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Bridging Green Certification and Occupant Well-Being: A Mixed Methods Study of IEQ and Quality of Life in Certified and Non-Certified Malaysian Office Buildings

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Abstract

Indoor environmental quality (IEQ) significantly impacts people's comfort, health, and productivity in buildings, and modern green rating systems are primarily focused on energy efficiency rather than the direct user experience. This paper analyses the relationship between IEQ and the perceived quality of life (QoL) of certified and conventional office buildings in Malaysia using a mixed-methods design. The questionnaires were completed by 162 employees working in four open-plan offices: two were certified under the Green Building Index (GBI) established in Malaysia, and two were traditional. This was supplemented by 14 semi-structured interviews and 2 focus groups. The factors of IEQ were divided into ambient, designed, and behavioral environments. It was statistically determined that behavioral factors, such as visual privacy, personalization, ergonomics, and control, exhibited the strongest correlations with overall QoL, compared to ambient factors such as air quality or thermal comfort. Green buildings performed better in terms of daylighting and esthetics than conventional buildings, though they did not always deliver higher occupant satisfaction. The results indicate that current green certification frameworks pay insufficient attention to occupant-centered aspects. The proposed research adds a validated IEQ-QoL framework that predicts the incorporation of subjective user experience into building performance indicators, which can be important for certification reform, post-occupancy evaluation (POE), and human-centered sustainable design approaches.

Keywords: indoor environmental quality; green buildings; quality of life; post-occupancy evaluation; Green Building Index

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1. Introduction

1.1. Background and Rationale

The growing interest in sustainable building is driven by the need to address climate resilience, support environmental stewardship, and enhance resource efficiency. In fact, buildings are estimated to consume about 40% of the worldwide energy and are major contributors of greenhouse gases, thus representing important areas of intervention for the sustainability of the environment [1,2]. Green building rating systems are now unavoidable tools for guiding and certifying sustainable construction practices worldwide. Projects in over 170 countries and territories have been certified by the Leadership in Energy and Environmental Design (LEED) structure by the U.S. Green Building Council, whereas the Building Research Establishment Environmental Assessment Method (BREEAM), inaugurated in the United Kingdom in 1990, has the distinction of being the longest-running green building certification system ever [1,3]. Local initiatives have been implemented to meet localized needs, such as the Green Building Index (GBI) in Malaysia, launched in 2009 to address tropical weather conditions and regional sustainability concerns [4,5]. Despite widespread adoption, the pace and nature of implementation vary widely across regions, driven by differing regulatory frameworks, market incentives, and cultural priorities.

The certification frameworks define performance standards across various sustainability aspects, such as energy efficiency, water conservation, material choice, site ecology, and indoor environmental quality (IEQ), and thus provide standardized assessment tools and third-party verification mechanisms [3]. However, it has been argued that a substantive debate has emerged over whether the largely technical orientation of these systems is sufficient to support occupant well-being and quality of experience. Modern-day literature is becoming more accepting that the health, comfort, satisfaction, and productivity of occupants are paramount sustainability outcomes, not merely secondary factors that exist in second place to the performance metrics of environmental performance [6–9]. This recognition marks a broader evolution toward human-centric sustainability, recognizing that buildings primarily serve human needs and that genuinely sustainable design must combine environmental stewardship with occupant well-being [2,10,11].

However, despite this increased awareness, green certification programs generally focus on carbon reduction, energy efficiency, and general environmental impact, and usually fail to appropriately address the well-being of occupants and their experiences, especially in long-term workplaces where an individual spends a significant percentage of their life [6,8,9,12]. The average office worker spends 8–10 h a day in the workplace environment and, accordingly, 2000–2500 h per year in the workplace, which makes the quality of the latter environment of crucial importance to the health of humans, their productivity, and overall quality of life (QoL) [13,14].

The current investigation aims to clarify one of the topical research issues: the possible discrepancy between the goals of green certification and the actual satisfaction and well-being outcomes for occupants. The empirical data collected so far show that the buildings with high certification scores do not always translate into better occupant experiences; numerous studies have found the same or even lower satisfaction between certified and conventional buildings in key comfort areas, including a Malaysian field study documenting comparable thermal discomfort responses in green and conventional offices [12,15–17]. This study, therefore, adopts a mixed-methods approach, combining occupant surveys and qualitative interviews to examine how certification scores relate to lived experiences in Malaysian office buildings.

1.2. Green Certification and Human-Centered Design

The frameworks of green building certification systems are mostly based on the notion that environmental performance indicators are measurable, and the assessment criteria focus on energy consumption, carbon emissions, water efficiency, and the lifecycle effects of materials [6,18]. Systematic reviews of large rating schemes show that although the criteria for indoor environmental quality (IEQ) are present, they are often given little

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consideration during certification evaluations, with a focus instead on actual occupant satisfaction outcomes, a pattern also observed in Malaysian GBI-rated commercial offices, where IEQ has been modeled in relation to the economic dimension of sustainability [18–20]. Such a technical orientation prioritizes measurable physical parameters over experiential, behavioral, and psychological aspects of human-environment interaction [6,8]. Though certification frameworks have broadened in scope, they continue to lack systematic health-oriented guidance for ongoing operational phases of office buildings [21]. Incorporating routine post-occupancy evaluation (POE) and occupant-centered metrics into certification protocols would help align technical performance with lived experience.

Modern research highlights the importance of a person-centered, holistic approach to the assessment of IEQ, which suggests extending the boundaries of technical requirements to incorporate the social, psychological, and symbolic aspects of the built environment [7,22,23]. A humane work environment is a concept that includes such factors as territoriality, visual and acoustic privacy, perceived control, cultural identity, and personalization, which have a powerful impact on the quality-of-life indicators, including health, satisfaction, comfort, and productivity [24–26]. However, certification standards have little to say about these psychosocial aspects, specifically workspace customisation, space ownership, and psychological comfort, which are the aspects identified by environmental psychology as crucial to well-being [25,27]. Design guidance that explicitly recognizes territoriality, perceived control, and opportunities for personalization can make certified buildings more responsive to occupants' psychosocial needs.

Empirical studies show that green-certified office buildings may exhibit decreased occupant satisfaction with thermal comfort, acoustics, and user control, especially in open-plan designs [28–30]. The design choices that are geared towards earning certification points, including open-plan layouts that maximize the amount of daylight infiltration, centralized automated control systems that optimize energy performance, and expansive glazing strategies, can all be counterintuitive in terms of occupant comfort since they create acoustic problems, reduce individual control of the environment, and cause thermal discomfort [15,16,19]. Inhabitants of green buildings often complain more about critical aspects of IEQ than their conventional counterparts do, suggesting that the goals of sustainable design and the experience of its users are misaligned [4,13]. These results shed light on a major omission: green certification systems often do not enforce post-occupancy evaluation (POE) requirements and do not systematically include occupant feedback in performance assessment or certification maintenance, a gap also documented in Malaysian green residential buildings [14,31–33]. Policy incentives and operational requirements that reward ongoing occupant engagement and adaptive management could reduce the mismatch between certification targets and everyday comfort.

