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Explanation of the System Dynamics Model for Altering the Balconies to Improve the Efficiency of the Common Residential Plans of the Cities of Guilan Province based on the Space Syntax

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Abstract

Today's common housing is not only built to be a shelter, but it is an effort to produce a life-oriented space. Now, as housing has been transformed into a capital good and due to its price value and the necessity of providing comfort to the residents, it requires special attention. Therefore, based on the mechanism of today's common buildings, the concept of functional efficiency has a very special role in strengthening the utilization of spaces. On the one hand, understanding the issue that residence is a process during which a person has turned the "place of being" into a home, and considering the discussions of recent years regarding the relationship between human being and nature in apartment housing, the importance of attitude toward the relationship between man and the natural environment is developed through some kind of in-between spaces like a balcony. Therefore, this research sought to investigate the arrangement of balconies to improve the functional efficiency of these spaces to increase the desired spatial quality. In this regard, the effective indicators have been examined using the system dynamics method, and the data has been measured through depthmapx software (0.50), and finally, the main results have been obtained through logical reasoning. The investigated samples were randomly selected from the common residential buildings of the cities of Guilan province in governmental and private mass parts. Based on the obtained results, in the rearrangement of the balconies by increasing their connection with more spaces and also by increasing the area of the balconies, more access and visibility have been given to the balconies, and also the depth of the spaces has been reduced compared to the balconies and its functional efficiency has been improved.

Keywords: Improving functional efficiency; System dynamics; Space syntax; Balcony

1. Introduction

The appropriate interaction of the physical environment and the different needs of the people who use it, creates the concept of the efficiency of an architectural work (Reverson, 2009) James Gibson was the first person presenting the concept of efficiency in residential environments. In addition to introducing the concept of capability in human-made environments, he emphasized on the role of this issue in solving the different needs of users and also introduced this concept as a platform for evaluating the desirability of environments (Gibson, 1986). For this purpose, the concept of functional efficiency has been used to increase the efficiency of spaces. The concept of functional efficiency means functional balance (Hillier, 2007). Functional balance means proper distribution (and not homogeneity) of services to different types of spaces for a single purpose, considering the needs of each part and the level of sensitivity of their performance (Heydari, 2015). It is worth mentioning that the concept of functional efficiency is measured relatively and its interpretations are different depending on the type of space usage (Yakhchali, 1401). One of the most important approaches that conveys the concept of efficiency in man-made environments, is the space syntax approach. This method introduces the efficiency of a micro space in a space configuration system in terms of its usability by users (Kiyai, 2015). The micro space investigated in the current research was chosen due to the importance of human interaction with the natural environment of the balconies of residential buildings. Because achieving coexistence with nature is a comprehensive expression of various human psychological needs (Kamal, 2015). In this regard, the question is raised whether it is possible to increase the efficiency of the balcony space in the residential plan using a different layout. Thus, in the current research, the independent variable was the change of balcony space in a residential building and the dependent variable was the functional efficiency of the balconies. Considering the diversity and interaction of the obtained indicators related to the role of balconies in buildings and considering the systemic effect of the indicators on each other, the relationship between the indicators was analyzed based on documentary studies using the system dynamics method. The hypothesis of the research was that the different arrangement of the balconies would increase the functional efficiency of the balcony space in the residential plan.

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2. Research Background

In recent years, there have been researches on the centrality of the role and impact of the balcony on residential spaces in international arenas, among which one had examined the role of the balcony in thermal and acoustic comfort (Mozaffari, 2017) (Shemirani, 2017) (Einifar, 2013). Another study investigated the effect of the balcony in revitalizing the residential space (Bokharai, 2018) (Kafashzadeh, 2014) (Nasif, 2017) (Raheb, 2015) (PETERS, 2022). An a research examined the effect of the balcony on the quality of the indoor environment (Ribeiro, 2020) (Ainifar, 2013) (PETERS, 2022) (Shamseldin, 2022) and another study considered the balcony as an interface space (Ragavan, 2021) (Kaplan, 1995) (Einifar, 2013). Also, in the review of the articles of the last 5 years using the VOS viewer (1.6.18) software, the most repeated words in the research field related to the research topic have been examined, which can be observed in figure 1 regarding their communication domains and table 1 depicts the number of repetitions of the main related words.

