Studying Flexibility and Adaptability as Key Sustainable Measures for Spaces in Dwelling Units: A Case Study in Baghdad

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Abstract. This paper studies the functional flexibility as a sustainable design option used in housing. Family medium size has been grown and their needs of social and economic conditions have changed. In order to satisfy these needs, spatial layouts of their housing have developed or modified. Flexibility that is the capacity of spatial adaptation of development has considered as a useful sustainable option in the existing design. Since 2003, there is still a clear problem of covering the rapidly escalating demand on dwellings in Baghdad, the existing housing has been suffered from the densification, although the small capacity of spaces and fixed-designs. In addition to that, a trend of building dwelling units based on the retail sales of lands has been widely adopted from people to meet their dwelling needs. This paper thus answers the question: how can Iraqi dwelling occupants evaluate the flexibility and adaptability as key sustainable measures in their own homes? Methodology used a case study approach, Baghdad, Iraq has been selected for the case study, cooperated with the questionnaire technique to examine a set of apartments and homes. Results have shown that dwellers preferred the functional modification based on the inner space to meet the flexibility, but they have never relied on the flexibility as a sustainable tool of design.

Keywords: Flexibility, adaptability, sustainability, dwelling, space, reuse

1. Introduction

Flexibility considers as one of the most important designing tool using in the field of architecture and urban design [1, 2]. This tool can be involved in the process of meeting the dwelling demands of people. After 2003 and democracy arrived, new trends of turning many land uses in particular open spaces and green areas into residential areas have adopted in Baghdad and many other Iraqi cities [3, 4]. These new trends have generated new small urban subdivisions that provided new small sizes of plots comparing with the previous ones practiced before 2003 [5]. This led to adopt the flexibility in the design process that was by the new small housing spaces, in shape and size. As a result of that turn, the existing conflict between the standard requirements of the dwellings and the existing changes that were derived by Iraqi communities was determined the research problem. In Baghdad, this problems was divided into two parts that associated with the flexible housing design. First, limits of structures; and second, spatial properties of housing design.
Structural flexibility has determined the rate of access points inside and outside, the restriction of new changes of dwellers’ demands, and the locations of services and maintenance points. Space flexibility refers to the increase or decrease the capacity of free use of spaces and adopts future scenarios of room options. So, the space flexibility here means the kind of sustainability that this

This paper investigates flexibility and adaptability as sustainable key measures in the individual and multi-family dwellings in Iraq. Investigation was done by reviewing peer-reviewed studies published in the recent periods as well as relevant core papers. Therefore, we, aim to identify the flexibility and adaptability which were experienced by Iraqi dwellings’ occupants, considering social and cultural values, and suggest proper design proposals.

The paper was launched by reviewing and addressing dwelling flexibility and adaptability concepts, topics, and issues due to identify the research problem which is: how can Iraqi dwelling occupants evaluate the flexibility and adaptability as key sustainable measures in their own homes? Then, research objectives and methods’ stages have determined. Follow that, a designed questionnaire was distributed, using a snowball method, and surveyed Iraqi dwellers in both townhomes and apartments. Responses of dwellers led us to identify the advantages and disadvantages of flexibility and adaptability for each type of dwellings and classify the effective tactics and strategies embraced new activities in dwellings. Ultimately, we have discussed the results and provided the conclusion.

1.1. Flexibility and Design

Flexibility as a concepts used in architecture designs has used to properly respond to the changes that might occur in the future. Advantages of flexibility used in architectural designs are included, but not limited to: (1) building spaces remain in use for a long time; (2) accept the dwellers’ development and intervention for some extent to meet their needs; (3) invest the innovations and attributes of technology systems to enhance the performance of building and spaces’ properties; (4) support the objectives and values of economy and ecology systems; and (5) provide opportunities for hosting societal and cultural activities that annually practiced.

According to Sybestyen (1978), some resource of construction institutions classifies the flexibility into three classes: ‘Parameter flexibility’, ‘qualitative flexibility’, and space flexibility’ [6, 7].

- Parameter flexibility meets the changing requirements and needs, based on simple tactics and modifications, without making radical interventions led to change the building.
- Qualitative flexibility achieves quality criteria and needs without changing the settlements by an addition or a replacement process.
- Space flexibility meets needs of re-use spaces to adopt new functions or temporary activities, which were required building changes made inside the building (internal space flexibility) or outside (external space flexibility).

