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The Role of Biophilic Interior Design in Enhancing Social Sustainability in Shopping Malls: A User-Based Study

Maha A. Alsarhan, Khawola F. Mahmoud*

Department of Architectural Engineering, College of Engineering, University of Mosul, Mosul 41002, Iraq

Corresponding Author Email: khawola.mahmoud@uomosul.edu.iq

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ABSTRACT

Biophilic design is founded on the connection people have with nature, and it is now a rapidly growing area of study in interior design due to the many positive impacts it can have on individuals' physical health and mental well-being. However, its role in advancing social sustainability within commercial interior environments remains underexplored. This study addresses this gap by examining the relationship between biophilic interior design dimensions and social sustainability outcomes in shopping malls. A comparative case study was conducted in three major malls in Erbil, Kurdistan Region of Iraq, using systematic observation and user perception surveys (n = 151). Biophilic design strategies were categorized into Nature in The Space, Natural Analogues, and Nature of the Space, while social sustainability was assessed through indicators of inclusivity, psychological comfort, sense of place, and perceived safety. The findings indicate that biophilic interior design contributes significantly to social sustainability, with spatial qualities such as openness, visual depth, and prospect–refuge emerging as the most influential factors. The study also provided empirical evidence of the linkages between biophilic interior design strategies and social sustainability, and demonstrated the potential of biophilic interior design strategies to create shopping malls as inclusive and restorative urban interiors.

1. INTRODUCTION

Biophilic design has emerged as a critical approach in interior architecture, emphasizing the integration of natural elements into built environments to enhance human well-being and performance [1]. Rooted in Wilson's biophilia hypothesis, which suggests an innate human affinity for nature [2], biophilic design seeks to reconnect occupants with natural systems [3, 4]. In interior environments, particularly public and commercial spaces, biophilic design has been shown to improve psychological comfort, reduce stress, and promote positive user experiences [5-7]. Within interior design practice, social sustainability promotes well-being, supports community and cultural identity, and promoting equality within shared spaces [8]. As such, the intersection between biophilic design and social sustainability presents a promising area for advancing the quality of interior environments.

Shopping malls are no longer merely retail establishments; they are social spaces in contemporary urban environments where people gather, engage in leisure activities, and participate in community functions [9]. The interior design of shopping malls (i.e., spatial configuration, environmental comfort, visual connections to nature, and availability of common areas) influences user behavior and social interactions [10-12]. Notwithstanding the increasing awareness of biophilic interior design as an effective tool to improve humans' quality of life, its effects on social sustainability in commercial interior spaces have been understudied. Most of the existing literature emphasizes benefits related to psychology and the environment but pays little attention to the impact of biophilic interior design on larger-scale phenomena, such as interactions, inclusion, and perception of belonging. There is also an absence of empirical studies involving real-life cases of shopping malls and a data-driven comparative analysis of relationships between certain biophilic design dimensions and specific social sustainability indicators.

Consequently, the purpose of this study is to examine empirically the relationship between biophilic interior design and social sustainability in the context of shopping malls. Using multiple case studies conducted under similar urban conditions, the researcher attempts to analyze the effect of different biophilic design dimensions on the perceptions of users. These dimensions include Nature in the Space, Natural Analogues, and Nature of the Space. In order to answer the following research questions, several shopping malls located within the same urban space will be compared.

1. What is the effect of different biophilic interior design dimensions on users' perceptions of social sustainability in shopping malls?
2. Which biophilic design dimension affects social sustainability indicators most significantly?
3. Are there significant differences in biophilic design implementation and social sustainability perceptions among the selected shopping malls?

2. LITERATURE REVIEW

2.1 Biophilic design theory

Biophilic design theory emerges from the concept of biophilia, which refers to the innate human tendency to seek connections with nature. According to recent review studies by Tekin et al. and Wijesooriya et al. [13, 14], biophilic design is rooted in Wilson's notion of biophilia and was subsequently developed and expanded within the field of design through the work of Kellert and colleagues. Building on this foundation, Browning et al. and Ryan et al. [4, 15] advanced the theory through the 14 Patterns of Biophilic Design, which organize design strategies into three categories (Figure 1): Nature in the Space (direct presence of vegetation, water, and daylight), Natural Analogues (use of materials, textures, colors, and patterns that mimic natural forms), and Nature of the Space (spatial configurations such as prospect, refuge, and complexity that evoke natural experiences).

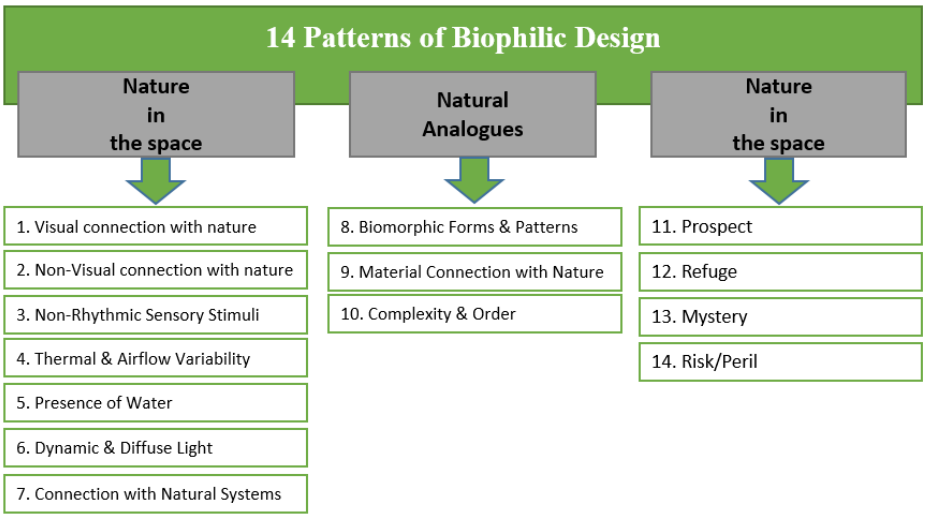

Figure 1. 14 patterns of biophilic design (adapted from [4])

These patterns provide a practical guide for designers, linking empirical evidence of nature's restorative effects to architectural applications.