3. Theoretical Framework

Turning a space into a place is the existential goal of architecture, and spatial organization of architecture can be considered as an effective action in the maximum benefit of human functions. On the other hand, with the interaction of place and environment, the concept of inside and outside has gained meaning, and by discovering this meaning, humans have experienced dwelling (Einifar, Alinia; 2013). And due to the existence of the outer space next to the inner space, the third space appears, through which the in-between space or the space connecting inside and outside provides spatial organization. In the concept of communication in architecture, what is more important than the two elements that require communication is the role of the communicator, which tries to establish this communication with its properties. This in-between space always has an identity, sometimes in the form of a defined border and sometimes in the form of a space. In any case, this interstitial space, like a joint, makes possible the separation or connection of two spaces inside and outside (Ismaili, Piri; 2019). Now, in contemporary architecture, the two poles of "inside" and "outside" have taken an interactive form and their real connection has been formed through new thinking in the field of architecture. Wright, one of the exponents of naturalistic style architecture, has an opinion on the physical and presence connection between the inside and outside of the architecture, which is an all-encompassing connection, and therefore believes that every house should form a unit with its surrounding environment. In Sullivan's opinion, since the external effects are the same as the internal ones, thus, architecture seeks to create and grow naturally, logically and poetically

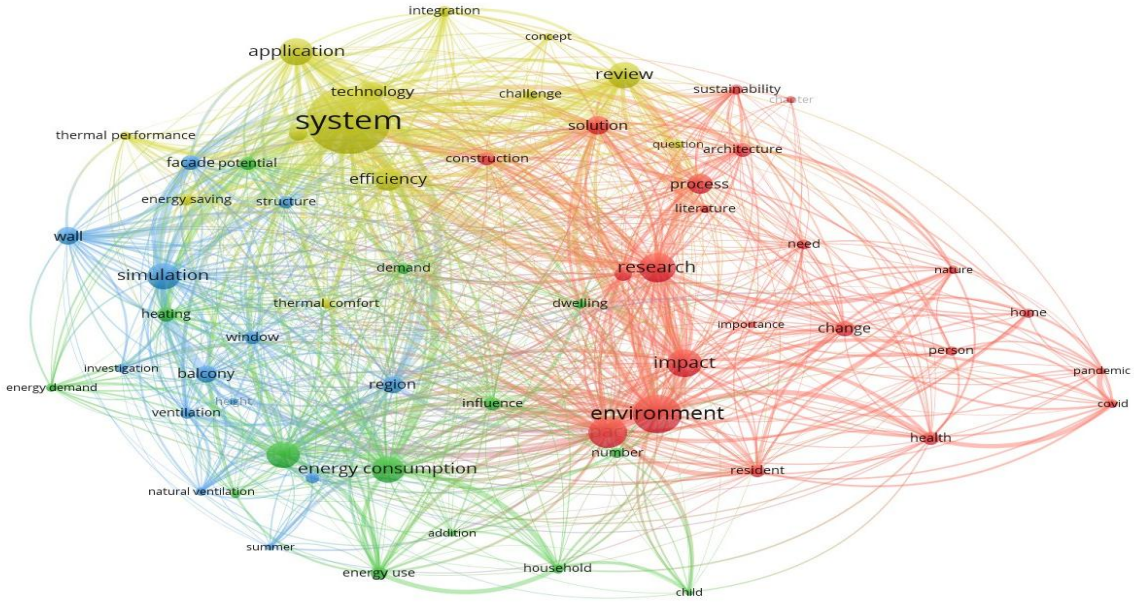


Fig. 1. Communicative classification of the most repeated words in the research field related to the research topic Software output VOS viewer (1.6.18)

