

# Explaining the Ratio of Flexibility and Spatial Organization in Housing with Space Syntax Method; Case Study: Atisaz, Mahan, and Hormozan Residential Complexes\*

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## ABSTRACT

Architectural spaces with the capability of spatial organization and internal transformations can respond to a greater number of their users' needs at different times and thus provide more desirable performance than single-functional spaces. The necessity to access this ability is one of the subcategories of flexibility in housing as a contemplative subject. The purpose of this research is to provide an analytical model in relation to recognizing the space syntax method and using its indicators to measure flexibility in housing. Residential complexes in Tehran city are evaluated as a research society. In order to better express the problem, this research attempts to answer the question of how to use the indicators of the space syntax method to measure flexibility in housing. The research method in the present study will be of mixed type and its performance method will be based on computer simulation. The information-gathering method is based on the library study, and also the field survey includes using available information and observation. The information-gathering tool includes cognitive maps, noting, coding, and testing for the space syntax method through the Depthmap software. The information analysis method in space syntax is done through five components of connectivity, integration, choice, control, and depth. Flexibility is also examined based on the concepts of multi-functional space, seasonal and daily displacement, and segregation and aggregation. The results show that the spatial organization in residential complexes in Tehran city is based on the connection of the kitchen space with the living, dining, and catering spaces. Accordingly, the most connectivity, integration, and control, as well as the least depth, take place between them, which has led to the increased flexibility of spaces in relation to various activities. However, bedrooms are just a place to do a specific activity and rest, which confirms the reduction of their flexibility.

**Keywords:** Housing, Flexibility, Spatial Organization, Space Syntax.

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## 1. INTRODUCTION

Nowadays, on the one hand, it can be seen that designers' connection with users has decreased over time, which reduces their knowledge of basic needs and wants. On the other hand, also living difficulties, rising prices, and the ever-changing situations of families have been cited as leading to flexibility and spatial organization in housing. But most of the projects have lacked the necessary productivity by ignoring or less attention to the living needs of the residents, and their inability to respond optimally to the needs of users is clear. Housing is one of the vital elements of human life and supplier of his or her various needs, which is called the place of rest or stop, and its role and importance as a convenient accommodation are sensitive and key. The importance of housing stems from the fact that many of each person's basic needs are met there. Considering the increase in the rate of migration, the expansion of urbanization, the technical advances in construction, the greater awareness of individual rights, and the need to meet social demands, the housing issue and the need to access it is taking on new dimensions day by day (Habibi & Ahari, 1988, p. 24). Today houses in the world and in Iran have not been able to succeed in meeting the needs of users. Because the changes in them have not been derived from changes in needs, but only correspond with a particular style at a particular time that they are predictable in a short time in the economy. Therefore, the main concern is the limitation of various choices in housing species according to their type and also the inability to regulate the residence of users over time based on their wants and needs or in accordance with demographic changes (Albostan, 2009, p. 23). The great cities of the world in the new age have become the place of the density of population and the place of exchange of goods, objects, and information. The collection of these factors has led to problems such as increasing domain of inequalities, expanding degradation of criteria, and even changes in norms, values, and behaviors of individuals and has led to humans living more time in a more limited context of society whole. On the other hand, Iran has also faced a sudden population growth in recent years. The economic downturn, social problems, and the lack of specialized personnel in the fields of civil, architecture, and urbanism with a clear rationale led to hasty decisions that put housing supply solutions in an unsuitable cycle. Today, housings are being developed without the provision of complementary elements. In other words, services, facilities, and also qualities of different spaces are ignored. Meanwhile, public and private investors have begun to build by seemingly emulating the experiences of countries and importing new technologies, regardless of the conditions that this type of housing brings.

Discussion about flexibility in architectural spaces is among the topics that have received a lot of attention in recent years. Satisfying a variety of needs of different

users at different times is one of the reasons for this attention. However, most researches in this field have attempted to provide general definitions and also, in some cases, introduced strategies and tools to make human living spaces flexible, especially housing. Among them, we can mention the modular approach and prefabrication in flexible housing (Eghbali & Hessari, 2013, p. 53), flexibility criteria for design of apartment housing in Iran (Ghafourian & Aghaei, 2016, p. 41), and such cases. Analyzing them this important can be achieved that the conceptual dimensions and the way of demonstration of such a subject in various spatial patterns have been less studied. In some ways, it can be mentioned that there is no research on housing based on this content. Although in some researches flexibility has been used and in others space syntax has been considered, this research affects study by using them simultaneously with each other. On the other hand, seeks to provide an analytical model in relation to recognizing the space syntax method and using its indicators to measure flexibility in housing. In order to better express the problem, this research attempts to answer the question:

How to use the indicators of space syntax method to measure flexibility in housing?

## 2. THEORETICAL FOUNDATIONS

In the following, the main theoretical issues and concepts related to research are discussed.

### 2.1. Research Background

In the field of flexibility and spatial organization in housing, various theories and experiences with different orientations have emerged, especially in recent times. This multiplicity and diversity of opinions point out the importance and urgent need for the issue. Reviewing the body of knowledge, some of the research achievements in this field have been categorized and presented based on the time of publication.