Several subsequent reviews have indicated that the 14 Patterns is one of the most inclusive frameworks available and offers many ways in which designers can incorporate design strategies that will elicit positive physical (physiological), cognitive, and psychological reactions [14]. Commercial environments have been increasing their use of biophilic elements in order to create comfortable environments that will help to decrease users' levels of stress and increase their level of satisfaction [16], thereby placing biophilic design at the intersection of aesthetics and functionality for creating sustainable interior spaces.

2.2 Social sustainability in the built environment

Social sustainability refers to the capacity of built environments to support human well-being, inclusivity, and community cohesion. Unlike environmental and economic sustainability, it remains less defined, yet it is critical in shaping equitable and resilient societies. Scholars emphasize that socially sustainable spaces foster belonging, encourage participation, and enhance quality of life, making it a vital dimension of sustainable architecture.

In identifying indicators of social sustainability, Kefayati and Moztarzadeh [17] found social interaction, architectural identity, security, flexibility, and participation to be fundamental characteristics of incorporating social sustainability into architectural designs. Similarly, Lami and Mecca [18] suggested that equity, social networks, well-being, safety, and design identity are also important considerations; authors further emphasize that culturally responsive and inclusive spaces will have a positive impact on the quality of life [19].

Collectively, these studies confirm that accessibility, cultural sensitivity, identity, and psychological comfort are indispensable dimensions of socially sustainable built environments across different architectural scales.

2.3 Social sustainability in interior architecture

Extending this discourse to interior environments, previous studies highlight that interior design plays a significant role in supporting social sustainability. Altamimi et al. [20] demonstrate that workplace interiors influence social sustainability through spatial qualities related to comfort, privacy, social interaction, and spatial organization, highlighting the importance of indoor environmental quality in promoting collaboration, inclusion, and user satisfaction. Similarly, in housing contexts, Ebbini and Bleibleh [21] emphasized that sense of place, dignity, and social belonging are essential factors shaping residents' well-being, underscoring the need to integrate social and psychological considerations into the evaluation of interior environments.

2.4 Shopping malls as social spaces

Shopping malls are rapidly changing from just retail stores into multi-use spaces for social gathering. This change is evidenced by shopping malls being "third places" for people to go and meet each other outside of their homes or workplaces. The research shows that interior space design has a large impact on these experiences. How people interact with one another, whether they feel included, and how they experience a space are all influenced by the way that space is

designed, including how it is laid out, how people circulate through it, what kind of environmental conditions exist in it, and what kinds of communal spaces exist in it [22].

Biophilic design can further amplify the social aspects of an interior space. As demonstrated in studies conducted in Surabaya and Kuwait, incorporating natural elements, such as green walls, water features, daylight, and organic shapes, reduces stress, increases well-being, and promotes restorative experiences in shopping malls [22, 23]. Furthermore, empirical evidence supports that biophilic malls are perceived as being more attractive, restorative, and socially interactive by shoppers, thus increasing their likelihood to visit again and refer friends and family [24]. Similarly, Rosenbaum et al. [25] found that lifestyle centers (shopping malls that have been designed to provide additional amenities, such as gardens, fountains, and natural lighting) act as transformative services capes that provide opportunities for prolonged social interaction and relief from mental fatigue.

Therefore, shopping malls that incorporate biophilic elements expand their use beyond commerce to become important urban social spaces. By creating environments that promote restoration, socialization, inclusion, and community cohesion, shopping malls serve an increasingly significant role in providing sustainable and socially responsible centers in today's cities.

2.5 Previous empirical studies

Existing empirical research continually illustrates how biophilic design positively impacts human health and wellness across different types of buildings. For example, when it comes to healthcare environments, there is a significant body of evidence showing that adding natural light, plants, water features and using natural products in the built environment, all contribute to reducing stress, creating healthy environments for healing and improving patient satisfaction; and overall support the use of multisensory and environmentally responsive designs that support physiological and psychological recovery [26, 27].

In addition, biophilic strategies have been used successfully in hospitality settings to create better indoor environmental quality, comfort, user satisfaction, and encourage users to spend more time in those spaces and engage in positive behaviors [1, 28-30]. Similarly, researchers have also demonstrated that biophilic elements such as skylights, vertical gardens, and water features in commercial environments create better sensory experiences and support the emotional well-being of visitors, and ultimately lead to increased levels of visitor engagement. Restorative experiences are further related to increased lengths of visit and consumers' positive behaviors [23, 24, 31, 32].

While numerous studies have investigated the effects of biophilic design in individual functional contexts and the resultant psychological/behavioral outcomes, relatively little research exists regarding the relationships between biophilic design and social sustainability measures, including inclusiveness, sense of place, and community engagement—specifically in shopping mall environments. Therefore, this study seeks to address this research gap by conducting comparative, user-based research that investigates the relationships between specific biophilic interior design strategies and social sustainability measures in shopping malls. Malls are environments where collective experiences and community-oriented spaces can provide greater societal impact than other environments.

2.6 Research gap

Biophilic design has been demonstrated to enhance both the psychological comfort of occupants and their overall satisfaction; however, research focused on shopping malls primarily examines a consumption-based focus. Specifically, previous research has examined the ability of biophilic design to promote a restorative experience for shoppers as well as positively affect retail performance, yet has neglected to address the broader social sustainability outcomes of this type of environment. Although social sustainability includes aspects such as inclusivity, social interaction, sense of place, comfort, and perceived safety, the theoretical foundation is rare in terms of its implementation within interior design research focused on commercial environments.