Table1
Number of repetitions of main related words

Main related words	Number of repetitions
Environment	196
Space	158
Region	87
Energy consumption	69
Health	67
Integration	55
Need	52
Nature	44
Natural ventilation	44

from conditions and situations. Le Corbusier also believes that the plan goes from the inside to the outside and introduces the outside as the result of the inside. An important part of the meaning of architecture is hidden in the balance of the two poles of function and body or the interaction between inside and outside. Therefore, emphasizing too much on the outside and considering the form as important, or vice versa, will lead to a decrease in meaning (Mahoboubi; 2016). Meaning is a mental perception that includes beauty, kinship, belonging, peace and trust, which are like the parameters of place identity. Based on this, the third space or the interactive area or the in-between space can be the place of transformation of the situation, therefore, it can be the place of multiple meanings.

complexity of internal and external relations, is actually an introduction to the mental and physical preparation and acceptance of the users of the building. The middle elements of this diagram have a dual presence, which have both external and internal properties and have the property of coexistence and the mutual influence of inside and outside interact with them. Humans need inner space and outer space at the same time as well as the possibility of moving between these two spaces in housing. Therefore, the space inside and outside cannot be separated completely and is always connected. In order to face the inner and outer space and the possibility of interaction and communication between them, an in-between space is formed (Asl, 2014). If the main characteristics of the architectural space be the three cases of describing the

