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Requirements for Flexible Housing Design in Worn-out Urban Fabrics (Case Study: Shaheed Maghoul Neighborhood located in the Worn-out Fabric of District 6 of Mashhad, Iran)

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ABSTRACT

As the most human subject of architecture, housing and residential environments meet various needs of people and provide peace, health, nurture, and self-improvement [1]. Housing must be flexible to the circumstances growing or moving families face. Providing housing in worn-out urban fabrics deals with particular conditions. The Shaheed Maghoul Neighborhood is one of the worn-out fabrics of District 6 of Mashhad, where ethnic diversity can be witnessed. There are numerous non-Mashhadi individuals who did not build their houses and were forced to choose the pre-built residential units for living. The failure of the residential units to fulfill the needs of the residents through different stages of life brings about population relocation, followed by identity loss of the fabric. Flexibility is a proper response to solve housing in worn-out fabrics. In this study, which uses an applied objective and analytical methods, flexible housing provision strategies were initially identified. Next, the preferences of people of various ethnicities for changes to improve living conditions were introduced through a survey method in the study area. Considering the type of life stage people were in, strategies regarding flexibility were identified. According to research results, the cultural characteristics of people living in the urban fabric favor different strategies to meet housing needs in all life periods. Thus, to decrease housing problems in worn-out urban fabrics, attention to cultural and ethnic differences will be fundamental to the effectiveness of the design. However, the divisibility of units in worn-out urban fabrics is suggested among all flexibility strategies. In general, the research results can serve as a guide to enhancing housing quality in worn-out fabrics.

Keywords: *housing; flexible housing; worn-out urban fabric; district 6 of Mashhad*

1. Introduction

Settlement is a long-term and persistent behavior that continues throughout one's life. As the most human subject of architecture, housing, and residential environment meet various needs of people and provide peace, health, nurture, and self-improvement [1]. Housing cannot be limited only to a physical unit, but it comprises a residential environment that must provide all of the necessary facilities and services considering welfare, education, and health [2].

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Change is one of the issues associated with housing. Change is an inevitable case in life because individuals evolve and adapt to new lifestyles. Those places that are applicable for various purposes provide more choices for users compared to those places just designed for a certain use. Those environments providing such options have a quality called flexibility.

The changeability of housing has turned into a substantial design issue due to the complexity of lifestyles and their differences. A flexible house is indeed a house providing change in the area and performance creating a suitable condition to achieve various space layouts by changing residence place borders and adding new constructions. Although the changeability of the building may lead to higher initial costs, it brings a reduction in consumption price by extending the life of residential units in the long term [3].

Adaptability to change is an underlying presumption for society's future, which pertains to the buildings that have long-term future, and correctability for changing desires also needs [4].

Moreover, inattention to the lifestyle of individuals in decisions made about housing would lead to failure and non-acceptance of the decisions by occupants [5]. Consideration of the communication between a product and the consequences of its application and users' values is a chain used to create flexibility features in house design [5]. The more choices or options in the physical environment, the higher the perceived control and welfare of users [6].

In housing design, choice is a dynamic process in which, individuals set their goals based on their values, look for suitable solutions, and evaluate and select the solutions [7].

As an ecosystem, a house consists of three main parts: environment (medium), users, and system (construction). Any change in the mentioned components affects another one, and other variables must be changed to keep the ecosystem balance and sustainable while organizing themselves based on the new circumstances [8].

Because the environment is assessed physically and culturally, the role of culture must be considered in the building design process. Over-attention paid to physical and technical solutions without considering the cultural environment's impact may disturb the house balance (ecosystem).

The worn-out urban fabrics are vulnerable textures that physically worn-out has led to improper road access, vulnerable service facilities and urban infrastructures, and low environmental and economic values. Moreover, some factors such as industrial structure, housing, and land price, stopped investment in public spaces of fabric, and increase unemployment rate have led to this crisis [2]. Cultural and social issues of worn-out urban fabrics are the most critical factors considered in decisions because all decisions are made for occupants based on the acceptance and adaptability of the decision's features with the customs and lifestyle of occupants [5].

With a 76-hectare area, the Shaheed Maghoul Neighborhood is situated in the municipality District 6 of Mashhad. Worn-out fabric constitutes 91% of the neighborhood area. Due to a lack of proper facilities for living and failure to meet the wants and needs of people, most of the local residents have emigrated. Additionally, generally, economically disadvantaged individuals from different ethnicities who are strangers to the neighborhood reside there due to financial inability; however, these individuals have no place attachment nor attention to its latent values. Population relocation in this neighborhood is defined as a cycle after settlement and the household achieving adequate financial ability. Failure of the residential space and residential units to meet the needs of the individuals throughout various stages of their lives is one of the most significant reasons behind their relocation. Further, the Shaheed Maghoul Neighborhood has identical residential units despite its cultural diversity. Making any decision regarding providing housing requires sensitivity. The weak emigrant class is one of the primary reasons behind the similarity of residential units as they had no role in building the houses and only managed to buy a unit by saving up the little money they had or renting the cheap units. Considering the points above, it is substantial to design a house with changeability to meet the needs of people of various cultures in worn-out fabrics.

2. Research Background

According to the literature review, some research achievements about flexible housing have been mentioned herein.

HoseinPour and Keynejad [2] carried out a study under the title of 'analyzing and evaluating the applicability of design practices in small-scale housing to identify different apartment types through a survey of architecture experts. The results indicate the position of different spaces and the relationship between them in the plan had the highest correlation with housing functionality, which shows the importance of plan geometry and the way it is designed to provide applicability.

Abbaszadeh et al. [9] conducted a study under the title of 'analyzing a proper flexible and adaptable pattern for promoting the housing quality in Iran,' and concluded that the design of a flexible and adaptable house based on the occupants' need variations in different life cycles is an underlying solution to make residents satisfied and prevent change in their houses.

Kisnarini et al. [10] studied apartments in developing countries. Their results showed that dramatic population rise in developing countries led to housing needs in urban areas. Residential units must be able to change the function and spatial dimensions based on the user's need due to the lack of designed residential units with useful lifespans and occupant change.

Howe [11] conducted a study under the title of flexible house designing for changing needs and concluded that this mode of design facilitates the housing design adapting to the changing needs and modifies the demand for new housing in developing districts. Howe investigated the financial barriers to the flexibility of residential buildings believing that the house that is constructed in the present time must be able to meet the social needs of the present and 50 years later.