Additionally, prior research has rarely investigated which specific biophilic interior design dimensions contribute to social sustainability. As a result, the differentiated impacts of Nature in the Space (direct natural elements), Natural Analogues (materials, textures, and forms), and Nature of the Space (spatial configuration, openness, and prospect–refuge) have rarely been investigated in comparison to measurable social sustainability indicators. In general, comparative, quantitative examinations of the linkages among these three dimensions and users' social perceptions in shopping malls are very limited. This provides evidence of a research gap that indicates the need for empirical research that specifically links each of the three biophilic interior design dimensions to social sustainability outcomes in shopping mall environments.

3. CONCEPTUAL FRAMEWORK

To address the identified research gap, this study develops a conceptual framework that examines the relationship between biophilic interior design and social sustainability in shopping malls. Grounded in biophilic design theory and social sustainability principles, the framework explains how design strategies influence users' spatial experiences and social outcomes.

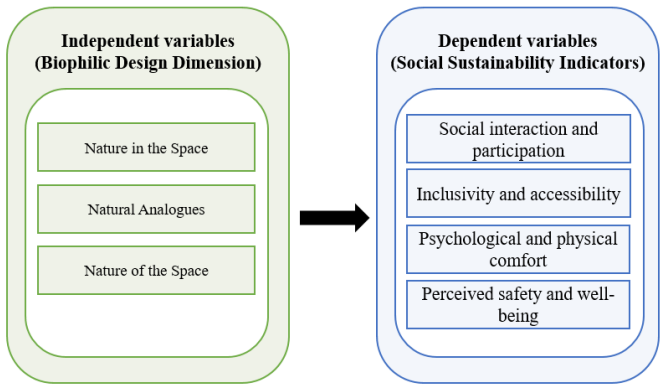

Figure 2. Conceptual framework illustrating the direct relationships between biophilic interior design dimensions and social sustainability indicators

The framework conceptualizes biophilic interior design dimensions—namely Nature in the Space, Natural Analogues, and Nature of the Space—as independent variables that directly influence social sustainability indicators within

shopping mall environments. Social sustainability is represented through four dimensions: Social interaction and participation, Inclusivity and accessibility, Psychological and physical comfort, and Psychological and physical comfort. The framework assumes that different biophilic design strategies contribute to users' perceptions of social sustainability through their influence on the overall quality of interior environments. Figure 2 illustrates the proposed direct relationships between biophilic interior design dimensions and social sustainability indicators, while Table 1 provides a detailed description of each construct.

4. METHODOLOGY

In this study, a quantitative comparative approach was used to establish the connection between the use of biophilic interior design elements and social sustainability within shopping malls. In order to improve the credibility of the findings and minimize the possibility of single-source bias, the research utilized mixed methods for collecting the data by combining systematic observation with surveys assessing the users' perception of the malls. The focus of the comparative analysis was made on three different shopping malls located in the same urban environment (the city of Erbil), to control contextual variables while capturing variation in the extent and type of biophilic interior design implementation.

4.1 Case study

A comparative case study approach was adopted to evaluate shopping malls with different levels of biophilic interior integration. Three major shopping malls in Erbil, Kurdistan Region of Iraq—Grand Majidi Mall, Family Mall, and Gulan Mall, were purposively selected (Figure 3). The selection criteria included:

(1) Scale and multifunctional role as major commercial and social spaces.

(2) High accessibility and diverse user groups.

(3) Variation in the degree of biophilic interior design implementation. This approach enabled a controlled comparative analysis while maintaining contextual consistency across the selected cases.

Erbil was selected as the study context due to its rapid urban development and the increasing role of shopping malls as primary social and recreational destinations. The selected malls represent some of the most prominent and frequently visited commercial centers in the city, making them appropriate cases for examining user experience and spatial qualities within a consistent urban context.

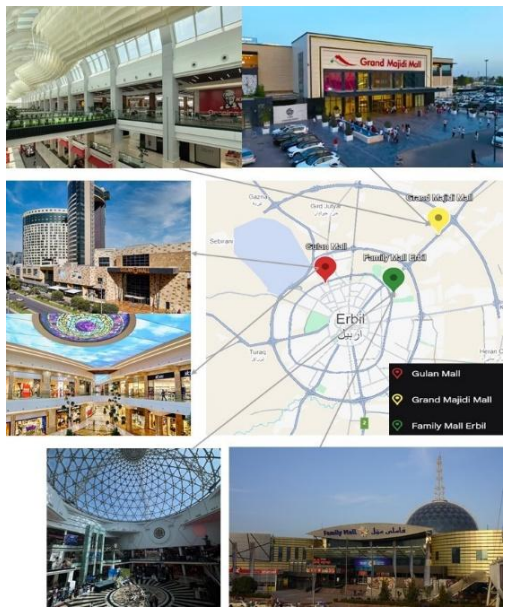

Figure 3. Case study locations on the Erbil City map

Table 1. Conceptual framework of the relationship between biophilic interior elements and social sustainability indicators (by author)

Variables	Dimension	Description
Biophilic Elements (Independent)	Nature in the Space	Direct presence of natural elements such as indoor vegetation, water features, natural daylight, and visual connections to outdoor environments [15].
	Natural Analogues	Use of natural materials (e.g., wood, stone), organic forms, textures, and nature-inspired colors within interior spaces [15].
	Nature of the Space	Spatial configurations inspired by natural environments, including openness, prospect and refuge, visual depth, and quality of circulation [15].
Social Sustainability Indicators (Dependent)	Social Interaction and Participation	Degree to which the interior environment encourages social engagement and communal activities among users [33].
	Inclusivity and Accessibility	Extent to which the interior design accommodates diverse user groups and promotes equal access [33].
	Psychological and Physical Comfort	Users' perceived comfort resulting from environmental quality, spatial organization, and sensory experience [33].
	Perceived Safety and Well-being	Users' feelings of security, relaxation, and overall well-being within the interior space [33].

