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Post occupancy evaluation of private open spaces in dwelling units in single family investment housing projects in Erbil city

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ABSTRACT

Due to urbanization, it has been found that in many cases public open spaces in the city are not maintained, as new investments are trying to make use of the land to construct more buildings The shortage of public open spaces can be treated by providing a sufficient amount of private open spaces in housing estates. Furthermore, the designers need to consider the dwelling layout to provide the best environment for the residents; this will maintain a high level of household satisfaction. One main element of household satisfaction is open spaces. In this research paper, private open space assessments in 4 investment projects with 98 samples in Erbil were considered. To investigate and examine how the exterior environment of the dwellings affects the residents' satisfaction, based on plot size and number of bedrooms, surveys were performed on selected projects through documentation surveys and questionnaires. Then the evaluation was performed through two stages, firstly the technical assessment stage according to Iraqi standards, and secondly the residents' response stage regarding satisfaction levels. The research objectives were obtained using SPSS software, through the use of descriptive statistics, correlation, and regression analysis. The results of the research discovered that all the projects except Minara B were slightly above the minimum level, thus in the range of Iraqi standards. Moreover, the level of overall satisfaction with these projects ranged from neutral to slightly satisfied, with the residents' responses stating that they needed more private open spaces.

1. Introduction

In general, when the designers of a residential project design the houses, they take the user's needs into consideration, but that is only implied for the building part of residential units, despite that, while planning open space areas, they practically neglect residents' point of view. In addition, due to urbanization, the space specified for open space in those projects has decreased because they want to have as much closed space as possible. As Oktay says, Open areas around residences are extremely important for developing and/or boosting social interaction among inhabitants as well as enriching daily living in individual units - especially in hot climates, [1]. Furthermore, the success of a building or a project does not only depend on the interior design but according to some studies, the space around and between the buildings has more effect on the success of a project. While designing an open space the residents' requirements, culture, and lifestyle should be considered; all these factors affect people's satisfaction with a project. However Open space is a significant part of every residential area, because Residential open space as a housing setting is related to the form, shape, plan, structure, and functions of the built environment and has a valuable effect on the quality of the residential environment, [2-4].

Open space can be categorized into four groups: public, semipublic, semipublic-semiprivate, and private spaces, [5-7]. In this paper, private open spaces were evaluated, and the main defined parts are Balcony, Private Garden, Garage or Car Parking, and Outdoor Circulation. These

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areas are important for the residents, and Principles of private open spaces ensure that the dwelling has an outdoor living area that is an extension of the indoor living area. It must be large enough to be usable, [8]. In addition, open space is a very important part of the design of a dwelling because it affects satisfaction positively, and it provides a place for the residents to relax, play, and enjoy nature.

1.1. Definition terms

1.1.1 Post Occupancy Evaluation (POE)

Is the most widely used method of building assessment and planning among building inspectors and planners, The term 'post-occupancy' refers to a building that has previously been occupied and is available for inspection [9-11]. As a result, assessment is utilized to collect feedback from building users and specialists to enhance the building's condition. According to Fronczek-Munter (2017)[4], traditional POEs typically focus on technical building performance. Jensen (2012)[8], on the other hand, proposes that combining technical and user-oriented building evaluation performance could result in significant improvements in building performance

1.1.2. Open Space

Open space is any open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public. Open space provides recreational areas for residents and helps to enhance the beauty and environmental quality of neighbourhoods. However, since it is believed that plazas, playing fields, and urban squares are contributing to improving public health and the environmental quality of the neighborhood, they are often included in the definition as well,[12]. It can even be thought of as extending to include all significant outdoor spaces, which fall within the influence of the urban area [13].

1.1.3. Dwelling Unit

A dwelling unit is a building or a portion of construction that is used by one person to maintain a household or by two or more individuals to maintain a joint household as their place of residence, sleeping spaces, or other living arrangements [14].