For these previous classes, although the townhomes are different from apartments in terms of design concepts, we note that the flexibility can represent itself in the aforementioned classes based on using the existing spaces and facilities or forming new spaces and building new facilities. Using the existing space and facilities can invest time and cost when dwellers want to meet requirements of new modern living conditions. Forming new spaces with building new facilities can allow many choices to achieve high-quality in re-using spaces since the construction and structural systems will be subject for modification and improvement. Thus, the manipulation of spatial productions, whether for individual dwellers of townhomes or multi-family dwellings of apartments, opens many opportunities for more sustainable proposals that might not be as difficult as they seem.

According to Asfour and Al-Susi, the design flexibility has applied at multiple levels in townhomes [8], such as:

- Flexibility in the structural level includes an open structural flexibility and a limited structural flexibility.
• Flexibility in functional level includes a versatility, reuse space, an open plan.
• Multi-use space.
• The long-term adaptability.
• Expansion include add-in and add-on.

1.2. The Relationship between Design Flexibility and Sustainability

There is an important relationship between flexibility and sustainability. Sustainability provides the best conditions for both humans and nature in the present and future. It has related to the economy, society, and environment. The economic sustainability has promoted humans to find out strategic methods used to create a balance between development requirements and preserving the nature. The social sustainability forms a balance among social, cultural, and psychological aspects. The environmental sustainability emphasizes a balance among ecology, nature, and built-environment [10]. Flexibility is an essential key to reduce the cost of house and help dwellers to use spaces for multiple functions and by using the potentials of building, furnishing, and maintenance of existing spaces.

Flexibility is mentioned as one of the social sustainable features used in the modern houses. These features are included human comfort, health, safety, security, universal design, and sense of community. The importance of achieving social sustainability in dwellings is the potential that creates a balance between dwellers and society’s features and attributes. Social sustainability can be adopted and used differently in relation to the features, values, and conditions of a particular society [12].

2. Theoretical Background

Last forty years, there was a considerable literature conducted to address many topics and issues of space flexibility and adaptability of dwellings. Many tactical solution and prefabricated units of dwelling designs were introduced by catalogues that broadly adopted in the last century. Flexibility was an important idea applied broadly to meet the increase demands of mass social housing implemented in cities [13]. Improvement of construction technology and materials helped residents to be part of the design process of their own dwellings, when they purchased open plan dwellings or houses with unfinished spaces [14]. Flexibility tactics and strategies are integrated to cover daily demands and activities and operated many programs in accordance with habitual activities. In addition, there were studies discussed the potentials of flexibility based on the capability of spaces in providing choices, customizations, and configurations [15, 16]. The plurality of a space can embrace various functions and activities with keeping the form configuration as it is; therefore, generating an ideal solution [17, 18]. Abdulpader et al. (2014) stated that housing flexibility, however, has integrated the opposite variables including construction techniques, structures, materials, partitions, and services [19]. Flexibility can be achieved by dealing with the little details as well as at large scale by integrating tactics and strategies which vary based on the level of use.

Adaptability has also considerable literature on housing typologies. Recently, dwelling designs has focused on producing adaptable buildings focusing on circular solutions and sustainable issues [20, 21, 22]. Promoting the idea of economic sustainability, Pinder et al. (2013) confirmed that an adaptable design could facilitate costs of future activities and reconstructions, demanded by occupants, and in some cases they were implements with cost free [23]. Adaptability could also provide an opportunity for sustaining the living lifespan and allow substantial re-constructions and relevant materials; this meets the trend toward environmental sustainability [24]. For residential buildings, adaptability has broadly applied as a useful solution to achieve long-term mass social sustainability. Boström (2012) has considered that adaptability provided many opportunities for producing more attractive housing, met the requirements of cultural and societal diversity, and forming a good life quality for dwellers [25]. The possibility of meeting a household’s stability and safety was reached by using adaptive design of dwellings that led to the satisfaction of residents individually and collectively [26, 27]. In the same regard, the adaptation processes in dwellings have increased residents’ control over the conditions and situations of housing [28]. Although above advantages showed an ideal approach of
adaptability, it has allowed very limited opportunities for residents’ future changes in the designs of apartments [29].

According to what has been reviewed above, one can notice that flexibility and adaptability provided circular solutions and cover occupants’ daily and future needs with consideration to the required cost, time, and effort. Many relevant tactics and strategies that used in dwelling types have met the sustainable values of economy, society, and environment. However, comparative topics and issues have not been addressed in Iraqi dwellings, individually and collectively.

Understanding flexibility and adaptability of housing is still problematic and being rare in the local literature. Thus adoption of flexibility and adaptability as key sustainable measures for producing long lifespan dwellings in Iraq needs to be precisely studied. The current study fills in this gap.

