain attributes that can be observed or consistently evaluated	Supports checklist/ questionnaire development
Contextual suitability	Cross-framework + workplace evidence	Consider hot–humid, centrally cooled, standardised office conditions	Ensures local practicality and comfort compatibility
Redundancy reduction	Framework mapping	Merge overlapping attributes and remove duplicates	Produces a compact, usable shortlist

Figure 1 further illustrates the conceptual linkage between biophilic elements (attribute inventory), restorative mechanisms (patterns), and experience pathways supporting indoor office operationalisation. (Ulrich et al., 1991; Kaplan, 1995; Terrapin Bright Green, 2014; Tabassum & Park, 2024).

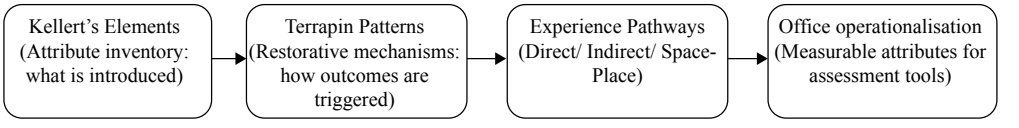

Figure 1. Conceptual relationship between biophilic elements, patterns, and experience pathways supporting office operationalisation

METHODOLOGY

This study employed a two-phase framework development design to derive and validate biophilic attributes suitable for restorative indoor government offices in Malaysia. Phase 1 consisted of a desk study to short-list office-relevant attributes through structured framework comparison. Phase 2 validated and refined the shortlist through an expert FGD supported by qualitative coding and thematic analysis. This staged design ensures methodological traceability from theory to local operationalisation. (Creswell & Poth, 2018; Guest et al., 2012).

Phase 1: Desk Study (Framework Comparison and Attribute Shortlisting)

The desk study compared four established biophilic design frameworks to align core constructs and identify office-relevant attributes: (i) Biophilic Design: Theory and Practice (Kellert et al., 2008), (ii) Biophilic Design Experiences and Attributes (Kellert & Calabrese, 2015), (iii) Terrapin Bright Green's 14 Patterns of Biophilic Design (2014), and (iv) Biophilic Design Elements (McGee et al., 2019). The purpose of the comparison was to consolidate overlapping concepts, strengthen mechanism-based interpretation (restorative logic), and ensure that the resulting shortlist could be applied and measured in indoor office environments. Table 2 summarises the framework comparison and the refinement rationale leading to the final 57-attribute shortlist for expert validation.

Table 2
Framework comparison and refinement rationale supporting development of the 57-attribute shortlist

Criterion	Kellert et al. (2008)	Kellert & Calabrese (2015)	Terrapin (2014)	McGee et al. (2019)	Final 57 attributes (desk shortlist)
Focus / purpose	Broad biophilic theory & design applications	Biophilic experiences + design attributes	Evidence-based patterns linking design to outcomes	Indoor biophilic design elements	Office-operational shortlist for expert validation
Structure	6 elements	3 experience pathways	3 pattern categories	6 elements	6 categories (desk-study organisation)
Strength	Comprehensive attribute inventory	Emphasises human experience pathway	Mechanism/ outc-ome-based logic	Supports interior operationalisa-tion	Balanced theory + feasibility + measurability
Contextual Limitation	Too broad; overlaps; not office-specific	Requires operational translation for assessment	Pattern-level (not full attribute list)	Still needs localisation & screening	Context-fit shortlist ready for FGD review

Criterion	Kellert et al. (2008)	Kellert & Calabrese (2015)	Terrapin (2014)	McGee et al. (2019)	Final 57 attributes (desk shortlist)
Desk-study revision	Consolidate overlaps; refine office wording	Align experience pathway to measurable attributes	Use patterns to justify restorative mechanisms	Support measurability in indoor settings	72 → 57 using merge/refine/omit rules
Action taken	Merge / refine / screen out unsuitable items	Translate into office-ready attributes	Guide mechanism-based prioritisation	Improve clarity + measurement suitability	Final shortlist used as FGD input instrument

Desk-study shortlisting rules

Kellert's 72 attributes were used as the baseline inventory due to their comprehensive biophilic coverage. Reduction into a 57-attribute shortlist followed explicit desk-study rules to ensure suitability for Malaysian government office environments: attributes were merged when conceptual overlap occurred across frameworks, refined when definitions were unclear or required measurable office wording, and screened out when attributes were judged impractical or weakly applicable within centrally conditioned institutional workplaces. These rules ensured that the shortlist retained theoretical validity while improving usability for subsequent expert evaluation and tool development.