1.1.4. Household Satisfaction

The household satisfaction index is not only an important measurement index of household living quality but also a reflection of the housing industry's economic performance and production effectiveness, [15]. Housing satisfaction refers to how a customer reacts to the overall components of housing items in response to their expectations. It is also the extent to which residents believe their housing is assisting them in achieving their goals, [16].

1.2 Literature Review

Oktay's 2010 research paper is about the usage and meaning of housing's open spaces. The author says that the success of housing does not depend on the interior design only, but it depends more on the spacing between the buildings. Moreover, the designers should consider the users' culture and lifestyle, while designing the open spaces. He discovered that the response from people who were living in flats was more negative in comparison to the house residents. For flats, the private open space comes in the form of balconies, so in general, their level of satisfaction is found to be lower. Furthermore, the author has shown that the garden plays an important role in people's lives and their satisfaction, so it should be considered carefully for the success of the projects. Most people are not satisfied with their open spaces due to poorly designed open spaces both in flats and house residents. Azad, Morinaga, and Kobayashi's 2020 [17] research paper talks about the 'effects of housing layout and open space on the residential environment'. They identified that urban development has led to a decrease in open space, but it is important for designers to consider the layout and take open space into consideration because it is directly related to the residents' satisfaction. As mentioned in the article, "Residential open space as a setting of dwelling is related to form, shape, plan, structure, and functions of the built environment and has a positive impact on residential environment quality. The open space provides some privacy for the residents to relax, play, enjoy nature, and communicate. Moreover, there are several environmental functions of open space, and those functions are defined as the borders between houses, separating neighborhoods, and allowing the entering of fresh air and sunlight. Private open spaces are directly associated with individual houses and with individuals' satisfaction. The authors identified that "Because of the importance of indoor-outdoor connections in a sub-tropical climate, the design, orientation and furnish ability of these spaces are critical to resident satisfaction." (Sarkissian, et, al. 2013). Moreover, they mentioned that besides the public open spaces, there should be private open spaces in the dwellings as shown in Fig.1. In addition, the effects and effect on the importance of private open spaces should not be underestimated because it has direct residents' mental and physical health

Figure 1. Private open space: general site overview source [13]

According to the authors, there are several aspects of private open spaces, and those aspects are as follows. The direction of the gardens should not be facing south, and they should not have high walls so that the plants can grow. In addition, "Avoiding significant overshadowing from adjacent buildings, fencing or trees in designing the development as far as possible" [13].

Irwin and Bockstael's 2020 paper talks about the 'measure and effects of open space on residential property value'. They have found that the effects of open space on land value depend on the size of the neighborhood that is being considered; they say that "within a tenth of a kilometer radius, the proportion of open space has a positive and significant effect on land values, but within a larger than one-kilometer buffer has a negative and significant effect." [19].

Al-Noori's paper is about the 'environmental design evaluation of housing in Baghdad'. She discovered that the satisfaction of residents is directly affected by open space. Moreover, privacy is a very important aspect of open space that should be considered by the designers. She mentioned that during the site visits, the number of private gardens surprised her even though it had not been included in the designs. That shows the need for open space by people. The study has shown that more people who were living in flats were satisfied with their type of open space with its balcony. Nevertheless, it has been found that people were using their balconies for other purposes. Meaning it was not the same purpose that the designers had intended. According to the author, "the studies suggested that private open space, whether it is a garden, patio, or balcony, is a highly significant component of the housing environment, which is appreciated and used by the majority of residents for outdoor living and as an extension of the indoor living area, as well as for leisure and hobbies.