Howe (1990), in an article entitled "The Flexible House Designing for Changing Needs," concludes that this mode of design will facilitate the adaptation of the house to changing household needs and dampen the demand for new housing in developing areas. Lee et al. (2003), in an article entitled "Typical Plan Types of Flexible Housing Based on the Analysis of Variation Trends," conclude that the quantitative analysis using space syntax model is also insightful to offer a set of numerical data for the development of better flexible housing unit plans. Rian and Sassone (2012), in an article entitled "Flexible Housing, a Healthy Housing: A Brief Discussion about the Merits of Flexibility in Designing Healthy Accommodation," conclude that flexibility can offer a better, adaptable, customizable, affordable, and accessible domestic setting in every aspect that brings comfort to the occupants' physical, mental, and socio-emotional health. Abbaszadeh et

al. (2013), in an article entitled "Analyzing a Proper Flexible and Adaptable Pattern for Promoting the Housing Quality in Iran," conclude that a flexible and adaptable home designing on the basis of the residents' requirements changes in their different lifecycles is one of the strategies to satisfy the residents and prevent them from changing their homes. Seo and Kim (2013), in an article entitled "Interpretable Housing for Freedom of the Body: The Next Generation of Flexible Homes," conclude that more precisely designed houses can guarantee the freedom of the body and thus alternatives for the flexible domestic life. Son et al. (2014), in an article entitled "Study on Connectedness of Flexible Housing as an Application of Space Syntax," conclude that flexible housing can be classified as the central core type for improving the connectedness between spaces and central hall type for creating independent spaces from each other. Cellucci and Di Sivo (2015), in an article entitled "The Flexible Housing: Criteria and Strategies for Implementation of the Flexibility," conclude that flexibility can be considered as the antidote to obsolescence or the characteristic of the system that guarantees slippage over time. Estaji (2017), in an article entitled "A Review of Flexibility and Adaptability in Housing Design," concludes that flexibility is the ability and the potential of a building to change, adapt, and reorganize itself in response to the changes. Gharavi Alkhansari (2018), in an article entitled "Strategies for Flexibility in Housing in Response to Changing Family Patterns," concludes that the realization of the capability to segregation and integration in the residential unit is the independence of constituencies in access to the entrance, kitchen, and sanitary services and the realization of the capability to develop is the attention to identity and spatial features of the plan before and after development. Ghafourian (2018), in an article entitled "Identification of Flexible Types in Designing Iranian Apartment Housing," concludes that the four types of flexibility are introduced in order of priority, including extensibility, the capability of different furniture arrangements, segregation, and multi-functionality in housing space.

Examining the mentioned items, it appears that flexibility is an issue related to spatial relations and current activities in them. But what is less considered are the conceptual dimensions and the way of demonstration of it in various spatial patterns. Accordingly, the present research tries to explain the ratio of flexibility and spatial organization in housing with the space syntax method

## 2.2. Flexibility

Flexibility is an essential concept in the field of housing due to changes in the needs and wants of users. Flexible housing can be defined as housing that is designed to change in its lifespan. Therefore, flexible housing is suitable for users with different and changing lifestyles. Accordingly, the ability of housing

to meet the needs of users from the very beginning and during its use can be considered as one of the main fields of flexibility measurement in the field of architecture (Schneider & Till, 2005, p. 157).

Generally, flexibility is referred to as the capability to change objects and things. In architecture and environmental design and particular housing design, the term of this word refers to the spatial flexibility and the organization of human-made space and change in it to achieve new conditions, needs, and applications. Some spaces provide many activities without the need for reorganization, and some other spaces can be modified to meet different needs (Einifar, 2003, p. 66). Priemus (1969) considers the role of the capability of volumes or sub-components displacement as well as the spatial arrangement and the potential of segregation and aggregation fundamental in creating flexibility. Schroeder (1979) considers the physical properties of space, such as changeability, extension, and division important for creating the flexible structure of a building. Poddubiuk (1983) concludes that flexible housing is defined in three contexts of space, function, and the capability of internal change, and thus considers multi-functional space to meet needs changing. Beisi (1995) concludes that housing flexibility is explained inconclusive without regard to educating residents, and to achieve such a quality considers family adaptability to home space necessary. Galfetti (1997) considers the built-in facilities in a flexible space with the capability of seasonal and daily displacement or rearrangement as flexible elements. Habraken (1998) considers spatial variability and flexibility achievable through active users' participation and informing them.

The artificial environment has some kinds of flexibility that require analysis. In this regard, the indicators of variability (multi-functional space), adaptability (seasonal and daily displacement), and changeability (segregation and aggregation) have been defined. Variability is the capability to provide different uses of space. This kind of flexibility deals with the two variables of space and time. Space of housing will be able to be used for several functions simultaneously and for different functions at different times. Variability can be achieved by designing a plan with a regular geometric structure, readable access to building equipment, and adjusting the size of spaces. Adaptability is the ability of a space to adapt to new conditions required. The most effective method to achieve this in architectural programming is fixing the internal components and the possibility of creating various combinations of them. In housing, it is the capability to meet the new needs by changing the interior walls and installing the components, provided that these changes do not make a change in the area of the building. Generally, adaptability includes all internal changes such as structural change, micro-elements, and spaces composition. Changeability refers to the decrease and increase of quantity or the segregation and aggregation of spaces and the

possibility of returning to the original design after the conversion or expansion of its area. In this case, flexibility means the capability to respond to population growth at different stages of life. In other words, this ability makes it possible to change the size of housing in order to make it smaller or larger. The concept of changeability is related to the study of infrastructural changes, spatial needs, and its shape (Heidari, Arian Mehr, & Karimian Shamsabadi, 2018, p. 266). Friedman (2001) has studied the effect of flexible housing and design strategies on the flexibility of the home by introducing them. The varieties of methods proposed about flexibility are categorized into eight groups as the main flexible design tactics:

1. Open plan that causes the minimization of the structural elements as the permanent parts and making free other elements as the changeable parts in the space,
2. Extendable unit that may be considered in one defined space or it may have occurred in one free space,
3. Attachment or detachment of adjacent units that is provided through a nonbearing wall between the units that can easily be removed or located,
4. Prefabricated modules that create an easy, rapid, and economic process not only in initial design but also in future changes of spaces,
5. Similar rooms that are composed of some similar spaces with similar distribution and access,
6. Common space between adjacent units that can attach to any one of the units,
7. Portable wall that provides the possibility of merging or splitting adjacent spaces,
8. Retractable furniture that increases the variety of possible functions in the space (Gharavi Alkhansari, 2018, p. 122).