3. The functional flexibility in housing

According to PARCI in 2005, the versatility has considered a simplest type of the functional flexibility, it has switched the existing spaces by replacing their locations; this can be done by adding or removing some activities and functions according to the occupants’ needs, as shown in Figure 1. Prins (1992) has mentioned that there is another type of flexibility, which means the reuse of space, reintroducing the existing spaces in dwellings for new activities and functions without making any physical changes in size, shape, and connections, reduced effort and costs that vary in the levels of use [8].

Raafat (1996) has described another type of functional flexibility found in the interior spaces of architecture. He classified functional flexibility into two types: first, the open plan system that consists of mixing homogeneous and mergerable living spaces such as, living, dining, and sitting spaces, which could be merged as a one space embracing different uses. The space could be separate by furniture, moveable partisans, and sliding doors [30], see Figure 2. The second type was the multi-use plan (or multi-use space) that relies on the design of an open plan system, which dedicated a particular space for multi-uses. This type of space has needed light furniture, helped in changing the use of space according to the time of use. For example, the sitting space was used in the morning and coil be changed for sleeping or gathering spaces during other times [31], see Figure 3.

Figure 1: Versatility as functional flexibility [8].
Figure 2: Open plan systems allow choices for dwellers in a single space [32].

Figure 3: The multi-use space as a functional flexibility [33].

According to Prins (1992), there were other types of functional flexibility like the long-term adaptability representing the ability of renewing dwelling spaces by using modern technologies when dwellers have needed to bring new activities into their own homes. These needs have implemented inside the home spaces without making large physical modifications. So, the form itself has been conserved from changes as well as its basic activities. Most of modifications have used the partitions to divide or re-organize space areas in relation to the new activities and uses [8], see Figures 4 and 5. The other type was represented by the expansion, which included increasing the homes’ areas by adding new spaces to the home according to the occupants’ needs and desires. This type of functional flexibility includes two types are: add-in and add-on.
- Add-in means the expansion of the areas homes’ spaces, including the third dimension of these spaces.
- Add-on includes the increase of the homes’ areas of inside and outside spaces. For example, the space of the courtyard has added to the home’s area [8], see Figure 6.

Figure 4: Examples of the long-term adaptability, suggesting spatial solutions for a same space [34].

Figure 5: Various patterns of spatial configurations of an apartment within a composition [35].
4. Methodology

4.1. Deriving the Key Measures

These measures were derived from the covered topics and issues of flexibility and adaptability. The measures are included: (1) versatility and the reuse space, (2) the multi-use space, (3) the open plan system, (4) the long-term adaptability, and (5) expansion. Then, these key measures used in the questionnaire in order to examine the responses of Iraqi dwellers about their satisfaction of flexible and adaptable practices applied on their own homes’ spaces.

4.2. The Questionnaire

During December 2019, a questionnaire was included a 20 questions sent to over than 100 households living in the townhomes (the single-family dwelling) and apartments (the multi-family dwelling) in Baghdad, Iraq. It was made up by three groups of questions: 1) information of the functional flexibility for each sample; 2) evaluating the types of functional flexibility (alterations made to the original space layouts, and the modification that was made by adding partitions in their own spaces); and 3) dwellers’ thoughts about the functional flexibility (including changes, replacements, or refurbishments).

First group of questions has gathered the demographic information which helped the analysis to partially know about the sample’s attitudes. For the second group of questions, a ‘Likert Scale’ has used for assessing the dwellers’ priorities with five point scales: 1) Worst; 2) Bad; 3) Neutral; 4) Good; and 5) Best. Questions aimed to examine how dwellers have adopted the flexibility and adaptability based on their own experience with their homes’ spaces. In the last group of questions, once again, the ‘Likert Scale’ has been used to allow the dwellers to express how much they agree or disagree with a particular statement in the questionnaire. Dweller have made their choice based on five points: 1) Strongly disagree; 2) Disagree; 3) Neutral; 4) Agree; 5) Strongly agree.

The questionnaire targeted only homes with 200 m² area and in some cases examined dwellings with a less than 200 m². The dwellers were diverse in age, gender, and profession. Only 32 responses were turned back the questionnaire. The last question was an open-ended question that asked dwellers to express their thoughts, knowledge, or experience about the functional flexibility, see Table 1.