1.3. Indoor Environmental Quality (IEQ) and Quality of Life (QoL)

The concept of indoor environmental quality refers to the physical, sensory, and psychological characteristics of interior spaces that affect occupants' comfort, health, satisfaction, and performance [13,34]. Traditionally, IEQ frameworks have been focused on four central ambient areas that include thermal comfort (temperature, humidity, air velocity), indoor air quality (ventilation rates, CO_2 concentrations, volatile organic compounds, particulates), lighting quality (illuminance levels, uniformity, glare control, daylight access), and acoustic comfort (background noise levels, reverberation, speech privacy), as confirmed by field measurements in Malaysian GBI platinum-rated buildings [18,35,36]. Quantitative IEQ metrics should be complemented by qualitative measures of perceived control and meaning to capture the full spectrum of occupant experience. Modern research, however, posits in favor of a more conceptualized approach that also includes designed environmental variables, including spatial layout, esthetic quality, ergonomic furniture, wayfinding clarity, hygiene standards, and behavioral environmental variables, including psychosocial and symbolic variables, like territoriality, privacy, opportunities of personalizing the environment, environmental control, and safety perceptions [7,24,27,37]. This enhanced framework acknowledges that occupant satisfaction is not just a result of technical environmental performance but rather an amalgamation of complex relations among physical conditions, functional spatial adequacy, and psychological meaningfulness.

Workplace quality of life is a complex construct that combines subjective well-being, perceptions of health, comfort, and satisfaction, and performance [23]. The studies of environmental psychology have created a strong connection between the elements of IEQ and the QoL indicators to prove that a high level of physical environmental quality has a significant impact on psychological states, behavioral patterns, levels of stress, job satisfaction, and life satisfaction overall [25,26]. Standardized, validated survey instruments and longitudinal monitoring are needed to link short-term comfort measures with longer-term quality-of-life outcomes. The effects of IEQ on cognitive performance are well documented empirically, and researchers have found that better air quality is correlated with improved decision-making skills, optimized lighting is associated with greater productivity, and acoustic comfort is associated with lower error rates, relationships also confirmed in Malaysian office contexts [13,34,38]. The health outcomes also show sensitivity to IEQ, as poor indoor air quality is associated with increased sick-building syndrome symptoms, respiratory issues, and absenteeism, whereas poor thermal comfort is associated with increased physiological stress, a pattern particularly pronounced in tropical Malaysian offices, where occupants report dissatisfaction with overcooling despite overall certification compliance [12,39–42].

Empirical studies of the relationship between IEQ and QoL reveal multifaceted, context-specific, and even counterintuitive results across green and conventional buildings. In 2023 and 2025, studies still report a gap between user satisfaction and technical compliance in green buildings. Kent et al. [16] found that LEED-certified buildings consistently performed poorly in the comfort areas most appreciated by tenants, with the greatest losses in personal environmental control, acoustic privacy, thermal comfort, and workspace adaptability. According to Karimi et al. [10], Green-building certification systems often prioritize energy-saving optimization measures, which may undermine thermal comfort and restrict occupants' personal control. The need for practical metrics that link energy and environmental performance with occupant comfort and behavior was highlighted by Slieiman et al. [11], who argued that current certification schemes fail to connect environmental goals with human-related outcomes. The meta-analyses with the synthesized results of multiple studies show mixed results, with some reporting an increase in satisfaction with certified buildings, especially with air quality and lighting, and others showing no significant differences or even lower satisfaction with thermal and acoustic comfort [4,9]. Such inconsistency implies that the certification status is an ineffective proxy for occupant satisfaction, and real outcomes depend on design choices, operational behaviors, and circumstantial factors that the certification assessment cannot fully capture [2,7]. Recent comparative evidence confirms that environmental autonomy and personal adaptation behaviors are more critical to occupant IEQ satisfaction than resource-intensive design interventions, even across different workplace typologies [43]. This evidence suggests that adaptive, low-cost interventions that increase environmental autonomy may yield greater improvements in occupant satisfaction than some high-intensity design measures.

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1.4. Gaps in Current Green Building Research

Despite extensive research examining green building performance, significant knowledge gaps persist. To start, there is a notable shortage of human-centered post-occupancy evaluation studies that methodically compare certified and non-certified buildings using comprehensive IEQ frameworks that integrate technical, experiential, and behavioral dimensions [9,14]. Most existing research employs limited IEQ assessment, focusing on traditional ambient parameters but ignoring designed environment factors and behavioral environment dimensions, thereby obscuring how certification-driven design decisions broadly affect occupant experience [7]. There is a particular lack of longitudinal POE studies that track occupant outcomes across different operational phases, from commissioning to routine use. Second, existing research mainly uses quantitative survey methodologies to measure satisfaction ratings, while neglecting qualitative insights into lived experience, behavioral adaptation processes, and the coping strategies occupants develop in response to environmental conditions [14]. Mixed-methods research frameworks integrating quantitative assessment with qualitative experiential exploration are rare in green building research. Despite being necessary for a comprehensive understanding of complex human-environment interactions [9,44]. Integrating sensor-based objective monitoring with in-depth qualitative interviews would allow causal links between design features, operational practices, and occupant adaptation strategies to be more clearly established. Third, current studies do not properly address behavioral and symbolic comfort dimensions, including territoriality, environmental identity, pride in sustainable workplaces, personalization as identity expression, and the environmental psychology research that views these as fundamental for psychological well-being but remains conceptually underdeveloped in building science scholarship [25,45]. Fourth, research examining tropical and subtropical contexts remains limited, despite unique climate challenges, cultural factors, and design paradigms that set tropical buildings apart from green buildings in temperate regions, which dominate the existing literature, with Malaysian affordable housing studies providing some exceptions [4,46–48]. This study addresses these gaps through a convergent parallel mixed-methods design that methodically integrates quantitative IEQ-QOL assessment with qualitative exploration, focusing on behavioral and symbolic factors alongside technical parameters, and examining Malaysian tropical contexts. Findings from temperate climates cannot be assumed to be transferable to tropical settings without contextual validation of both design solutions and occupant behaviors.

1.5. Theoretical Framework: The IEQ-QoL Model

The study's theoretical foundation builds on a three-domain IEQ framework that treats the office as an environment-behavior system. The ambient environment has quantifiable environmental parameters, including thermal conditions (temperature, humidity, air velocity), indoor air quality (ventilation rates, CO_2, VOCs, particulates), lighting quality (illuminance, uniformity, glare, daylight access), plus acoustic comfort (background noise, reverberation, speech privacy), showing traditional IEQ factors usually prioritized in green building assessment [13,18]. The designed environment is a concept that encompasses spatial composition, esthetic quality, ergonomic design, and material qualities. It therefore concerns how architectural and interior design choices shape the form of the environmental experience, beyond quantifiable ambient conditions. This area covers office layout, aesthetic dimensions, including color scheme, material finishes, and biophilic features; ergonomic considerations (e.g., adaptable furniture, job lighting); clarity of wayfinding; and hygiene quality [22,24]. The model is intended to be empirically testable and adaptable, allowing for context-specific weighting of ambient, designed, and behavioral factors during analysis. Psychosocial and symbolic aspects, such as territoriality, visual and acoustic privacy, personalization possibilities, environmental control, crowding perceptions, safety and security, cultural identity expression, and environmental pride, are part of the behavioral environment, which are of utmost importance to the psychological comfort and overall environmental satisfaction [25,27]. This model incorporates the environmental comfort theory by Vischer [27], which identifies three distinct types of comfort: physical (measurable ambient conditions that fulfill physiological needs), functional (spatial and functional adequacy that facilitate task accomplishment), and psychological (symbolic meaning, environmental identity, and emotional resonance). According to the model, complete environmental satisfaction requires all three types of comfort; however, existing certification systems focus primarily on physical comfort, neglecting functional comfort and completely ignoring psychological comfort [45]. Operationalising psychological comfort requires validated survey scales and observational indicators that capture symbolic meaning and identity expressed through space use. This theoretical framework, shown in Figure 1, defines the relationship between domains of IEQ and core QoL indicators, such as comfort, satisfaction, health, and productivity, and needs fulfillment. This three-part model not only shapes the choice of variables to include in the surveys but also the creation of qualitative coding categories, ensuring consistency throughout the mixed-methods design on a theoretical level. The framework recognizes that interactions among domains are dynamic and reciprocal; the present study adopts an exploratory analytical approach using Pearson correlations to map these associations, acknowledging that future work employing mediation and moderation analysis will be needed to test the full structural model.