### 2.3. Spatial Organization

Spatial organization is a basic pattern for creating a composition in architecture that brings together different spaces and provides a coherent structure for design (Hillier, 1996, p. 73). In general, there are conditions for different types of spaces in a house which are:

1. Spaces have special functions or require special forms,
2. Spaces should be functionally flexible and freely adjustable,
3. Spaces must be easily accessible and adjacent to other spaces,
4. Spaces have similar functions and can be placed together as a functional set or repeated in a linear order,
5. Spaces must be open to the outside to provide light, ventilation, visibility, or access to open spaces,
6. Spaces should be distinct and separated from each other for being private,
7. Spaces have a unique and the only function or degree of importance.

The arrangement technique of these spaces can clarify their relative importance and functional role in the

organization of one building (Ching, 2018, p. 204). There are several methods for analyzing it that each of them has its own quantitative and qualitative tools that the executive results of all of these somehow lead to a description of the function of space.

#### 2.3.1. Space Syntax

Space syntax is a developed method in the analysis of the spatial organization of human-made environments, which its aim is to describe spatial models and display these models in the form of graphic shapes and thus facilitate scientific interpretations of the desired spaces. In this technique by transforming the spatial organization of the artificial environment into graphic patterns, the relationships between its different spaces are presented as mathematical data, so that from the analysis of these data, the interrelationships between the environmental space and its user behavior can be found out. Using this method can be mentioned the analysis of the spatial organization of the buildings based on the indicators of permeability, functional differentiation, and integrity, different patterns of exploiting them, and also the prevailing social logic of them (Hillier & Hanson, 1984, p. 294).

Permeability means that it is possible to access different parts of one space and has a direct connection with the amount of public or private, which increases it means to increase access and as a result is more public and decreases it means to decrease access and as a result is more private. Functional differentiation means that the proper segregation of spaces in the functional dimension into both public and private sectors can provide users with an understanding of this issue and make it possible to better adapt their desired activities to the relevant fields. Integrity means that the possibility of direct connection of one public or private space with its adjacent spaces, or each of them can regain its separate and original nature, in which case an integrated set has been formed between them.

The method of space syntax analyzes the different features of samples through five components of connectivity, integration, choice, control, and depth, and they are appeared according to the indicators of permeability, functional differentiation, and integrity. Connectivity is defined by the number of points that a point connects directly to other points. In other words, the amount of connectivity of a space that has two inputs to adjacent spaces is two (Madahi & Memarian, 2017, p. 51). Space has a lot of connectivity that is more integrity with other spaces. Integration indicates the amount to which a point is connected or detached from other points. This concept has a linear relationship with connectivity so that more integration means more connectivity with adjacent spaces (Jiang, Claramunt, & Klarqvist, 2000, p. 164). Space has a lot of integration that is more integrity with other spaces. Choice is a general scale of the amount of flow that exists at a point. In fact, one space has a high degree of choice when a large number of the shortest communication paths pass



through that space (Klarqvist, 1993, p. 12). Space has a lot of choice that is more functional differentiation than other spaces. Control is a parameter that indicates the choice amount of a point to which other points are connected. In other words, the less choice one space has than a given space, the less control it has over it (Jiang, Claramunt, & Klarqvist, 2000, p. 164). Space has a lot of control that is more functional differentiation than other spaces. Depth is defined as the number of steps that must be taken to move from one point to other points. One space is called deep if there are many steps between that space and other spaces (Madahi & Memarian, 2017, p. 52). Space has a shallow depth that is more permeability than other spaces.

### 3. RESEARCH METHOD

The work method of this research will be done in combination and with mixed nature. Initially, information is collected through the library study, and the field survey includes using available information and observation. On the one hand, various demonstrations of flexibility including variability, adaptability, and changeability are categorized, in which the focus is on providing the qualitative components needed to design the desired spatial organization. On the other hand, indicators of space syntax are identified. Then the possibility of a relationship between the components of flexibility and space syntax is determined that this relationship is analyzed with the help of logical reasoning. In order to implement this result in real case samples, residential complexes in Tehran city are evaluated as a research society. Using the Depthmap software in space syntax method for computer simulation, the indicators of permeability, functional differentiation, and integrity are analyzed. Finally, inductive reasoning will be used to draw a conclusion about the subject.

#### 3.1. Analysis

Flexibility is a two-dimensional concept that is related on the one hand to physical structures and, on the other hand, to behavioral patterns. Accordingly, in order to recognize the various fields of its formation, it is necessary to study spatial relations and current activities in them. Demonstrating the concepts of flexibility and space syntax and investigating the case study samples are introduced below.

#### 3.1.1. Demonstrating the Concepts of Flexibility and Space Syntax

Variability is a concept related to current functions in a spatial organization and means the capability to perform different activities of users in it. In a user such as housing, whatever space is more public, the capability to diversify activities increases in it, and whatever space is more private, the capability to diversify activities especially activities related to the public domain decreases in it. Accordingly, one of the things that affect the quality of one multi-functional space is whether the space is public or private. Therefore analyzing the set of factors can be examined the amount of flexibility of one space. One of these factors in space syntax is the analysis of the permeability concept, which can be evaluated using the depth component.

Adaptability is also another demonstration of flexibility that depends on the user and the type of his or her desires more than on the space and the existing activities in it. Therefore recognizing the functional differentiation and the possibility of choosing the appropriate field to perform the desired activity of the user is one of the most important concepts of space syntax related to the subject, which can be evaluated using the components of choice and control.