Estaji [12] Carried out a study under the title of 'A review of flexibility and adaptability in housing design,' and found that flexibility was the ability and potential of a building to change, adapt, and reorganize itself in response to the changes.

Cellucci and De Sivo [13] conducted a study entitled 'the flexible housing: criteria and Strategies for Implementation of Flexibility' and found that flexibility could be considered the antidote to obsolescence.

According to the reviews, no practical method exists to use the flexibility concept in these fabrics. Veitch and Gifford [6] believe that the more options or choices available in the physical environment, the higher the perceived control of users and welfare will be.

Beisi [14] suggests designing a house, by using flexible elements and furniture to allow user easily change the indoor characteristics and elements of the house based on the time and their daily activities.

Friedman [15, 16] points to another model called Extending Core Plan (EC), which includes two renovation forms. The first form is additive, which considers an extra space in the house plan's area. The second is an add-on that allows adding space vertically and horizontally.

Alaraji and Bin Mohd Jusan [17] conducted a study entitled 'Perceived by end-users,' and referred to the relationship between a product and the consequences of its applications and users' values. They considered five values (family security, hedonism, benevolence, self-concept, and self-guidance) as a cause of the desire for housing flexibility. They also investigated the relationship between the mentioned values and architectural elements in flexible design, including changeable furniture, enlarged rooms, the ability to change the floor coverage, the ability to change the wall's color, adding a room without changing the plan, the ability to change the window size, ability to renew equipment and adding a floor vertically.

Holtz [18] proposed some strategies to reduce required energy through passive design measures and construction techniques to adapt the current needs of residents to their futures. Finally, Holtz considers attention to direction, glaze, insulation, construction, building coverage, and adaptability as effective factors for access to regular control over energy consumption and its control by the end user.

Zairul et al. [3] suggest the possibility to change open spaces' use, such as a space for horticulture, an open balcony, and a roof garden, and providing units' arrangement to achieve a flexible house and circular economy, reducing price consumption, and increase the lifespan of the residential unit by providing some strategies, including structure changes (structure supplication and making it flexible by providing extra unit and extension in the future).

Schneider and Till [4] have written several papers about flexibility in architecture. In a paper entitled 'flexible housing: opportunities and Limits,' they studied flexibility and its impact on the long-term costs of a building. They concluded that if technology systems, service strategies, and spatial principles are used to provide a flexible application of a building then the building has a longer lifespan and would be affordable since they reduce the need and frequency of renewal.

In another paper under the title of 'Opportunities of flexible housing,' they investigated the flexibility between units, connectivity or easy separation of units both vertically and horizontally, interior arrangement of a unit, and consideration of some spaces with same sizes by putting wall and service cores [4].

In the paper entitled 'flexible housing: means to the End,' they confirm adaptability as one of the sustainability parameters on a small scale but believe that flexibility must be accepted as a prerequisite for sustainability. They consider adaptability with change an underlying presumption for society's future that is related to those buildings that need a long-term and

changeable future to change desires and needs. They also point to the 'soft' approach in the construction or 'incomplete building' [6].
Radha suggests that technology can improve life quality by making homes smart, adaptive, and customizable, overcoming fixed layouts' limitations, and anticipating user needs [19].
Rauws and De Roo [20] found conditions that can enhance urban adaptability in 12 Dutch development projects, including two analyzed in this paper, related to spatial-functional configurations and local actors' capacity building.

Table 1. Component type based on criteria and indicators.

Component	Criteria and indicators
The functionality of small-scale housing	Importance of plan geometry role and its design to provide functionality [2]
Flexible pattern	Designing a flexible and adaptable house based on the residents' needs changes during different life cycles [9]
Apartments in developing countries	Possibility to change performance and spatial sizes based on the user's needs [10]
Flexible housing	Facilitating housing design adapting to changes, and modifying demand for new houses [11]
	Antidote to obsolescence [13]
	Using technology systems, service strategies, and spatial principles [4]
	Adaptability [4]
	Provide more options or choices in the physical environment [6]
	Use flexible elements and furniture [14]
	Extending core plan [16]
Increase flexibility	Changeable furniture, enlarging rooms, changing floor covering, changing the color of the wall, adding a room without changing the plan, changeability of window size, ability to renovate equipment, and adding a floor vertically [17]
	Passive design and construction techniques [18]
	Structure changes [3]

3. Theoretical Framework

Two different changeability and adaptability are detectable that are sometimes synonyms in the flexibility scope. The difference between these two concepts depends on the changes that occupiers can create in a space. In an adaptable house, a little intervention is possible to create changes by moving furniture, while a changeable house is

ready to accept those interventions that create considerable changes in a residential building. In other words, adaptability is limited to functional and functional-spatial flexibility, while changeability consists of structural and structural-spatial flexibility. Adaptable designs do not accept considerable physical changes. In this way, the area of the residential unit remains fixed, and all changes are done without changing the open space of the building [4].

Flexible housing is defined as follows. In proposed definitions, the comprehensive rate of definition is reduced from top to bottom.
Flexibility is an important concept in the field of housing due to changes in users' needs and wants. Flexible housing can be defined as housing designed to be changed throughout its lifespan. Flexible housing is suitable for users with different and changing lifestyles [4].
Flexible housing is housing designed for easy response to changes over life [21].
Flexible housing allows occupants to create their desired potential spaces and change them based on their residential needs over time [22]. This type of housing indeed allows users to choose a dynamic process in which, 'individuals set their foals based

on their values, look for suitable solutions, evaluate these strategies, and finally select them' [7].
Flexible housing provides the ability to change the area and performance and creates proper conditions to achieve different space arrangements by changing the residence place's borders and adding new constructions [23].
Flexibility is now a valuable resource for urban planners to address the challenges of complex, unpredictable, and diverse cities, despite its unfavorable past perception [24].
Flexibility varies across fields, denoting the extent to which objects can vary while maintaining essential characteristics. In economics, it relates to sensitivity to changes in related variables [25].
Adaptability is a concept closely related to flexibility. Adaptability often requires prediction and planning to accommodate unforeseen events; however, flexibility can be more immediate and temporary, often requiring adjustments to other factors. These two concepts are sometimes used interchangeably, and distinguishing them regarding the broader domestic framework of home could be difficult. Flexibility leaves borders and open spaces for furniture movability and is closely related to manual adaptability that introduces mobile or changeable elements, such as walls, furniture, and partitions, which changed manually by the occupier.
Table 2 illustrates the perspectives of some renowned theorists in flexibility.