Organisation of the 57-attribute shortlist

The 57 shortlisted attributes were structured into six categories to facilitate systematic expert review and reduce interpretive ambiguity. These categories were: Actual Natural Features (Items 1–7), Natural Shapes and Forms (8–15), Natural Patterns and Processes (16–27), Colour and Light (28–40), Place-Based Relationships (41–47), and Human–Nature Relationships (48–57). Table 3 presents the category and attributes structure used to guide expert validation during the FGD phase.

Table 3
Desk-study shortlisted attributes (57 items) organised by category for expert validation

Category/ Element	Item range	Attributes
Actual Natural Features	1–7	Natural Ventilation; Plants; Facades Greening; Animals; Natural materials; Views and vistas; Habitats & Vistas
Natural Shapes and Forms	8–15	Botanical motifs; Animal-like; Shells and spirals; Egg, oval, and tubular forms; Curves and arches; Organic and Fluid Forms; Abstraction of nature; Inside-Outside

Category/ Element	Item range	Attributes
Natural Patterns and Processes	16–27	Sensory richness; Age, change and the patina of time; Area of emphasis; Patterned wholes; Transitional space; Bounded spaces; Linked series and chains; Integration of parts to wholes; Complementary contrasts; Dynamic balance and tension; Fractals Geometry; Natural ratios and scales
Colour and Light	28–40	Coloration; Chromotherapy; Natural light; Filtered light; Light and Shadow; Reflected light; Light pools; Warm light; Light as shape and form; Spaciousness; Spatial variety; Space as shape and form; Spatial harmony
Place-Based Relationships	41–47	Geographic connection to place; Historic connection to place; Ecological connection to place; Cultural connection to place; Local Material; Integration of culture and ecology; Spirit of place
Human–Nature Relationships	48–57	Prospect/Refuge; Order/Complexity; Curiosity/Enticement; Security and protection; Mastery/Control; Attraction, Attachment and Beauty; Exploration/ Discovery; Information and Cognition; Fear/Awe; Reverence/Spirituality

Phase 2: Expert Validation using FGD

Following desk-study shortlisting, expert validation was conducted through a FGD to evaluate the contextual relevance, feasibility, and clarity of the 57 shortlisted attributes for Malaysian government office environments. The FGD approach was selected because it enables structured expert judgement, interactive clarification of overlapping concepts, and defensible refinement decisions required for framework development studies. (Krueger & Casey, 2015; Guest et al., 2012).

Experts were recruited using purposive sampling to ensure credible validation of biophilic attributes for Malaysian government office settings. Selection criteria required participants to have: (i) at least 10 years of relevant professional/academic experience, (ii) demonstrated expertise in biophilic/restorative environments and indoor environmental quality, (iii) familiarity with tropical/hot–humid contexts, (iv) experience with institutional or large-scale office projects, and (v) recognised academic or professional standing; experience with sustainability frameworks or assessment tools was considered an added strength to support operationalisation. (Guest et al., 2012; Krueger & Casey, 2015; Shanteau et al., 2002). Table 4 shows the expert panel profile summary.