Open space affects the price of the houses, so the designers should consider it. According to the research, houses without gardens are cheaper than houses with gardens. Moreover, garage, which is another type of open space, have also affected the price of the houses. It is not as significant as a garden, but it affects people because people are satisfied with their garages. The importance of a garage comes when the evaluated house is without a garden. As the author says, "For a house without a garden, the age of the house and the number of garages are factors that have a strong impact on the house price. Land size for a house without a garden is less important compared to a house with a garden. On the other hand, the age of the house, the number of bedrooms, and the number of garages and amenities around the house areas do impact the house price for a house without a garden when compared to a house with a garden. This research paper is concerned with 'planning indicators of open spaces in residential areas. While designing a residential area several important factors should be considered besides interior design and structures, open space should also be considered. As it is mentioned, "All family dwellings must be provided with space close to the dwelling for the activities of the family. This may be done in one of two ways - either by providing enough Private Open Space around the house to accommodate all the activities as shown in Fig.2, or by providing a Communal Open Space shared between several dwellings to accommodate some of the activities and a small Private Open Space near the dwelling for activities which cannot be accommodated in the Communal Open Space." (Open Space in Residential Areas) Open space should be provided for the dwellings to accommodate activities for the residents, and its area should not be less than 50 meters square. It should receive sufficient sunlight and daylight; and not be overlooked by other houses, and housing committees should allow it for change, extension, and development[19-20].

1.3 Research problem

Due to urbanization, investment in residential areas has increased, and some estates failed to follow standards that guide the designers in a way not to underestimate private open space. In addition, there is not enough control over areas provided for open spaces in both private and public projects, with a low commitment to standards by the designers to provide sufficient services for householders. Mainly their satisfaction is ignored when it specifically comes to private open space. There is limited research about public open spaces, with even fewer numbers about private open spaces.

1.4 Research objectives

The main aim of this research paper is to investigate private open spaces within dwelling units in Erbil's housing estates, defining its parts, total area, and indication of resident satisfaction. To focus on the value of open spaces that makes designers better consider this subject.

1.4 Research objectives

The main aim of this research paper is to investigate private open spaces within dwelling units in Erbil's housing estates, defining its parts, total area, and indication of resident satisfaction. To focus on the value of open spaces that makes designers better consider this subject. Hence, this study is subjected to achieve finding answers to the stated issues:

- To understand the terms and parts of private open space in single-family houses.
- To compare those parts of private open spaces in different dwelling unit types.

Comparing dwellings overall private open spaces with Iraqi standards.

To discover the relation between demographic factors and satisfaction factors of residents in each dwelling units type. Discovering the overall household satisfaction about private open spaces in each selected dwelling unit, and factors contributing to this satisfaction.

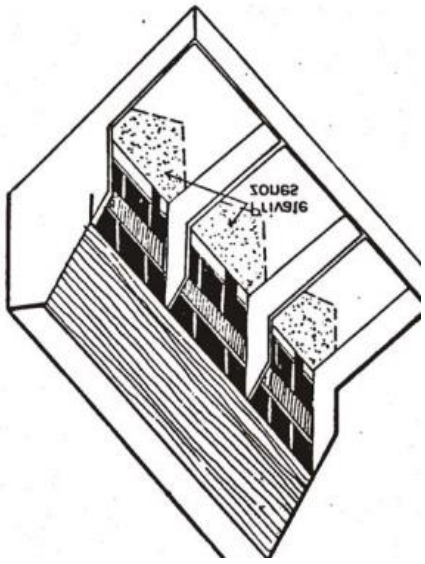

Figure 2. Private open space source (Limsombunchai 2014)

2. Methodology

To attain research, aim, and objectives, the current study methodology consists of two main parts which are documentation and survey adopting questionnaire:

2.1 Documentation

This stage consists of general information about housing estates to select dwelling units that represent whole housing in Erbil city based on several bedrooms and plot size of dwellings.