Table 2. Factors affecting the spatial changes of a residential unit.

Theorist	Flexibility criteria
Friedman [15, 16]	Adding space in:
	Horizontally in the plan area
Xu and Zhang [24]	Vertically
Beisi [14]	Flexible furniture
Zairul et al. [3]	Expansion of structure and making it flexible
	Ability to change the use of open spaces
	Ability to combine units
Schneider and Till [4]	Ability to connect or separate units horizontally or vertically
	Having spaces with equal sizes
	Placing walls and cores of services (service spaces)
	Movable walls, folding furniture
Schneider and Till [4]	'soft' approach in structure or 'incomplete building'
	The ability of blocks to be easily connected or sectioned (vertically and horizontally)
	The adjustability of the interior arrangement of a block
	Considering some spaces with equal sizes (by placing walls and service cores)
Estaji [12]	Partitionability
	Expandability (horizontally/vertically)
	Multifunctionality (shared space)
	Divisibility
Alaraji et al. [17]	1. Changeable furniture, 2. Expanding rooms, 3. The changeability of floor covering, 4. The changeability of the wall's color, 5. Adding a room without changing the plan, 6. Changeability in size of the window, 7. Renewal of equipment, and 8. Adding a floor vertically
Zairul et al. [3], Malakouti et al. [26]	Expansion of structure and making it flexible
	The changeability of open spaces' use
	Ability to combine blocks or units

Flexibility in housing includes four key subjects that must be considered in the design process:

3.1. Structural system

Various factors exist in structure design that affects the flexibility of the building: modularity, non-bulky, type of connections, and or load reduction are variables that must be examined in this case. For instance, wall structures fully limit the flexibility of indoor spaces, or shear concrete walls or metal windbreakers in the structure disturb the interior spaces. Moreover, the type of ceiling plays an effective role in vertical connections between spaces. Structural systems are fixed and permanent parts of buildings, which influence the flexibility rate of the projects. The flexibility rate of residential units depends on their variable and constant elements. When future wants of the space are anticipated in the design process then a project appears that is adapted to the changing conditions and wants of users in the future [27]. For instance, proper ideas for structural elements allow projects to implement these changes in the future. Two

underlying approaches exist in this strategy to achieve flexibility: base structure and multi-capacity organization. The base structure refers to a structural system in which, the project can implement all uses and activities that are usually allowed by beam and column structures, and the second approach designs the spaces that can provide the required conditions for different activities [26]. Schneider and Till [4] point to the 'soft' or 'incomplete building' approach in the case of the flexible buildings' structure. It means that a basic frame opens a space for the personal interpretation of the user, including the number of rooms, location, and practical uses. Occupants can decide how to divide the space, live there, where to sleep, and where to eat food. If family composition is changed, the house can be adjusted and enlarged to some extent> structural framework is a semi-finished product that everybody can complete based on his or her needs.

3.2. Service spaces

Some spaces, such as staircases or restrooms are inflexible parts of the plan due to their various installations and specific quality of materials used in the floor and walls that are mainly certain materials in these spaces, as well as different horizontal and vertical connections with other spaces. Hence, the organization and placement of these spaces in the plan are highly important because their surrounding spaces must be able to change sizes, proportions, and accesses. On the side connected to such inflexible spaces, the mentioned capabilities face serious challenges in terms of expansion, separation, or access. Quality and number of accesses to these spaces or the type of facilities used in them can provide interaction between these spaces and other flexible parts of the house. This adaptability and interaction between inflexible spaces and other adjacent spaces are crucial, so it is highly useful and effective to provide proper access to these spaces and anticipate their surrounding communicational spaces. Accurate placement of these spaces in the place at the first phase of design is considered in a way that spaces are shaped based on the efficient proportion around them.

3.3. Organizing architectural space

This is about deciding on the organization of architectural spaces. The type of connections, accesses, size of spaces, light, etc. are all factors affecting this area. In the design of flexible housing, spaces must be extendable, collectible, and separable. Collecting adjacent spaces or separating a space dividing it into two spaces with similar or different use is one of the most important capabilities that must be considered. The more spaces with such ability in the housing, the higher flexibility will be achieved. Moreover, access must be provided for the space in a way that can have qualified and easy access to that space at other times or when change occurs in adjacent spaces. Accurate proportions in the initial location of spaces and primary divisions are the most important issues in the design process. Spaces must keep their spatial qualities, such as natural light or ventilation or proper access after being extended or separated. This case depends on the starting point of design, placement or layout, and spatial proportions. The organization of architectural spaces affects the share of external facades of the building with specific characteristics and qualities of those facades after a space is separated or extended.

3.4. Flexible equipment and furniture

Movable, sliding, and folding partitions, changeable and movable furniture, and other equipment types are highly important elements in the flexible operation of housing. The mentioned flexible equipment allows users to use the space and amenities based on their needs. Application of these facilities and partitions requires using dry connections, such as screws, types of rails, rivets, and or crotch and tabular connections to provide a field for various changes, disconnections, and connections. If these types of equipment reach mass production like other amenities used in the construction industry, such as double-glazed windows, elevators, and so forth then they can create new industries and jobs and provide these amenities at affordable prices for contractors. Beisi suggests designing a house, by using flexible elements and furniture so users can easily change the features and elements inside the house based on their daily activities and daytime [14]. Design flexibility includes margins and open spaces for furniture movement and manual adaptation, which integrates movable or transformable elements like walls, furniture, and partitions that users can adjust [28].

According to conducted studies, factors affecting the special changes of a residential unit or apartment are classified as follows (Table 3).

Table 3. Factors affecting the spatial changes of a residential unit.