5. Results and Discussions

5.1. Versatility and Reuse of Space

Dwellers’ responses for both townhomes and apartments have shown that the versatility was very limited and restricted due to the space structures of their residential units. Versatility of townhomes has come above the one that found in apartments. A 50% of townhomes’ dwellers have practiced the versatility to meet their needs in accommodating the new activities, and they evaluated the versatility with 65% as it was a good choice. Dwellers also have experienced the reuse of spaces with a 29% in their own homes’ spaces, and they found that adopting versatility to serve their needs was a good choice, rated 27.3%, see Figures 7 and 8.
Responses of apartments’ dwellers of adopting versatility to meet their requirements were very poor and rated only an 8%. Then, they have assessed the choice of reuse of spaces with a 25%. For both adoptions, versatility and reuse spaces, dwellers have rated them with 17% as they were good for accommodating their needs and requirements, see Figures 7 and 8.

The reasons that stood behind these results would be explained in two categories: first, due to the location of service areas and limitations of structures construction of the apartments, the adaptability and the reuse of space are restricted for the flexibility and sustainability purposes. Second category, townhomes included less than a 200 m$^2$ have well-restricted plans, which impacted the opportunities for adopting new activities, because the distribution of spatial layouts of activities has been rigid. The implementation of this kind of townhomes has broadly repeated in the modern urban developments, starting from the 1970s up to the late of 1980.

Table 1: The Questionnaire

| NO. | Statements                                                                                                                                                                                                 | Worst (1) | Bad (2) | Neutral (3) | Good (4) | Best (5) |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|--------|-------------|----------|---------|
| 2.1 | How did you rate your own personal experience in changing the space use the activity from one to another? For example, changing ‘the reception hall’ to ‘the office room’.                                    |          |        |             |          |         |
| 2.2 | If you have a multi-use space, how did you rate your own experience with its performance?                                                                                                                      |          |        |             |          |         |
| 2.3 | How did you rate your own experience about the location of the open space in relation to the other spaces inside the home?                                                                               |          |        |             |          |         |
| 2.4 | How did you rate your own experience of changing a space use of your home from one activity to another? For example, changing your ‘office room’ into a ‘bed room’.                                            |          |        |             |          |         |
| 2.5 | If you have made a modifications in your own home spaces such dividing or merging spaces, how did you rate this action?                                                                                      |          |        |             |          |         |

Group Three – Below are the statements regarding to attitudes to space flexibility and adaptability in the dwellings’ units. You may read each one and indicate to what extent you agree or disagree with each statement.

| NO. | Statements                                                                 | Strongly Disagree (1) | Disagree (2) | Neutral (3) | Agree (4) | Strongly Agree (5) |
|-----|---------------------------------------------------------------------------|-----------------------|-------------|-------------|-----------|-------------------|
| 3.1 | Achieving flexibility-based on switching the use of their own homes’ rooms. |                       |             |             |           |                   |
| 3.2 | The reuse of the existing spaces for new activities.                       |                       |             |             |           |                   |
| 3.3 | Performance of the open plan system found in the home’s spaces.           |                       |             |             |           |                   |
| 3.4 | Existence of a multi-use space in the dwelling.                            |                       |             |             |           |                   |
3.5. The ability of adaptation processes of the dwelling without impacting the construction structure, basic materials, and services' location.

3.6. Expansion within the internal spaces' boundaries of the dwelling.

3.7. Expansion based on merging the exterior space[s] into the dwelling.

You may use your thoughts, knowledge, or experience to respond to the below question, even with a simple one-word answer.

3.8 How do you define the functional flexibility?

5.2. The Multi-use Space

Dwellers have showed that the multi-use space was very limited in the townhomes, in particular those that their areas above 200 m². However, a 67% of this type of adaptability (functional flexibility) was adopted by the dwellers who lived in the apartments. A 53% was only practiced by dwellers who lived in the townhomes, by which their areas less than 200 m², see Figure 7. A 43% of the examined population were evaluated this type of functional flexibility as a good choice by the apartments’ dwellers, while a 29% was evaluated by townhomes’ dwellers, see Figure 8. Variation of responses was existing because the multi-use space was impacted by the available area. So, it was very useful when the given area was small, but here the privacy of social and functional requirements was impacted.

5.3. The Open Plan System

Dwellers stated that the open plan system was a 37.5% used in the apartments and a 53% found in the townhomes. This type of flexibility was used by the dwellers in both townhomes and apartments when their areas less than 200 m², see Figure 7. This type of flexibility was evaluated by the townhomes’ dwellers as a very good choice, scored a 58.8%, while only a 25% was appraised by apartments’ dwellers as good choice, see Figure 8. An appraisal variation of dwellers has come out because of two reasons: first, the absence of privacy of socio-functional requirements for each particular adopted activity. Second, the whole open area was available for the new adopted activities as well as this kind of spaces allowing a visual control and monitoring for the majority of interior areas.