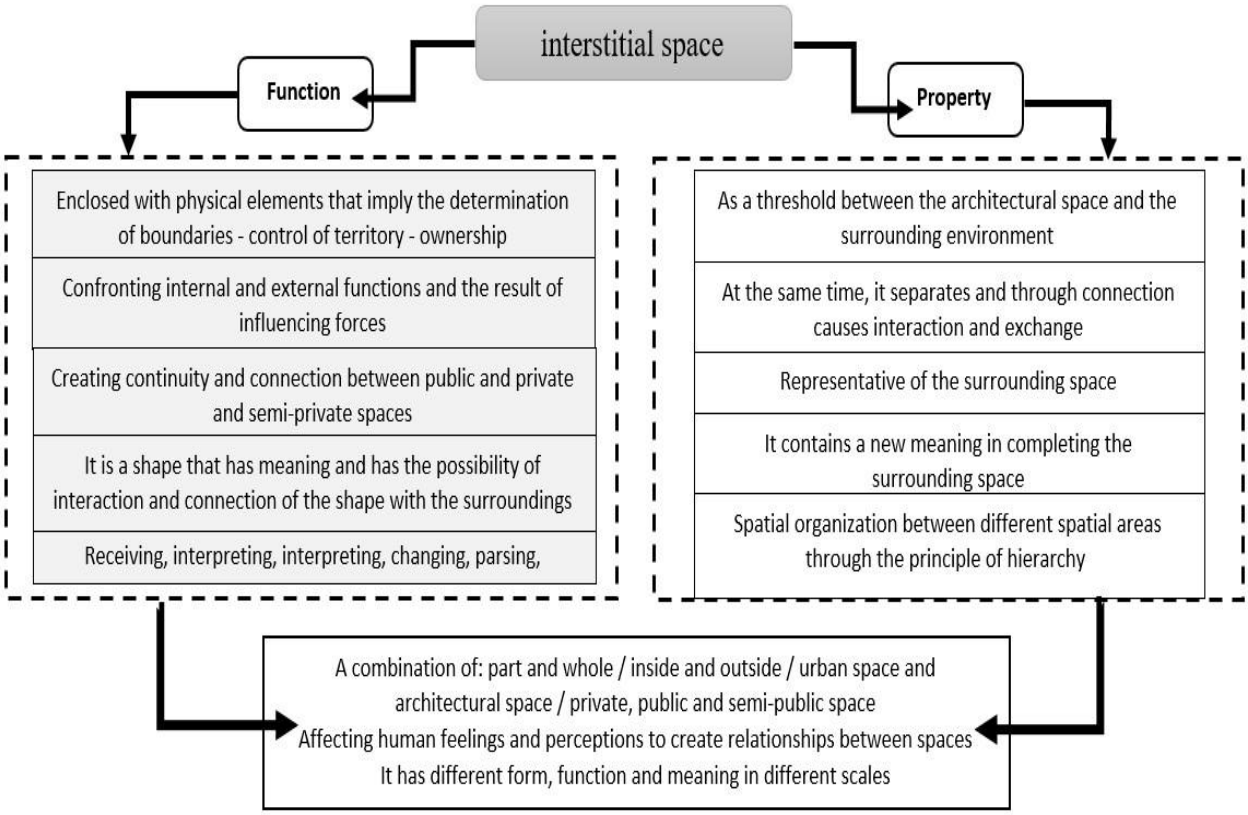


Fig.2. Properties and functions of interstitial space.

"The in-between space has the task of receiving, interpreting, changing, and transforming data due to its dynamic and high flexibility, like the cell membrane. In a rotational movement, the intervening space is effective in using the bases and principles governing spatial relations, as well as the way the spatial organization of the collections is performed" (Asl, 2016). The connection of the outside to the inside inevitably follows the basic pattern of communication, passing and doing (Ardalan; 2019). According to the presented diagrams (Diagram 2 and 3), it can be seen that by changing the elements from the external surface to the internal volumetric spaces, the degree of coexistence of the outside and the inside has been strengthened, and the elements in the in-between (transition) area, which introduces the spatial hierarchy , while it has a direct relationship with the importance and

form, function and meaning (Capen, 1392), the space in between, in addition to having physical characteristics and the conditions of differentiation between these components, would have several conceptual functional characteristics. As the in-between space has a special concept and validity in terms of dimensions and spatial understanding, it gains validity and value from semantic opinions, and in total, the connection of these three characteristics defines and limits the third space. In other words, according to Kappen's opinion, the in-between space is the space that is enclosed based on the physical elements that indicate the determination of borders and boundaries (physical-physical). Within this, the center of focus becomes meaning (semantic) and the place of interactions (communicative-functional) (Balilan Asl et. al., 1932). Now, since the examination and analysis of all

interspaces is broad, this research examined the concept of inside-outside and in-between space or intermediary in apartment housing in the range of the balcony as the link between inside and outside in the apartment. Considering the spatial hierarchies in common apartment housing,since the type of connection between inside and outside in architecture is detailed and creates both connection and separation (Rezakhani, 2013), this communication joint, today, has been reduced to a simple connection; in other words, the role of the in-between space has been moved away from communication and has reached the definition of a simple connection (Aini Far, Alinia; 2013).

with the construction of apartments and the increase in urban density for vertical living, it is possible to connect to the outside space with the presence of a balcony (Kisnarini, 2018). Such semi-open spaces play a significant role in creating visual qualities and natural landscapes. Balconies create interaction between humans and the natural environment (Shamseldin, 2022). By examining the factors affecting the relationship between man and the environment, their desirability and importance in the private balconies of residential apartments, it is possible to consider the factors affecting the quality of life in this space. In addition, by explaining the importance and

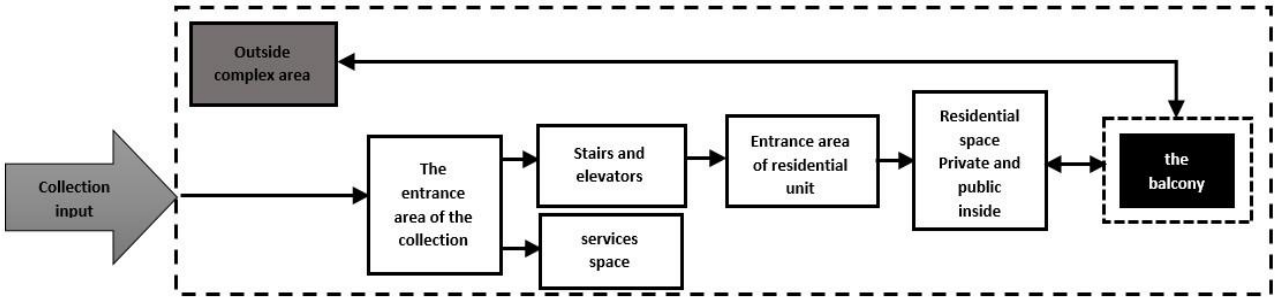


Fig3. Properties and functions of interstitial space.