Theorist	Flexibility criteria
Friedman [15]	Adding space in:
	Horizontally in the plan area
	Vertically
Beisi [14]	Flexible furniture
Zairul et al. [3]	Expansion of structure and making it flexible
	Ability to change the use of open spaces
	Ability to combine units
Tatiana and Till [4]	Ability to connect or separate units horizontally or vertically
	Having spaces with equal sizes
	Placing walls and cores of services (service spaces)
	Movable walls, folding furniture
	'soft' approach in structure or 'incomplete building'
Tatiana and Till [4]	The ability of blocks to be easily connected or sectioned (vertically and horizontally)
	The adjustability of the interior arrangement of a block
	Considering some spaces with equal sizes (by placing walls and service cores)
	Partitionability
Estaji [12]	Expandability (horizontally/vertically)
	Multifunctionality (shared space)
	Divisibility
Holtz [18]	1. Changeable furniture, 2. Expanding rooms, 3. The changeability of floor covering, 4. The changeability of the wall's color, 5. Adding a room without changing the plan, 6. Changeability in size of the window, 7. Renewal of equipment, and 8. Adding a floor vertically
Zairul et al. [3]	Expansion of structure and making it flexible
	The changeability of open spaces' use
	Ability to combine blocks or units

In general, factors affecting the spatial variations of a residential unit are as follows (Table 4) [29].

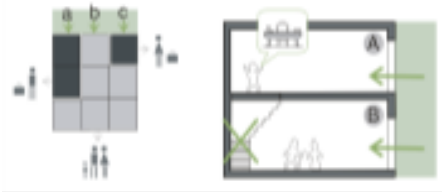
Table 4. Factors affecting spatial variations of a residential unit.

Factors affecting the spatial variations of a residential unit	Criteria
Economic and technical factors	Saving energy consumption
	Economic changes in household
Cultural and social factors	Lifestyle
	Change in household size
	Change in household structure
Physical and spatial factors	Dividing rooms
	Connecting rooms
	Displacing rooms
	Changing the size of rooms

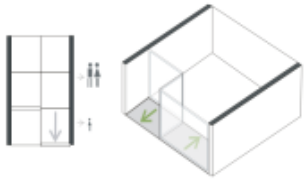
3.5. Flexibility strategies

According to definitions for flexibility, various experiences exist in this context. The most substantial strategies used in the world have been summarized in Table 5.

Table 5. Flexible housing strategies [13].

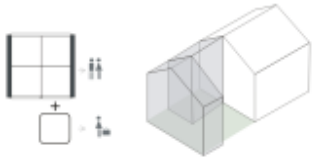
Strategy: Redundancy access.	
	This strategy ensures the possibility of a decrease in the size of the house over a period of time, in which the user does not need more of the entire surface of the house and can divide it into two or more units, or may assign part of the surface to another home or to a task (studio). To schedule a minimum of two accesses can significantly affect costs (technical and constructive) related to the eventual realization of the same division into two units.

Strategy: Increased surface on existing support.



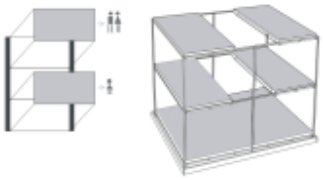
This strategy allows the increase of the surface of the house through the closure of spaces that are already built but that are not considered habitable. The new space can be a balcony or a terrace, where small architectural interventions may be closed to form part of the interior of the house.

Strategy: Increase in house size on new media and increasing the initial volume.



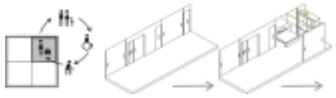
This strategy allows the growth of useful surface of the house by creating new spaces, compared to the initial volume, over a new support, then through the addition of structural elements. In this case, the house must be designed for modular elements that can be expanded in the three spatial directions, according to needs planned for in the design stage, through the use of prefabricated modular elements.

Strategy: Increased of the inner surface by adding environmental units



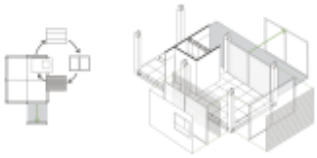
This strategy allows an increase in the useful surface of the housing, without affecting the initial volume because the increase takes place within it. This increase is possible inside a house on two levels, such as through the closure of horizontal full-height spaces in favor of environmental new units, or by adding an extra bedroom for the birth of a child.

Strategy: Indeterminacy of environmental units



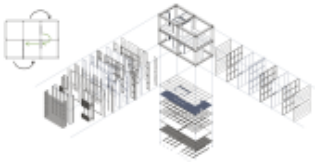
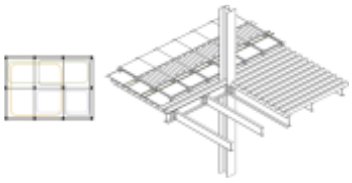
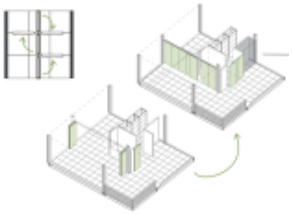
This strategy is based on providing the house with indeterminate spaces. Users can change the use of space without physical changes. This is possible either through a neutral downsizing of the environmental units to accommodate any function and a hierarchization of the same or through the conception of space as a universal container in which the organization of environmental units and their transformability is given by moving walls and furniture containers.

Strategy: Adequacy and modifiability of the housing casing.



This strategy allows an upgradable facade of the housing. Among the possible solutions is the use of movable facades that slide on preexistent lodges to ensure the expansion of the internal space; non-bearing curtain walls that allow users to dismantle some closure elements and replace them with others, or to reassemble them later with a new configuration.

Strategy: Using closures that are dried and stratified.

	This strategy allows for housing reversibility with fast deadlines that reuse part or all of the components. This strategy allows, therefore, a total housing reversibility, the replacement of some components with others that provide higher performance, and the change of position of the same (e.g., seals or partition walls).
Strategy: Structural regularity and adaptable floors.	
	This strategy consists in organizing the structural system on a regular grid, essential to ensure the easy convertibility of the building. Hollow beams or trusses are also used that are capable of integrating the plant system in a structural morphology, making the interior space completely free from constraints that might hinder the convertibility of the space. Anticipation of possible extensions is also an important part of this strategy.
Strategy: Use of mobile equipment.	
	This strategy allows the spatial and functional reorganization of the entire housing unit with quick turnaround, thanks to the displacement of equipped walls, furniture cabinets or prefabricated modular interior partitions mounted with dry joints. This solution is effective especially in small spaces, without partitions, where the partitioning is done through the use of mobile equipment enabling the user to use the same surface differently

3.6. The necessity of housing flexibility and factors affecting spatial variations

Demographic changes in a family usually follows an identical pattern, which is distinguishable in different communities. According to studies conducted by Friedman, demographic changes in family structure mainly cause physical and spatial changes in housing. These changes usually are done by occupants and can be seen in certain periods of the family lifecycle (Figures 1 and 2) [15, 16].