4.2 Data collection

Data were collected using two complementary methods:

(i) Structured observation.

(ii) Questionnaire survey.

The observation checklist was developed based on existing literature on biophilic design principles and specifically the 14 patterns of biophilic design. Standardized evaluation criteria were adopted to ensure consistency in measuring biophilic qualities across all cases. quality was scored using a rating scale ranging from (1 = absent/very weak to 5 = strongly present). Observations were conducted at three time periods (morning, afternoon, and evening) to capture temporal variations in environmental conditions, including daylight availability, visitor density, and activity levels. The same observational procedure was applied across all case studies to ensure comparability.

The second stage of data collection involved the use of

questionnaires that were distributed to users of the shopping malls to assess their perceptions of biophilic qualities and social sustainability. The questionnaires were distributed both online and in-person to obtain a representative sample of users. The sampling technique used was non-probability convenience sampling. In total, 151 responses were collected, all of which were complete and valid for analysis.

4.3 Measurement and instrument development

Survey items were developed based on established literature on biophilic design and social sustainability. Biophilic perception was operationalized through three constructs: Nature in the Space, Natural Analogues, and Nature of the Space. Social sustainability was measured using four indicators: Social interaction and participation, Inclusivity and accessibility, psychological and physical comfort, and perceived safety and well-being.

Psychological and physical comfort was defined as users' perceived environmental and emotional ease within the interior space, influenced by factors such as lighting quality, thermal conditions, noise levels, and spatial organization. Perceived safety and well-being referred to users' feelings of security, relaxation, and overall well-being within the shopping mall environment [18, 21]. Social interaction and participation reflected the extent to which the interior environment encouraged communication, social engagement, and communal activities among users, while Inclusivity and accessibility referred to the degree to which the space accommodated diverse user groups and promoted equal access to facilities and services.

These indicators were selected based on their consistent identification in the literature as core dimensions of social sustainability in the built environment. They reflect key aspects of user experience in interior spaces, particularly in commercial settings, where factors such as comfort, inclusivity, social interaction, and perceived safety play a significant role in shaping overall spatial satisfaction and user well-being. All items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Prior to distribution, the questionnaire was reviewed to ensure clarity and face validity, and minor revisions were made to improve comprehensibility and reduce ambiguity.

The final questionnaire items are presented in Appendix A, including Nature in the Space (Table A1), Natural Analogues (Table A2), Nature of the Space (Table A3), social interaction and participation (Table A4), inclusivity and accessibility (Table A5), psychological and physical comfort (Table A6), and perceived safety and well-being (Table A7).

4.4 Reliability and internal consistency

Internal consistency reliability was assessed using Cronbach's alpha coefficient for each construct. Cronbach's alpha values of 0.70 or above are generally considered acceptable; however, lower values may be tolerated in exploratory studies within the social and built environment fields. Following the initial reliability assessment, the construct "Sense of Place & Identity" was excluded from further analysis due to its extremely low reliability ($\alpha = 0.178$), indicating insufficient internal consistency among its items. The remaining constructs were retained for subsequent analyses after scale refinement. The final reliability results are presented in Table 2.

Although some constructs yielded Cronbach's alpha values slightly below the commonly recommended threshold of 0.70, they were retained because the study is exploratory in nature and the scales were adapted from previous literature to suit the shopping mall context. Several methodological studies have noted that reliability coefficients between 0.50 and 0.70 may be considered acceptable in exploratory social science and built environment research, particularly when constructs consist of a limited number of items. Therefore, the retained constructs were considered sufficiently reliable for subsequent correlation, regression, and comparative analyses. The final questionnaire items retained after scale refinement are presented in Appendix A.

Table 2. Reliability results (Cronbach's alpha)

Variable	Construct / Scale	No. of Items	Cronbach's Alpha (α)
Biophilic Element	Nature in the Space	4	.677
	Natural Analogues	5	.827
	Nature of the Space	5	.695
Social Sustainability	Social Interaction & Participation	3	.563
	Inclusivity & Accessibility	3	.677
	Psychological & Physical Comfort	4	.593
	Perceived Safety & Well-being	4	.615

4.5 Data analysis

Quantitative data were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) Statistics. Descriptive statistics including Frequencies, percentages, means, and standard deviations, were used to summarize respondent characteristics and key variables. One-way analysis of variance (ANOVA) was conducted to examine differences between the selected shopping malls, followed by Tukey post-hoc tests where significant differences were identified. Pearson correlation was used to determine the association between biophilic design and social sustainability variables. Regression analysis was performed to evaluate the predictive contribution of biophilic design variables on social sustainability.

Before interpreting the regression model results, key assumptions were examined, include normality of residuals, homoscedasticity, independence of errors, and multicollinearity. All assumptions were satisfied within acceptable ranges. Homoscedasticity was confirmed through residual scatterplots. While normality was verified using Q-Q plots and the Shapiro-Wilk test. Independence of errors was supported by the Durbin-Watson statistic 1.970. Multicollinearity was not a concern, as Variance Inflation Factor (VIF) values ranged between 1.945 and 2.399 and Tolerance values between 0.417 and 0.514.

5. RESULTS

5.1 Sample characteristics (descriptive statistics)

Tables 3 and 4 outline the demographics and visit-related attributes of the subjects (N = 151). The sample has a varied

composition in terms of age, gender, and education level, with the most common education level among the respondents being that of a bachelor's degree. In terms of shopping mall visit attributes, the sample largely consists of people who visit malls to shop and relax, spending an average of one to two hours on the premises. Such attributes indicate that the sample is representative of shopping mall users.