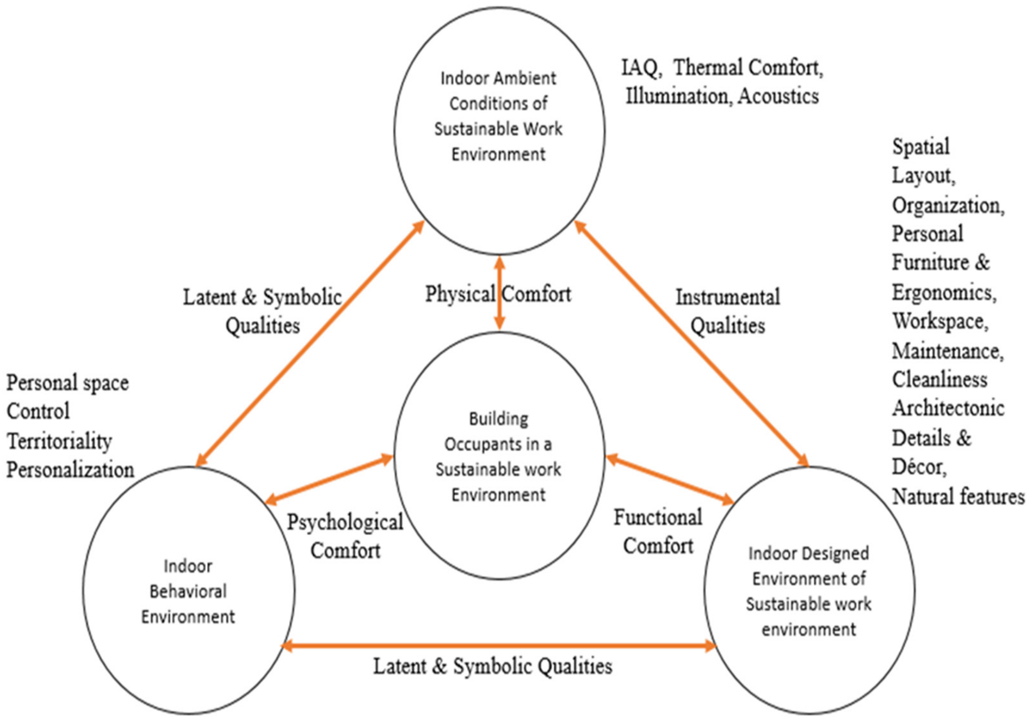

Figure 1. IEQ-QoL Theoretical Framework.

1.6. Research Objectives

This research paper analyses the relationship between indoor environmental quality (IEQ) and the quality of life (QoL) of occupants in four office buildings in the Klang Valley, Malaysia, comprising two buildings certified by the Green Building Index (GBI) and two non-certified buildings. The following are the research objectives: 1. Evaluate occupants' perceived QoL among green versus non-green building offices; 2. Identify IEQ factors related to QoL across the ambient, designed, and behavioral environmental domains; 3. Define humane work environment constructs from lived experience. The results of the study can guide improvements to the GBI criteria by using human-based IEQ indicators, enabling architects and facility managers to use evidence-based methods to promote healthier, more efficient office placements.

2. Materials and Methods

2.1. Research Design and Approach

This study utilized a convergent parallel mixed-methods design under a pragmatic paradigm, combining quantitative and qualitative methods to achieve a comprehensive analysis of occupants' perceptions of the quality of the indoor environment (IEQ) and its impact on their quality of life (QoL) in workplaces. The given methodological approach enables the simultaneous gathering and examination of quantitative patterns and qualitative information, thus allowing validation and complementarity between unlike data sources through concurrent triangulation [44]. The data collection was carried out in three interrelated stages: Phase I, a primary survey questionnaire with built-in open-ended questions; Phase II, a set of semi-structured interviews with a purposively selected sample; and Phase III, a focus group discussion to support and elaborate on the emerging themes. The triangulation protocol assigned equal importance to all data strands, with each analyzed separately and then incorporated into the interpretative stage to verify and cross-check results.

The mixed-methods approach makes sense given the complex characteristics of humane and sustainable work environments, which cannot be fully examined using positivist metrics alone. While environmental performance assessments usually rely on physical parameters, including CO_2 levels. Illumination. Temperature, users commonly work with symbolic, behavioral, and psychological aspects of space, such as privacy, autonomy, identity, and pride [22,25,31].

2.2. Case Study Selection and Building Profiles

Nineteen building managers were contacted; four buildings permitted access: two GBI-certified (GBI1, GBI2) and two conventional (NGBI1, NGBI2), all of which had open-plan offices in the Klang Valley, Malaysia. Feasibility assessment was incorporated into the selection process, along with access permissions, thereby enabling a comparative design across different certification statuses within similar office typologies. Thus, these locations strike a fine balance between accessibility, necessary permissions, and the heterogeneity of architectural elements and mechanical systems, which allows for substantive comparative analysis.

Buildings were selected from the Klang Valley through access permissions to enable a controlled comparison of two GBI-certified and two conventional open-plan offices. This comparative case design supports inference on certification effects while holding constant workplace function and typology. All buildings exhibited comparable workplace functions (administrative and technical operations), layouts (open-plan offices), and building typologies (multi-story commercial offices), thereby offering a controlled environment to investigate differences in IEQ perception and QoL outcomes. Table 1 presents the essential characteristics of the four case study buildings, encompassing certification level, architectural strategies, workstation design, and ventilation systems that directly impact occupants' environmental experiences. As shown in Table 1, this variation among case studies enables a comparative evaluation of the extent to which certified green buildings enhance occupants' comfort and well-being, or whether these outcomes are more significantly influenced by behavioral and psychosocial factors independent of certification status.

Table 1. Building characteristics and environmental systems.

Building Code	Certification	Key Architectural Features	Workstation Type	Ventilation/Cooling System
Green Building Index 1 (GBI1)	GBI Platinum	Daylighting façade, radiant floor cooling, certified facade shading	High/low partitions	Radiant slab cooling, VAV, mechanical fresh air with dehumidification
Green Building Index 2 (GBI2)	GBI Platinum	Green roof, solar-assisted HVAC, central atrium, daylight harvesting	High/low partitions	Under-floor air distribution, operable windows
Non-Green Building Index 1 (NGBI1)	None	Conventional lighting and HVAC, no daylighting controls	Low partitions	Central HVAC system with limited user control
Non-Green Building Index 2 (NGBI2)	None	Partial daylight access, basic mechanical ventilation	High/low partitions	Central HVAC with operable windows

2.3. Participants and Sampling Strategy

A total of 162 valid survey responses (GBI = 101; non-GBI = 61) were obtained from 290 questionnaires distributed across the four buildings, which housed about 600 (GBI2), 400 (GBI1), 150 (NGBI2), and 100 (NGBI1) occupants, respectively. Sample sizes were developed with the Raosoft Sample Size Calculator. With a 10% margin of error and an 80% confidence level, target sample sizes of 40–60 per building type. Recruitment used building-level convenience sampling based on access permissions and willingness to participate, combined with random selection of employees within each building.

