

Biophilic Design Patterns Implementation in Houses A Case Study of Residential Villages in Erbil City

Adeeb Nuri Ahmed ¹ & Shaaban Mustafa Shukur ²

¹Architecture Department, College of Engineering, Salahaddin University, Erbil, Iraq

²Master Student at Joint Program between Tishk International University & Salahaddin University, Erbil, Iraq

Correspondence: Shaaban Mustafa Shukur, Erbil, Iraq.

Email: shaabanmustafa.sm@gmail.com

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Abstract: In the last decade, rapid growth of Erbil city population needed more buildings to be built, due to which natural environment was faded away in order to expand built environment that led to an isolation of human beings from nature. In response to this separation, biophilic design qualities are considered as tools for reconnecting people with the benefits of nature in built environment (Kellert, 2008). This study investigated the application of biophilic design patterns practically in three residential projects located in Erbil city. The methodology was a mixed method approach through using a non-participant structured observation and an interview among residents that reside in 60 single houses to test research hypotheses. The results showed that averagely the presence strength of biophilic design patterns was low in studied houses, while more than half of respondents were aware about the benefits of biophilic design qualities. In conclusion, the factors that influence the presence strength of biophilic design qualities inside single houses are stated. Finally, the outcomes of this research provided recommendations that will help in more shifting single houses to be aligned with biophilic design strategy in Erbil city.

Keywords: Biophilic Design Patterns, Nature, Single Houses, Residents' Awareness, Income Level, Erbil

1. Introduction

Generally, the unusual rapidity of urbanization around the world is associated with a decline in accessibility to nature (Kellert, 2005). Compacted urban zones are enforcing people to consistently spend a major amount of their time inside buildings (Beatley, 2017), which is about 90% of their life. Theorists think that this has left a gap in people's life that nothing can fill artificially, based on the reality that when nature is incorporated into interiors consciously, we are unconsciously reconnected with outdoors. Nature is a vital aspect of human's needs inside living spaces as it contributes in progression of human wellbeing, satisfaction, and comfortability which is the core of Biophilia. The fixation of biophilia theory is based on the human's inner biological desire to connect with nature (Kellert, 2005). In another statement, biophilic design looks at building spaces from a human wellbeing's point of view (Heerwagen & Hase, 2001; Browning, Ryan & Clancy, 2014; Gillis & Gatersleben, 2015; Cvetanovic, Kekovic & Stankovic, 2019; Bolten & Barbiero, 2020).

2. Biophilia

Biophilia was coined by Erich Fromm (1964) in his book "The Anatomy of Human Destructiveness".

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Then the idea was more generalized by American biologist Edward O. Wilson who proposed that individuals originate from nature and have an innate tendency toward life-like processes (Wilson & Kellert, 1993). According to Browning (2014), biophilia is not a new idea due to evidences that show the existence of natural patterns in early buildings. He explains that biophilic design is the codification of history, rather than a new field of applied science. Nature and green landscape are getting reduced and deteriorated in a rapid way due to the growth of population inside cities, which has negatively influenced the human-nature attachment (Beatley, 2017). This isolation also might happen by a designing problem due to lack of knowledge about biophilic design and impact of nature on human wellbeing, which can be solved to an extent by progressing the design of buildings by designers (Kellert, 2008).

Recently, biophilic design is considered as a strategy for confronting human's wellbeing issues inside building spaces (Browning et al., 2014). In developing societies, nature is getting faded away in a rapid way to expand built environment. Moreover, there is a significant neglect about integrating natural elements inside buildings, particularly single houses. Therefore, the main focus of this research paper was to investigate practically by field survey the application of biophilic design patterns inside single houses in Erbil new villages within the period of 2003-2020 AD.

3. Biophilic Design Patterns

Based on the biophilia theory, theorists have been working on finding models to translate biophilia theory inside buildings. The most confirmed prescriptions are by Kellert & Wilson (1995) and Kellert (2008), which stated that a building can be biophilic if it contains certain parameters. In accordance, Terrapin Bright Green (2014) identified 14 biophilic design patterns and categorized them into three groups; namely, Nature in the Space, Natural Analogues and Nature of the Space, as explained below.

3.1 Nature in the Space: it covers the straight and material presentment of nature in a space or place. It encompasses seven biophilic design patterns:

[Pattern1] (Visual Connection with Nature): it refers to direct view to nature elements and living process.

[Pattern2] (Non-Visual Connection with Nature): it refers to indirect connection with nature, in another words, auditory (sense of hearing), olfactory (sense of smell), haptic (sense of touch) or gustatory (taste) stimulation that creates a positive reference to nature.

[Pattern3] (Non-Rhythmic Sensory Stimuli): it refers to an accidental, temporary and unpredicted connection with nature in built environment that can be analyzed statistically, since the senses that are achieved through non-rhythmic sensory form of nature lasts a brief time.

[Pattern4] (Thermal and Airflow Variability): it can be achieved when there is diversity of surfaces or elements that reflect natural environment in terms of air temperature and air flow.

