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Spatial Adaptability Of Low-Income Apartments In Erbil City According To User Preferences

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A R T I C L E   I N F O

A B S T R A C T

The focus of today's apartment design is on spatial adaptability. Because apartments have a fixed size, when a family's needs for a space change, the apartment plan cannot accommodate those needs, and the family is forced to move to another apartment. Hence, an adaptable apartment plan is considered a desirable alternative that can provide a variety of solutions to households' changing spatial needs in the present and the future. It could be argued that apartment design would be more effective if users were given the opportunity to select post-occupancy space adaptation techniques that are suitable for their needs and culture. Therefore, the aim of this study is to evaluate the degree of compatibility between user preferences and apartment floor plan designs for post-occupancy space adaptation. Based on post-occupancy space adaptation user preferences, the study evaluates the levels of spatial adaptability in low-income apartments in Erbil City. Post-occupancy space adaptation user preferences are determined using a questionnaire survey, and levels of spatial adaptability based on those preferences are determined using plan analysis. This study concluded that users did not prefer all the suggested strategies of spatial adaptability; they preferred the ones that most suited their needs and lifestyles. However, Erbil's low-income apartment floor plan designs don't match the users' preferences for space adaptation after occupancy.

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1. Introduction

1 According to Beisi (1995), adaptability is the ability to use the
2 possibilities offered by building technology and management systems to
3 meet the changing needs of residents within the same building [1].The
4 variety of human activities as well as more time spent in a house emphasizes
5 the need for adaptability in housing design [2]. Theories and concepts
6 relating to adaptability suggest that buildings are made up of several layers,
7 including "location, structure, skin, services, space plan, and stuff." A space
8 plan's adaptability is determined by its capacity to change in response to
9 various spatial configurations, whether on an hourly, daily, or weekly basis,
10 or over the course of various seasons or even decades [3]. This makes it
11 possible for residents to alter their living space in accordance with their
12 needs and allows a variety of ways to occupy a residence [4] Using adaptable
13 space layouts, users are given the freedom to arrange or use the space
14 anyway depending on their activities and preferences [5] .The goal of this
15 paper is to enhance stability. The objective of this study is to assess the low-
16 income apartment designs in Erbil City based on post-occupancy space
17 adaptation user preferences. This study is critical because it aims to provide
18 insights to the designer for future projects and, in the long run, raise the
19 quality of housing through its recommendations.

20 *2.* **Background**

21 Most designers agree that the concept of spatial adaptability in multi-
22 family residential buildings can be condensed into three fundamental
23 strategies: flexibility, generality, and elasticity [6-9].

24 The term "flexibility" refers to the capacity to adapt the floor plan to
25 accommodate new space needs at a low cost and with the least amount of
26 functional interruption [10]. Flexibility lets you change the number, size, and
27 configuration of rooms without changing the apartment's overall size (Figure
28 1.1) [9]. In practice, providing more sleeping space is often achieved by
29 reducing the quality of dimensional and organizational characteristics, such
30 as room size, connections and relationships between individual rooms,
31 zoning concepts, etc. Commonly, the issue of a lack of bedrooms is resolved
32 by adding a sleeping area to the living room [11]. The living room and
33 kitchen can also be combined to create a semi-public space. These ideas
34 support an area's adaptability to accommodate additional activities and the
35 most effective use of space [12].

36 Generality primarily refers to the interchangeability of activities
37 between different rooms [13]. Manum (2006) identifies it as having the
38 capacity to fulfill a variety of needs or desires in a fixed situation [7]. Size,
39 shape, and spatial organization of rooms are physical factors that affect the

40 generality of the room [14]. Seo and Kim argue that having aligned rooms
41 enables versatility as activities can be performed in any of the rooms. In his
42 example, he creates a central hall, arranges the rooms in a circular sequence
43 by separating the core, and places the technical core and entrance on opposite
44 walls [15]. In a flat of the central hall type, each room is characterized by
45 multiplex connections and functional neutrality toward the central hall. This
46 enables you to switch between functions in day and night modes [16] [15].
47 The living room and bedroom, which are all connected by a common hallway
48 and are approximately the same size, allow for generality in use [7]. Having
49 rooms of equal size means that the living room is slightly smaller than the
50 average and the bedroom is slightly larger than the average, allowing them
51 to be occupied by a variety of different user groups [17].

52 Elasticity in architectural design refers to the ability to divide a building
53 into separate functional units or expand it horizontally or vertically [18].
54 Flexible layout refers to the layout in which the size of the apartment space
55 can be expanded or reduced [9]. Dimensional expansion in multi-family
56 housing design can be achieved by joining adjacent units and through a non-
57 loading wall separating the units [19]. Merging the common space between
58 adjacent units is another way to expand the size of a flat based on an
59 agreement between adjacent users [19]. A large residential dwelling can deal
60 with the issue of the family's shrinking size by having the ability to be
61 divided into two independent units or to separate part of it [20]. The term
62 "separate part of an apartment" describes a room within the apartment that is
63 conveniently located near the kitchen, bathroom, and entryway. This room
64 could be used by a teenager to provide privacy or it could be rented out, for
65 example [9]. The division of space becomes simpler and more varied, with
66 more precise and compact shapes, without major layout changes or brakes
67 [16]. The center entrance position provides the best option for flexibility as
68 well [16]. It is possible to divide an apartment into two distinct units with
69 very basic tools, like an additional entrance [21].