Several factors drove the final sample size ($n = 162$): (1) the statistical power to perform correlation and comparative analyses was met, which ensured sufficient power (0.80) to detect medium effect sizes at 0.05; (2) consistency with prior research on similar mixed-methods IEQ studies, where a sample of 150 to 200 participants is considered adequate to support statistical rigor; (3) the thematic saturation of the qualitative strand, as no further significant themes were identified in the qualitative strand by additional interviews; and (4) practical constraints of organizational access along with voluntary participation in workplace studies. To address potential non-response bias, demographic comparison of respondents against known building occupancy profiles showed reasonable representativeness across gender, age, and job role distributions. Analysis of early versus late responders showed no significant differences in IEQ or QoL ratings (t-tests, $p > 0.05$), suggesting limited temporal bias in the sample. This sample had balanced gender distribution and diverse job roles and age groups, as outlined in Table 2.

Table 2. Sample characteristics ($n = 162$).

Characteristic	Category	GBI-Certified ($n = 101$)	Non-Certified ($n = 61$)
Gender	Male	41%	43%
	Female	59%	57%
Age	<30 years	20%	29%
	31–40 years	53%	40%
	>40 years	27%	31%
Job Category	Administrative	13%	20%
	Professional	30%	33%
	Technical	23%	14%
	Managerial	4%	6%
	Other	30%	27%
Weekly hours at the workplace	>30 h	79%	71%
Employment duration	>1 year	86%	77%

Participants were office workers from the four selected buildings who chose to respond to the survey. The study included people across diverse organizational levels (administrative, professional, technical, and managerial) and varying lengths of time at their current workplace. Most respondents (over 75% in most buildings) worked more than 30 h per week at their workplaces and had been at their current locations for over a year. All participants functioned in open-plan office environments. Workstation types include cubicles with low partitions (less than 1.5 m in height), cubicles with high partitions (1.5 m or more in height), and open-plan desks with no partitions. These demographic characteristics guaranteed representation from experienced users who regularly engage with their workspace environment, thus improving the validity of data gathered on indoor environmental experiences.

The qualitative inquiry included 14 interviews (GBI1 = 3, GBI2 = 4, NGBI1 = 4, NGBI2 = 3) and two focus groups, each with 4 participants, conducted in the GBI2 and NGBI1 buildings. Qualitative sampling sought maximum variation until thematic adequacy was achieved, with interviewees selected based on their willingness to engage in extended feedback sessions and their representation of varying levels of satisfaction, as indicated by survey responses. Interview and focus group protocols were built through iterative refinement: (1) literature review spotting key IEQ and QOL themes; (2) pilot interviews (n = 2) with occupants from buildings not included in the final sample, trying question clarity and flow; (3) expert review by the supervisory committee; and (4) cultural adaptation making sure of appropriateness for the Malaysian multicultural context. Preliminary thematic analysis conducted during data collection revealed saturation after 12 interviews, with two additional interviews yielding no new themes. Ethical clearance was received (protocol number JKEUPM-2021-242; the consent correspondence is also available, and all participants provided written informed consent, ensuring adherence to confidentiality and data protection regulations and to the principle of voluntary participation.

2.4. Data Collection and Analysis

The research used a bilingual questionnaire in English and Malay and included five-point Likert scales to measure 30 indoor environmental quality (IEQ) indicators distributed across three domains and five qualities of life (QoL) constructs. The measures were elicited from available instruments, such as the Building Usage Survey (BUS), Community-Based Evaluation (CBE), Vischer's scale, the Caroli scales, and the work of Woo, thereby ensuring content validity. Cronbach's alpha was found to be satisfactory for all scales (Ambient, a = 0.72; Designed, a = 0.74; Behavioral, a = 0.83; QoL, a = 0.72). Before Pearson correlation analyses were performed, the following statistical assumptions were checked: normality with Shapiro–Wilk tests and Q-Q plots, linearity with scatterplots, and possible outliers were identified and dealt with before the analyses.

A hybrid thematic coding scheme was used to scrutinize qualitative data, combining deductive, theory-driven categorization of predefined IEQ domains and inductive, data-driven theme generation. This was done with ATLAS.ti 9 software and a sophisticated method were used, such as repertory grid analysis with supplemented hierarchical clustering, which clarified the inter-factor relationships and prioritized the themes. To ensure coding rigor, all transcripts were independently coded by two researchers; disagreements were resolved through discussion and consensus, and a third researcher adjudicated in cases of persistent discrepancy. Inter-coder reliability was calculated using Cohen's kappa, yielding a coefficient of 0.81, indicating strong agreement. Member checking was conducted by returning a summary of emerging themes to a subset of participants (n = 6) for verification, and an audit trail of all analytical decisions was maintained within ATLAS.ti 9. The triangulation was done by a systematic comparison of quantitative patterns of correlation with the emergent qualitative themes and thus arriving at areas of convergence—where the numerical relationships were found to support the narratives given by the participants—and divergence—where the empirical results were found to oppose the narratives given by the participants—and complementary information—where the qualitative information obtained was found to give explanatory value to the quantitative patterns. triangulation was used through: (1) convergence analysis: thoroughly comparing statistical correlations with qualitative theme prominence (e.g., quantitative data revealing strong correlations between territoriality and QoL converged with qualitative themes where 89% of conventional building interviewees brought up territory); (2) difference analysis: finding cases where quantitative and qualitative findings appeared contradictory, leading to deeper investigation (i.e., GBI2 achieved moderate quantitative lighting satisfaction, but qualitative interviews showed nuanced dissatisfaction with glare control and uniformity, resolved by recognizing that aggregate satisfaction masks specific dissatisfaction dimensions; along with (3) supplementary analysis: studying how quantitative and qualitative findings uncovered different facets of phenomena, e.g., Quantitative data showed that personalization strongly correlated with QoL, whereas qualitative analysis indicated that personalization functions as a territorial demarcation, an expression of identity, and psychological ownership. Areas of convergence validated construct relationships, whereas differences identified important nuances needing theoretical refinement.

3. Results and Discussion

3.1. IEQ Perceptions Across Building Types

Addressing research objective 2 (identify IEQ factors associated with QoL), occupant perceptions of IEQ revealed significant variations across the three environmental domains, as illustrated in Table 3. The patterns of ambient conditions were not homogeneous, and the quality of lighting (mean = 4.17) and indoor air quality (mean = 4.09) received the highest scores in GBI2, confirming the successful implementation of daylighting strategies and mechanical ventilation systems. Acoustic quality, though, became a recurring shortcoming in the sample, with scores of 2.81–3.83; green buildings were disproportionately affected. Acoustic satisfaction was lowest in the GBI1 building, with a mean of 3.34, which suggests that green construction does not automatically translate into excellent environmental performance. These findings align with those of Altomonte et al. [15], who reported similar acoustic challenges in BREEAM-certified buildings, especially in open-plan designs where sustainability requirements may encroach on acoustic privacy. Comparable acoustic deficiencies have been documented in Malaysian GBI-rated office buildings, where noise from mechanical ventilation systems and open-plan configurations consistently undermined occupant satisfaction [49,50]. Occupants described these acoustic problems in everyday terms: difficulty concentrating, interrupted phone calls, and a constant sense of background distraction, which helps explain why noise scores remain low despite technical compliance.

Table 3. Mean IEQ ratings by building type and domain.