Table 4
Expert Panel Profile Summary

Code	Discipline	Sector	Years of Experience	Relevant Expertise
P1	Landscape Architecture	Academia	≥20	Restorative and therapeutic landscapes
P2	Architecture	Academia	≥30	Sustainable and institutional architecture
P3	Psychology	Academia	≥12	Job stress, behavioural therapy
P4	Interior Architecture	Academia	≥15	Nature experience and human behaviour
P5	Interior Architecture	Academia	≥15	Environmental sustainability and interior performance
P6	Architecture	Practice	≥25	Government office buildings, biophilic practice
P7	Landscape Architecture	Practice	≥20	Biophilic and sustainable landscape design
P8	Development	Practice	≥10	Product management and development feasibility
P9	Engineering	Practice	≥10	Green building certification and environmental systems

The FGD reviewed the 57 shortlisted attributes for contextual suitability, feasibility, and clarity of measurement in Malaysian government office settings. Participants were provided with the attribute list prior to discussion to enable informed evaluation. Informed consent was obtained, and the session was audio-recorded with permission to preserve verbatim expert input, support traceability, and minimise selective note-taking bias. Expert statements were linked to participant codes (P1–P9) during analysis.

Qualitative Analysis and Attribute Refinement

FGD recordings were transcribed and analysed using Atlas.ti to support systematic coding and ensure traceability between expert statements and attribute decisions. A confirmatory thematic analysis approach was applied, focusing on refinement of the predefined attribute shortlist rather than inductive theory generation. The analysis followed Braun and Clarke's thematic procedure: familiarisation with transcripts, initial coding, grouping into decision categories, consolidation of refined attributes, and final review for clarity and operational suitability. (Braun & Clarke, 2021; Saldaña, 2016).

Each attribute was assigned one refinement outcome—retain, refine, merge, conditional application, or omit—based on expert justification related to redundancy, feasibility, contextual suitability, and measurability for Malaysian government offices. The validated framework resulted in 34 final attributes consolidated into three operational domains. Figure 2 shows the staged framework development pathway from desk shortlisting to expert validation and final consolidation.

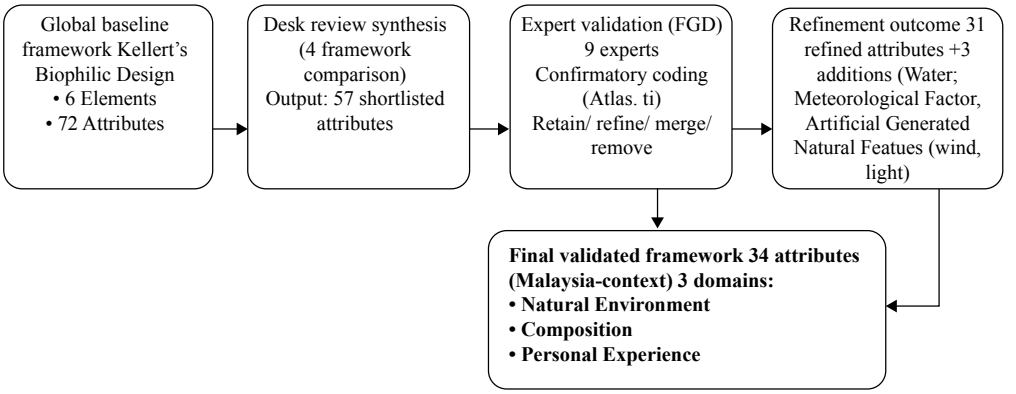

Figure 2. Staged framework development process from global inventory to validated Malaysian-context biophilic attribute framework

RESULTS

This section presents the staged outcomes of the framework development process. Results are reported sequentially to demonstrate traceability from the desk-study shortlist (57 attributes) to expert validation through the Focus Group Discussion (FGD) and consolidation into the final validated framework (34 attributes) for restorative indoor government office environments in Malaysia.

Desk Study Output: 57 Attributes for Expert Validation

The desk study produced a shortlist of 57 biophilic attributes, organised into six categories and used as the structured evaluation instrument for the FGD. To avoid redundancy, the full shortlist is not repeated here because it has been presented earlier in Table 3. This shortlist represents office-operational attributes refined from established biophilic frameworks and prepared for contextual expert validation.

FGD Outcomes: Attribute Mapping and Refinement Results

Expert validation confirmed that refinement was necessary to strengthen contextual suitability and operational clarity for Malaysian government office interiors. Table 5 shows the overall outcomes of the attribute refinement process, including the number of attributes in each decision category and representative examples illustrating how expert judgement shaped the final framework.