[Pattern5] (Presence of Water): it refers to a situation in which there is sense of seeing, hearing or touching connection with water.

[Pattern6] (Dynamic and Diffuse Light): it refers to translating the diversity of light and shadow that occurs in nature from time to time in built spaces.

[Pattern7] (Connection with Natural System): it refers to presence of natural process in built spaces, especially seasonal diversity.

3.2 Natural Analogues: it covers the indirect and non-living presence of nature in a space or place. Natural analogues category covers three biophilic design patterns:

[Pattern8] (Biomorphic Forms and Patterns): it refers to experiencing symbolic patterns or textures that exist in nature on surfaces and elements that reflect nature in built environment.

[Pattern9] (Material Connection with Nature): it refers to providing sense of being in nature through experiencing natural materials and elements that reflect local ecology through minimal or no process.

[Pattern10] (Complexity and Order): it refers to feeling of being in nature through using spatial hierarchies similar to those exist in nature. It allows occupants to have feeling of engaging and information-richness.

3.3 Nature of the Space: it covers the spatial configuration of a space or place. It straightly influences spatial design. Nature of the space category includes four biophilic design patterns:

[Pattern11] (Prospect): it refers to an unobstructed view over a distance, for surveillance/supervision and safety. It is related to both indoor and outdoor environments.

[Pattern12] (Refuge): it refers to a place or zone which enhances the sensation of safety and protection from environmental conditions. It is more related to indoor.

[Pattern13] (Mystery): it refers to a place or a path which gives curiosity for giving more information and can be achieved by view or other sensory that push human to explore further. It is less experienced in houses where user spends daily time inside.

[Pattern14] (Risk/Peril): it refers to an unconscious threat mixed with a reliable and defined safety.

4. Research Problem

In Erbil city, particularly from (2003-2020) a rapid growth of population due to coming refugees from other places and moving people from suburb zones to city, more residential projects needed to be built. Natural environment faded away in order to expand built environment that caused to isolation of human beings from nature. In addition, residents might be unaware about the positive role of biophilic design as it is a recent trend in architecture. Moreover, there is a limited knowledge concerning the investigation of biophilic design application inside single houses in Erbil city. Other studies about biophilic design application in Erbil city were by Mustafa & Yaseen (2019) in a private school building and Husein & Salim (2020) in a hospital building whose results couldn't be compared to this research because of difference in building function. Therefore, to fill that gap of knowledge, this research paper focused on single house spaces.

5. Research Hypothesis

H1: There is a positive relation between the presence strength of biophilic design patterns and awareness level of residents about the benefits of biophilic design qualities in single houses in Erbil city.

H2: There is a positive relation between the presence strength of biophilic design patterns and income level of residents in single houses in Erbil city.

6. Methodology

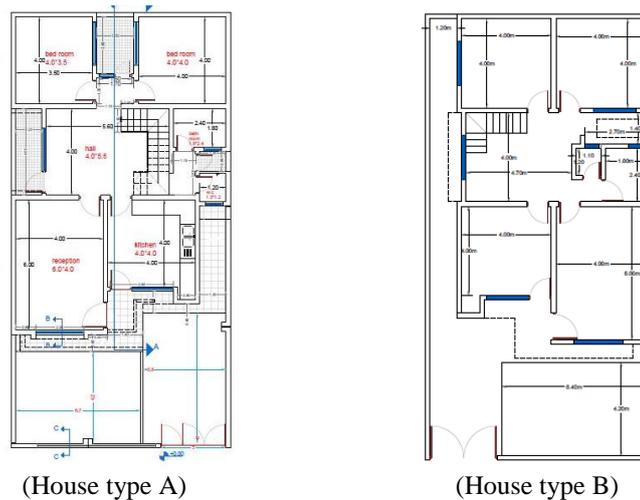
This research paper followed a mixed method approach through using a non-participant structured observation as quantitative measurement (numerical data and data that can be converted into numbers) and an interview as qualitative measurement (textual data) to collect primary data.

6.1 Sample Selection – Building Description

60 single houses (semi-detached and row) were chosen randomly at three residential projects located in Erbil city, which were built within the period of 2003-2020. "If the population is very homogeneous, then a small sample will give a fairly representative view of the whole" (Walliman, 2011). The samples were (project#1 (Golden city), project#2 (Refugee city), and project#3 (Academy city). The orientations of houses were (south and south-west). For a logical study analysis, all interior and interior-exterior spaces that have possibility to get used by occupants during a day-night were involved. During the visits, a walk through spaces was carried out, and any extra information were gained through conversation with occupants. Photography was limited because house is a private place for occupants. The relative data about residential projects are explained below:

Case (1): Residential Project#1 (Golden city)

The project#1 is surrounded by residential projects and vacant lands. It is approximately 1,070,750 sqm. It consists of 1658 house units of two design types (A and B) and both design types consist of one story, 112 villas of two design types (C and D) and both design types consist of two stories, and 1836 units in 27 multistory apartments. This research took type (A and B) houses for investigation. The ratio of type (A and B) houses floor area/lot area is about 132/200 and 120/200 sqm. Design of type (A) houses is composed of a reception, kitchen, family hall, two bedrooms, bath, three small indoor courts, a green space and a parking for one car in yard (figure 1). Design of type (B) houses is composed of a reception, kitchen, family hall, two bedrooms, bath, one small indoor court, a green space and a parking for one car in yard. Residents were resided in this project since 2012. The project's office staff claimed that averagely residents are of a low-income level. Beyond residential zone, the project's site plan contains public green areas and other building types such as educational zone, masjid, service zone, commercial zone, and recreation zone.