Table 3. Respondents' demographic characteristics

Criteria	Category	Frequency	%
Gender	Male	61	40.4%
	Female	90	59.6%
Age group	18-25	20	13.2%
	26-35	63	41.7%
	36-45	30	19.9%
	46-55	25	16.6%
	Over 55	13	8.6%
Educational level	Secondary or lower	2	1.3%
	Diploma/Institute	15	9.9%
	Bachelor's degree	98	64.9%
	Master's degree or higher	36	23.8%
Total		**151**	**100%**

Table 4. Respondents' visit characteristics

Criteria	Category	Frequency	%
Mall distribution	Gulan Mall	40	26.5%
	Family Mall	48	31.8%
	Grand Majidi Mall	63	41.7%
Total		**151**	**100%**
Purpose of visit	Shop	128	46.4%
	Dine & Entertainment	98	35.5%
	Watch a movie	12	4.3%
	Business or meetings	0	0%
	Casual visit	29	10.5%
	Other	9	3.3%
Total		**276**	**100%**
Duration of stay	Less than 30 min	0	0%
	30–60 min	26	17.2%
	1–2 h	66	43.7%
	More than 2 h	59	39.1%
Time of visit	Morning	26	17.2%
	Afternoon	73	48.3%
	Evening	50	33.1%
	Late evening	2	1.3%
Total		**151**	**100%**

5.2 Biophilic interior observation checklist

The results of the analysis based on the observation checklist reveal differences between the presence and quality of biophilic design aspects in the case study areas (Table 5). Overall, Grand Majidi Mall demonstrates the highest level of biophilic integration, followed by Family Mall and Gulan Mall. Among the evaluated dimensions, "Nature of the Space" shows relatively stronger implementation compared to direct natural elements (Nature in the Space), particularly in terms of openness, spatial configuration, and visual depth. In contrast, features such as water elements and vegetation were limited or weakly represented across all cases. These findings indicate that spatial qualities rather than direct natural elements dominate the biophilic design strategies within the selected shopping malls.

5.3 Users' perceptions of biophilic interior elements

As shown in Table 6, users generally reported moderate to high perceptions of biophilic interior qualities, with "Nature of the Space" receiving the highest mean scores across all malls.

Grand Majidi Mall consistently achieved higher scores compared to the other examples, indicating stronger perceived biophilic integration.

On the contrary, "Nature in the Space" scored significantly lower because of the limited presence of direct presence of nature, which could be confirmed based on the observations made during the evaluation process.

5.4 Social sustainability indicators results

The results presented in Table 7 indicate that users perceived relatively high levels of inclusivity and accessibility, as well as psychological and physical comfort, across the selected shopping malls. In contrast, Social interaction and participation showed comparatively moderate levels. Grand Majidi Mall recorded the highest scores across most social sustainability indicators, suggesting stronger overall performance in creating a socially supportive and user-friendly environment. The findings further highlight the importance of interior spatial qualities and biophilic design features in shaping users' perceptions of social sustainability within shopping mall environments.

Table 5. Observation checklist results for the case studies

Scoring Scale		Indicator	Gulan Mall (1–5)	Family Mall (1–5)	Grand Majidi Mall (1–5)
1 = Not present 2 = Limited presence 3 = Moderate presence 4 = Strong presence 5 = Very strong presence					
Biophilic element	**Nature in the Space**	Vegetation	3	2	3
		Water features	1	1	2
		Daylight access	2	4	5
		Visual connection to nature	2	3	4
	Natural Analogues	Natural materials	4	1	3
		Organic forms	4	3	4
		Nature-inspired colors/textures	2	2	2
	Nature of the Space	Openness	2	4	4
		Prospect–refuge	2	4	4
		Visual depth	2	3	3
		Spatial configuration	2	3	3
BIOC Score		—	**2.4**	**2.7**	**3.3**

Table 6. Mean ± standard deviation of users' perceptions of biophilic interior elements

Biophilic Category	Gulan Mall (Mean ± SD)	Family Mall (Mean ± SD)	Grand Majidi Mall (Mean ± SD)
Nature in the Space	2.19 ± 0.66	2.36 ± 0.67	3.22 ± 0.61
Natural Analogues	3.09 ± 0.58	2.65 ± 0.59	3.42 ± 0.55
Nature of the Space	3.25 ± 0.44	3.08 ± 0.57	3.64 ± 0.54

Table 7. Mean ± standard deviation of social sustainability indicators by shopping mall

Social Sustainability Indicator	Gulan Mall (Mean ± SD)	Family Mall (Mean ± SD)	Grand Majidi Mall (Mean ± SD)
Social interaction	2.92 ± 0.45	2.87 ± 0.64	3.30 ± 0.57
Inclusivity & Accessibility	3.88 ± 0.40	3.49 ± 0.63	3.93 ± 0.47
Psychological & Physical Comfort	3.54 ± 0.36	3.53 ± 0.53	3.83 ± 0.51
Perceived Safety & Well-Being	3.42 ± 0.43	3.10 ± 0.55	3.46 ± 0.58

5.5 Comparison between case studies (analysis of variance results)

One-way ANOVA results (Tables 8–11) reveal statistically significant differences between the three shopping malls across most biophilic design elements and several social sustainability indicators.

Post-hoc comparisons indicate that Grand Majidi Mall significantly outperforms the other malls in key variables, particularly those related to spatial qualities such as visual depth, openness, and circulation.

However, despite these statistically significant differences, the overall variation between malls remains moderate, suggesting that the primary distinction lies in the quality of spatial configuration rather than the presence of entirely different design strategies.