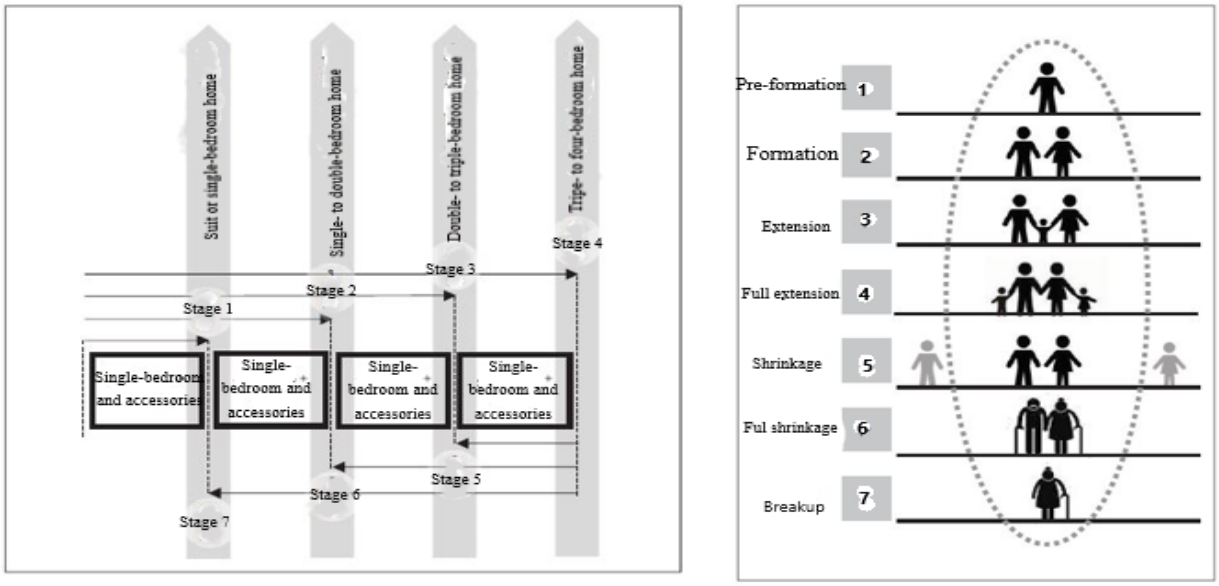


Figure 1. Factors affecting spatial variations of a residential unit [30]

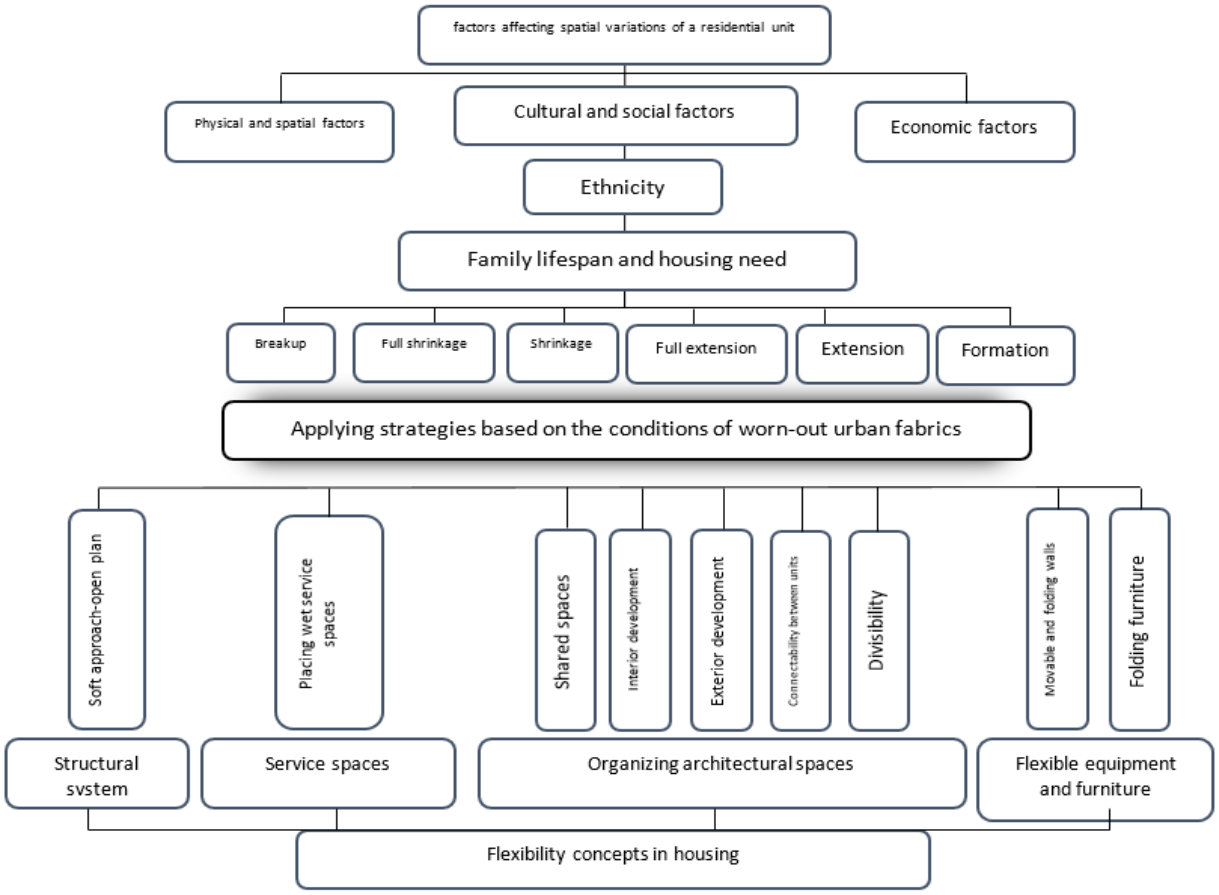


Figure 2. The conceptual model of the research.