Domain	Factor	GBI1	GBI2	NGBI1	NGBI2
Ambient	Indoor Air Quality (IAQ)	3.73	4.09	3.74	3.67
	Lighting Quality	3.98	4.17	3.81	3.60
	Thermal Comfort	3.59	3.96	3.71	3.77
	Acoustical Quality	3.34	3.63	3.65	3.83
Designed	Layout	3.56	3.87	3.81	3.80
	Ergonomics & Furniture	3.63	4.15	3.90	4.00
	Hygiene & Cleanliness	3.76	4.18	3.77	3.80
Behavioral	Personal Control	2.80	2.90	3.26	3.40
	Visual Privacy	3.24	3.55	3.74	3.83
	Crowding	2.78	2.55	3.32	2.80

The design-environment analysis highlighted the importance of the ergonomic and esthetic factors. The endorsement of hygiene and cleanliness was consistently high (4.0 in GBI2 and NGBI2), but ergonomics and furniture quality became the main distinguishing factors between buildings. Interestingly, the traditional NGBI2 construction performed equally well or better than green buildings across various design-environment indicators, suggesting that certification, as such, does not guarantee high environmental quality. This observation challenges the current discourse that green certification is bound to produce better occupant experiences [29]. For many users, a building that "performs well" on paper can still feel impersonal or awkward in daily use; small ergonomic choices and visible cleanliness often matter more to people than certification badges.

The most significant differences in building typologies were outlined in behavioral-environment results. Personal control was consistently one of the least-satisfied dimensions of the cohort (range 2.50–3.40), and green buildings were even less satisfactory (GBI1 = 2.80, GBI2 = 2.90). The most problematic, in terms of perceptions of green buildings, were crowding perceptions (GBI1 = 2.78; GBI2 = 2.55), which might be explained by design decisions that focused on energy efficiency rather than personal comfort zones. On the contrary, green buildings (4.0) had the highest scores in safety and security appraisals, demonstrating that occupants are receiving benefits from occupant-based outcomes.

Yet the low scores for personal control and crowding show that perceived autonomy and personal space are still lacking, issues that directly affect well-being, stress levels, and the ability to work effectively. Taken together, these perceptions suggest that technical upgrades must be paired with design and management practices that restore individual control and dignity in the workplace.

3.2. QoL Outcomes and Certification Paradox

The analysis of quality-of-life (QoL) indicators has revealed some surprising trends that do not align with existing expectations about the effectiveness of green edifices, as shown in Figure 2. The indicator GBI2 regarding green-building (GBI2) had the best overall QoL rating (mean = 4.07), which, however, is an indicator of successful integration of the environmental stewardship and human-centered design concepts. On the other hand, the traditional structure NGBI2 (mean = 3.83) was far superior to the green-certified GBI1 (mean = 3.63), which registered the lowest occupant satisfaction among the study sample. This divergence shows that certification labels alone do not capture how people actually feel and function in their daily workspaces. This disparity poses a significant challenge to green certification models, which assume a direct translation of environmental performance into occupants' well-being.

The QoL paradox is further intensified when an exploratory Pearson correlation analysis is conducted. Behavioral-environmental variables were consistently the most significant predictors of QoL across all buildings, often overshadowing the impact of ambient conditions, which predominate in green-certification measures. The personal control, visual privacy, and territoriality variables appeared to be the most predictive of occupant satisfaction; however, they performed poorly in green-certified constructions. In interviews, occupants described this gap in plain terms: inability to control temperature, constant background noise, and a lack of private space that makes focused work difficult.

This inconsistency between certification-related priorities and occupancy needs supports recent criticisms of green-building rating systems [6]. Various explanatory factors can explain this trend: (1) the focus on centralized automated energy-optimization systems in green buildings can suppress agency at the individual level, which generates frustration despite better technical performance; (2) open plan designs aimed at maximizing daylight and visual connectivity can undermine acoustic and visual privacy; (3) different organizational cultures between certified buildings and traditional counterparts can lead to the experience of disappointment when the lived reality does not meet the promises of sustainability; and (4) elevated expectations in green settings can trigger disappointment when the lived reality does not meet the promises of sustainability. Together, these mechanisms suggest that technical excellence can be undermined by design and management choices that reduce individual agency and everyday comfort.

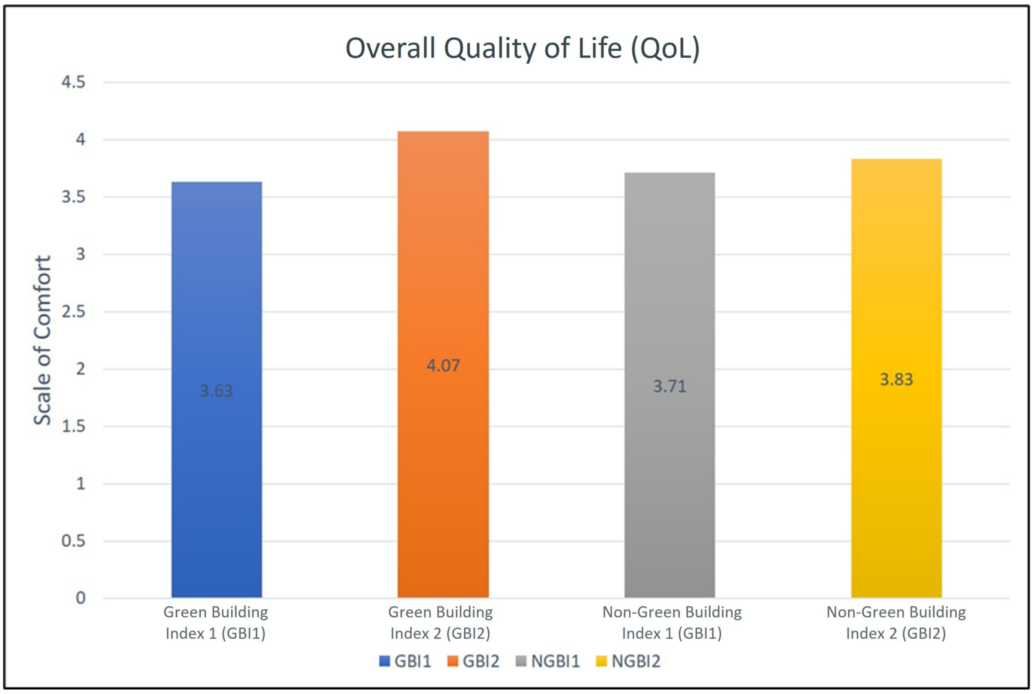

Figure 2. A chart showing the descriptive assessment for QoL.

3.3. Correlation Patterns and Factor Prioritization

Correlation tests showed that trends varied across building types, suggesting different avenues to occupant satisfaction. The strongest relationships between quality-of-life measures and green buildings were ergonomics and furniture (r = 0.47, $p < 0.01$), lighting quality (r = 0.45, $p < 0.01$), and views (r = 0.43, $p < 0.01$), indicating the application of modern environmental design principles. The prominence of lighting quality and views is consistent with evidence that daylighting performance is a contested objective in certified buildings, where shading and glazing optimization strategies simultaneously pursue energy efficiency and visual comfort, sometimes at the expense of glare control and occupant satisfaction [51]. On the other hand, personal control showed lower correlations (r = 0.29, $p < 0.01$), despite its fundamental significance for occupant autonomy.

Traditional buildings demonstrated a different range of correlations; the most important predictors of the quality of life were territoriality (r = 0.54, $p < 0.01$), office layout (r = 0.52, $p < 0.01$), and wayfinding (r = 0.50, $p < 0.01$). This evidence indicates that occupants of traditional office areas value spatial arrangement and individual boundaries more than technical environmental features. This pattern can be explained by adaptive mechanisms that evolved in the absence of advanced building systems. To understand why these patterns differ, it helps to listen to how occupants describe their routines and frustrations in each setting. In practice, clear boundaries, predictable layouts, and easy wayfinding reduce daily friction and create a sense of ownership that supports wellbeing. Table 4 summarizes the top correlates for each building type and highlights where designers should focus limited resources to improve QoL. Taken together, these results imply that improving occupant wellbeing requires pairing technical upgrades with simple, human-centered interventions that restore control, privacy, and legible spatial order. These correlations are cross-sectional; intervention studies are needed to confirm whether changing a single factor (for example, adding adjustable furniture) produces measurable QoL gains.