2.1.1 Selecting samples of case studies and data collection

After visiting several projects in Erbil city, four housing projects were chosen as case studies based on the ratio of dwellings according to a few bedrooms, and plot size namely, projects "Minara City, Lana City, Italy City, and Hiwa City." As shown in Table 1. Research classification based on several bedrooms to connect the private open space parts to the dwelling unit interiors, with the plot area to make a comparison with Iraqi standards. Then the sample questionnaire for each dwelling unit is conducted based on the total number of houses in each project. As the total sample reached 98 samples for all dwelling units, it satisfies two conditions, first number of cases per each type is to be more than 5 samples, secondly, the number of samples per group must be 24 and above for main groups except 3 bedrooms that reached 75% of cases as shown in Table 1. Then the questionnaire was conducted to 98 households in all dwelling units through direct interview.

2.1.2 Descriptions of the selected housing investment projects

- Minara city (200 m^2): this project is in the Kurdistan Region in Eastern Erbil city. It is an investment project that consists of 1436 units with two and four bedrooms; for this research, both units with two bedrooms have been selected for evaluation and household satisfaction with private open spaces.
- Italy 2 city (200 m^2): this project is in the Kurdistan region in Erbil city, on 120m road and Shaqlawa road. It is an investment project, which consists of 1560 houses with different sizes of houses and several beds.

In this research, paper all different types have been selected which are 200m^2, 240m^2, and 320 m^2 with three and four bedrooms, for evaluation and household satisfaction.

- Hiwa city (200 m^2): this project is in Kurdistan Region in Erbil city on Koya's road. It is an investment project that consists of 1247 houses, and they are divided into two types 200 m^2 and 400 m^2. For this research, both types with five bedrooms have been selected for evaluation and household satisfaction.
- Lana city (300 m^2): This project is in the Kurdistan Region in Erbil city on Koya's Road. It is an investment project, that consists of 519 units with two different areas 200 m^2 and 300 m^2. In this research, both types have been selected with three and four bedrooms for evaluating household satisfaction with private open spaces.

Table 1. Classification of dwelling units according to bedrooms and plot size, with Questionnaire sample

Dwelling units	Number of bedrooms	Plot area m^2	Total number of dwelling units	Optimum sample size	Optimum group size
Minara	2	200	1050	22	22
Lana	3	200	464	10	16
Italy 2	3	200	321	06	
Minara	4	200	386	08	36
Italy 2	4	240	670	14	
Lana	4	300	055	02	
Italy 2	4	320	569	12	
Hiwa	5	200	444	08	24
Hiwa	5	400	803	16	
Total			4762	98	98

2.2 Questionnaire list

In this part, the list of questions about parts of private open space in the dwelling units has been prepared. However, the questionnaire was designed using a Likert scale. The questions were written on the questionnaire paper as statements. The statements were represented by five points on the Likert scale, where (5) represents highly satisfied, (4) represents satisfied, (3) represents neutral, (2 represents dissatisfied and (1) represents highly dissatisfied. The research aims, and objectives are achieved through five main indicators which they are:

2.2.2 General indicators

Data here refers to the family and private open space parts, and the variables stated in each dwelling including relations between indicators of those variables

.

2.2.3 Specific indicators

Which refers to the size, number, and location of each part of private open space in addition to the total private open space size.

2.2.4 Derived indicators

Which consists of variables covering the Open Space Ratio (OSR) added to the percentage of each component.

2.2.5 Household Satisfaction Indicators

Concerning the private open spaces parts, variables of household satisfaction are stated as follows:

- Household Satisfaction with size, number, shape, location, level of privacy, ventilation, number of entries, outdoor activities, and accessibility for each type of private open space.
- Needs of the households about the size of private open spaces parts with
- The overall household satisfaction with each private open space part. And relating that to the total satisfaction with open spaces.

2.2.6 Needs (demands) Indicators

The questionnaire list determined the needs of the residents. To assess this portion, the same Likert scale degrees were employed, including (much smaller, smaller, same, larger, and much larger) for each area: garden, garage, balcony, and outdoor circulation.

Then the Result analysis and findings: the general dwelling unit characteristics compared to the Iraqi standards as well as the results of the questionnaire analyzed through SPSS and Excel programs to approach findings.