Table 5
Overall outcomes of the attribute refinement process

Attribute mapping outcome	No. of attributes	**Examples**
Retained (incl. conditionally applicable)	14	Indoor Plants; Natural Ventilation; Natural Materials; External View of Nature; Prospect & Refuge
Refined	11	"Views and Vistas" → External View of Nature; "Natural Light" → Daylighting *(standardised for measurability)*
Merged	19	Light-related attributes consolidated under Interplay of Natural Light; overlapping composition attributes consolidated into Integration of Parts to Whole / Organised Complexity
Omitted	13	Fire; Dynamic Balance & Tension; Fear/Awe *(low indoor office relevance and operational fit)*
Total	57	—

During the FGD, experts reviewed the 57 attributes systematically and applied decision outcomes based on feasibility, redundancy, clarity, and suitability for assessment. The refinement produced four main outcomes: retained (including conditional applicability), refined, merged, and omitted, resulting in consolidation of the initial shortlist into a more implementable and measurable framework. Overall, the refinement outcomes indicate that the largest proportion of changes involved merging overlapping constructs (n = 19) to reduce redundancy and improve usability, followed by refinement of definitions (n = 11) to strengthen clarity and measurement suitability. At the same time, 13 attributes were omitted due to limited feasibility or weak applicability to institutional indoor office settings, while 14 attributes were retained as core office-relevant biophilic strategies.

Domain Consolidation

Following the refinement outcomes, the validated attributes were further consolidated into a clearer operational structure to support practical adoption in Malaysian government office settings. While the desk-study shortlist (57 attributes) was organised into six categories for systematic expert evaluation, the final framework required a more implementable domain structure aligned with workplace experience and measurable design application. Accordingly, the refined attributes (refer Figure 3) were reorganised into three operational domains which includes Natural Environment, Composition, and Personal Experience with each reflecting a dominant pathway through which biophilic design supports restorative outcomes in indoor office environments.

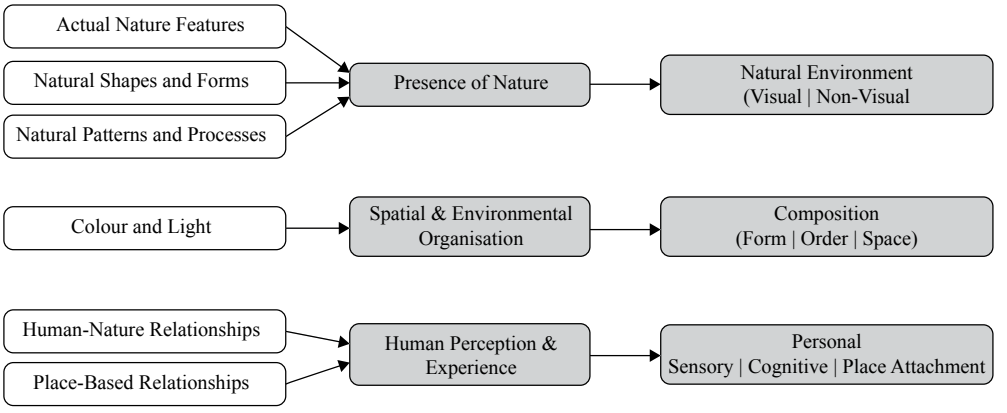

Figure 3. Consolidation of desk-study biophilic categories into three operational domains for Malaysian government office settings

To strengthen interpretability and enable consistent translation into workplace design decisions, each domain was structured into specific sub-domains representing how occupants encounter nature and experience restoration in indoor office settings. Table 6 summarises the mapping of domains and sub-domains together with the operational meaning and experiential rationale guiding their inclusion in the final framework.