Table 4. Top 5 IEQ factors correlating with QoL by building type.

Rank	Green Buildings	r	Conventional Buildings	r
1	Ergonomics & Furniture	0.47 **	Territoriality	0.54 **
2	Lighting Quality	0.45 **	Office Layout	0.52 **
3	Views	0.43 **	Wayfinding	0.50 **
4	Visual Privacy	0.43 **	IAQ	0.48 **
5	Hygiene & Cleanliness	0.39 **	Visual Privacy	0.46 **

** $p < 0.01$.

3.4. Triangulation and Findings of the Qualitative Insights

This trend interpretation of quantitative patterns in the context of a more comprehensive qualitative analysis framework, based on systematic interviews and focus groups, produces insights that go beyond superficial meaning. This is necessary to explain occupants' experiences holistically. Figure 3 illustrates the frequency of references to IEQ variables in the interview data set; the abscissa shows the frequency of occurrence of the IEQ variables, and the ordinate shows the specific IEQ construct, which clearly explains the relative importance of these variables to the built environment being studied. In green buildings, people often expressed pride in their environmental credentials. But at the same time, they stated that they were frustrated by their lack of control over the environment. One GBI2 resident commented, "I adore working in a green building; however, I am unable to regulate my own temperature or lighting. It seems the building is smarter than it is clever enough". Such comments capture the tension between system optimization and personal agency that recurred across interviews. This feeling expresses a conflict between environmental optimization and personal freedom that defines most green buildings.

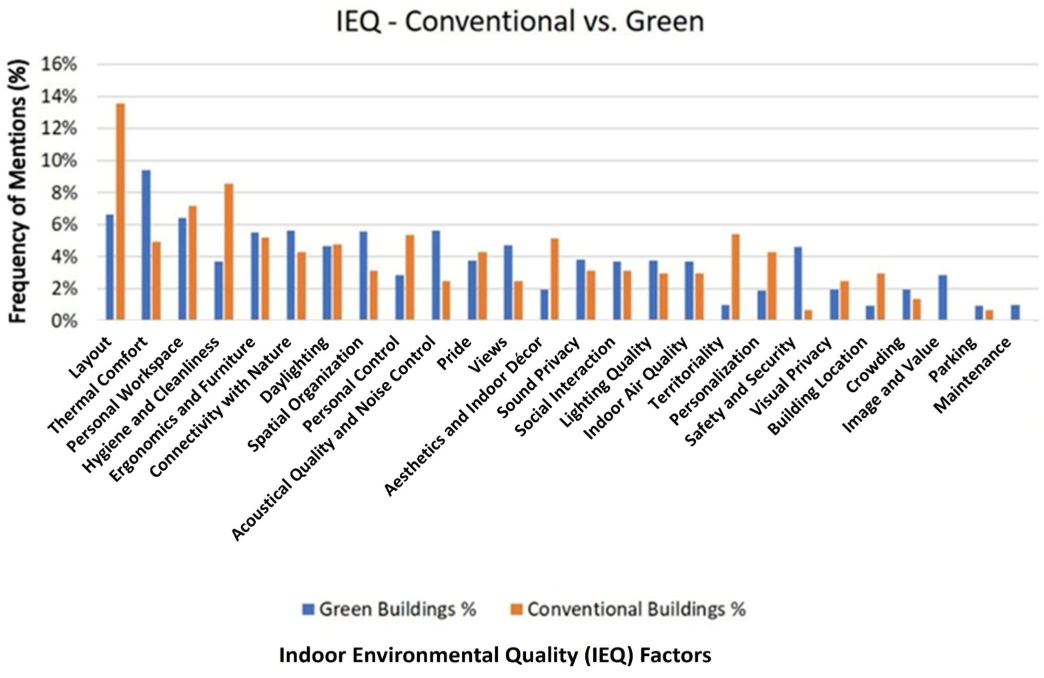

Figure 3. Frequency of IEQ factor mentions in interviews across green and conventional office buildings.

The hierarchical clustering analysis revealed core differences in the priorities of the factors used in building types, as shown in Figures 4 and 5. Figure 4 presents a hierarchical clustering analysis of IEQ factors in GBI2, with dendrograms showing factor groupings and distances indicating the importance of similarity. In green buildings, the most important factors influencing QoL are pride, followed by safety, cultural identity, and environmental features. This means that the symbolic and emotional aspects are also crucial in determining green building satisfaction, which extends beyond physical comfort. The prevalence of pride is consistent with research in environmental psychology, which points to identity formation as an important factor in occupant well-being [25]. This clustering shows that symbolic values like pride can sometimes outweigh measurable comfort in shaping satisfaction.

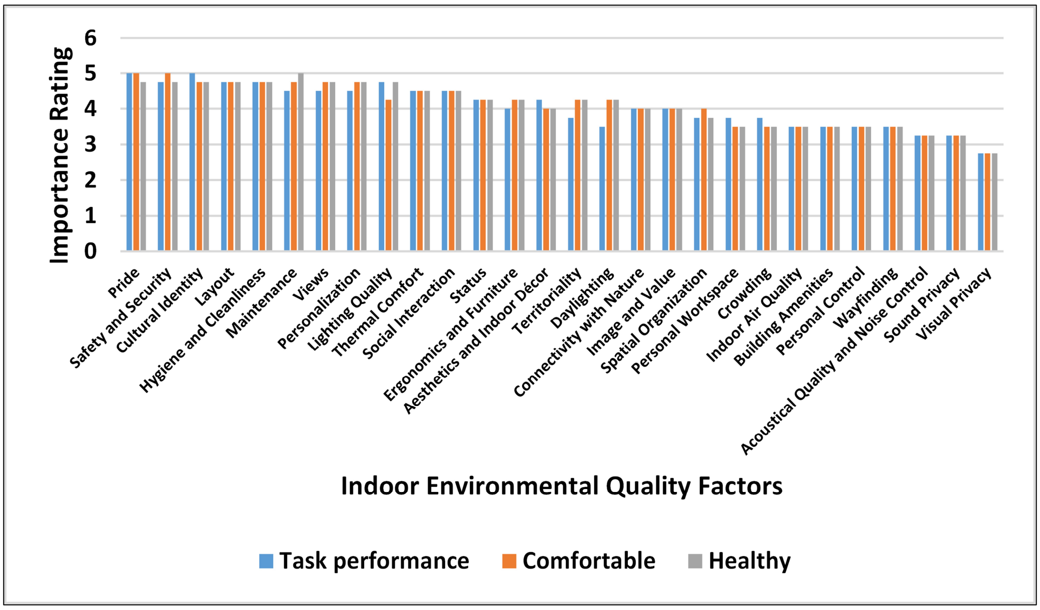

Figure 4. IEQ Factor Importance Ratings by Quality-of-Life Dimensions: GBI2 Focus Group Analysis.