70 An important factor to take into account in those situations is where the
71 service spaces are located. The location of technical installations is one of
72 the main fixed features of residential space [17]. When the service
73 installations (kitchen, bathroom, and toilet) and the main entrance are all
74 lined up in a row, centrally located technical installations with the entrance
75 along two opposed walls and the free-standing central core type offer the
76 maximum unit flexibility [16]. The technical core located between two flats
77 offers a minimum of flexibility and prevents a flexible redistribution of
78 interior spaces [16].

79 **3. Deriving the Key Measures**

1   This study suggests that for the first strategy of spatial adaptability,
2   which is flexibility, increasing the number of bedrooms by dividing the
3   master bedroom into two bedrooms or by splitting part of the living room
4   and providing an open plan by combining the living room and the kitchen;
5   for the second strategy (generality), switching activities between habitable
6   rooms (the living room and bedroom); and for the third strategy, which is
7   elasticity, increasing the size of the apartment either by merging common
8   space between two units or adjacent units, or decreasing the size of the
9   apartment either by separating a room near the entrance or by dividing the
10 dwelling unit into two independent units are some of the common space
11 adaptations that people would prefer after occupation to meet their needs.

12 **4. Research Questions**

13 This paper attempts to obtain convincing answers to the following
14 questions:
15   1. Does the existing low-income apartment design meet the needs
16   of the current residents?
17   2. What are the strategies for post-occupancy space adaptation,
18   according to user preferences?
19   3. Can the low-income apartment floor plans provide user
20   preferences for spatial adaptability?

21 **5. Case studies**

22 This article focuses on low-income apartments because Silas (2003)
23 argues that the housing that is provided to low-income people most requires
24 adaptability in space design. These people are less financially, intellectually,
25 and capable. Therefore, they had to modify their house and their ability to
26 modify the original design to get a design based on their capabilities and
27 cost. The survey found that there were eleven two-bedroom low-income
28 apartments. Six low-income apartments, or more than 50% of the study
29 samples, were chosen for this study based on the apartments' shared qualities
30 or traits, such as the number of bedrooms and areaa that are nearly close to
31 one another; for more information, see **(Table 1.1.)**.

32 **Table 1.1: Information about the selected case studies (researcher)**

Case study	Number of bedroom	Number of block	Number of floor	Number of flat/floor	Number of unit	Area	Year	Income group
Hana city	2	84	3	4	1008	98	2004	Low-income
444-apartments	2	37	3	4	444	98	2001	Low-income
Mamostayan city type A	2	6	8	4	192	106	2013	Low-income
Shahan city	2	28	6	4	672	128	2010	Low-income
Zhyan city	2	12	8	2	192	117	2014	Low-income
Lana city	2	4	10	4	160	108	2016	Low-income

33

34 **6. Research Methodology**

35 For the objectives and purposes of the study, a questionnaire survey with
36 363 participants and a floor plan analysis were used. The survey's first
37 section asks about the respondents' demographics; the second section
38 focuses on the respondents' current living situations with a Yes/No question
39 and the explanation for the "No" response; and the third section asks about
40 the respondents' preferences for post-occupancy space adaptation on a Likert
41 scale of 5, using a one-sample t-test with a test value of 3. A one-sample t-
42 test is a statistical test used to determine whether the mean of a single sample
43 differs significantly from a known population mean. The p-value indicates
44 the probability of obtaining the observed t-value under the null hypothesis,
45 in which H0 = 3. It means that people are neutral. If the p-value is less than
46 the significance level (usually.05), you can reject the null hypothesis and
47 draw the conclusion that either respondents want these strategies in the
48 apartment floor plans if the mean of respondents is greater than the t-value,
49 which is equal to 3, or respondents don't want them if the mean of
50 respondents is less than the t-value, which is equal to 3. Also, the study
51 analyzed apartment floor plans based on the extracted strategies that users
52 preferred for post-occupancy space adaptation. In conclusion, the study will
53 indicate whether or not they have answered research questions.

54 **7. Analysis and presentation of data**

55 This section shows the analysis and presentation of data collected via
56 questionnaire survey and floor plan analysis, which is then converted into
57 numerical and ratio (quantitative results).

58 **7.1. Questionnaire Analysis and Representation of Data**

59 **7.2. Socio-Demographic Characteristics of Respondents**

60

61 Results from the analysis of the socio-demographic characteristics of
62 respondents **(Table 1.2)** show that the largest number of respondents is male,
63 with an average of 51.5%, while 48.5% of respondents are female. The
64 majority of respondents (34.4%) are between the ages of 41 and 50. After
65 that, ages 31–40 provide the second largest number of respondents, with an
66 average of 31.7%; ages over 50 and between 18 and 30 provide the lowest
67 number of respondents, with an average of 20.9% and 12.9%, respectively.
68 In terms of working hours, 24.5% of respondents work full-time (free job),
69 while part-time (government employer) and full-time (company employer)
70 have nearly the same average, which is 19.3% and 20.9% of respondents,
71 respectively. Furthermore, those who do not work have the highest
72 percentage of respondents, with an average of 35.3%. This result came from
73 female respondents, 176 respondents were female; most females from low-
74 income families don't work and spend most of their time at home. The
75 survey also shows the average number of family members per flat and that
76 the majority of flats are occupied by families of 3-5 and 5-7 people, while
77 families of 7-9 people account for 9.9% of respondents, and one-person
78 families account for the least number of respondents. The majority of
79 residents occupied their flats for 4–7 years, with an average occupancy rate
80 of 38.8%, while more than 7 years, 1–3 years, and less than one year
81 provided 33.1%, 22%, and 6.1% of the respondents, respectively. Nearly half
82 of the respondents' numbers did not increase after occupation, with more
83 than two people providing the lowest degree of respondent increment. Most
84 families saw a one-person (23.1%) or two-person (19%) increase.