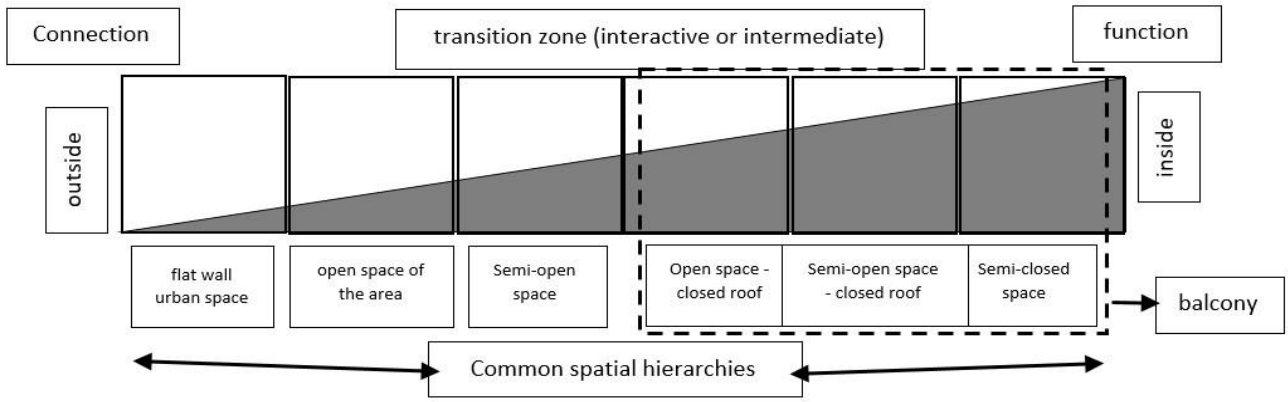


Fig.4. Properties and functions of in-between space.

On the other hand, communication with nature is very important, especially at the scale of residential unit, neighborhood unit, and neighborhood. As studies have shown, as the distance between the residence and the nearest urban green space increases, its use decreases (Grahn, 2003). Also, numerous studies have shown that contact with nature at home and natural living spaces in the open air in urban housing improves the health and well-being of residents (Tennessen, 1995). And since humans are always in contact with the environment and are affected by it, this interactive relationship is established in different scales. Based on this, the environment should establish an appropriate interaction with the human, so it is mandatory for the designers to have a sufficient understanding of the human, the environment, and the interaction between them (Shahcheraghi, 2014). But despite this importance, the aspects of "nature" that people need are almost completely ignored (Peters, 2022). Now it can be assumed that in line

desirability of these issues from the residents' point of view, the designers have been given the opportunity to recognize the problems and shortcomings, so that by finding their roots, they can provide solutions to improve the current situation at the same time as the cities are expanded and the area of residential spaces are overheaded or reduced so that with a complete knowledge, a design is provided (Kafashzadeh, 1400). Therefore, the access to the balconies is considered with the overall goal of connecting with the residential unit (PETERS, 2022). The system of designing and building a balcony as an in-between space can be implemented with the help of communicating outside and inside the apartment by observing the following features (diagram no. 4): physical-environmental features (correct climatic orientation and paying attention to the construction of the balcony as a part of the whole view), Functionality-behavioral features (the multi-functionality of the balcony and useful dimensions and size that can be

used according to the needs of the residents), perception-meaning features (paying attention to the external view and respecting the beauty of the balcony in combination with other facade elements) (Einifar, 2013). Moreover, the environmental functions of balconies can be categorized as follows: achieving thermal comfort, achieving visual and acoustic comfort, providing energy, maintaining and providing ecosystems due to the presence of plants and reducing air pollution, meeting psychological needs, performing Household activities and facade decorative elements (Shamseldin, 2022).