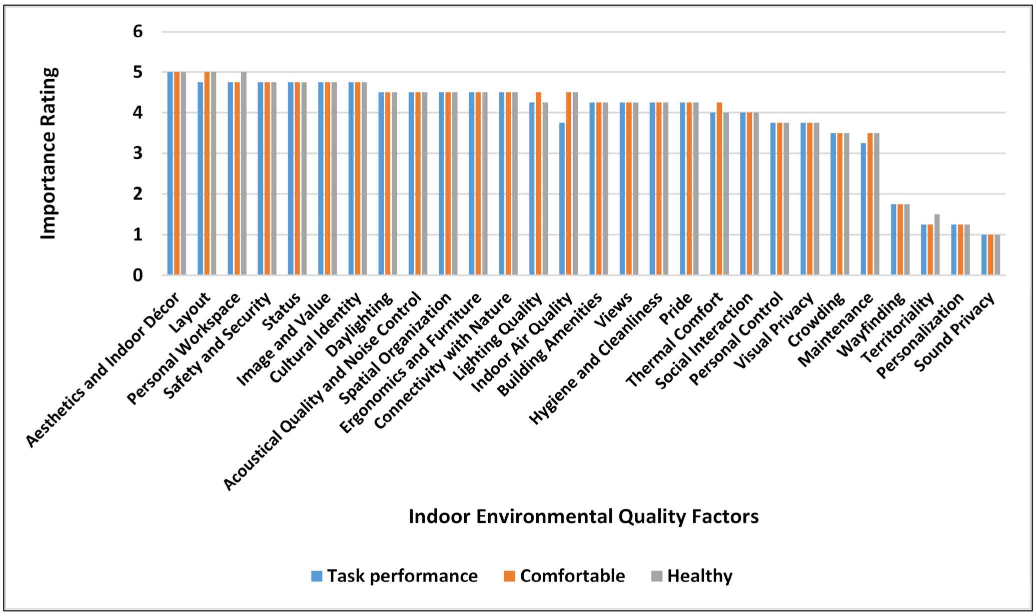

Figure 5. IEQ Factor Importance Ratings by Quality-of-Life Dimensions: NGBI1 Focus Group Analysis.

Traditional building users prioritized other aspects, such as esthetics, layout, and control over their personal workspace, as shown in Figure 5, which visualizes hierarchical clustering for NGBI1. The advanced adaptation measures that occupants implemented to address the lack of environmental controls were identified through focus group discussions. The respondents explained their personalization behavior, informal territorial marking, and the use of cooperative problem-solving strategies, which increased their satisfaction with the environment despite the building's limitations. Participants described simple, low-cost adaptations, such as desk plants, screens, and rearranged furniture, that materially improved their sense of control and comfort.

The triangulation procedure yielded three key insights by organizing comparisons of quantitative correlations and qualitative themes. First, convergence was achieved when strong statistical correlations matched frequent qualitative observations (e.g., the importance of personal control in both datasets). Second, there was divergence: the green buildings were characterized by high technical performance and low satisfaction narratives, revealing a disparity between objective and subjective environmental quality. Third, the additional evidence demonstrated that qualitative data clarified why some correlations were stronger in traditional buildings: occupants developed more complex adaptive strategies when there were no advanced building systems. Overall, the triangulation suggests that designers should prioritize interventions that restore autonomy and enable personalization alongside technical upgrades. These qualitative findings complement but do not replace quantitative evidence; they point to mechanisms that merit experimental testing.

3.5. Green Certification System Implications

These findings highlight fundamental flaws in the available green certification systems that focus solely on technical environmental performance, without considering the human aspects. Certification scores tell a technical story; occupants tell a lived one—and the two do not always match. Reconsidering the main goals of the study, the findings demonstrate that: (1) green certification does not necessarily guarantee a higher quality of life of the occupants, as the presence of a strong intra-category variability indicates; (2) behavioral environmental elements, including control, privacy, and territoriality, are more likely to be linked to satisfaction than the ambient variables, which rating systems consider most important; and (3) qualitative data help to understand why and how these trends occur and are explained by the conflict of automated efficiency and personal control over the situation. In short, technical compliance without attention to everyday agency can leave people feeling disempowered in otherwise "green" spaces.

A combination of these findings with the general literature shows both agreement and departures from the prior literature. However, the results are consistent with those of Altomonte et al. [15] and Lee et al. [12], who reported heterogeneous satisfaction outcomes in certified buildings. This study extends the literature by systematically identifying behavioral factors as the primary determinants of satisfaction. This study diverges from Paul and Taylor [29], who found generally positive satisfaction in green buildings; this divergence may reflect: (1) evolution of certification systems toward greater automation and control constraints; (2) Malaysia's tropical climate creating different comfort challenges than temperate contexts; (3) cultural factors influencing privacy and territoriality preferences in Southeast Asian contexts; or (4) organizational differences in how buildings operationalize sustainability commitments. These contextual differences suggest that certification frameworks must be sensitive to climate, culture, and management practices rather than assuming a one-size-fits-all solution.

The alternative interpretation of conventional buildings being more successful on certain QoL measures than green-certified ones can be viewed through several related lenses. First, user expectations: residents of green buildings tend to arrive with elevated expectations, which, when even minor flaws are not addressed, can lead to disproportionate disappointment. Second, organizational culture: the pursuit of certification is often accompanied by a unique management system that affects occupant satisfaction regardless of the built elements. Third, environmental perceptions may be moderated by unmeasured contextual factors (e.g., job satisfaction, organizational climate, recent workplace restructuring) that conventional measurement instruments cannot capture.

Lastly, adaptation and resilience: residents in traditional buildings might have developed more complex coping mechanisms, thereby maintaining satisfaction despite the purportedly lower technical performance. Expectations, culture, and everyday coping strategies, therefore, shape whether a building's technical merits translate into felt wellbeing. Like any other global rating system, the GBI focuses on energy efficiency, material selection, and measurable environmental performance, but places relatively low priority on occupant control, privacy, and territoriality [52,53]. Such methodological biases tend to predesignate environmental targets, usually to the detriment of human health and productivity. When certification rewards only measurable technical gains, it risks sidelining low-cost, high-impact human factors that directly affect concentration, stress, and long-term health.

The empirical evidence indicates that green certification systems should be substantively revised. First of all, a post-occupancy review must be an obligatory part of certification, ensuring that theoretical design plans are translated into concrete occupant satisfaction [54]. Mandatory POE would close the loop between design intent and lived reality, providing actionable feedback for continuous improvement. Secondly, environmental behavioral factors, such as personal control, visual privacy, and territoriality, need to be incorporated into the scoring rubric. A direct mapping of these constructs to current GBI scoring categories reveals concrete gaps: personal control is partially addressed under GBI's Indoor Environment Quality (IEQ) category through ventilation and thermal provisions, yet no points are awarded for occupant-adjustable systems, individual lighting controls, or user-operated shading devices. Visual privacy receives no dedicated scoring consideration within the GBI framework, despite its strong correlation with QoL found in this study ($r = 0.43$ in green buildings; $r = 0.46$ in conventional buildings). Crowding and territoriality, which emerged as the weakest-performing dimensions in both certified buildings, are entirely absent from GBI assessment criteria. These omissions translate into tangible design consequences: certification incentivizes open-plan layouts and centralized automated systems that maximize energy credits but systematically reduce the spatial boundaries and individual agency that occupants value most. Closing these gaps would require GBI to introduce dedicated credits for adjustable workstation systems, modular zoning strategies that restore perceived territory, and demonstrated occupant engagement processes verified through mandatory POE. Thirdly, certification schemes must put in place mechanisms and incentives that enable occupant adaptation, recognizing that successful buildings provide occupants with the opportunity to customize their environment and not be bound by strict environmental requirements. Incentives could include points for adjustable systems, modular furniture, and documented occupant engagement processes.

The existing approaches to certification, as expressed by Vischer [27], are more instrumental in nature: they are based on quantifiable physical values and fail to consider the functional and psychological facets of workspace efficiency, including symbolically and emotionally resonant comfort. A holistic strategy that synthesizes all three types of comfort offers a way forward toward more humane and sustainable building practices. Adopting a three-part comfort model, physical, functional, and psychological, in certification criteria would better align sustainability goals with human wellbeing and make "green" buildings genuinely livable.