Table 6
Mapping of biophilic domains, sub-domains and operational rationale

Domain	**Sub-domain**	**Operational Meaning in Indoor Office Setting**	**Rationale / Experiential Mechanism**
Natural Environment	Visual Connection	Visible nature cues (views, daylight cues, greenery) within work areas	Supports restoration through visual relief and perceived natural exposure
	Non-Visual Connection	Nature-related cues through airflow/thermal sensation/acoustic and tactile materials	Enhances comfort regulation and physiological calming through sensory cues
Composition	Form	Nature-compatible formal qualities (organic/curved forms, coherent geometry)	Improves perceptual fluency and reduces visual stress through coherent form
	Order	Legibility and organisation (hierarchy, alignment, rhythm, emphasis)	Strengthens perceived control and reduces cognitive load in workplace navigation
	Space	Spatial configuration (openness, enclosure, proportions, prospect/ refuge balance)	Supports comfort and psychological safety through spatial security and refuge

Domain	Sub-domain	Operational Meaning in Indoor Office Setting	Rationale / Experiential Mechanism
Personal	Sensory	Glare/noise/smell/thermal comfort and overstimulation control	Reduces irritation and fatigue while supporting stable restorative conditions
	Cognitive	Fascination, attentional recovery, focus support and mental refreshment	Supports attention restoration and reduces mental fatigue during office work
	Place Attachment	Meaning, belonging, identity and positive association with workplace	Strengthens long-term satisfaction and wellbeing beyond immediate comfort

Final Validated Framework: 34 Biophilic Attributes

Following expert validation and domain consolidation, the final framework comprised 34 validated biophilic attributes structured into three operational domains: Natural Environment (14 attributes), Composition (10 attributes), and Personal Experience (10 attributes). This domain-based structure strengthens usability for Malaysian government office interiors by clustering attributes according to how occupants encounter nature (environmental presence), how restorative spatial quality is organised (composition), and how restoration is experienced psychologically and sensorially (personal experience). Table 7 presents the complete final validated framework as the main outcome of this study.

Table 7
Final attributes after refinement from the FGD

Natural Environment (14 Attributes)	Visual
	Water, Daylighting, Natural Ventilation, Indoor Plants, Outdoor Plants, Therapy Animals, Meteorology, External View of Nature, Natural materials
	Non-Visual
	Actual Nature Motifs and Patterns, Imitations of Nature Motifs and Patterns, Organic and Fluid Forms, Artificial Generated Natural Features (wind, lights), Adaptation of Nature Colour
Composition (10 Attributes)	Form
	Fractal Geometry, Organised Complexity, Integration of Parts to Whole, Form Harmony
	Order
	Area of Emphasis
	Space
	Transitional Space, Spaciousness, Interplay of Natural Light, Spatial Variety, Space Harmony

Personal (10 Attributes)	Sensory
	Utilising Old Factory (Smell) to Experience Nature, Utilising Auditory (Hear) to Experience Nature, Utilising Tactile (Touch) to Experience Nature, Utilising Vision (Sight) to Experience Nature
	Cognitive
	Attraction and Beauty, Curiosity and Enticement, Prospect and Refuge, Chromotherapy
	Place Attachment
	Ecological and Cultural Connection to Place, Geographical Connection to Place

Overall, the final 34-attribute framework provides a structured and context-sensitive foundation for integrating biophilic strategies within Malaysian government office environments, supporting future application through design guidance and measurable workplace assessment tools.

CONCLUSION

This study developed and validated a context-sensitive biophilic attribute framework for Malaysian government office interiors through desk-study refinement and expert validation. The process produced a final set of 34 biophilic attributes, consolidated into three operational domains—Natural Environment, Composition, and Personal Experience—to strengthen clarity, measurability, and implementation suitability in institutional indoor workplaces.

Compared with Kellert's broader inventory, the final framework is more targeted to the operational realities of Malaysian government offices, including centrally conditioned indoor environments, standardised layouts, and implementation constraints. The three-domain structure is proposed as the best fit for the local workplace context because it integrates environmental nature cues, spatial composition mechanisms, and occupant-based restorative experience pathways.