Table 1.2: Socio-demographic Characteristics

Socio-demographic Characteristics		Count	Table N %
Gender	Male	187	51.5%
	Female	176	48.5%
Age	18-30	47	12.9%
	31-40	115	31.7%
	41-50	125	34.4%
	Over 50	76	20.9%
Time of work	Government employer	70	19.3%
	company employer	76	20.9%
	Free job	89	24.5%
	Doesn't work	128	35.3%
Family Size	1 person	12	3.3%
	1-3 person	43	11.8%
	3-5 person	145	39.9%
	5-7 person	127	35.0%
	7-9 person	36	9.9%
Increase in family members after settling in this apartment	Not increased	180	49.6%
	1 person	84	23.1%
	2 persons	69	19.0%
	More than two	30	8.3%
Number of Years that Occupied in this House	Less than one year	22	6.1%
	1-3 years	80	22.0%
	4-7 years	141	38.8%
	More than 7 years	120	33.1%

7.2.1. Responsiveness to Family Needs

This part of the questionnaire sheds light on the existing household situation and apartment design in order to understand how well the current apartment spaces and areas can accommodate family needs. According to **(Table 1.3)**, an average of 61.2% of respondents said that their apartment's space and area don't meet their needs. The parents' bedroom was not small, according to respondents in all design samples. Only 8.8% of respondents from 444 apartments thought the child's bedroom was small. Despite the fact that the children's bedroom area in apartment 444 exceeds the minimum Iraqi housing standard see **(Table 1.5)**, the irregular shape of the room and the location of two doors on one side of the room make it difficult for residents to arrange furniture. On average, more than half of the respondents, or 52.3%, saw that the number of bedrooms did not correspond to family needs in all of the design samples. The size, composition, and number of family members all have a significant impact on this result. As seen in the bar graph, there is a correlation between the number of bedrooms available and the size of the family; as the size of the family increases, the shortage in the number of bedrooms increases **(Fig. 1.1)**. In the absence of bedrooms, they have placed their small children's beds in their rooms, or their parents use the living room as a bedroom at night. Furthermore, the study discovered that, with the exception of Mamostayan City and Shahan City, respondents in Hana City, 444-apartment, Zyan City, and Lana City have 43.8% dissatisfaction with the kitchen area. The kitchen area in the design samples of Hana City, 444-Apartment, and Zyan City is below the minimum standard requirement and cannot satisfy the needs of the residents. In Lana City, however, the area is consistent with the minimum standard, but its residents complain that the area does not provide enough space for their kitchen furniture because it contains three doors. At last, the living room area in all the design samples meets the needs of families except in Mamostayan City, which is far below the minimum standards.
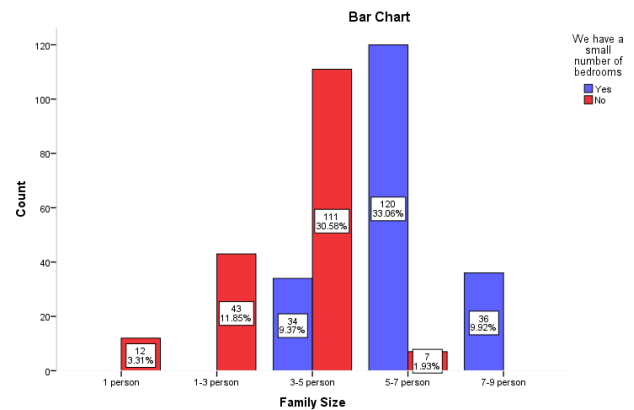
Figure 1.1: Bar chart: relationship between family size and number of bedrooms.

Table 1.3: Responsiveness to Family Needs

Responsiveness to family needs		Hana City Count	Hana City Table N %	Hbitat City Count	Hbitat City Table N %	Mamostayan City Count	Mamostayan City Table N %	Shahan City Count	Shahan City Table N %	Zhyan City Count	Zhyan City Table N %	Lana City Count	Lana City Table N %
Does your apartment meet your family's needs?	Yes	37	10.2%	18	5.0%	10	2.8%	45	12.4%	27	7.4%	4	1.1%
	No	90	24.8%	38	10.5%	14	3.9%	40	11.0%	29	8.0%	11	3.0%
The parent's bedroom is small	Yes	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	No	127	35.0%	56	15.4%	24	6.6%	85	23.4%	56	15.4%	15	4.1%
The children's bedroom is small	Yes	0	0.0%	32	8.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
	No	127	35.0%	24	6.6%	24	6.6%	85	23.4%	56	15.4%	15	4.1%
We have a small number of bedrooms	Yes	77	21.2%	34	9.4%	10	2.8%	39	10.7%	23	6.3%	7	1.9%
	No	50	13.8%	22	6.1%	14	3.9%	46	12.7%	33	9.1%	8	2.2%
Our kitchen is small.	Yes	87	24.0%	35	9.6%	0	0.0%	0	0.0%	27	7.4%	10	2.8%
	No	40	11.0%	21	5.8%	24	6.6%	85	23.4%	29	8.0%	5	1.4%
The living room(hall) is small	Yes	0	0.0%	0	0.0%	14	3.9%	0	0.0%	0	0.0%	0	0.0%
	No	127	35.0%	56	15.4%	10	2.8%	85	23.4%	56	15.4%	15	4.1%