*scale of house plans (1:400)

Figure 1: Ground plan of houses in Golden city (source: project office), modified by author

Case (2): Residential Project#2 (Refugee city)

The project#2 is surrounded by residential projects and vacant lands. It is approximately 219,170 sqm. It consists of 482 house units of two design types (A and B) and both design types consist of one story, 22 villas of one design type (C) and it consists of two stories, and 130 units in 4 multistory apartments. This research took type (A and B) houses for investigation. The ratio of type (A and B) houses floor area/lot area is about 125/200 and 170/220 sqm. Design of type (A and B) houses is composed of a reception, kitchen, family hall, two bedrooms, bath, two small indoor courts, a green space and a parking for one car in yard (figure 2). Residents were resided in this project since 2011. The project's office staff claimed that averagely residents are of a medium income level. Beyond houses, the project's site plan contains public green areas and other building types such as nursery, school, health center, commercial buildings, football yard, and motel buildings.



*scale of house plans (1:400)

Figure 2: Ground plan of houses in Refugee city (source: project office), modified by author

Case (3): Residential Project#3 (Academy city)

The project#3 is surrounded by residential projects. It is approximately 535,000 sqm. It consists of 762 house units of four design types (A, B, C and D). Type (A) consists of one story, and type (B, C, D) consist of two stories. The ratio of type (A, B, C and D) houses floor area/lot area is about 125/200, 120/200, 170/250 and 220/350 sqm. This research took type (C and D) houses which were opened from one side only. Design of type (C) houses composed of an entrance, reception, cold kitchen, hot kitchen, family hall, four bedrooms, bath, three small indoor courts, a green space and a parking for one car in yard (figure 3). Design of type (D) houses composed of an entrance, reception and dining, kitchen, family hall, four bedrooms, bath, laundry, two indoor courts, a green space and a parking for two cars in yard. Residents were resided in this project since 2015. The project's office staff claimed that averagely residents that reside in type (C and D) houses are of a high income level. Beyond houses, the project's site plan contains public green areas and other building types such as school, health center, masjid, football yard, sport center, commercial buildings, and residential multistory apartments.



*scale of house plans (1:500)

Figure 3: Ground plan of type (C and D) houses in Academy city (source: project office), modified by author

6.2 Observation

A non-participant structured observation was used to evaluate the presence strength of biophilic design patterns in chosen houses located in Erbil city. "Observation can be used for recording data about events and activities, or conditions of objects, such as buildings" (Walliman, 2011, P.100). Microsoft Excel program 2016 was used to analyze, deduct, and represent collected data in statistical results. In this research paper, the 14 patterns of biophilic design as highlighted by Terrapin Bright Green (2014), each with several application measurements and qualities, were adopted as a benchmark for measuring the presence of biophilic design patterns inside houses. The consents of residents were obtained before starting the walkthrough inside house spaces.

6.3 Data Collection Procedure

This research used a scoring method in data collection process for evaluating the presence strength of biophilic design patterns in house spaces. The most applicable way for this type of study is to create a scoring system (Alaqeel, 2019) as shown in Table 1.

Table 1: Data collection process using scoring method (adopted from Alaqeel (2019) and modified by author)

Biophilic Design Patterns	3	2	1	0
Name of the biophilic design pattern	The biophilic design pattern strongly presents in the house. Or The presence of more than 75% of application measurements.	The biophilic design pattern moderately presents in the house. Or The presence of about 25-75% of application measurements.	The biophilic design pattern lowly presents in the house. Or The presence of less than 25% of application measurements.	The biophilic design pattern does not present in the house

6.4 Interview

Data were collected by using a face-to-face interview with open format answers that was carried out among residents inside 60 single houses to evaluate their awareness level about the benefits of biophilic design patterns. The construction of interview was based on residents' idea about the role of 21 biophilic design qualities extracted from biophilic design patterns. Thereby, respondents were asked to explain their idea about the importance of qualities, about the difference between presence and absence of qualities, about the impacts of qualities, and through data analysis their awareness level was revealed. Microsoft Excel program 2016 was used to deduct, analyze and represent collected data.

6.5 Research Variables

In this research paper, the 14 patterns of biophilic design, as highlighted by Terrapin Bright Green (2014), were adopted as the dependent variables, where awareness level of residents was evaluated as the independent variable. Then it investigated the relationship between the presence rate of biophilic design patterns with awareness level of respondents, income level of respondents, and floor area/lot area of single houses at Erbil city.