This was applied research in terms of objective and an analytical study in terms of method. The theoretical framework of the study was identified using documentary and library methods. According to the nature of the considered subject, the research approach was a survey, and interviews, questionnaires, and field observations were used in the study. The statistical society of study comprised the units (N=7516 units) located in Shaheed Maghoul Neighborhood in the worn-out fabric of municipality District 6 of Mashhad, Iran. The sample size equaled 380 based on the Cochrane formula. Cluster sampling was used due to the extent of statistical society and districting method of the studied region.

4. Results

4.1. Introduction to the study area

District 6 of Mashhad City located in the southeast of this city with 3 areas and 15 neighborhoods is one of the large marginal areas with 1869 hectares and a population number of 232616 people based on General Census and Housing Population. The study area is Shaheed Maghoul Neighborhood limited to Hor Boulevard from the north, to Hor Street 13 from the east, Ghadir Highway from the west, and to the railway and Shirin Town from the south. The area of Shaheed Maghoul Neighborhood is around 76 hectares with a population number of 26379. Shaheed Maghoul Neighborhood has around 80 years of history, and thatched houses still exist in some areas of the neighborhood. Most people who live there are Muslims with Shia religion. Around 40% of the population are Sunni Muslims. Khavir ethnics are the first tribe who start living in this area. Baluch and Afghan tribes immigrated to this neighborhood gradually during the Iran-Iraq war. According to formal statistics, the population growth rate in Shaheed Maghoul Neighborhood has been descending from 2006 to 2016, while population increase occurred since 2016 due to an increased fertility rate after the entrance of immigrants the majority of whom are Sunni Muslims. This immigration has been mostly from adjacent villages and cities, such as Taybad, Khaf, Sarakhs, Sistan, and Baluchestan. Household size decreased from 4.2 years in 2006 to 3.4 in 2021 in this neighborhood.

Following immigrants have entered the Shaheed Maghoul Neighborhood:

Group 1: Sunni immigrants that live around the Masjed Jame Noor located on Shaheed Gholami Street.

Group 2: Domestic immigrants of Sistan and Baluchestan Province who live in Fooladi Hub at the end of Shaheed Gholami Street.
Group 3: Foreign Afghan immigrants who live in Moosavinejad Street (Hammam Alley) Street.
As mentioned, when providing flexible housing, the best result is achieved when people of different cultures are considered.

4.2. Data analysis based on the ethnicity

Hence, a survey was conducted on people with different ethnicities. Table 6 illustrates the information.

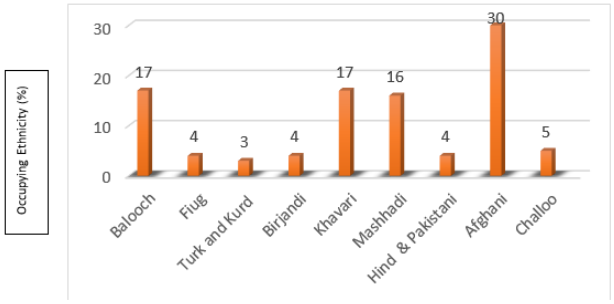


Figure 3. Ethnicities living in the Shaheed Maghoul Neighborhood in the worn-out fabric of District 6.

Table 6. Strategies' priority based on the lifecycles based on the ethnicity.

	Lifecycle	Open plan design	Placing wet service spaces	Shared spaces	Interior development	Exterior development	Connectivity between units	Divisibility of units	Movable and folding walls	Folding furniture
Formation	Balooch	3.2	1.6	6.9	4.1	6.9	7.9	2.5	7.1	5.9
	Fiug	2.6	1.9	6.5	7	7.2	7.4	3.2	6.8	6.1
	Birjandi	2.8	1.2	6.6	7.3	6.9	6.8	3.6	7.3	5.8
	Khavari	3	3.4	6.7	6.6	6.2	6.2	4	6.9	6.7
	Mashhadi	3.1	2.7	6.8	7.9	5.9	5.6	4.4	8.4	6.4
	Afghani	4	3.4	6.9	7.2	5.6	5	4.8	8.9	6.1
Extension	Balooch	3.2	3.1	6.2	6.7	7.1	5.3	3.2	5.2	5.2
	Fiug	2.6	3.4	5.8	7.2	7.4	4.8	3.9	4.9	5.4
	Birjandi	2.8	2.7	5.9	7.5	7.1	4.2	4.3	5.4	5.1
	Khavari	4.2	3.4	6	7.8	6.8	3.6	4.7	5.9	5.8
	Mashhadi	4.4	2.7	6.1	7.6	6.5	3	5.1	6.4	5.5
	Afghani	5.3	3.4	6.2	7.4	6.2	2.4	5.5	6.9	5.2
Full extension	Balooch	2.7	5.2	3.8	3.6	5.6	6.2	5.2	6.1	4.9
	Fiug	2.1	5.5	3.4	5.7	5.9	5.7	4.9	5.8	5.1
	Birjandi	2.3	4.8	3.5	6	5.6	5.1	6.3	6.2	4.8
	Khavari	3.3	4.1	3.6	6.3	5.3	4.5	7	6.8	4.5
	Mashhadi	3.5	3.4	3.7	6.6	5	3.9	7.4	7.3	4.2
	Afghani	4.4	4.1	3.8	6.9	4.7	3.3	7.6	7.8	3.9
Shrinkage	Balooch	5.1	6.2	4.5	3.5	3.4	6.1	4.9	5.3	4.1
	Fiug	4.5	6.5	4.1	3.5	3.7	5.6	5.6	5	4.3
	Birjandi	4.7	5.8	4.2	3.8	3.4	5	6	5.5	4
	Khavari	4.9	5.1	4.3	4.3	3.1	4.4	6.7	6	3.7
	Mashhadi	5	4.4	4.4	4.6	2.8	3.8	7.1	6.5	3.4

Full shrinkage	Afghani	5.9	5.1	4.5	4.9	2.5	3.2	7.5	7	3.1
	Balooch	5.9	5.8	3.6	1.9	3.1	5.7	7.8	1.8	4.3
	Fiug	5.3	6.1	3.2	3.2	3.4	5.2	8.5	1.5	4.5
	Birjandi	5.5	5.4	3.3	3.5	3.1	4.6	4.1	2	4.2
	Khavari	5.7	4.7	3.5	3.8	2.8	4	6.5	5.5	4.8
	Mashhadi	5.8	4	3.6	4.1	2.5	7.4	6.2	3	4.5
	Afghani	6.7	4.7	3.7	4.4	2.2	2.8	7.3	3.5	4.2

4.2.1. Balooch Ethnicity

In total, 48 respondents from Balooch ethnicity existed. Individuals who are spending the formation cycle of life introduce the strategy of connectivity or convertibility between units as the most important factor that improves living conditions. The responses of individuals were examined based on their life period and the area of the apartment they live in it to identify the subject more precisely. Those households that live in environments with areas smaller than 50m2 introduce the ability to develop exterior space of units and connectivity between units as important strategies. Those households that live in spaces with an area less than 50-100 m2, consider folding furniture as the most significant strategy. The households, who live in spaces with an area larger than 100m 2, consider the open plan design as the most important strategy. Individuals who are in the extension period consider exterior development as the most substantial factor in improving living conditions.