In terms of contribution, this research offers an evidence-informed localised framework that bridges biophilic theory and workplace application, supporting future design guidance and structured evaluation tools for government offices. Practically, the validated attributes can inform workplace retrofit priorities, interior specification strategies, and post-occupancy assessment instruments aimed at supporting stress reduction and improved workplace experience.

Several limitations should be noted. The validation relied on expert judgement within a qualitative refinement process, and the framework has not yet been empirically tested against physiological or productivity outcomes in operational office settings. In addition, feasibility of certain attributes may vary by office layout, policy constraints,

and facility management capacity across agencies. Future research should therefore test the validated attributes through real-world application and outcome-based evaluation (e.g., perceived restoration, stress indicators, and work performance measures), including controlled simulation and post-occupancy studies, and may further develop weighting or prioritisation schemes to support practical adoption across diverse government office typologies.

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REFERENCES

Bratman, G. N., Anderson, C. B., Berman, M. G., Cochran, B., de Vries, S., Flanders, J., **...** (2019). Nature and mental health: An ecosystem service perspective. *Science Advances, 5*(7), eaax0903. https://doi.org/10.1126/sciadv.aax0903

Bringslimark, T., Hartig, T., & Patil, G. G. (2009). The psychological benefits of indoor plants: A critical review of the experimental literature. *Journal of Environmental Psychology, 29*(4), 422–433. https://doi.org/10.1016/j.jenvp.2009.05.001

Chen, F., & Jim, C. Y. (2020). Urban forests as a restorative landscape: Cultural preference and perceptual evaluation. *Urban Forestry & Urban Greening, 48*, 126575. https://doi.org/10.1016/j.ufug.2020.126575

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.

Gillis, K., & Gatersleben, B. (2015). A review of psychological literature on the health and wellbeing benefits of biophilic design. *Buildings, 5*(3), 948–963. https://doi.org/10.3390/buildings5030948

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. Sage.

Ireson, J., Brooks, R., & Ajjawi, R. (2023). Qualitative data analysis: Approaches and practical strategies. *Medical Education, 57*(3), 205–215.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182. https://doi.org/10.1016/0272-4944(95)90001-2

Kellert, S. R. (2008). Biophilic design: Dimensions, elements, and attributes of biophilic design. In S. R. Kellert, J. H. Heerwagen, & M. L. Mador (Eds.), *Biophilic design: The theory, science, and practice of bringing buildings to life* (pp. 3–19). Wiley.

Kellert, S. R., & Calabrese, E. F. (2015). *The practice of biophilic design*. Terrapin Bright Green.

Krueger, R. A., & Casey, M. A. (2015). *Focus groups: A practical guide for applied research* (5th ed.). SAGE Publications.

McGee, B., Park, N.-K., Portillo, M., Bosch, S. J., & Swisher, M. E. (2019). DIY biophilia: Development of the biophilic interior design matrix as a design tool. Journal of Interior Design, 44(3), 35–52.

Shanteau, J., Weiss, D. J., Thomas, R. P., & Pounds, J. C. (2002). Performance-based assessment of expertise: How to decide if someone is an expert or not. *European Journal of Operational Research, 136*(2), 253–263. https://doi.org/10.1016/S0377-2217(01)00113-8

Sjövall, I. A. K., & Spiers, H. J. (2024). The potential of biophilic design and nature to improve health, creativity, and well-being. In S. Kühn (Ed.), *Environmental neuroscience* (pp. 291–314). Springer. https://doi.org/10.1007/978-3-031-64699-7_11

Sánchez, J. A., Téllez-Robles, J. A., & Aguilar-García, R. J. (2021). Biophilic design as a strategy to reduce stress in indoor environments. *Sustainability, 13*(15), 8519. https://doi.org/10.3390/su13158519

Tabassum, R. R., & Park, J. (2024). Development of a building evaluation framework for biophilic design in architecture. *Buildings, 14*(10), 3254. https://doi.org/10.3390/buildings14103254

Terrapin Bright Green. (2014). *14 patterns of biophilic design: Improving health and well-being in the built environment*. Terrapin Bright Green.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*(3), 201–230. https://doi.org/10.1016/S0272-4944(05)80184-7