7.2.2. Post-Occupancy Space Adaptation User Preferences

Long-term occupancy of the same apartment will be achieved by meeting the different needs of the user. The one-sample t-test **(Table 1.4)** indicated that increasing the number of bedrooms by splitting the master bedroom into two bedrooms resulted in (Mean=4.36, P<0.05), which indicates that the majority of respondents would prefer to have a large master bedroom in order to divide to increase the number of bedrooms in apartment floor plans in order to accommodate their needs in the future. Furthermore, the result of increasing the number of bedrooms by dividing a large living room was (Mean=2.66, P<0.05); this means that despite the fact that on average, more than half of the respondents saw that the number of bedrooms did not correspond to family needs in all of the design samples, low-income families do not want to build an additional bedroom within the living room because of privacy; they do not want to mix the living room with the bedroom zone, and most low-income families would like to have a separate bedroom zone. Further, the result for merging the living room with the kitchen to provide an open plan was (Mean=2.64, P<0.05). Most families of low-income people prefer a closed plan in which the living room is not open to the kitchen, and they don't want to merge these spaces in the future. Most of their restrictions were about issues of privacy and smell.

Performing activities in any of the rooms or switching activities between habitable rooms (the living room and bedroom), is highly significant (mean (Mean=3.82, P<0.05) and they believe that it will help to provide more freedom in holding the activity in each room according to their preferences.

For elasticity strategies, increasing the size of the apartment is highly significant, either by merging common spaces or by merging adjacent apartment units (Mean=4.31, P<0.05 and Mean=3.62, P<0.05 respectively). The respondents' mean revealed that the majority of respondents would prefer to have a common space because it would provide a solution for the bedroom deficit and be less expensive than merging adjacent units. As opposed to this, respondents did not prefer to reduce the size of the apartment by dividing a room close to the entrance to be used as an office or studio apartment for teenagers who want to live alone or rent it out (Mean=2.13, P<0.05). However, respondents with a (Mean=3.96, P<0.05) preferred dividing the apartment into two separate small units because they stated that it is a good option for families who want their sons to be beside them when they get married.

Table 1.2: Post occupancy space adaptation user preferences

Strategies of adaptability	Possible value	Mean	t	P-value	User preferences
Flexibility	Increase the number of bedrooms by dividing the master bedroom.	4.36	21.560	.000	✔
	Increase number of bedrooms by dividing the living room	2.66	-4.458-	.000	×
	Merge living room and kitchen	2.64	-3.938-	.000	×

Continue **(Table 1.4)** ……..

	Possible value	Mean	t	P-value	User preferences
Generality	Performing an activity in any of the rooms or changing the activities between habitable rooms (the living room and bedroom)	3.82	11.414	.000	✔
Elasticity	Increasing the size of an apartment by merging common space between adjacent units	4.31	6.528	.000	✔
	Increasing the size of an apartment by merging adjacent units	3.62	21.875	.000	✔
	Decreasing the size of the apartment by separating a room near the entrance	2.13	8.338	.000	×
	Decreasing the size of the apartment by dividing it into two independent units	3.96	-11.555-	.000	✔

7.3. Floor plan analysis

The analysis of each apartment unit's floor plan aims to measure the level of spatial adaptability according to user preferences. The floor plan analysis is divided into two parts: first, a comparison with Iraqi housing standards; second, to measure the level of spatial adaptability based on user preferences.

7.3.1. Size of Low-Income Apartment and Its Spaces

Table 1.5 shows the indoor useful floor area of each apartment and its spaces and displays the difference in square meters, to determine whether they meet the Iraqi housing standards in their existing condition or not. It is important that activities be built in accordance with these standard dimensions; otherwise, having a comfortable apartment that meets all basic needs would be difficult. The average area is as follows: indoor useful floor area, 88.32 square meters; master bedroom, 16.96 square meters; children's bedroom, 14.39 square meters; living room, 24.9 square meters; kitchen, 11.33 square meters; bathroom and toilet room, 6.53 square meters; storage, 2.92 square meters; circulation space, 14.58 square meters. The habitable rooms (master bedroom, children's bedroom, and living room) were built nearly above the minimum standard in most cases, whereas the average kitchen area was built below the standards in most cases, and storage was not provided in 66.7 percent of design samples. The basic problem here is that the average indoor useful floor area in low-income apartments is below the minimum standard. Meanwhile, the bathroom, toilet, and circulation space areas are over the minimum standards. Due to a lack of indoor useful floor area and excessively large services and circulation spaces, the kitchen and storage do not have the required amount of space, and storage is not built in the majority of samples.