In addition to being able to provide a favorable view to the residents like a window, the balcony, creates a timely connection with the outside world to provide a platform for direct and tangible communication with nature as well as a place for performing desirable activities and generally it helps residents experience revitalizing activities (Bokharai, 2018). The balcony offers an opportunity to have a view of the outside and nature, and from the user's (human) point of view, a balcony may offer a panoramic view and a wider indoor environment (PETERS, 2022). Allocating the appropriate geometry and sufficient area of the balcony space on the one hand, and its necessities and the direct connection of the balcony to the communal space of the house such as living room (ceremonial and communal zones) by creating privacy and a suitable visual effect in the balcony are among issues that add to the combination of using the balcony for increasing the interactions of family members (Kafashzadeh, 1400). It is very important for the residents to benefit from a controlled and designed space related to the outside space having a good view, the possibility of lighting, and proper ventilation through balcony. Today, the result of the indiscriminate and unregulated increase in the number of floors in buildings, the smaller parts in the separation of the land, the way buildings are placed in relation to each other, and the reduction of open spaces in apartments have caused a decrease in the use of private semi-open spaces (Rahab, 2015). For example, the relationship between the house and the balcony can be seen as having a direct effect on the comfort and ease of use, just as the access from the living room and bedroom is necessary and effective (PETERS, 2022). These positive effects of balconies can be counted as follows: creating thermal comfort including air temperature and average radiant temperature and relative humidity and energy consumption, increasing air quality through air flow pattern and speed, creating visual comfort including lighting level and lighting distribution, creating acoustic comfort through sound pressure levels, and reverberation (Ribeiro, 2020). Moreover, the internal or external nature of the balcony and its availability or distance and proximity to other spaces are two factors that can be studied for balconies (Ragavan, 2021). By increasing the uniformity of indoor air distribution, the balcony improves thermal comfort and acts as a panoramic shade, and guarantees the prevention of annoying sun rays and solar heat, and