Changeability means the capability to make a change in the spatial organization of a set in order to perform the desired activities of users in it. This concept which is mostly related to the body and physical structure of a building such as housing is examined in two forms of convertibility and expandability which are related to the possibility of segregation and aggregation of spaces due to the presence of intermediate elements between them and also the capability to be converted it into a smaller or larger space. Using this method makes it possible to create flexibility in different spaces. In space syntax, this capability is measured by analyzing the concept of integrity, which can be evaluated using the components of connectivity and integration.

Thus, the indicators of variability, adaptability, and changeability in flexibility are related to the indicators of permeability, functional differentiation, and integrity in the space syntax method to analyze the spatial organization, and thus affect the spatial organization in housing (Figs. 1 and 2).

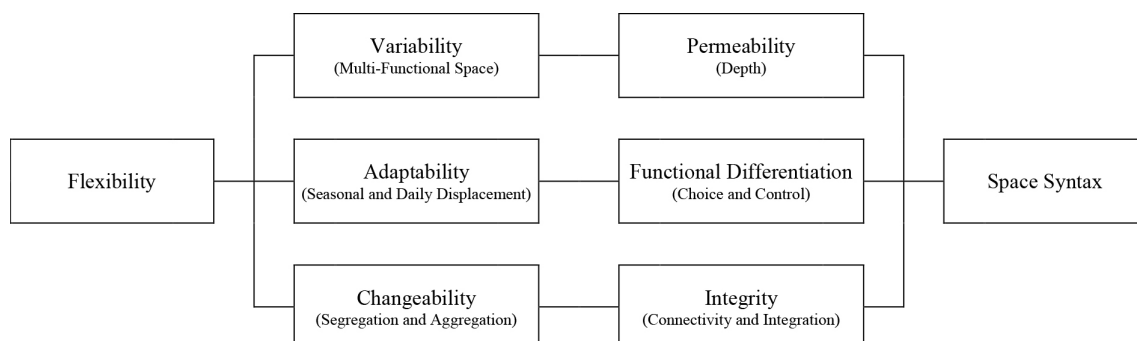


Fig. 1. Demonstrating the Concepts of Flexibility and Space Syntax

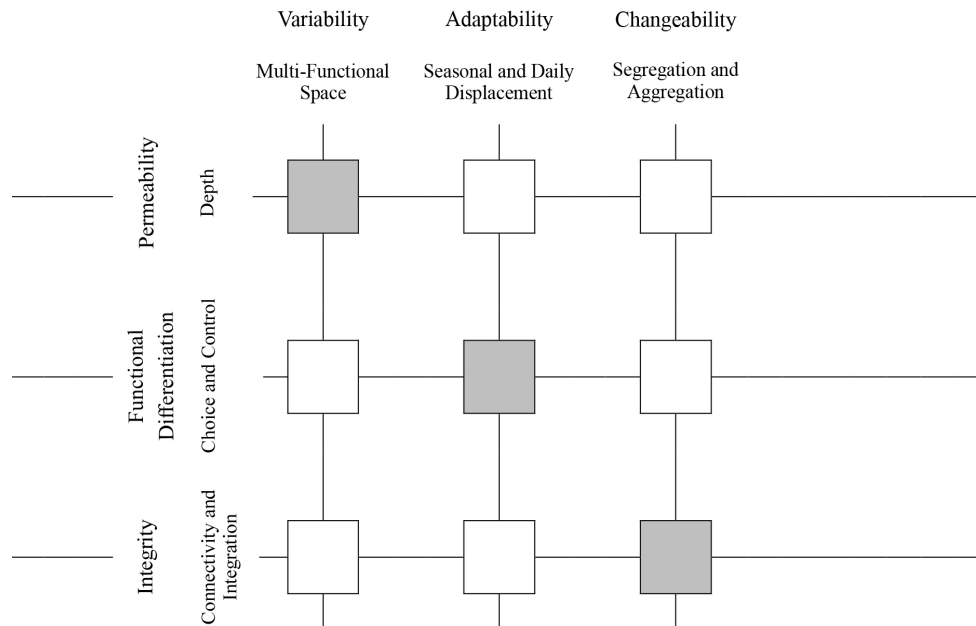


Fig. 2. Matrix of Demonstrating the Concepts of Flexibility and Space Syntax

### 3.1.2. Investigating the Case Study Samples

Based on the available statistics, the second district of Tehran municipality was selected with the highest number of residential complexes. Then based on the collected information, matching the data, and comparing them, common factors such as the

number of units, height, and shape of open space were extracted and three residential complexes of Atisaz, Mahan, and Hormozan were eligible for the most species to build were identified. Atisaz with 23 blocks, Mahan with 5 blocks, and Hormozan with 20 blocks are located in regions one, nine, and seven respectively (Figs. 3-5).