Table 1.3: Comparison of indoor useful floor and space areas with Iraqi housing standards

Indoor useful floor spaces	Area (Iraqi Housing Standard)	Cases study-two bedroom					
		Hana city	UN habitat apartment	Mamostayan city	Shahan city	Zhyan cityt	Lana city
Indoor useful floor area	93-99	92.94	71.3	84.86	103.7	92.24	84.86
master bedroom	15	15.3	14.36	17.28	22.36	17.5	15
children bedroom	12	14	12.8	15.76	15.2	14.8	13.76
Multi-purpose living room	24	25.74	24	15.76	29.89	32.6	21.46
Kitchen	12	9.9	7.56	12.23	15.4	10.92	12
Bathroom & toilet room	5	8.6	5.58	5.97	5.52	6.6	8.74
Storage	6	3.6					2.24
circulation space	12	15.8	12.9	17.86	19.45	9.82	11.66

7.3.2. Level of Spatial Adaptability

Based on users' preferences for space adaptability after occupancy, each apartment's floor plan is analyzed to determine the level of space adaptability, divided into three strategies: flexibility, generality, and elasticity.

7.3.2.1. Flexibility of Floor Plans

Respondents of low-income study samples stated that providing an additional bedroom by dividing master bedrooms is one of the most important space adaptations after occupancy. According to the analysis **(Table 1.8)**, only Shahan City can support additional bedrooms in this study by dividing the master bedroom into two small, dependent children's bedrooms (11.18 square meters each) and using the children's bedroom as the master bedroom (15.2 square meters). In 83.3 percent of low-cost apartments, there is no possibility for dividing a master bedroom to create an additional bedroom. The major constraint for this alteration is the size of the master bedroom. The average master bedroom area in the study samples is 16.97 square meters, which is not sufficient to be divided in order to increase the number of bedrooms. In addition, the number of windows is not considered; there is only one window that will restrict dividing the master bedroom into two small independent bedrooms in the future.

7.3.2.2. Generality Plan Analysis

In order to switch the activity between rooms, room size (equitable room size) and spatial organization (central hall type) are two factors that work together. A general room size requires a general spatial organization. **Table 1.6** shows the room size analysis and displays the difference in square meters. According to room size analysis the average size of the master bedroom is 16.97 square meters, the children's bedroom is 14.41 square meters, and the living room is 24.91 square meters. The survey discovered a significant difference between the size of private sleeping rooms and public living rooms. All design samples, with the exception of Mamostayan City, have bedrooms that are smaller than living rooms, restricting the convertible usage of the rooms. The size of the children's bedroom and living room in Mamostayan City are equal. According to the spatial organization analysis **(Table 1.8)**, the central hall type, in which movable space is placed at the center through the arrangement of the service core and entrance at the center of two opposite walls, is not provided in any of the design samples. Despite the fact that Mamostayan City has rooms of equal size, they are unable to exchange activities because the service core is situated on one side of the apartment and does not offer movable space in the middle.

Table 1.4: Room size analysis

Category of rooms	Room name	Two-bedroom apartments						Mean
		Hana city	UN habitat	Mamostayan city	Shahan city	Zhyan city	Lana city	
Habitable rooms	Master bedroom	15.3	14.36	17.3	22.36	17.5	15	16.97
	children bedroom	14	12.8	15.8	15.2	14.9	13.76	14.41
	Living room	25.74	24	15.8	29.9	32.6	21.46	24.97

7.2.2.3 Elasticity analysis

Modifying the size of apartments meets the varying needs of families for space, and families can stay in their homes for extended periods of time.

Enlarging the size of apartment: Another type of space adaptation that the user preferred after occupancy is to increase the apartment's size. According to **(Table 1.8)**, the study came to the conclusion that, with the exception of Zhyan City, it is possible to increase the size of an apartment by joining adjacent units by 83.3%. In Zhyan City, there are only two apartments on one floor, and they are not placed next to one another. There are dispersed service locations in 66.7 percent of the design samples, including Hana City, Mamostayan City, Zhyan City, and Lana City, and some of these services are situated between adjacent apartments, which reduce the flexibility of interior spaces after combining apartments. For the second criteria, common space between adjacent units is not considered in all the design samples. So, there is no possibility for enlarging the size of an apartment by merging common spaces.

Contracting the size of apartment: Participants only preferred shrinking the size of an apartment by dividing the apartment unit into two independent units. After spatial analysis, compact form without major breaks in the plan layout doesn't present in all the design samples **(Table 1.8)**. 66.7 percent of design samples have irregular floor plan layouts, as in Hana City, Mamostayan City, Shahan City, and Lana City, and two of them, as in 444-Apartment and Zhyan City, have major breaks in the layout. Furthermore, 50 percent of samples, such as Hana City, Shahan City, and Lana City, have peripheral entrances, while the other design samples have entrances that are nearly central. The majority of the apartments provide entrance in extremely constrained spaces where there is no space for an additional door for the new apartment. The location of services is also another restriction for this

division. Technical services are dispersed in 66.7 percent of design samples and grouped peripherally in 33.3 percent. It is difficult to easily provide bathrooms, toilets, and kitchens for both apartments due to dispersed and peripherally located technical services. In conclusion, in all the design samples, it isn't possible to divide the apartment into two independent units because of the flat form, entrance location, and service location.

8. Discussion of Findings

The previous section's outcomes and data that were obtained from the questionnaires of 363 low-income study participants as well as the analysis of the floor plans of six low-income apartment units will indicate whether or not they have answered research questions.

8.1. The First Research Question

Does the existing low-income apartment floor area and spaces meet the needs of the current residents?