3. Results and discussions

3.1 General indicators and housing indicators results

First general indicator results: it was discovered that there is differentiation in the area of private open spaces in the units, as shown in Table 2. In addition to that the total private open space area was found to compare with the Iraqi standards, which is called Plot open space Coverage as shown in Table 3. Due to the number of bedrooms, in some dwelling units such as Italy-two 200m^2 and Lana, there are different sizes in each part of the private open spaces. Even though the two units were designed with three bedrooms, the private open space parts were different. For example, the front garden in Lana 200 m^2 is 41.15 m^2, which is bigger than the front garden in Italy-Two 200 m^2, which is 19.84 m^2, as well as the other parts of private open spaces in the same units and other dwelling units with different numbers of bedrooms. As clarified in Table 2. Furthermore, due to the plot size area of the dwelling units, the overall private open space was compared to the Iraqi standards. Then it was discovered that all the projects were considered within standards, except Minara B with 200m^2, where the overall private open space parts are 28.9% while the corresponding minimum plot open space coverage in Iraqi standard for this plot area is 30%. Furthermore, some dwelling units' ratios exceed the minimum standard area, such as in Hiwa dwelling units' type 400m2 and both types of Lana city as shown in Table 3. In the second part of the results of general indicators: the relation between general and housing indicators was dealt with, classification based on the number of bedrooms, indicators included built-up area, plot area, family size, size of each private open space item, and total private open space area. It has been discovered that most of the indicators had significant correlations to other indicators by using SPSS software. The following findings are stated from strong to weak correlations with the support of Table 4.

- The strongest correlation between indicators is the relation between total private open space area and the size of the garden, which is 99% followed by the size of a plot with 95%. Meaning the total private open space area became bigger mainly due to the size of the garden and the plot in dwelling units. Outdoor circulation also follows the above ones with 90%.
- Medium level of correlations with private open spaces with values of 60% and 57% followed by 42% obtained by several bedrooms and total built-up areas then garage size means some degree of synchronization.
- The family size increase didn't contribute to the open space ratio increase in housing projects in Erbil.

Table 2. Area of the Private Open Spaces (P.O.S.) parts in nine selected units based on number of bedrooms

Bedrooms in D.U. / P.O.S. parts	2	3 bedrooms		4 bedrooms				5 bedrooms	
	Minara-A 200 m²	Italy-Two 200m²	Lana 200m²	Minara-B 200m²	Italy-Two 240m²	Lana 300m²	Italy-Two 320 m²	Hiwa 200m²	Hiwa 400m²
Front Garden size m²	19.80	19.84	41.15	18.00	30.40	82.70	25.23	18.85	50.50
Back and side garden or court size m²	07.15	13.70	09.90	01.50	10.92	06.12	14.00	No	89.44
Total garden area	26.95	33.54	51.05	19.50	41.32	88.82	39.23	18.85	139.94
Garage size m²	25.20	26.52	30.76	19.20	32.00	39.68	32.30	23.10	30.00
Outdoor circulation size m²	14.40	04.96	04.00	15.30	06.50	No	41.27	23	62.10
Balcony size m²	No	No	No	03.96	No	No	No	No	09.20
Total P.O.S. area m²	66.55	65.02	85.81	57.96	79.82	128.5	112.8	64.95	241.24
P.O.S. ratio P.O.S.R.=OS/LA	33.3%	32.5%	42.9%	28.9%	33.3%	42.8%	35.3%	32.5%	60.0%

Table 3. Overall private open space area in units with Iraqi standards based on plot size area

Dwelling units	Plot size area m²	Private open space ratio %	Min plot open space coverage	Max built coverage %
Minara A	200	33.27	30	70
Italy 2	200	32.51	30	70
Lana 200m²	200	42.90	30	70
Minara B	200	28.90	30	70
Hiwa	200	32.48	30	70
Italy2	240	33.25	30	70
Lana	300	42.38	35	65
Italy2	320	35.25	35	65
Hiwa	400	60.03	35	65