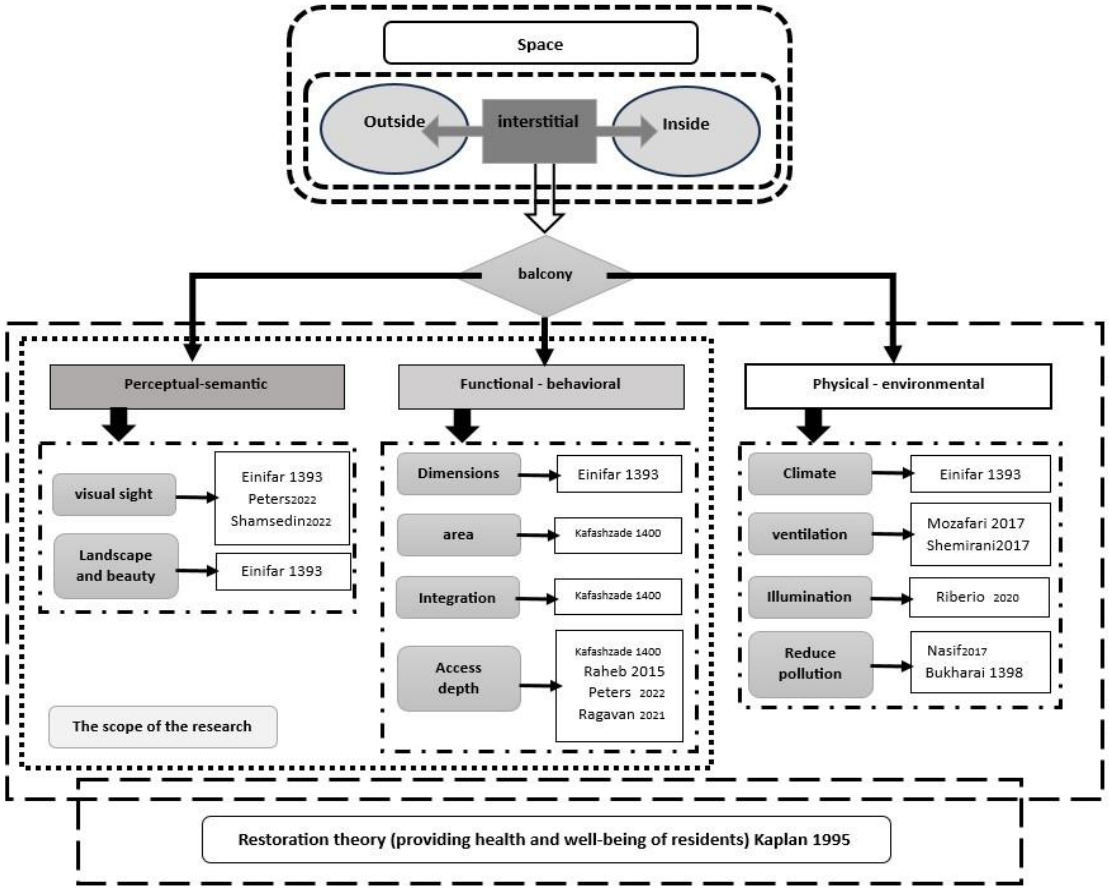


Fig.5. Properties and functions ofin-between space.

reduces energy consumption for air conditioning (Mozaffari, 2017). The balcony significantly changes the external air flow and creates ventilation. It is known as a transitional space for creating and controlling natural ventilation and internal and external correlation in buildings (Shemirani, 2017). The role of the balcony in reducing smoke pollution caused by fire is undeniable because in a fire incident, a significant amount of smoke is released, which may cause risks such as poisoning (Nasif, 2017). Finally, it should be noted that based on the restoration theory, balconies can have a positive effect on the health and well-being of residents (Kaplan, 1995).

According to the considered studies, it seems that one of the important indicators in examining the functional efficiency of the balcony was the degree of its connection with the rest of the spaces. Also, its area could play a decisive role in this relationship. It should be noted that the depth of the placement of the spaces relative to the balcony was effective in the degree of connection between that space and the balcony and provided a better view. Finally, by considering the index of connection, the impact of the balcony on internal spatial communication could be measured. Other criteria, such as ventilation, climate, pollution, and lighting, which were mentioned in the theoretical foundations, were also considered, which were not included in the scope of this research. Therefore, the main variables investigated in this research included area, connectivity, integration, visibility, and depth.

4. Research Methodology

This research, which was both quantitative and qualitative in nature, had been carried out with the aim of improving design knowledge using an experimental method, and it was an applied research, and its hypothesis was explained based on the inductive method.

After reviewing the literature and documents, the interaction between the variables and their relationships have been categorized using the system dynamics method, and their impact on each other has been reviewed. System dynamics is a new way to evaluate and control the performance (Forrester.j.w, 1997). The system dynamics approach enables the identification of interactions between variables and processes that guide the system behavior. (sterman.j.d, 2000), The research process can be observed in diagram 6.

The main idea in the system dynamics method is that every system consists of components that interact with each other. In this regard, the feedback loops of interactions between system components and the general pattern of system behavior have been drawn (Gorji, 2023).