In this study, a questionnaire was provided to determine how well the current apartment spaces and areas can accommodate current family needs, taking into consideration floor plan area and space comparisons with minimum standards and socio-demographic characteristics. The majority of respondents, or 61.2% on average, stated that their apartment's spaces and area don't meet their needs. The following factors contributed to this lack of responsiveness to family needs: 8.8% stated that the children's bedroom area is small; 52.3% stated that there is a shortage of bedrooms; and 43.8% and 3.9% stated that the kitchen and living room areas are small. The lack of bedrooms contributed to a significant portion of not meeting family needs due to the occupancy rate (number of people per apartment), which was 44.9% higher than 3-5 people, and family structure. Some of the 3–5 families with children of different genders will need additional bedrooms. Similarly, a large number of respondents stated that the kitchen area does not meet the needs of the current residents because it is built below the minimum standards in most cases due to oversized circulation areas and indoor useful floor area, which is below the minimum Iraqi housing standards. The areas of the children's bedrooms and the living room achieved the lowest percentage of not being consistent with family needs.

In conclusion, low-income apartment floor plans in Erbil City don't meet the needs of current residents because of family size, family structure, and substandard apartment floor area.

8.2. The Second Research Question

What are the strategies for post-occupancy space adaptation, according to user preferences?

This study used a one-sample t-test in order to determine the most critical type of space adaptation that people would prefer to meet their needs after occupation. Based on **(Table 1.4)**, people prefer dividing the master bedroom to increase the number of bedrooms as their family members increase while separating part of the living room to be used as an additional bedroom is not preferred. The majority of respondents preferred a closed plan with distinct spaces for each activity, meaning that combining the living room and kitchen to create a multipurpose space was not preferred. Another type of post-occupancy space adaptation that participants in the low-income study samples preferred were carrying out activities in any of the habitable rooms or switching the activity between habitable rooms. Additionally, it was preferred to increase the size of apartments to accommodate residents' needs after occupation, but primarily by merging common space between adjacent units. Conversely, it was preferred to decrease the size of flats only by dividing the apartment unit into two independent units rather than separating a room close to the entrance.

In conclusion, according to user preferences, the most significant post-occupancy space adaptations include dividing the master bedroom to create more bedrooms, changing the activity between rooms, expanding the apartment, and dividing the apartment unit into two independent units.

8.3. The Third Research Question

Can the low-income apartment floor plans provide user preferences for spatial adaptability after occupancy?

According to the questionnaire, participants in the low-income study samples preferred having a large bedroom that could be divided to provide an extra bedroom. However, based on the floor plan analysis, the study revealed that the master bedroom area in 83.3 percent of the study samples is not large enough to be divided in order to increase the number of bedrooms. As a result, low-income apartments in Erbil City do not meet the user's preferences for dividing master bedrooms into two small bedrooms.

Changing the activities between habitable rooms is one of the non-physical space adaptations that people prefer after occupation. According to floor plan analysis, equitably sized rooms only exist in 0.17% of the study samples and spatial configuration is not of the central hall type in all study samples, so they cannot provide generality **(Table 1.6 and 1.8)**. If the spatial configuration is not of the central core or central hall type, the depth of the plan increases and does not provide equitable access to service spaces and entrances. So, in contrast to user preferences, low-income apartment floor plans do not provide generality due to room size and spatial configuration.

Depending on participant preferences, an elastic apartment space configuration will present a good option to meet residents' needs. As was already mentioned, not all study samples have a compact form with no significant breaks and a central entrance; thus, dividing the dwelling unit into two independent units is not possible. Additionally, respondents to this study preferred enlarging apartments by combining common spaces and adjacent units. In 83.3% of the study samples, it was possible to increase the size of an apartment by combining adjacent units, but in all of the study samples, it was not possible to do so by combining common space. As a result, the only way to increase an apartment's size in Erbil's low-income apartments is by joining adjacent units.