According to the explanations mentioned above, the households who live in the area smaller than 50m2 introduce exterior development as the most important strategy in this context. Those households who live in an area less than 50-100m2 consider folding furniture and movable walls as the most important strategies. Those households that live in a space with an area larger than 100m2 consider interior development as the most important strategy.

Those individuals who are spending the full extension period consider the strategy of connectivity between units as the most important factor for the improvement of living conditions. The households who live in environments with an area smaller than 50m2 introduce exterior development as the most substantial strategy. Those households who live in a space with an area of less than 50-100m2 consider shared spaces as the most crucial strategy. Those households who live in a space with an area larger than 100m2 consider connectivity between units as the most important strategy.

Those individuals who are spending the shrinkage period consider the strategy of placing wet service spaces as the most important strategy. The households who live in environments with an area smaller than 50m2 introduce interior development as the most substantial strategy. Those households who live in a space with an area less than 50-100m2 consider the divisibility of spaces as the most crucial strategy. Those households who live in a space with an area larger than 100m2 consider open plan design as the most important strategy.

Those individuals who are spending the full shrinkage period consider the strategy of space divisibility as the most important factor for improving the current conditions. Those households who live in a space with an area less than 50-100m2 consider folding furniture and movable walls the most crucial strategy. Those households who live in a space with an area larger than 100m2 consider interior development as the most important strategy.

4.2.2. Fiug Ethnicity

In total, 12 respondents from Fiug ethnicity existed. Connectivity between residential units, exterior development, wet service spaces, and divisibility of units are the most important strategies used to improve living conditions in Fiug ethnic during formation, extension and full extension, shrinkage, and full shrinkage periods, respectively. The strategy of units; divisibility reaches the maximum percent during full extension and shrinkage periods. The reason may raise from occupants' concerns for providing housing for their children, which is shown in mentioned cycles.

4.2.3. Birjandi Ethnicity

In total, 12 respondents from Birjandi ethnicity existed. Folding and movable walls, exterior development, divisibility of units, and open plan design strategies are considered the most important factors used to improve living conditions of Birjandi ethnic during formation, extension, full extension and shrinkage, and full shrinkage periods of the lifecycle, respectively.

4.2.4. Khavari Ethnicity

In total, 73 respondents from Khavari ethnicity existed. Folding and movable walls, interior development, folding and movable walls, and units' divisibility strategies were considered as the most important factor used to improve living conditions of Khavari ethnicity during formation, extension, full extension and shrinkage, and shrinkage and full shrinkage periods of the lifecycle.

4.2.5. Mashhadi Ethnicity

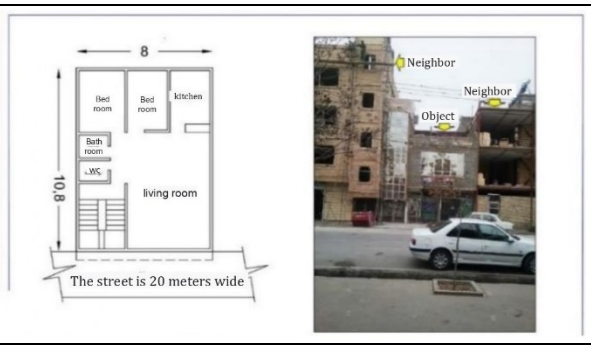
In total, 65 respondents from Mashhadi ethnicity existed. Strategies of interior development, units' divisibility, and connectivity between units were considered the most important factors used to improve living conditions of Mashhadi ethnicity during formation and extension, full extension and shrinkage, and full shrinkage periods of the lifecycle.

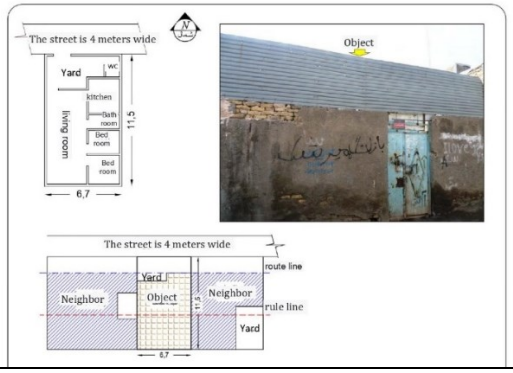
4.2.6. Afghani Ethnicity

In total, 138 respondents from Afghani ethnicity existed. Interior development, movable and folding walls, and units' divisibility strategies were considered the most important factors used to improve living conditions of Afghani ethnicity during formation.

Given the low financial ability of residents in worn-out urban fabrics and considering housing simply as a shelter, different life periods under current circumstances have no specific pattern of influence on choosing the residential units. The proposed responses by the residents of the worn-out fabric of District 6 were strongly affected by the current housing situation of people, meaning individuals with big-scale households forced to live in 50m2 units consider the exterior development strategy as a substantial solution, in which little attention is paid to the cultural characteristics of people. Hence, several instances of residential units with the selected strategies will be analyzed.

Table 7. Strategies' Priority in case studies.