5.4. The Long-term Adaptability

Dwellers indicated that this type of flexibility was rarely used and scored a 20% in their apartments. However, an 82.3% of townhomes’ dwellers adopted this type due to meet their purposes, see Figure 7. Dwellers who lived in the townhomes evaluated that this type of adaptability was very good, scored a 78.4%. In contrast, those who lived in the apartments have indicated that this type was poor in meeting their scenarios for the new uses in the existing rooms, the rate was 20%, see Figure 8. They relied on partitions as a technique used to re-define the existing spaces into new ones that used for including the new activities.

5.5. Expansion

This type of space flexibility that relied on functions was included two types: add-in and add-on. Add-in type has very rarely adopted in both townhouse and apartments, while add-on type was adopted in the townhomes more than apartments. Dwellers who lived in the townhomes evaluated the add-on type as a very good one, scored 47%. They stated, however, that adoption this type should not impact the open spaces (or gardens) and the design of facades. Other dwellers who lived in apartments evaluated the add-on type as very poor one, scored 10%. They claimed that it did not allow spatial capacity for their choices; also, it was impacted the unity and beauty of the complex facades, as
described in Figure 7. A 44.6% of townhomes’ dwellers have evaluated the expansion of space as a very good, while a 23.1% of apartments’ dwellers stated it was a very good, see Figure 8.

![Figure 7](image1)

**Figure 7:** Responses of dwellers for adopting the key sustainable measures in the dwelling units.

![Figure 8](image2)

**Figure 8:** Dwellers’ preferences for adopting the key sustainable measures in their dwellings.

6. **Conclusions**

The versatility of reuse of housing spaces, for both townhomes and apartments, was the least typology that used based on the space flexibility. Reuse of spaces was primarily practiced in the apartments’ typology due to meeting the dwellers’ needs; then it has rapidly spread in Baghdad and other Iraqi
cities. As an approach, it was adopted more than the reuse of spaces that devoted for the spatial layouts of townhomes, which seemed to be less flexible and more restricted. Despite of the differences found in the two typologies of housing in Iraq, results showed that the dwellers were not expected future extensions or activities when they occupied their dwellings until the new life needs showed up. So, the dwellers often achieved their needs without planned decisions, and instead they totally relied on the capacity of spaces, even if they were not proper as they should be.

The multi-use space and the open plan system are more functional flexible types that found in both townhomes and apartments, in particular areas that were smaller than 200 m². These types of functional flexible spaces provided an optimal capacity for the dwellers’ needs; however, the privacy of adopted activities was not spatially-socially proper for each activity.

The long-term of adaptability has evaluated as good; this type of flexibility was practiced in the apartments’ spaces more than those found in the townhomes. The reuse of spaces was achieved by adding the partitions, by which the new spaces were identified.

The add-in type was rarely used in both townhomes and apartments, while the add-on type adopted in the spaces of townhomes more than the spaces found in the apartments. Dwellers stated that the add-on type as a functional flexible approach has advantages and disadvantages depending on the capacity of spaces. Dwellers recommended that more attention should be paid to the open areas as well as the unity and beauty of facades.

Common points stated by the dwellers of the two typologies of housing could be summarized as follow: first, ideal uses of the existing dwelling spaces should be sustained the privacy of socio-functional requirements, when spaces were turned by the dwellers to accommodate the new activities. Second, the importance of having green spaces in dwellings has given an opportunity for the dwellers to be socially-culturally practiced the outdoor activities with the family members, relatives, or neighbours. Third, facades’ representation should not impact the unity and beauty of dwellings, whether individually or collectively, when the new adoptions have taken place. The most important types of functional flexibility that well reflected the sustainability of new adopted uses. Based on the current study results, the functional flexibility’s proposals are included two proposals. First, a proper functional flexibility approach for the townhomes is the multi-use space as it meets the space capacity with consideration to the local socio-functional requirements. This space should have the ability long-term adaptability for accepting the additional partitions used to accommodate the new activities. A priority of using this space should be given for the family members. The multi-use space of dwellings represents the main area, avoiding future changes, which can be an interior garden that provides a sustainable green space. In the same manner, any changes or developments would not impact the unity and beauty of façade. This proposal is appropriate for the traditional townhomes, when they included an open-to-sky courtyard used for socially and environmentally purposes. Second, another proposal that shows the long-term adaptability for the apartment can be relied on the flexibility of space layouts of the design, by which allows dwellers to meet their future changes. This proposal does not require structural changes or additional construction, instead it depends on the capacity of existing spaces.

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