Conclusion: Based on **(Table 1.7)**, out of the five types of space adaptations that respondents preferred, only one of them can be met by merging adjacent units, at 83.3 percent. In summary, floor plans for low-income apartments do not accommodate post-spatial adaptability based on user preferences.
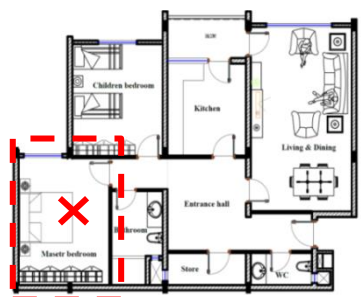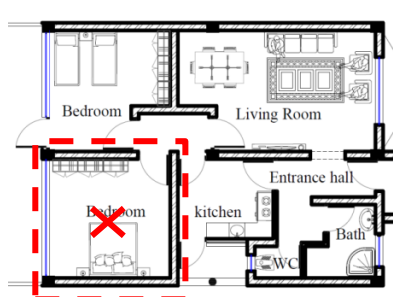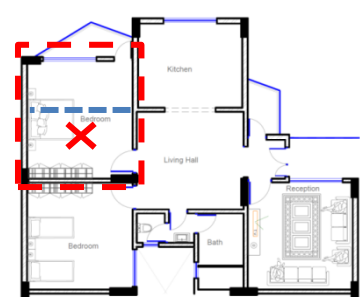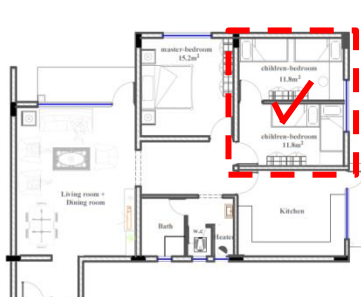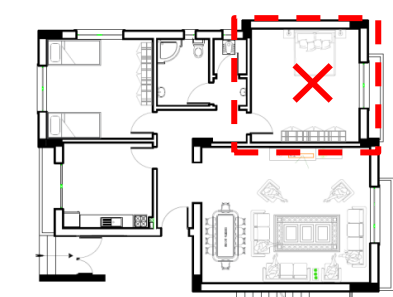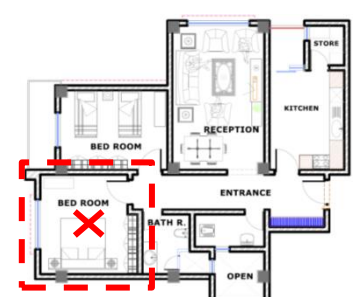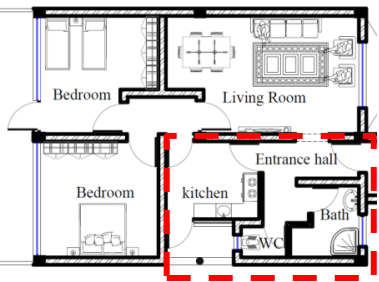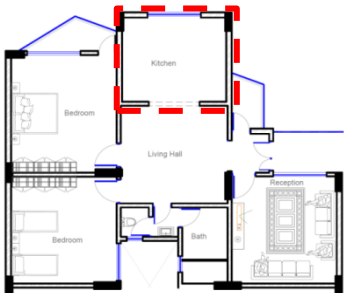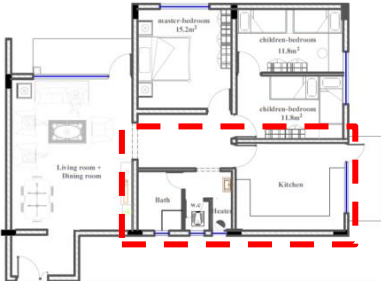
Table 1. 5: Responsiveness to Family Needs

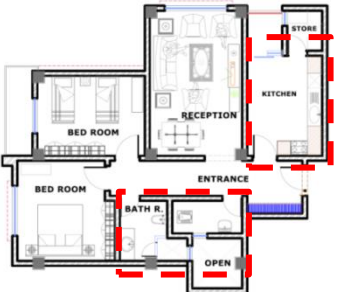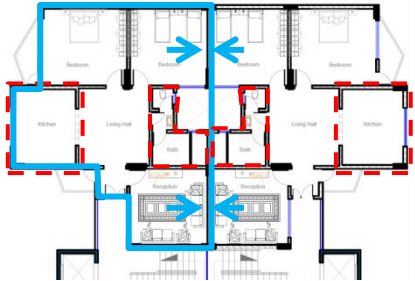| Strategies of adaptability	Possible value	Post-occupancy space adaptation user preferences			Apartment floor plan analysis								Possibility of post-occupancy space adaptation in apartment floor plans according to user preferences
		Mean	P-value		Hana city	444-apartments	Mamostayan	Shahan city	Zhyan city	Lana city	Percentage of floor plan adaptation		
Flexibility	Increase the number of bedrooms by dividing the master bedroom.	4.36	.000	✓				▓			16.7%	×	Not possible
Generality	Change the activity between rooms (equitable room size with a central core type or a central hall type)	3.82	.000	✓							0.0 %	×	Not possible
Elasticity	Increasing the size of an apartment by merging common space between adjacent units	4.31	.000	✓							0.0 %	×	Not possible
	Increasing the size of an apartment by merging adjacent units	3.62	.000	✓	▓	▓	▓	▓		▓	83.3%	✓	possible
	Decrease the size of the apartment by equally dividing the flats (a compact form with central entrance).	3.96	.000	✓							0.0 %	×	Not possible

Table 1.8: Spatial adaptability of two-bedroom apartment

1-Flexibility of spatial organization
Criteria
- Dividing the master bedroom into two bedrooms
-number of windows

1- (Hana City) - Area (98 square meter)	2- (444- apartment) - Area (98 square meter)	3- (Mamostayan City) - Area (106 square meter)

| -Master-bedroom size is built nearly to the minimum standard (15.3 m2).
-There is only one opening.
-Dividing is not possible. | -Master-bedroom size built below the minimum standard (14.36 m2)
-There is only one opening.
-Dividing is not possible. | -Master bedroom size built nearly over the minimum standard (17.3 m2)
-There is only one opening.
-Dividing is not possible |

4- (Sahan City)-Area (128 square meter)	5- (Zhyan City) - Area (118 square meter)	6- (Lana City)- Area (108 square meter)