7. Results and Discussion

7.1 The Presence Rate of Biophilic Design Patterns in Case Houses

The case buildings consisted of 60 single houses located in Erbil city. The results and analysis of the observation are shown in Table 2. The important aspects of results are discussed.

Table 2: Descriptive statistics for presence rate of biophilic design patterns in 60 single houses at all projects. By using a scoring method: (by author)

(Presence of more than 75% of biophilic design application measurements = high presence **3**)(Presence of 25-75% of biophilic design application measurements = medium presence **2**)(Presence of less than 25% of biophilic design application measurements = low presence **1**)(None of biophilic design application measurements = absent **0**)

Biophilic Design Pattern	Mean of presence rate		
	Project#1 Golden city	Project#2 Refugee city	Project#3 Academy city
Visual connection with nature	1.9	1.9	1.75
Non-visual connection with nature	0.85	0.9	1.05
Non-rhythmic sensory stimuli	1.4	1.45	1.2
Thermal and airflow variability	2.15	2.85	3
Presence of water	0.15	0.15	0.3
Dynamic and diffuse light	1.4	1.9	2.65
Connection with natural system	2.7	2.6	2.8
Biomorphic forms and patterns	0.5	0.65	1.8
Material connection with nature	2	1.8	2
Complexity and order	0	0.05	0.1
Prospect	0.75	0.8	1.75
Refuge	0.7	1.45	1.95
Mystery	1	0.95	2
Risk/peril	0.05	0.45	0.4
Total Mean	1.11	1.28	1.62

The results showed that the presence of thermal and airflow variability took highest score in project#3 by (3) points. A factor was that lot area of studied houses was efficient which was helpful in providing well sized and well positioned courts to provide natural airflow variability. Another factor was high income level of respondents which was helpful in providing sufficient thermal and airflow system inside spaces. The occurrence of this pattern was through natural ventilation from window, efficient mechanical ventilation system, comfortable thermal system, and exposure of indoor surfaces to direct sunrays. Dynamic and diffuse light took a high score at project#3 by (2.64) points and the factors were sufficient lot area of houses, well sized and positioned courts, and income level of respondents, since the occurrence of this pattern was through natural daylight from window, artificial diffuse light, using sun shades, and controlling the color and rate of light fixtures to connect them to (circadian) system. Where, the presence of complexity and order took lowest score in project#1 by (0) point. A factor was high cost of establishing this pattern compare to other patterns; however, all patterns seem to be somehow costly at first, but the initial costs of biophilic design are not compared to the long period pay backs through providing optimized spaces for occupants and decreasing poor health. On the other hand, the results showed a low presence of complexity and order in project#3 by only (0.1) points

despite the high-income level of respondents, which indicated that there could be other factors causing to low presence of this pattern. Another important result was the low presence of water in houses at all project by (0.2) points averagely. The factors were establishing cost and insufficient condition of water supply in Erbil city generally. The occurrence of this pattern was low to absent through establishing fish tanks and small water fountains. Another pattern with lowest score at all projects was risk/peril by (0.3) points averagely. Beyond establishing cost, another factor was that in designing houses risk/peril is not a priority because residents look for experiencing safety feelings inside houses. Where mystery took a medium score in project#3 by (2) points compare to other projects because of applying an open plan strategy and fluidity in houses at project#3 that motivate users to explore further and find what is happening in next spaces, especially between entrance-kitchen-living hall. However, confronting the same familiar spaces may decrease mystery and it will decay during a long time in houses. Related to establishing cost, biomorphic forms and patterns took higher score in project#3 by (1.8) points where income level of respondents was high. The occurrence of this pattern was through spiral staircase, using organic forms and patterns for finishing materials, furniture, lighting features and openings.

Biophilic design patterns can be used with endless possibilities in either retrofitting existing house spaces with less cost or designing new ones. In another words, different levels and forms of biophilic design patterns can be incorporated inside houses depending on resident's income and awareness level, which will positively impact resident's wellbeing in all ways. Averagely, the presence strength of biophilic design patterns in the three projects was low, which took highest score in project#3 by (1.62) points, and lowest score in project#1 by (1.11) points, as shown in Figure 4.

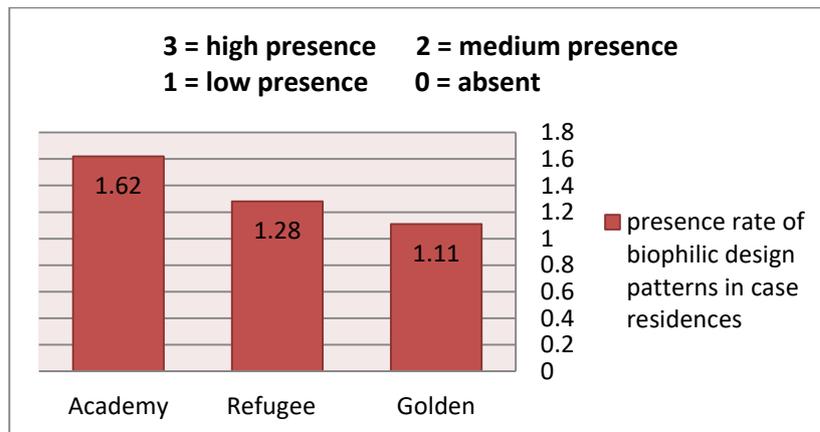


Figure 4: Presence rate of biophilic design patterns at residential projects in Erbil city (by author)