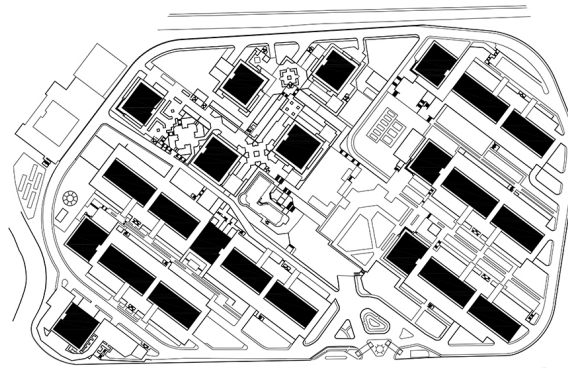


Fig. 3. Atisaz Residential Complex Site Plan

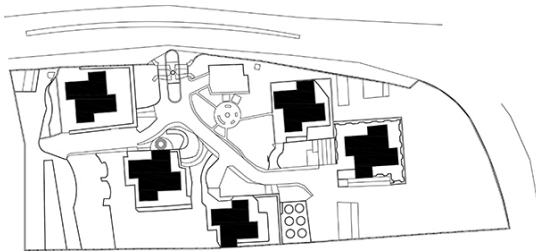


Fig. 4. Mahan Residential Complex Site Plan

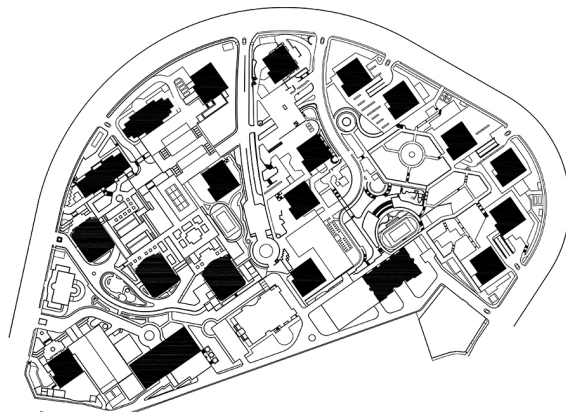


Fig. 5. Hormozan Residential Complex Site Plan

The 1, 2, and 3 bedroom plans were selected from similar blocks in each one, and evaluated with the visibility graph analysis approach and components of connectivity, integration, control, and depth in the

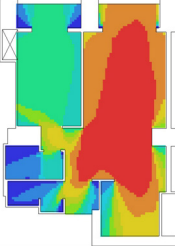
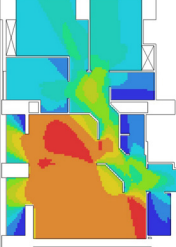
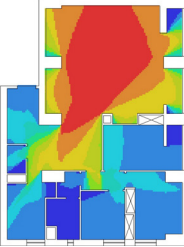
Depthmap software. The reason for investigating the case study samples with these four concepts is the lack of choice component in this approach (Tables 1-5).

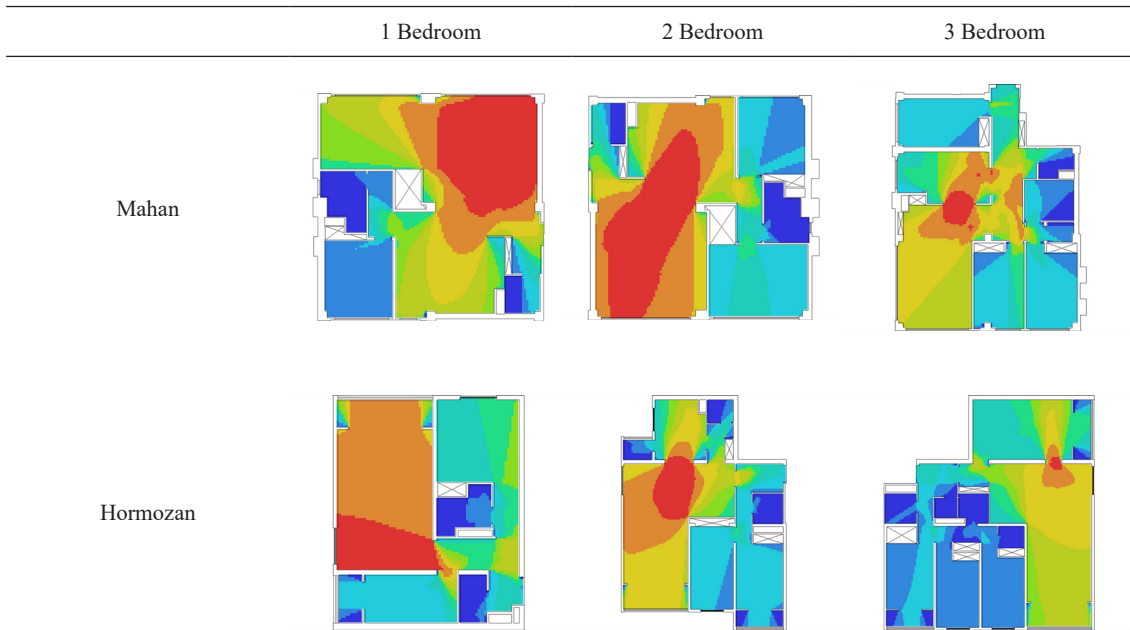
Table 1. 1, 2, and 3 Bedroom Plans from Similar Blocks in Atisaz, Mahan, and Hormozan Residential Complexes