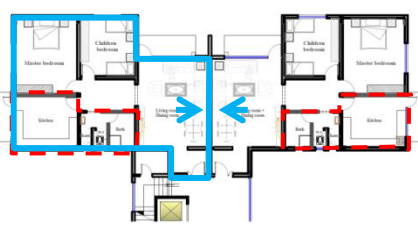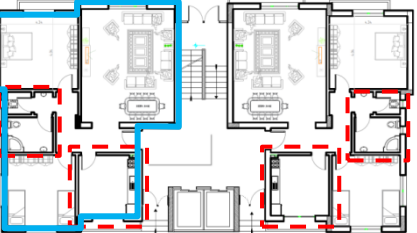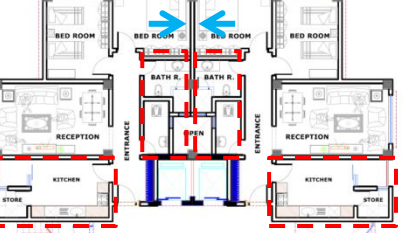| -Master bedroom size is over the minimum standard (22.36 m2)
-There is only one opening.
-Dividing is possible | -Master bedroom size built nearly over the minimum standard (17.5m2)
-There is only one opening.
-Dividing is not possible. | -Master bedroom size built perfectly to the minimum standard (15 m2)
-There is only one opening.
-Dividing is not possible. |

2-Generality of spatial organization Criteria - A central hall type with a centrally located technical core and entrance along two opposite walls		
1- (Hana City) - Area (98 square meter)	2- (444- apartment) - Area (98 square meter)	3- (Mamostayan City) - Area (106 square meter)
-There is no central hall type -Dispersed service spaces, some located between two adjacent units.	-There is no central hall type -Service spaces grouped peripherally on one side of the walls.	-There is no central hall type -Dispersed service spaces, some located between two adjacent units.
4- (Sahan City)-Area (128 square meter)	5- (Zhyan City) - Area (118 square meter)	6- (Lana City)- Area (108 square meter)
-There is no central hall type -Service spaces grouped peripherally on one side of the walls.	-There is no central hall type -Dispersed service spaces	-There is no central hall type -Dispersed service spaces, some located between two adjacent units

Elasticity of spatial organization Enlarging the size: Criteria - A non-bearing wall between the units with consideration of the position of technical services (the central service core or kitchen and bathroom with the main entrance are grouped in arrows). -Common space between adjacent units		
Decreasing the size: Criteria -Compact form without major breaks with consideration of the position of technical services (the central service core or kitchen and bathroom with the main entrance are grouped in arrows). -central entrance		
1- (Hana City) - Area (98 square meter)	2- (444- apartment) - Area (98 square meter)	3- (Mamostayan City) - Area (106 square meter)
-A non-bearing wall between the units. -The service area with the main entrance is not grouped in a row and is not centrally located. -Dispersed technical service; some technical service is positioned between two flats. -One peripheral entrance. -It is possible to merge adjacent units by removing a store. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.	-Non-bearing wall between the units. - The service area with the main entrance is not grouped in a row and is not centrally located. -kitchen and bathroom are grouped peripherally along one wall. -Entrance is nearly in the center. -It is possible to merge adjacent units. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.	-Non-bearing wall between the units -The service area with the main entrance is not grouped in a row and is not centrally located. -Dispersed technical service, some technical service positioned between two flats. -Entrance is nearly in the center. -It is possible to merge adjacent units. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.

Continue table 1.8…   35

4- (Sahan City)-Area (128 square meter)	5- (Zhyan City) - Area (118 square meter)	6- (Lana City)- Area (108 square meter)
-Non-bearing wall between the units -The service area with the main entrance is not grouped in a row and is not centrally located. -Kitchens and bathrooms are grouped peripherally. -One peripheral entrance. -It is possible to merge adjacent units. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.	-There is no unit adjacent to another. -The service area with the main entrance is not grouped in a row and is not centrally located. -Dispersed technical service -entrance is nearly in the center. -It is not possible to merge the units. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.	-Non-bearing wall between the units -The service area with the main entrance is not grouped in a row and is not centrally located. -Dispersed technical service, some technical service positioned between two flats. -One peripheral entrance. -It is possible to merge adjacent units. -There is no common space between adjacent flats. -It isn't possible to divide the apartment into two independent units because of the entrance location, service location, and flat form.

9. Conclusion

Spatial adaptability is the ability of floor plans to adapt to families changing needs and requirements throughout time. Designing floor plans that accommodate user preferences for space adaptation after occupancy is important in order to create functional and comfortable living spaces. The mismatch between user preferences and apartment design has a direct impact on a person's ability to stay in the same apartment for a long time. As a result, the apartment's floor plan is not designed according to the user's preferences and cannot meet his changing needs over time; as a result, the person is forced to move to another apartment to meet the new needs. The aim of this study is to identify the levels of spatial adaptability in low-income apartment floor plans based on user preferences. In this regard, this study identifies user preferences for space adaptation after occupancy and evaluates the selected apartment floor plans based on extracted user preferences. For the objectives of this study, a questionnaire survey with 363 participants and a floor plan analysis were adopted. The existing low-income apartments don't meet the needs of the current residents, and they need adaptations to their floor plans. The study concluded that only 5 of the 8 types of post-occupancy space adaptation were preferred by the respondents based on their needs and lifestyles, and low-income apartment designs in Erbil City were unable to accommodate these preferences. Over time, the residents of low-income apartments are forced to move to another apartment, creating an unstable community. When designers invite users to provide feedback and insights, they can gain new perspectives and ideas that they would not have explored otherwise. This can lead to more distinctive and creative living spaces that are suited to the specific demands of the residents.

10. Limitation of the study

This study focuses on multi-story residential dwelling units because of their fixed size; they require more spatial adaptability strategies than single-family homes, which can be easily extended, expanded and torn down.

Further, the focus of this study was on low-income apartment buildings because low-income people commonly need to adapt their homes and require options for changing the original design to meet their needs.

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