Table 8. One-way analysis of variance (ANOVA) results for biophilic interior elements by shopping mall

Biophilic Element	Indicator	F	*p*-Value
Nature in the Space	Indoor vegetation	21.37	<0.001
	Water features	27.23	<0.001
	Natural daylight	28.07	<0.001
	Visual connections to outdoor environments.	11.99	<0.001
Natural Analogues	Natural materials	20.58	<0.001
	Nature-inspired forms	11.19	<0.001
	Textures inspired by nature	13.35	<0.001
	Use of natural colors	13.35	<0.001
	Lighting and color scheme	10.66	<0.001
Nature of the Space	Spatial layout	4.20	0.017
	Circulation	8.17	<0.001
	Openness and open spaces	4.12	0.018
	Visual depth	23.13	<0.001
	Prospect–refuge	7.15	0.001

Table 9. Tukey HSD post-hoc comparisons for biophilic interior elements

Variables	Biophilic Element Indicators	Significant Differences ($p < 0.05$)
Nature in the Space	Indoor vegetation	Grand Majidi > Gulan, Family
	Water features	Grand Majidi > Gulan, Family
	Natural daylight	Grand Majidi > Gulan
	visual connections to outdoor environments.	Grand Majidi > Gulan, Family
Natural Analogues	Natural materials	Grand Majidi > Gulan > Family
	Nature-inspired forms	Grand Majidi > Gulan, Family
	Textures inspired by nature	Grand Majidi > Family
	Use of natural colors	Grand Majidi > Family
	Lighting and color scheme	Grand Majidi > Family
Nature of the Space	Spatial layout	Grand Majidi > Family
	Circulation	Grand Majidi > Family
	Openness and open spaces	Grand Majidi > Gulan
	Visual depth	Grand Majidi > Gulan, Family
	Prospect–refuge	Grand Majidi > Family

Table 10. One-way analysis of variance (ANOVA) results for social sustainability indicators by shopping mall

Variable	Social Sustainability Indicator	F	*p*-Value
Social Interaction	Social interaction	0.21	0.813
	Social activities	8.50	<0.001
	Use of communal spaces	11.99	<0.001
Inclusivity & Accessibility	Accessibility	8.33	<0.001
	Disability services	6.80	0.001

Psychological & Physical Comfort	Inclusiveness	5.51	0.005
	General comfort	3.38	0.037
	Lighting comfort	15.30	<0.001
	Ventilation	6.71	0.002
	Noise level	3.05	0.050
Perceived Safety & Well-Being	Safety	4.06	0.019
	Privacy	7.15	0.001
	Crowd level	4.03	0.020
	Quiet areas	1.95	0.146

Table 11. Tukey HSD post-hoc comparisons for social sustainability indicators

Variable	Social Sustainability Indicator	Significant Differences ($p < 0.05$)
Social Interaction	Social activities	Grand Majidi > Gulan, Family
	Use of communal spaces	Grand Majidi > Gulan, Family
Inclusivity & Accessibility	Accessibility	Gulan > Family; Grand Majidi > Family
	Disability services	Grand Majidi > Family; Gulan > Family
	Inclusiveness	Grand Majidi > Family
Psychological & Physical Comfort	Lighting comfort	Grand Majidi > Gulan; Grand Majidi > Family
	Ventilation	Grand Majidi > Family
	Noise level	Grand Majidi > Family
Perceived Safety & Well-Being	Safety	Gulan > Family
	Privacy	Grand Majidi > Family
	Crowd level	Gulan > Family

5.6 Correlation between biophilic design and social sustainability

Results from the Pearson correlation coefficient analysis (Figure 4) demonstrate significant positive correlations between all dimensions of biophilic design and social sustainability factors ($p < 0.01$). In terms of these three dimensions, Nature of the Space exhibited the strongest correlations with social sustainability indicators, particularly with Psychological and physical comfort ($r = 0.736$). Natural Analogues also showed consistent moderate-to-strong positive relationships with all social sustainability factors, while Nature in the Space demonstrated significant but comparatively weaker associations, especially with Inclusivity and accessibility ($r = 0.284$).

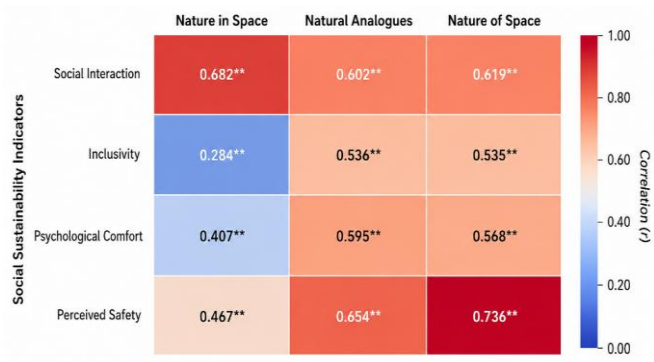

Figure 4. Correlation heatmap using a blue–red gradient to illustrate the strength of relationships between biophilic design dimensions and social sustainability indicators ($p < 0.01$)

5.7 Regression analysis results

Multiple linear regression analysis (Table 12) was conducted to assess the predictive effect of biophilic design dimensions on social sustainability. The model was statistically significant ($F = 108.788$, $p < 0.001$), explaining 68.9% of the variance ($R^2 = 0.689$). The results indicate that Nature of the Space is the strongest predictor of social sustainability ($\beta = 0.481$, $p < 0.001$), followed by Natural Analogues ($\beta = 0.394$, $p < 0.001$). In contrast, Nature in the Space did not show a statistically significant effect ($\beta = 0.029$, $p = 0.648$). To enhance interpretation, the regression results are visually summarized in Figure 5, highlighting the dominant influence of spatial characteristics and nature-inspired design elements over the direct presence of natural features.