Priority of selected strategy		
Interior development	1	
Exterior development	2	
Open plan design	3	
Shared spaces	4	
Placing wet service spaces	5	
Connectivity between units	6	
Folding furniture	7	
Movable walls	8	
Divisibility of units	9	
Priority of selected strategy		
Exterior development	1	
Interior development	2	
Shared spaces	3	
Open plan design	4	
Placing wet service spaces	5	
Folding furniture	6	
Movable walls	7	
Divisibility of units	8	
Connectivity between units	9	
Priority of selected strategy		
Exterior development	1	
Open plan design	2	
Connectivity between units	3	
Interior development	4	
Movable walls	5	
Folding furniture	6	
Placing wet service spaces	7	
Divisibility of units	8	
Shared spaces	9	
Priority of selected strategy		
Open plan design	1	

Exterior development	2	
Connectivity between units	3	
Interior development	4	
Placing wet service spaces	5	
Folding furniture	6	
Movable walls	7	
Shared spaces	8	
Divisibility of units	9	

To summarize the research findings, different ethnicities first consider achieving minimum standards. In the second stage, they pay attention to cultural characteristics and the suitability of the residential unit with such characteristics.

First-stage research findings are as follows:

During family formation, due to the low household population, most individuals in worn-out fabrics live in small units. Small units are formed by dividing a bigger unit in worn-out neighborhoods; therefore, forward-thinking people residing in worn-out urban fabrics choose the "connectivity between units" strategy, which will be effective for them.

During extension and full extension, and simultaneously with the birth of children, families seek to create private spaces for the new members, which increases the need for bedrooms. Thus, the selected strategy by the residents from all ethnicities was the possibility of exterior and interior development.

During shrinkage, the marriage and education of the kids causes reduction in the family population, and the kids return with their spouses. Therefore, there is a need for an increase in the public space area of the house in the living and dining rooms while there is no need for private rooms. This is because the return of their kids is often in the form of guests.

During full shrinkage, maximum family shrinking and increased economic damages due to inability leads to selecting the strategy of dividing and selling residential units.

5. Discussion and Conclusion

The objective of socially resilient housing design is to cater to the evolving and varied social requirements of the inhabitants [25]. Because of the difficulties in predicting the number and types of Investors favor inflexible buildings due to the high cost of flexible designs and the difficulty of predicting future adaptations. However, this approach can harm their interests [31]. Flexible housing meets diverse requirements and accommodates modifications during development, improving housing quality [11].

Flexibility means the response of an environment to different conditions and life variations over time to allow users to do various activities without any restrictions in that environment. Housing is one of the most important uses that need flexibility. The population rise and housing needs, as well as unknown users and their wants, require us to have some designs that can support society at different environmental, economic, and social levels, so can create adaptability and use it to replace the previous patterns with a new pattern of modern life.

Numerous studies have been conducted on housing flexibility. Many of these studies introduce flexibility as a general solution to meet the needs of residents throughout time. By acknowledging the cultural differences of residents, this study has selected worn-out fabrics encompassing ethnic and cultural diversity, as well as extensive intra-neighborhood relocations, among different urban fabrics. Flexibility strategies appropriate for social and cultural features of people in worn-out urban fabrics can be introduced as the design pattern of new constructions with small floor areas.

Given the questionnaire results, meeting the need for housing can be analyzed at two levels. The first level is achieving minimum and required family standards, which is the same in all Iranian ethnicities regardless of cultural matters. The second level is the susceptibility of housing from Iranian sub-cultures.

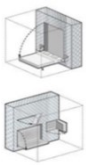
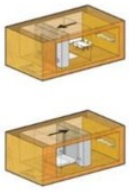
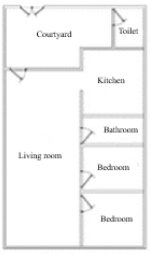
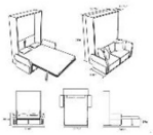
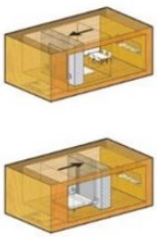
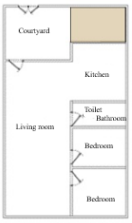
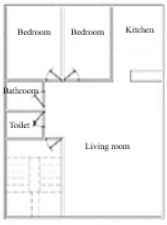
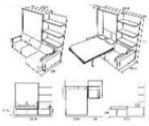
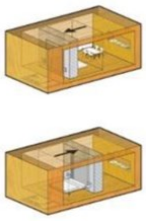
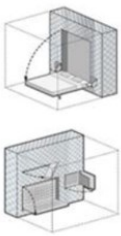
The adaptability of residential spaces to new and changing needs of a family, responding to various functions simultaneously, and using interfaces of housing spaces at different scales are some of the substantial matters to follow in designing a new house. Achieving such residential units increases the feeling of attachment in the residents to their houses and decreases residential relocations, which

will prevent chaos in functions, loss of identity in forms, and disorder in housing for unspecified individuals concerned.

Considering ethnic diversity in worn-out urban fabrics and lack of precise planning regarding attention to the characteristics of all ethnicities, practical and general solutions for positive changes will be proposed to meet the needs of residents of worn-out fabrics.

1. The possibility of extending the floor space of the residential unit by predicting spaces before the design, such as a balcony with a proper area that can convert into a room.
2. Meeting new needs by changing the interior walls and installing parts in residential units without changing the house area.
3. Designing a pan with a regular geometric structure.
4. The possibility of providing various uses for a space to have simultaneous functions.
5. Creating spatial diversity by using light, color, and texture in the interior spaces of the residential unit.
6. Moving non-load bearing walls to access flexible spaces and substituting partitions.
7. Using new pieces of furniture to clear various functions and versatile spaces.

Table 8. Suggested solutions based on plans typing and strategy.

Row	Plan typing	Strategy				
		Open plan	Folding furniture	Movable wall	Increasing exterior level	Increasing interior level
1					—	
2		—				—
3		—			—	
4						

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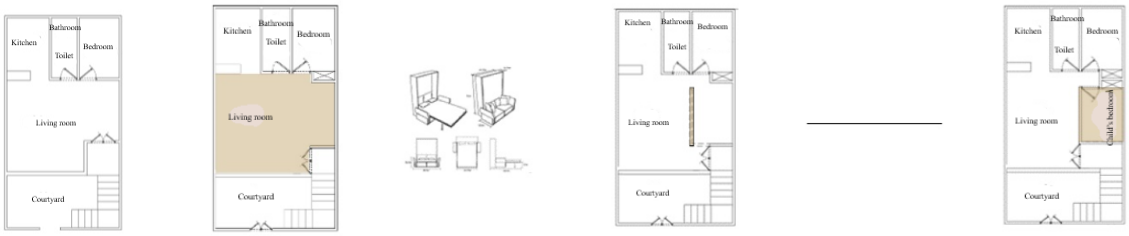

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