	1 Bedroom	2 Bedroom	3 Bedroom
Atisaz			
Mahan			
Hormozan			

1. Entrance, 2. Hall, 3. Toilet Service, 4. Kitchen, 5. Living, 6. Dining, 7. Catering, 8. Bedroom, 9. Bathroom Service

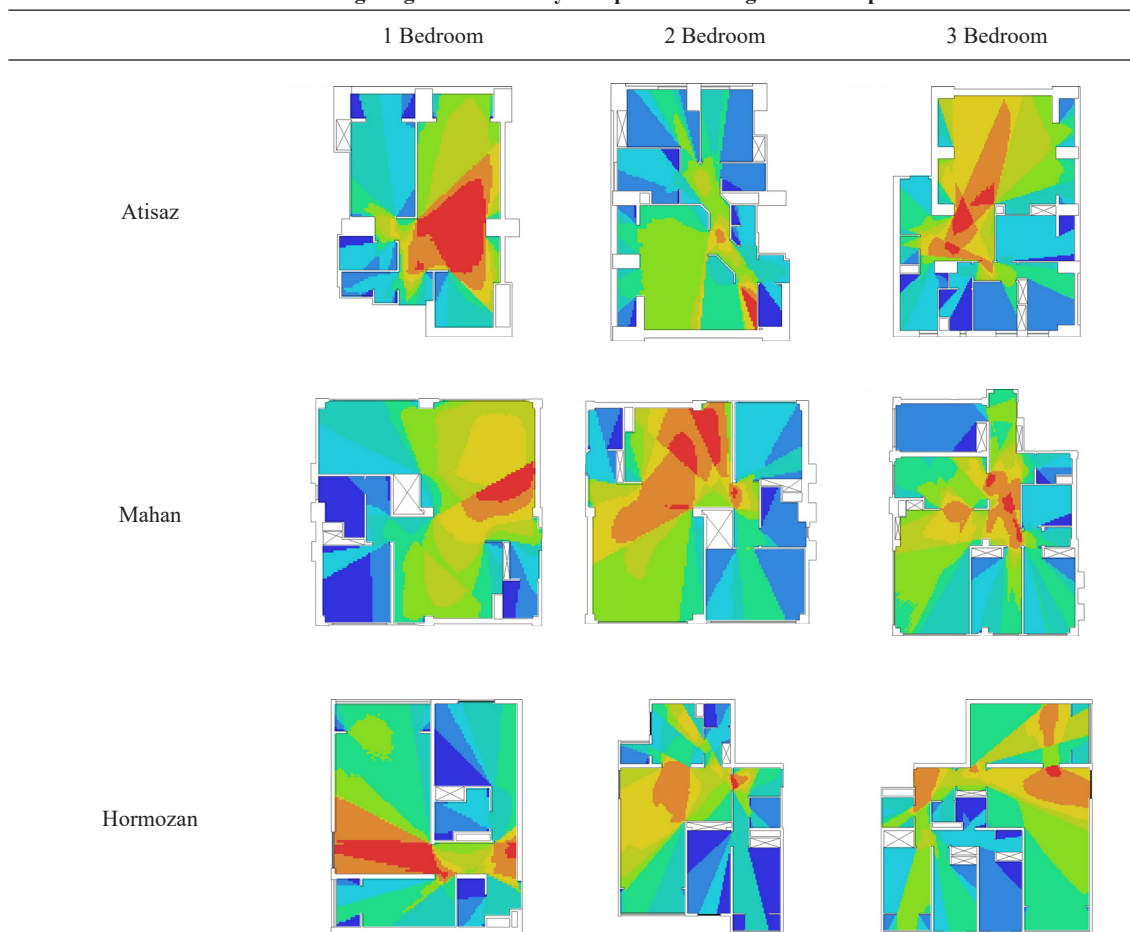
Table 2. Investigating the Case Study Samples with Connectivity Component

	1 Bedroom	2 Bedroom	3 Bedroom
Atisaz			



In each plan, the red to blue color spectrum respectively indicate the highest to the lowest level of connectivity.

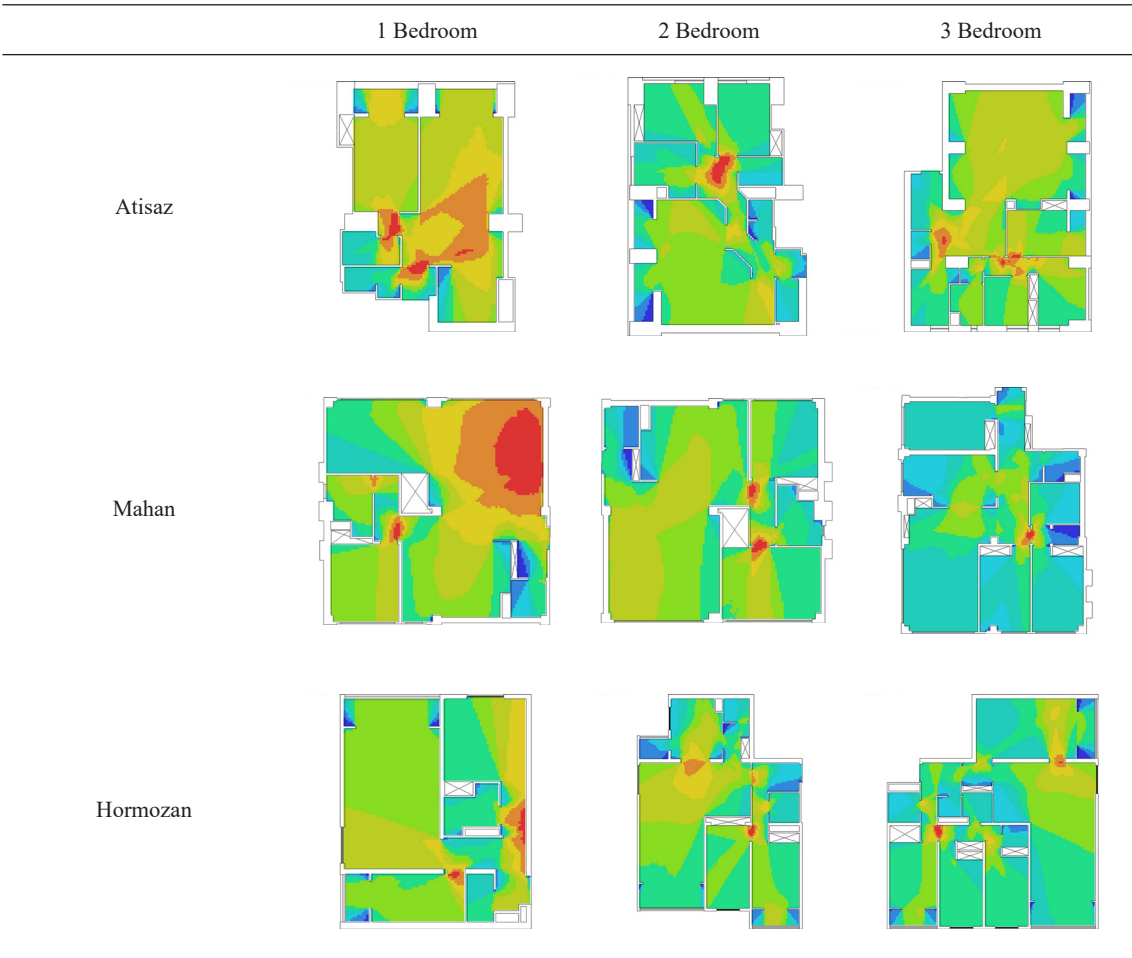
**Table 3. Investigating the Case Study Samples with Integration Component**



In each plan, the red to blue color spectrum respectively indicate the highest to the lowest level of integration.