Table 4. Correlation between general indicators and specific indicators

	Corr.	Built U. m²	Plot A. m²	Family size	Garden, m²	Garage, m²	Out. m²	T.P.O.S.
No. B.R	Pear.	.86	.65	.51	.59	.21	.62	.60
	Sig	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Built U.	Pear.		.72	.50	.52	.47	.60	.57
	Sig		0.00	0.00	0.00	0.00	0.00	0.00
Plot A.	Pear.			.34	.91	.51	.93	.95
	Sig			0.001	0.00	0.00	0.00	0.00
Family	Pear.				.26	.01	.32	.24
	Sig				0.01	0.33	0.001	0.008
Garden	Pear.					.41	.85	.99
	Sig					0.00	0.00	0.00
Garage	Pear.						.25	.42
	Sig						0.014	0.00
Out D.C.	Pear.							.90
	Sig							0.00

Table 5. The level of satisfaction about each type of private open space variables

Private O.S. parts	Variables	N	Mean	satisfaction level
Garden	size	98	3.26	Neutral
	number	98	3.50	Satisfied
	shape	98	3.34	Neutral
	location	98	3.50	Satisfied
	privacy	98	3.60	Satisfied
	as the rest area	98	3.20	Neutral
	number of the	98	3.60	Satisfied
	outdoor activity	98	3.00	Neutral
	Overall satisfaction	98	3.02	Neutral
Garage	size	98	3.18	Neutral
	number	98	3.59	Satisfied
	shape	98	3.50	Satisfied
	location	98	3.10	Neutral
	Accessibility	98	3.60	Satisfied
	Overall satisfaction	98	3.30	Neutral
balcony	size	24	4.00	Satisfied
	functional use	24	3.00	Neutral
	shape	24	3.30	Neutral
	location	24	3.70	Satisfied
	Privacy	24	4.00	Satisfied
	Accessibility	24	3.10	Neutral
	Overall satisfaction	24	3.20	Neutral
outdoor circulation	size	82	3.70	Satisfied
	functional use	82	3.20	Neutral
	shape	82	2.80	Neutral
	location	82	3.10	Neutral
	Accessibility	82	2.90	Neutral
	Movement	82	2.80	Neutral
	Overall satisfaction	82	3.02	Neutral

Table 6. The results of regression between household satisfaction and parts of private open space variables

Overall satisfaction of P.O.S parts	Regression variables	Unstandardized Coefficient B	Sig
Garden	Number	0.89	0.010
	Size	0.183	0.016
	Outdoor activity	0.163	0.420
	R^2=0.48		
Garage	Number	0.39	0.000
	Size	0.28	0.001
	R^2=0.29		
Outdoor circulation	Movement	0.67	0.000
	Accessibility	0.16	0.018
	Location	0.95	0.060
	Size	-0.02	0.033
	R^2=0.67		

3.2 Household Satisfaction Results

The results of residents' satisfaction have been achieved based on the first analysis of Variance ANOVA then regressions of both satisfaction about individual items separately with determinants and overall satisfaction with determinants or variables results are supported by Table 5 and Table 6, which are:

- The results of household satisfaction with size, location, number, shape, and other variables of all private open space parts in the dwelling units were discovered. The level of satisfaction is between neutral and satisfied. For example, the households were satisfied with the number and location of the gardens in their dwelling units, while they felt neutral about the size and shape of the garden, the same for other parts of the private open space.
- None of the open space's components were evaluated as non-satisfied with or highly satisfied with as averages. The highest value was balcony size and privacy scored 4.00 while lower satisfaction corresponded to outdoor circulation shape and movement may be due to design partial ignorance
- Garden: the regression model of the garden variables and household satisfaction regarding gardens is significant with a strength of 0.48 as stated in Table 6, the satisfaction of a household regarding a garden depends here mainly on the size of the garden and the number of activities carried in.
- Garage: the garage model is acceptable and there is a significant relation between household satisfaction and the garage variables. The most effective variable of garages that has a direct impact on household satisfaction is the number and size of the garages.
- Outdoor circulation: the achieved regression model of satisfaction about outdoor circulation is significant, with a strength of 0.67, items contributing to the model are the movement in outdoor spaces the accessibility to outdoor circulation a very slight negative effect of sizes of outdoor circulation exists in a model that can be neglected.
- Overall sat. of gardens in D.U. = 0.52 + 0.89 sat. about number + 0.183 sat. about size.
- Overall satisfaction of garage in D.U. = 0.59 + 0.39 sat. about number + 0.28 sat. about size.
- Overall satisfaction about outdoor circulation in D.U. = 0.20 + 0.67 sat. of movement + 0.16 sat. of accessibility - 0.02 sat. of size.
- The second part of the regression is the overall household satisfaction for all private open space areas with overall household satisfaction of each private open space parts, it has been concluded that there is a significant model between them with a strength of 0.47, the outdoor circulation was discovered as the most important part contributed to the model of the overall household satisfaction as shown in Table 7.

Overall satisfaction about all areas =1.49 + 0.34 the overall sat. about outdoor circulation. In addition to the satisfaction of households about each part of private open space; the households' needs or demands for the size each of part has been checked to discover future needs by residents. It has been found that the households in selected dwelling units felt neutral about garden and garage size and they wanted them to be larger. As for balcony size, they were satisfied and they recommended larger ones, except for the outdoor circulation's size, they were satisfied, and they wanted them to be with same size as clarified in Table 8.

Table 7. Result of regression between overall satisfaction about open space areas and overall satisfaction of each part area

Overall satisfaction of all open areas	Unstandardized Coefficient B	Sig
Overall satisfaction with outdoor Circulation	0.34	0.00
	R^2=0.47	

Table 8. The household needs about the size of each part of the private open space

O.S. parts	Size satisfaction		Overall satisfaction for each part		Household needs	
	Mean	Level	Mean	Level	Mean	Need
Garden	3.26	Neutral	3.00	Neutral	3.60	Larger
Garage	3.18	Neutral	3.30	Neutral	3.60	Larger
Balcony	4.00	Satisfied	3.20	Neutral	3.50	Larger
Outdoor Cir.	3.70	Satisfied	3.00	Neutral	3.10	Neutral

4. Conclusions

It is proven through this study that open spaces, which include gardens, garages, balconies, and outdoor circulation, are important in the daily life of people, and people's satisfaction regarding their houses depends on the quality of the provided open space. Each part of private open space in these dwellings was compared to Iraqi standards, and it was found that most of those projects were within the minimum range of Iraqi standards except Minara B, which was below Iraqi Standards, and Hiwa City, which was high above the standards. Significant relations between general indicators

were found. For example, the relation between total private open space area and size of garden, size of plot, and circulation, are 99%, 95%, and 91%. By performing ANOVA analysis for all parts of private open spaces, this research found. The results of households' satisfaction regarding their private open space units are between natural and satisfied. Through the use of the regression, we were able to recognize the most impactful factors on household satisfaction(as shown in the previous section). The overall satisfaction of all open spaces parts was identified, and garages were found to be the main contributor. Regarding the demand for private open space sizes, we found that all ask for a slight increase in all aspects except outdoor circulation.

5. Recommendations

Since a house is the place, we spend most of our time in and the best place to relax, house designs should be planned carefully by designers. Householders claim the need for more open space in their dwellings, setting out detailed standards for all open space parts. These standards should be updated frequently, and designers must take into consideration household satisfaction results.

Authors' contribution

All authors contributed equally to the preparation of this article

Declaration of competing interest

The authors declare no conflicts of interest.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request

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