7.2 The Awareness Level of Residents about the Benefits of Biophilic Design Patterns

The participants consisted of residents that live in 60 single houses at three house projects. The analysis of interview is shown in Table 3. The results are discussed below.

Table 3: The percentages of awareness level of residents about biophilic design qualities in 60 single houses at all projects (by author)

Biophilic design qualities	Awareness level of respondents about biophilic design benefits					
	Project#1 Golden city		Project#2 Refugee city		Project#3 Academy city	
	Aware respondents	Unaware respondents	Aware respondents	Unaware respondents	Aware respondents	Unaware respondents
Visual access to indoor plants and outdoor plants: garden, courtyard, balcony, window boxes, patio, green walls, and vegetated roofs.	100%	0%	100%	0%	100%	0%
Visual access to water features: aquarium, wall water flow, and fountain.	80%	20%	40%	60%	60%	40%
Having non-threatening pets and birds.	55%	45%	30%	70%	25%	75%
Access to natural ventilation system through establishing operable windows or skylight in all spaces.	100%	0%	100%	0%	100%	0%
Exposure of indoor surfaces to direct sun ray.	100%	0%	100%	0%	100%	0%
Access to control comfortable thermal system including (heating and cooling).	55%	45%	50%	50%	20%	80%
Establishing window/skylight to provide dynamic and diffuse daylight for indoor spaces.	100%	0%	100%	0%	100%	0%
Using tinted glass for window/skylight to control intense sun rays.	0%	100%	0%	100%	0%	100%
Using sunshades for window to control intense sun rays.	0%	100%	0%	100%	0%	100%
Indoor artificial diffuse light or the play of lightness-darkness or task	45%	55%	45%	55%	70%	30%

lighting or lighting with specific functions, such as movement guidance.						
Providing access to control the color of indoor light to provide (circadian) lighting system.	10%	90%	30%	70%	30%	70%
Existence of indoor/outdoor spaces that use only at a certain weather month, hot or cold months, including balcony and patio.	100%	0%	100%	0%	100%	0%
Existence of biomorphic textures for finishing materials based on natural organic.	15%	85%	40%	60%	25%	75%
Existence of biomorphic forms, textures, and colors for furniture based on natural organic.	15%	85%	40%	60%	40%	60%
Applying biomorphic (natural organic) forms and pattern for openings.	5%	95%	35%	65%	40%	60%
Using wood or stone material for surface finishing materials	15%	85%	35%	65%	40%	60%
Using wood material for living, bed room, and kitchen and dining furniture materials.	75%	25%	80%	20%	75%	25%
Using wood material for opening materials.	100%	0%	80%	20%	80%	20%
Existence of spaces with canopy effect to provide refuge.	100%	0%	100%	0%	100%	0%
Existence of small-scale windows between interior spaces to provide mystery.	0%	100%	0%	100%	0%	100%
Provision of visual access to oversize hung lighting features to provide risk.	40%	60%	45%	55%	55%	45%
Mean	52%	48%	55%	45%	55%	45%

The results showed that no respondents were aware about the benefits of using tinted glass and sunshades for window/skylight to partly block intense sun rays. However, based on the observation results, there were sunshades established in few houses for rain protection purposes, but the users had

no idea about their benefits for blocking direct sunrays. However, all respondents inside the three projects were aware about the benefits of following qualities: having access to indoor and outdoor greenery, having dynamic and diffuse daylight through window/skylight in all spaces, natural ventilation through window/skylight, the benefit of exposing indoor surfaces to direct sunrays for thermal variability and health in terms of sterilization and sanitation, having spaces that get used in certain weather conditions such as patio, and the benefit of having spaces with canopy effect for rain and sun protection purposes as a refuge. Based on the observation results, experiencing all of these qualities was occurring in various level and forms depending on the occupants' income level. The awareness level of respondents about the rest of biophilic design qualities was ranged between them. For example, 80 percent of respondents in project#1 were aware about the benefits of visual access to water features, which was highest among the three projects. However, the presence of water was low and respondents considered cost as a main factor. Another important result was low awareness level about the benefits of controlling color and rate of lighting to connect to (circadian) system, which was averagely (23) percent of respondents in all projects. However, based on the observation results, lighting system with various color and rate were established in some houses, but the occupants had no idea about circadian system and they didn't get benefit of it. Finally, the awareness level of respondents about the benefits of using wood for opening material was higher than using wood for furniture and envelope surfaces. Beyond the cost, another factor was the respondents' wrong idea about strength and durability of other materials such as aluminum compare to wood. Moreover, some respondents believed that using wood for envelope surface material is not applicable because of winter humidity inside spaces.