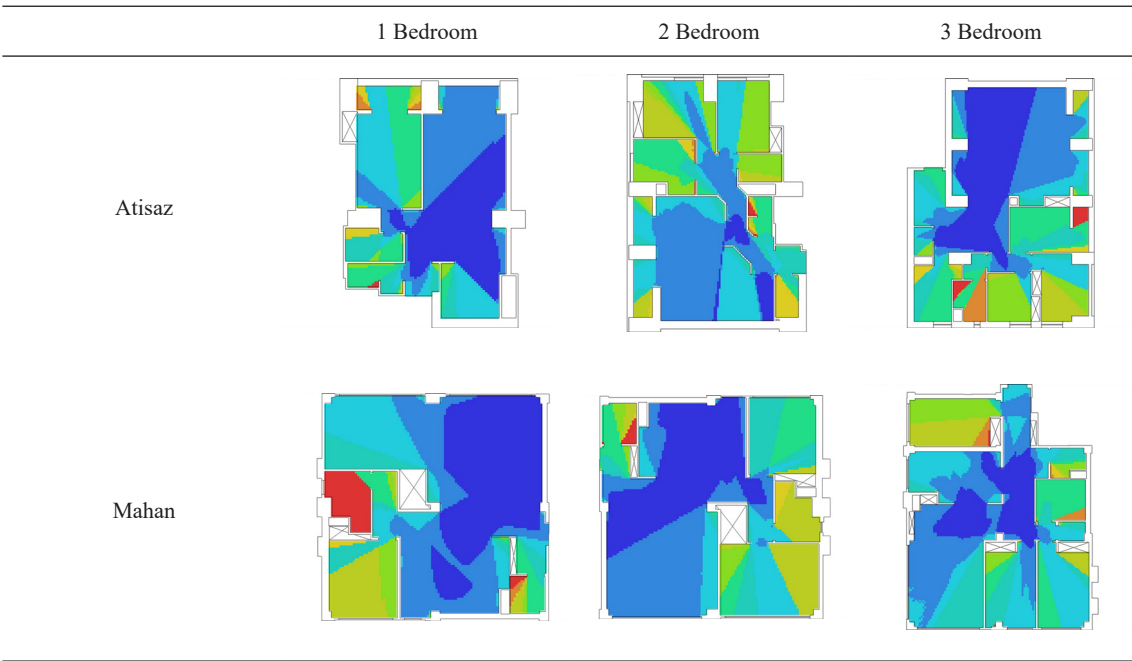


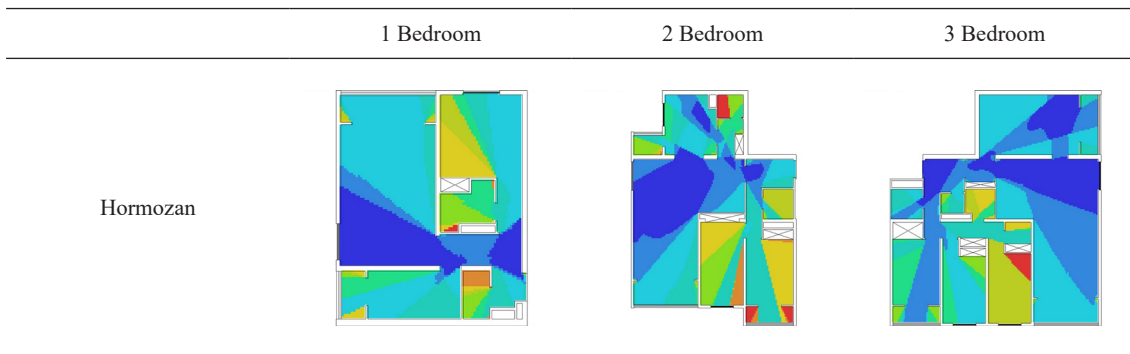
Table 4. Investigating the Case Study Samples with Control Component



In each plan, the red to blue color spectrum respectively indicate the highest to the lowest level of control.

Table 5. Investigating the Case Study Samples with Depth Component





In each plan, the red to blue color spectrum respectively indicate the highest to the lowest level of depth.

#### 4. RESULTS AND DISCUSSIONS

Based on the above contents, an analysis of the relationship between demonstrating the concepts

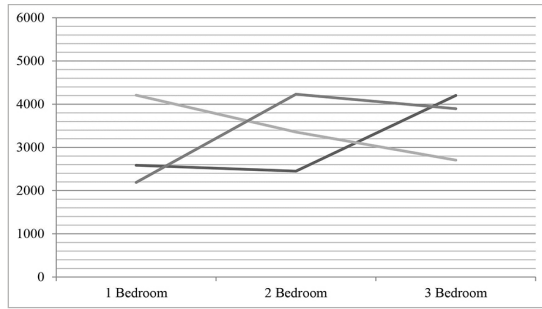
of flexibility and space syntax has been done by investigating the case study samples that have led to the comparison of their components with each other (Table 6).