Table 12. Regression coefficients for predicting social sustainability

Predictor Variable	β (Standardized)	t	*p*-Value
Nature in the Space	0.097	1.573	0.118
Natural Analogues	0.337	4.906	<0.001
Nature of the Space	0.497	7.515	<0.001

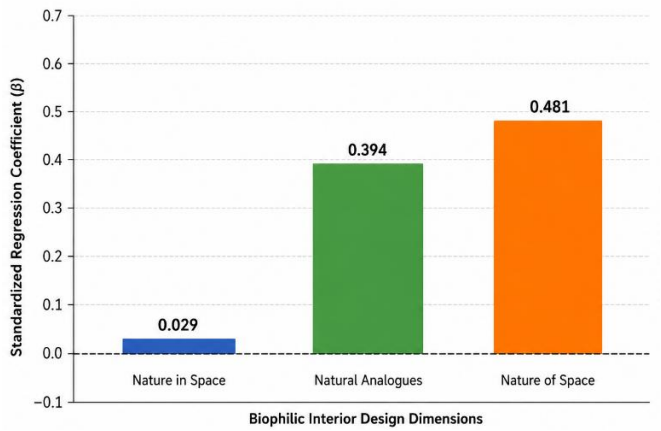

Figure 5. Graphical representation of standardized regression coefficients (β) showing the relative influence of biophilic interior design dimensions on social sustainability

5.8 Summary of key finding

Overall, the results reveal several consistent patterns across the analyses. First, it is important to note that the most

significant dimension in terms of the observed influence on social sustainability of shopping mall spaces is the Nature of the Space category. This variable demonstrates excellent performance in all of the employed methods – observations, evaluations, correlations and regressions.

Natural Analogues is another category demonstrating moderately strong but still noticeable influence on social sustainability. Apparently, indirect representation of nature in spatial composition (materials, textures, forms) contributes to psychological comfort of the users and their ability to perceive the space positively. At the same time, the dimension of Nature in the Space reveals low level of influence and even statistical significance.

The statistically significant differences between the two examined shopping malls do not imply that the level of variability in terms of design solutions is high; hence, the essential difference should be sought for in the quality of spatial design.

6. DISCUSSION

This section discusses the key findings of the study by interpreting the relationship between biophilic interior design and social sustainability in shopping mall environments, with reference to biophilic design theory and social sustainability literature.

6.1 Interpretation of key findings

The findings of this study provide empirical evidence that biophilic interior design contributes positively to social sustainability in shopping malls; however, the degree of influence varies across different biophilic design dimensions. Among these dimensions, nature of the space emerged as the most influential factor in shaping users' perceptions of social sustainability. The spatial characteristics of interior spaces, such as openness, visual depth, legibility of circulation paths, and prospect-refuge conditions, are the aspects of the physical environment that contribute to an individual's sense of safety, comfort, and connection to a given environment. It follows that socially sustainable interiors are largely influenced by the way space is organized and experienced rather than simply through the incorporation of natural elements. From a practical perspective, this finding suggests that designers should prioritize spatial configuration strategies, such as openness, visual connectivity, and clear circulation systems over the mere addition of decorative natural elements. In commercial environments like shopping malls, these spatial qualities enhance users' sense of orientation, safety, and comfort, thereby supporting more inclusive and socially interactive environments.

The findings of this study support the theoretical underpinnings of biophilic design proposed by Browning et al. [4]. Specifically, the Nature of the Space pattern types, which identify the importance of spatial experiences that mimic those of the natural environment for psychological restoration and well-being. In the context of shopping malls, coherently organized space encourages intuitive movement and visual connectivity resulting in prolonged time spent in the environment thus creating a socially supportive environment. In addition to enhancing users' sense of comfort and emotional attachment to interior spaces, natural materials, organic forms and nature inspired textures also have a positive impact on the psychological experience of the interior environment. Given the constraints associated with incorporating large amounts of vegetation or water features into commercial interior space settings, the use of indirect representations of nature are especially valuable.

Finally, whereas the use of natural elements in the space (i.e., vegetation, water features, and daylight) are highly valued by users of shopping malls, the results of this study suggest that their ability to predict social sustainability is contingent upon their spatial integration. Thus, while users perceive these elements as having a positive impact, it appears that the inclusion of these elements functions as supplementary components of social sustainability in the shopping mall setting, rather than primary drivers of social sustainability, especially if they are incorporated in a decorative or fractured manner. Overall, the findings of this study indicate that social sustainability of shopping malls is more significantly impacted by the quality of the spatial experience generated by the application of biophilic design principles, rather than the amount of biophilic elements that are utilized. Therefore, biophilic design approaches that prioritize spatial coherence and experiential continuity are more likely to create commercially inclusive, comfortable, and socially sustainable environments.

6.2 Theoretical and practical contributions

The theoretical contributions of this study provide empirical evidence for a connection between biophilic interior design and social sustainability in shopping mall spaces. In contrast to much of the prior literature, the results of this study demonstrate how biophilic design is a key component of social sustainability in terms of inclusivity, sense of community, and perceived safety, three important aspects of social sustainability. The practical implications of this study are that designers and other decision makers should place a greater emphasis on developing and using space planning principles based upon nature (using analogues of natural forms, materials, and processes) to create spaces with open views, continuous sightlines, clear paths through buildings and prospect/refuge spaces instead of simply decorating spaces with biophilic elements. If designers incorporate these principles into their designs, it could lead to shopping malls being able to act as commercially viable, but socially sustainable, urban interiors. These findings reinforce the argument that biophilic design should be approached as an integrated spatial strategy rather than a collection of isolated natural elements.

6.3 Limitations and future research

This study has several limitations. First, the sampling method employed was a non-probability convenience sampling approach, and the study was limited to three shopping malls within a single city, which may restrict the generalizability of the findings to other urban contexts. Second, the cross-sectional nature of the study captures users' perceptions at a single point in time and does not account for potential changes in perceptions resulting from repeated exposure to biophilic environments. Longitudinal studies could provide deeper insights into how users' social experiences evolve over time.