Overall, the presence strength of all biophilic design patterns inside houses was low and not parallel to awareness level of respondents about the benefits of patterns which indicated that there were other factors such as cost and space sizes that can have a negative effect on the presence of biophilic design patterns. Averagely, (55) percent of respondents were aware about the benefits of biophilic design patterns in both project#2 and project#3, where it was lower in project#1 about (52) percent of respondents, as shown in Figure 5.

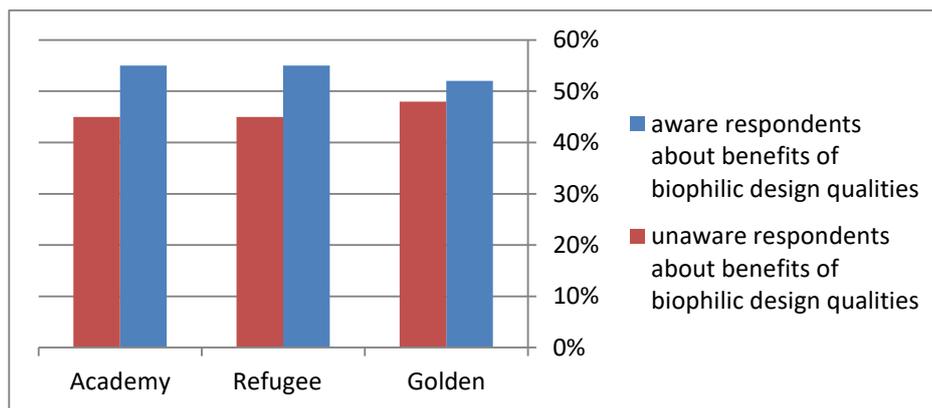


Figure 5: Awareness level of respondents about benefits of biophilic design qualities at three residential projects in Erbil city (by author)

7.3 Relation between the Presence Strength of Biophilic Design Patterns and Awareness Level of Respondents about Benefits of Biophilic Design Patterns

This research hypothesized that there is a positive relation between the presence strength of biophilic design patterns and awareness level of respondents about the benefits of biophilic design qualities. To test this hypothesis, it evaluated the relation between the two variables as shown in table 4.

Table 4: Descriptive statistics for relation between the presence strength of biophilic design patterns and awareness level of respondents about the benefits of biophilic design qualities in case projects (by author)

Project name	Total mean presence of biophilic patterns	Awareness level of respondents about the benefits of biophilic design quality	
		Mean of aware respondents	Mean of unaware respondents
Project#1 (Golden city)	1.11	52%	48%
Project#2 (Refugee city)	1.28	55%	45%
Project#3 (Academy city)	1.62	55%	45%
Total Mean	1.33	54%	46%

The results showed that the presence rate of biophilic design patterns and awareness level of respondents about the benefits of biophilic design qualities in project#2 were parallel to project#1, which indicated that there was a positive relation between the two variables in project#2 compared to project#1, that matched the research hypothesis (H1). While the change in these two variables in project#3 were not parallel to project#2, which indicated that there was no relation between the two variables in project#3 compare to project#2, that didn't match the research hypothesis (H1), as shown in Figure 6.

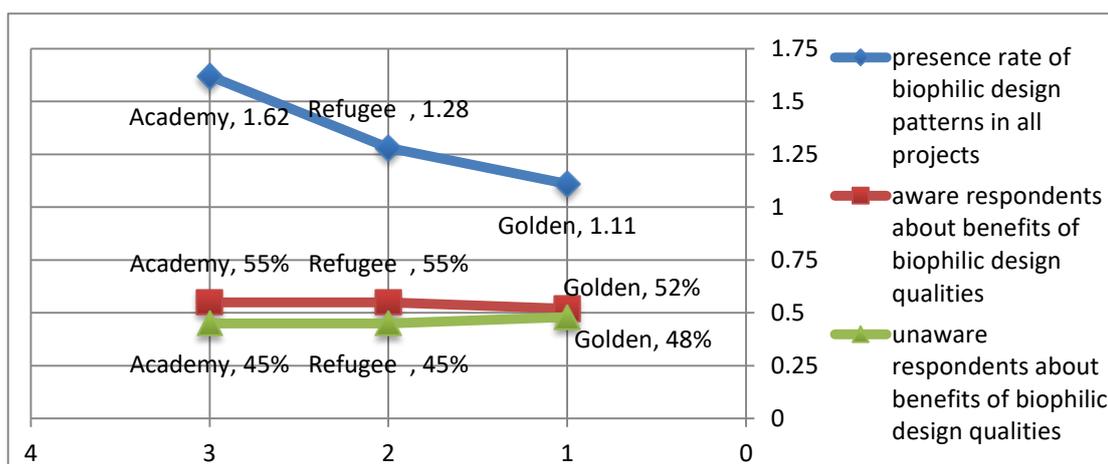


Figure 6: The relation between the presence strength of biophilic design patterns and awareness level of respondents about the benefits of biophilic design patterns in three residential projects in Erbil city (by author)

Averagely, the presence strength of biophilic design patterns in case projects was low by (1.33) points, where 54 percent of respondents were aware about the benefits of biophilic design qualities, as shown in Table 4.