**Table 6. Analysis of Demonstrating the Concepts of Flexibility and Space Syntax by Investigating the Case Study Samples**

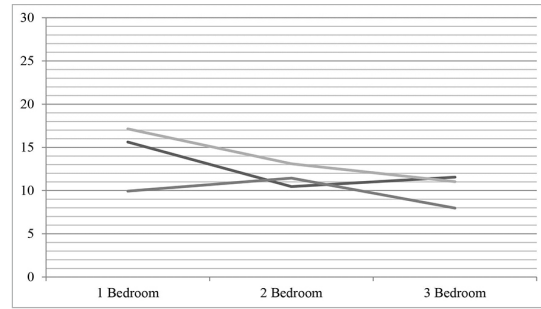
		Atisaz			Mahan			Hormozan			
Flexibility	Space Syntax	Component	1 Bedroom	2 Bedroom	3 Bedroom	1 Bedroom	2 Bedroom	3 Bedroom	1 Bedroom	2 Bedroom	3 Bedroom
Variability	Permeability	Depth	01.73	02.10	02.10	01.75	01.91	02.06	02.13	02.08	02.58
Adaptability	Functional Differentiation	Control	00.47	00.36	00.40	00.53	00.47	00.34	00.46	00.45	00.40
Changeability	Integrity	Connectivity	2586	2450	4201	4209	3355	2705	2189	4231	3896
		Integration	15.62	10.46	11.55	17.14	13.10	11.03	09.94	11.44	07.97
Area			123	195	300	185	184	223	145	271	362

Comparison of space syntax components in all three of these samples shows that integration and depth depend on the area, as by increasing area, integration

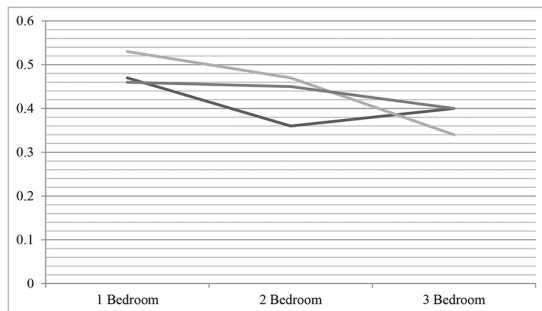
decreases, depth increases, and consequently the spatial organization in housing becomes less flexible (Figs. 6-9).



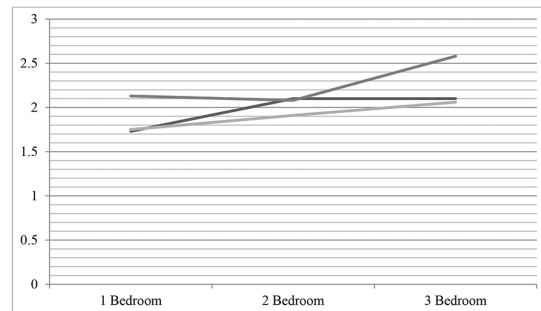
**Fig. 6. Comparison Chart of the Connectivity Component**  
Atisaz (Dark Gray), Mahan (Bright Gray), Hormozan (Gray)



**Fig. 7. Comparison Chart of the Integration Component**  
Atisaz (Dark Gray), Mahan (Bright Gray), Hormozan (Gray)



**Fig. 8. Comparison Chart of the Control Component**  
Atisaz (Dark Gray), Mahan (Bright Gray), Hormozan (Gray)



**Fig. 9. Comparison Chart of the Depth Component**  
Atisaz (Dark Gray), Mahan (Bright Gray), Hormozan (Gray)

The comparison chart of the connectivity component has fluctuations that its value varies with different areas, and thus the possibility of recognizing the integrity of spaces and consequently, the changeability varies. The comparison descending chart of the integration component with internal fluctuation indicates that as the area increases, its value decreases, and as a result, the integrity of spaces decreases, and consequently the changeability decreases. The comparison chart of the control component has fluctuations that its value varies with different areas, and thus the possibility of recognizing the functional differentiation of spaces and consequently, the adaptability varies. The comparison ascending chart of the depth component with internal fluctuation indicates that as the area increases, its value increases, and as a result, the permeability of spaces decreases, and consequently the variability decreases.

## 5. CONCLUSIONS

According to the analysis that has been done on explaining the ratio of flexibility and spatial organization in housing with space syntax method and in answering the proposed question, the results were obtained as follows:

- The indicators of variability, adaptability, and changeability in flexibility are related to the

indicators of permeability, functional differentiation, and integrity in the space syntax method to analyze the spatial organization, and thus affect the spatial organization in housing.

- Spatial organization in residential complexes in Tehran city is based on the connection of the kitchen space with the living, dining, and catering spaces. Accordingly, the most connectivity, integration, and control, as well as the least depth, take place between them, which has led to the increased flexibility of spaces in relation to various activities. However, bedrooms are just a place to do a specific activity and rest, which confirms the reduction of their flexibility.
- Comparison of space syntax components in all three of these samples shows that integration and depth depend on the area, as by increasing area, integration decreases, depth increases, and consequently the spatial organization in housing becomes less flexible.
- Due to the lack of choice component in the visibility graph analysis approach in the Depthmap software and the need to use its concept in flexibility, it is suggested that the possibility of creating this component be provided in future versions.
- The achievements of this research could help researchers provide an analytical model in relation to recognizing the space syntax method and using its indicators to measure flexibility in housing.

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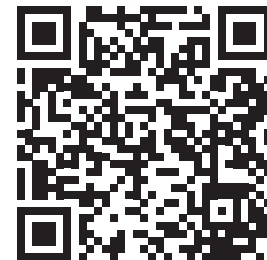
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