Third, although the use of a structured observation checklist contributed to methodological triangulation, some degree of

subjectivity may remain in the evaluation process. Future studies may strengthen reliability by incorporating inter-rater reliability assessments and objective environmental measurements, such as daylight levels, vegetation coverage ratios, thermal comfort indicators, and acoustic performance metrics. Future studies may expand the research to different urban contexts and commercial environments while employing larger and more diverse samples.

In addition, advanced analytical techniques such as Structural Equation Modeling (SEM), Partial Least Squares Structural Equation Modeling (PLS-SEM), or PROCESS-based mediation analysis could be used to investigate whether psychological and physical comfort, perceived safety and well-being, and social interaction mediate the relationship between biophilic design dimensions and broader social sustainability outcomes. Such approaches would provide a more comprehensive understanding of the mechanisms through which biophilic interior design contributes to social sustainability.

7. CONCLUSIONS

This study explores the linkages between biophilic interior environments and social sustainability outcomes within shopping malls by comparing and contrasting three shopping malls in the city of Erbil (Grand Majidi Mall, Family Mall, and Gulan Mall). Using systematic observation with surveys to gather users' perceptions on their experiences in shopping malls with high and low degrees of biophilic design integration, this paper presents evidence that biophilic design strategies have a significant impact on social sustainability indicators (Social interaction and participation, inclusivity and accessibility, perceived safety and well-being, and psychological and physical comfort) in shopping malls.

A key finding from this study is that shopping malls with greater biophilic integration (specifically Grand Majidi Mall) consistently produced higher scores in all of the perception categories related to biophilic design and in all of the social sustainability indicator categories. In addition, spatial configurations with openness, prospect-refuge, and visual depth were found to be the most effective characteristics in creating inclusiveness, comfort, and community engagement. As a result, it was confirmed that biophilic design represents an effective approach to advancing social sustainability in urban commercial spaces through embedding natural elements and nature-inspired qualities into the interior designs of shopping malls. Therefore, designers can use the inclusion of natural elements and nature-inspired qualities to create restorative environments that promote inclusivity, positive social experiences, and user well-being within shopping mall environments. This paper bridges the gap between biophilic theory and social sustainability practice, providing evidence that biophilic interiors can be used as catalysts to create a socially sustainable urban life.

To further develop the understanding of how biophilic design strategies can be optimized to create commercially viable, inclusive, and sustainable environments, future research should increase the comparative context to other cultures and geographies and employ longitudinal methodologies to measure the changes in users' perceptions over time. Ultimately, the findings of this paper provide strong justification for the intentional incorporation of biophilic principles into the design of shopping malls to enhance both human well-being and collective urban sustainability.

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APPENDIX

Appendix A. Final questionnaire items used in the analysis

Table A1. Nature in the Space

Code	Item
NIS1	The presence of green spaces or plant-based decorative elements positively affected my comfort level.
NIS2	There are indoor green spaces or open areas for sitting and relaxation.
NIS3	There are windows or openings that provide views of outdoor natural scenery.
NIS4	Natural lighting (sunlight) is available and positively influences the overall atmosphere.

Note: NIS = Nature in the Space.

Table A2. Natural Analogues

Code	Item
NA1	Natural materials such as wood, stone, or plants are clearly incorporated into the interior design.
NA2	The design includes forms inspired by nature, such as leaves or organic patterns.
NA3	The colors and materials used in the design enhance the feeling of comfort.
NA4	Water features contribute to the attractiveness and comfort of the space.
NA5	The mall design allows interaction with nature through natural lighting or indoor vegetation.

Note: NA = Natural Analogues.

Table A3. Nature of the Space

Code	Item
NOS1	The interior environment is balanced and does not cause discomfort.
NOS2	The spatial layout encourages movement and exploration with ease and comfort.
NOS3	Open spaces such as atriums and central halls provide psychological comfort.
NOS4	Quiet zones or areas for relaxation are available away from commercial noise.
NOS5	Open or semi-outdoor spaces allow natural airflow or provide outdoor views.

Note: NOS = Nature of the Space.

Table A4. Social interaction and participation

Code	Item
SIP1	Shared spaces encouraged interaction and communication with other visitors.
SIP2	The mall design provides places that encourage people to meet and gather together.
SIP3	Biophilic elements create an environment that encourages social interaction.

Note: SIP = Social Interaction and Participation.

Table A5. Inclusivity and accessibility

Code	Item
IA1	The mall accommodates cultural and linguistic diversity through signage and services.
IA2	Accessibility and services are equally available for different user groups.
IA3	Facilities for people with disabilities are satisfactory.

Note: IA = Inclusivity and Accessibility.

Table A6. Psychological and physical comfort

Code	Item
PPC1	Temperature and ventilation were appropriate and comfortable throughout the visit.
PPC2	Interior lighting was sufficient and non-intrusive.
PPC3	Noise levels did not negatively affect my experience.
PPC4	Seating quality and resting areas were comfortable and adequately provided.

Note: PPC = Psychological and Physical Comfort.

Table A7. Perceived safety and well-being

Code	Item
PSW1	I felt safe and respected regardless of my background or physical abilities.
PSW2	The distribution of seating areas and public facilities supports privacy and psychological comfort.
PSW3	The levels of lighting and colors created a pleasant and relaxing atmosphere.
PSW4	Crowd density during my visit was appropriate and not excessively congested.

Note: The construct 'Sense of Place & Identity' was removed from the final analysis due to insufficient internal consistency (Cronbach's $\alpha = 0.178$). PSW = Perceived Safety and Well-being.