7.4 Relation between the Presence Strength of Biophilic Design Patterns and Income Level of Respondents in Case Houses

This research paper hypothesized that there is a positive relation between the presence strength of biophilic design patterns and income level of respondents in case houses. To test this hypothesis, it evaluated relation between the two variables as shown in table 5.

Table 5: Descriptive statistics for relation between the presence strength of biophilic design patterns and income level of respondents in case projects (by author)

Project name	Total mean presence of biophilic patterns	Income level of residents in projects
Project#1 (Golden city)	1.11	Low
Project#2 (Refugee city)	1.28	Medium
Project#3 (Academy city)	1.62	High
Total Mean	1.266	

The presence strength of biophilic design qualities in project#1 took (1.11) points, where income level of respondents was low. While the presence strength of biophilic design qualities in project#2 took (1.28) points, higher than that in project#1, where the income level of respondents was medium, which indicated that there was a positive relation between the two variables in project#2 compare to project#1 that matched the research hypothesis (H2). While the presence strength of biophilic design qualities in project#3 took (1.62) points, higher than that in project#1 and project#2, where the income level of respondents was high, which indicated that there was a positive relation between the two variables in project#3 compare to other projects that matched the research hypothesis (H2), as shown in Figure 7.

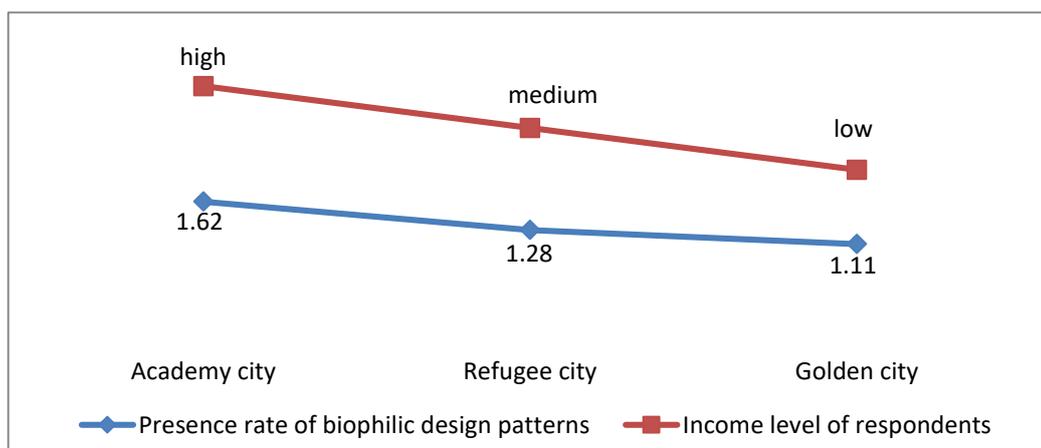


Figure 7: The relation between the presence strength of biophilic design patterns and income level of respondents in three residential projects in Erbil city (by author)

Averagely, the presence strength of biophilic design qualities was lowest when respondents were at a low income level compare to houses with high income level respondents in which the presence strength of biophilic design qualities was higher, as shown in Table 5.

8. Conclusion

Current interior space designs inside single houses are not providing biophilic spaces for occupants where they can enjoy the advantages of nature. The results of this research showed us the same situation inside single houses in three residential projects in Erbil city. According to findings of this research, the three residential projects cannot be used as a model to evaluate the biophilic design criteria in other buildings.

Based on the findings, it can be concluded that the awareness level of respondents cannot be the only factor for low presence strength of biophilic design qualities in houses, as the findings indicated that averagely more than half of respondents were aware about the benefits of biophilic design qualities in houses. Parallel to awareness level, cost can be another factor, as findings indicated that the presence strength of biophilic design qualities was lowest when respondents were at a low income level compared to houses with high income level respondents in which the presence strength of biophilic design qualities was higher. Another factor could be the floor area/lot area of houses, as findings indicated that the presence strength of biophilic design qualities was highest when floor area/lot area of houses was biggest, however there was a weak relation between these two variables in 2 out of 3 residential projects.

Future study would be beneficial to investigate other factors that influence the presence strength of biophilic design qualities in houses. It is recommended to repeating this study focusing on other house types (such as detached house and multi-story residential apartment) and other functions (such as malls, mixed use buildings and museums).