3.6. Theoretical Contributions and Framework Development

The study provides a highly validated model that balances the assessment of indoor environmental quality (IEQ) with quality-of-life (QoL) outcomes across the three environmental domains of the tripartite framework (see Figure 1). The academic contribution goes beyond traditional building-performance indicators, as it explains the development of occupant satisfaction through complex interactions among ambient, design-based, and behavioral environmental factors. This framework reframes evaluation: it treats occupant experience as an outcome to be measured, not as an afterthought inferred from technical metrics. Thus, the framework provides prescriptive guidance for constructing assessments that reflect occupant perspectives rather than solely technical parameters.

This research advances the theory of environmental psychology by revealing the critical role of the symbolic and latent comfort constructs in office settings. The pride, environmental identity, and territorial control variables are also strong predictors of occupant well-being, suggesting that edifices are identity-supporting ecosystems rather than inert, utilitarian containers. Recognizing buildings as identity ecosystems helps explain why small symbolic affordances, such as a plant, a personalized desk, or a visible sustainability plaque, can have outsized effects on well-being. This perspective echoes more recent developments in environmental psychology that foreground social and cultural aspects of built-environment experience [26].

In practical terms, the study delivers clear, actionable recommendations for architects, interior designers, and facilities managers. It shows that truly sustainable buildings must balance environmental performance with human-centered design principles, including adaptive controls, privacy, and symbolic affordances that foster occupant identity and autonomy. Design interventions that restore simple choices, adjustable lighting, movable screens, and modular furniture often produce immediate, measurable improvements in comfort and satisfaction.

3.7. Study Limitations and Future Research

This research has identified limitations that constrain the generalizability of the results. The geographic and cultural representativeness of the sample was limited because the empirical focus was confined to four office buildings in the Klang Valley of Malaysia. The buildings were selected based on available access permissions, rather than using a systematic sampling approach, which could have introduced selection bias in favor of organizations that are more confident in their environmental performance or more inclined to participate in research activities. In addition, the cross-sectional design of the study captured perceptions of the occupants at a single time point, thereby precluding the observation of seasonal changes and longitudinal adaptation mechanisms that occur over longer periods.

These limitations could have resulted in a series of methodological implications: (1) the geographic positioning towards the tropical environment of Malaysia restricts the generalization of the findings to the temperate climate where indoor environmental quality (IEQ) issues are not the same; (2) the possible selection bias might have produced a sample that contains buildings with superior management practices compared to the overall population of buildings; (3) the cross-sectional nature of the study is intrinsically incapable of capturing adaptation processes, which in turn could prompt the effects of dissatisfaction among occupants of newly commissioned green buildings to be still acute.

To overcome these constraints, future studies should follow the following methodological improvements: (1) extend the geographic scope to test the generalizability of the results to other divergent climatic regions and cultural settings; (2) use longitudinal designs that trace the occupant experiences between the first move-in and the long-term occupancy and thus explain the pattern of adaptation, including adaptive thermal comfort responses documented in Malaysian office contexts [55]; (3) combine the objective environmental measurements with the subjective ones to determine whether the experienced phenomena are GBI-specific or reflective of systemic problems, drawing on post-occupancy evaluation frameworks linking IEQ to productivity and QoL [35]; (4) compare various green-building certification systems, including LEED and BREEAM, to test whether findings reflect GBI-specific issues or systemic problems; and (5) extend the scope to other occupancy types, including hospitality settings, where IEQ-comfort relationships have been similarly documented [56]. The comparison between GBI-certified and non-certified buildings was based on descriptive statistics without inferential testing, limiting statistical generalizability. Future research should use larger samples and apply inferential and clustered analyses to strengthen the validation of the certification paradox.

4. Conclusions

This study systematically investigated the relationships among IEQ, green building certification, and QoL in Malaysian office buildings using a convergent mixed-methods approach. By examining GBI-certified and conventional offices in Klang Valley, the research successfully addressed its primary objectives, revealing that green certification does not automatically ensure superior occupant satisfaction. A notable "certification paradox" emerged: while one certified building achieved the highest QoL ratings, a conventional counterpart significantly outperformed the other green-certified site, which recorded the lowest satisfaction levels. These findings challenge fundamental assumptions in building science and highlight a potential misalignment between technical green goals and actual human well-being outcomes.

A critical insight of this research is the dominance of behavioral environmental factors over traditional ambient metrics. Territoriality, privacy, personalization, and control demonstrated stronger correlations with QoL than the physical parameters typically emphasized in certification frameworks. While green buildings often excel in technical features such as lighting quality and views, conventional buildings frequently prioritize spatial and territorial factors that significantly contribute to occupant satisfaction. This suggests that certification-driven design decisions often reshape the determinants of satisfaction, sometimes at the expense of psychological comfort and personal freedom.

The study further validates a tripartite model of a humane work environment, comprising instrumental, functional, and psychological comfort. While inhabitants of green buildings expressed pride in their environmental qualifications, they frequently reported a lack of personal control, creating a contradiction between environmental optimization and individual autonomy. In contrast, residents of traditional buildings utilized advanced personalization and adaptive behaviors to compensate for technical limitations. The triangulation of data confirmed that these behavioral factors are essential components of a supportive work environment, and qualitative insights clarified why conventional buildings occasionally outperform certified ones through superior occupant adaptation.

The theoretical and practical implications of these findings are substantial for architects, facility managers, and policy developers. The validated IEQ-QoL framework provides a robust conceptual basis for human-oriented building assessment, bridging the gap between environmental psychology and building science. To realize truly sustainable architecture, certification systems must evolve. We argue that positive occupant satisfaction ratings should function as a foundational, gating criterion within certification frameworks, serving as a prerequisite without which other performance indicators lose practical meaning. A building that fails to satisfy the majority of its users cannot be considered genuinely sustainable, regardless of its technical scores. Under this principle, certification bodies

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should withhold or suspend ratings where post-occupancy evidence reveals widespread occupant dissatisfaction until its root causes are identified and remedied. Only once a minimum threshold of occupant well-being is demonstrably achieved should further certification activities (covering energy efficiency, water conservation, material performance, and related parameters) be considered valid and meaningful. This reordering of priorities would not merely improve occupant outcomes; it would yield significant resource savings by preventing the perpetuation of technically compliant but humanly inadequate buildings. Furthermore, the current practice of awarding certifications on the basis of design-stage project documentation, before buildings are occupied, warrants critical reconsideration. Pre-construction certificates should be treated as provisional, subject to mandatory post-construction examination of technological and planning solutions. Such an examination, conducted alongside standard regulatory reviews of fire safety, structural integrity, and engineering systems (water supply, sewerage, heating, ventilation, and communications), should constitute a prerequisite for the granting of a full construction and occupancy permit. Integrating occupant-centered post-occupancy evaluation into this regulatory sequence would close the gap between certified design intent and lived building performance, ensuring that sustainability credentials reflect real-world human experience. Moving forward, the industry must shift irreversibly from a purely technocentric paradigm toward a humanistic approach that recognizes healthy buildings and healthy people as indivisible objectives.

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Abbreviations

The following abbreviations are used in this manuscript:

BREEAM	Building Research Establishment Environmental Assessment Method
GBI	Green Building Index
IAQ	Indoor Air Quality
IEQ	Indoor Environmental Quality

LEED	Leadership in Energy and Environmental Design
HVAC	Heating, Ventilation, and Air Conditioning
POE	Post-Occupancy Evaluation
QoL	Quality of Life

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