9. Recommendation

To enhance the space qualities inside houses, real estate companies and designers should measure the resident's fulfillment and plan the spaces in the light of resident's desire and needs; so, in Erbil city, they should do the same. Overall, single houses (semi-detached and row) in residential villages are less shifted to be aligned with biophilic design patterns compare to detached houses outside residential villages, because of the initial costs of establishing the biophilic design patterns which is a prior concern of real estate companies. However, occupants can establish the biophilic design resolutions in various forms and strengths that: (a) match their level of income, (b) match their house spaces, and (c) are not disagree with the client company guidelines, to retrofit and shift the existence houses to be aligned with biophilic design trend.

Hudson (2013) believes that biophilic design is a philosophy rather than a list of regulations to follow, and design thoughts should be shifted to be aligned with biophilic design patterns. However, with knowledge about some practice-based resolutions for implementing the biophilic design patterns, it would be more helpful to incorporate them into house spaces, as follows:

Visual connection with nature

- Allocating most of front yard space for diverse green landscape that can be visible.

- Providing physical and visual access to indoor greenery in form of potted plants, as well as green walls and vegetated roofs especially for houses with limited areas.
- Enhancement of residents' contact with outside through window area and design.

Non-visual connection with nature

- Selecting the local plants and trees that are: (a) suitable climatically, and (b) can provide olfactory experience for residents.

Thermal and airflow variability

- Establishing well positioned and efficient sized indoor courts to provide natural ventilation inside spaces.
- Establishing well positioned skylight where lot area of houses is limited.
- Establishing an efficient mechanical ventilation system HVAC inside spaces.
- Establishing a comfortable thermal system including (heating and cooling) inside spaces, which could be through passive solar systems applied by architectural designs.

Presence of water

- Establishing indoor and outdoor water features in form of wall water flow, fish tank as a part of wall, and small fountain that are friendly water consuming, as water supply condition in Erbil city is being insufficient.

Dynamic and diffuse light

- Establishing well positioned and efficient sized windows and indoor courts to allow more natural daylight inside spaces as part of building regulations.
- Providing daylight from multiple sides.
- Using manual sun shades to control glare, especially at east, south and west orientated houses.
- Using materials that don't have high reflective properties to avoid glare.
- Preference of using diffuse lighting system to allow more diffuse light inside spaces as being more comfortable for eyes.
- Preference of using variety of lighting options to allow more dynamic light inside spaces.
- Allowing users to control the color and rate of lights during a day to connect them to circadian circle.
- Make use of orientation to get more natural daylight in addition to heat gain in winter through intended architectural design stages.

Connection with natural system

- Maximizing the indoor-outdoor spaces that only used at certain weather conditions in form of patio and balcony.
- Establishing roof landscape in the case of two-story houses.

Biomorphic forms and patterns

- Using materials based on organic patterns and forms for wall, ceiling, floor, and openings.
- Minimizing geometric patterns for wall, ceiling and floor.

- Using furniture based on organic forms.
- Using natural-based forms for staircase.
- Maximizing artificial lighting that symbolizes natural patterns.

Material connection with nature

- Preference of using natural and minimally processed materials such as wood, stone, brick, and leather over processed materials for wall, ceiling, floor, openings, and furniture, depending on the availability of local materials to decrease cost, and maintenance by local professionals.
- Preference of using local materials to improve place-based experience inside spaces.
- Preference of using materials with natural-inspired colors which has minimal toxicity.

Complexity and order

- Using spatial planning scheme that reveals fractal hierarchies.
- Using fractal geometries for surface material patterns.

Prospect

- Following an open plan strategy that provides view to multiple spaces wherever possible.
- Providing maximum visual access to front yard landscape.

Refuge

- Using (a) canopy effect, (b) particular lighting and temperature, and (c) lowering ceiling wherever possible to provide sense of refuge inside a space.
- Taking advantage from the space under stair case for sitting purpose.
- Maximizing deepness of window boxes to be used for sitting purpose.
- Using furniture that is covered from more than one side.

Mystery

- Following fluidity in spatial planning and preference of smooth curved lines over straight ones.
- Establishing small scale openings between spaces wherever possible, for example kitchen-dining area.

Risk/peril

- Proving risk/peril that is mixed with a defined safety in form of (a) oversized lighting fixtures, (b) glazed handrail, (c) establishing double volume spaces, and (d) fireplace.

General recommendations for raising the social and individual awareness about the role of biophilic design:

- Increasing the role of municipality to create regulations or put some incentives for real estate companies for applying qualities of biophilic design which are related to human wellbeing.
- Increasing the role of education from kindergarten till university to encourage and explain the role of nature on human wellbeing practically through visits, surveys, and researches.
- Biophilic design could be part of architecture and interior design department's syllabuses as new theory and applied practically in student projects.

- Conducting workshops and seminars for architects and people about the role of nature on human wellbeing.
- Increasing the role of advertisement (TV, radio, cinema, and social media) to encourage and explain the role of nature on human wellbeing.

Accordingly, the results of this research showed what type of spaces are required as biophilic space, and arranged architectural resolutions for it. Thereby, these appropriate recommendations will inspire the future renovation and new design of single houses. Finally, we can say that single house design orientation within residential projects needs to be re-assessed based on the reality that the recent house space designs are trying to be more attuned to residents' desires.

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