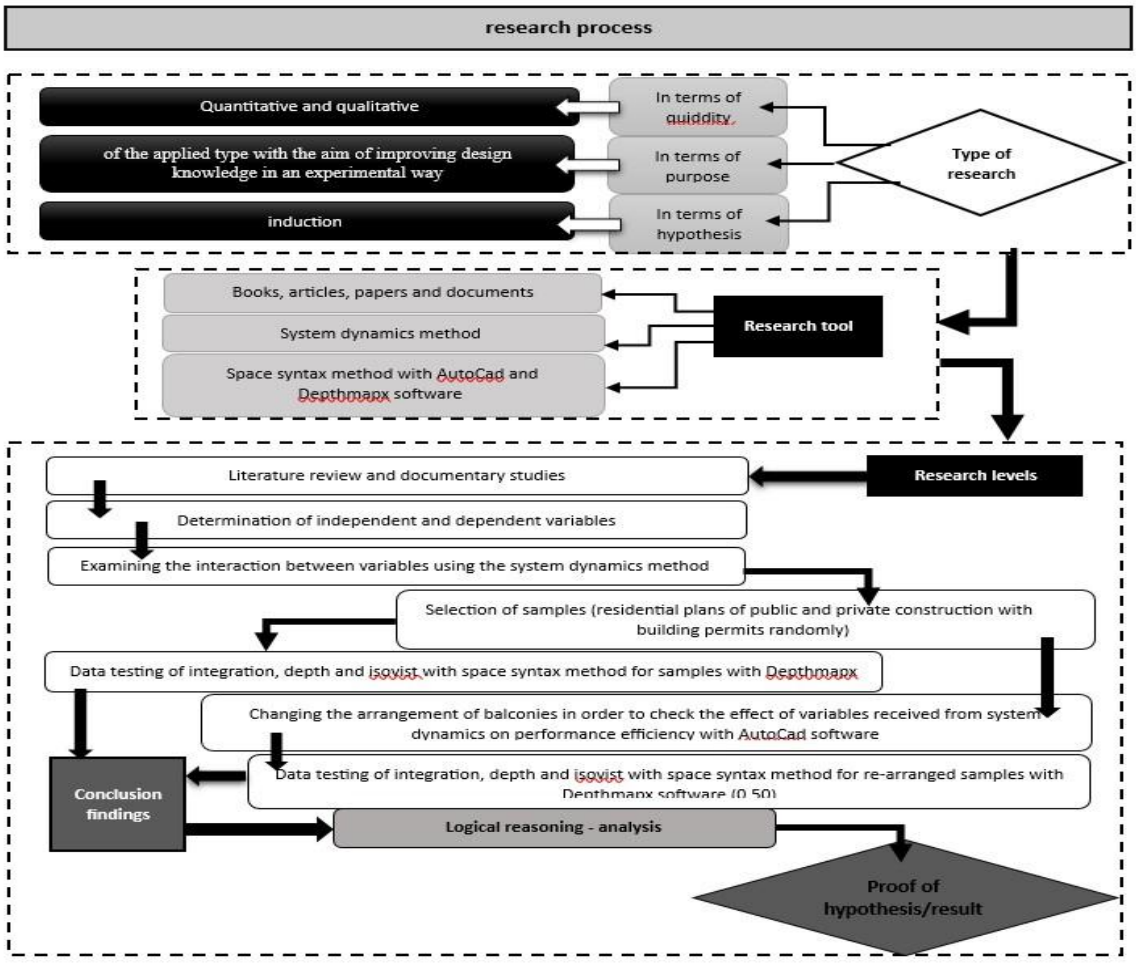


Fig. 6. The research process

Considering all effective variables simultaneously, non-

linearity, and management feedback loops of this model are its three main features (Ostadi , 1402). In this method, an amplification loop has been emphasized, in which the amplification of the initial value took place (Arranz, 2023). Based on the method defined in the process of system dynamics, the work steps include defining the boundaries of the problem, determining information sources and the most important variables, drawing causality loop diagrams, determining feedback diagrams, simulating the model, and testing the data and results (Sterman, 2001). Therefore, at this stage, after examining the sources and obtaining the main variables, the variables that behaved in relation to each other in the system were explained in the causality and feedback loop diagrams. At first, the relationship between the variables was examined by drawing the balance loop and the reinforcement loop, and finally, the feedback loop was presented as the main conceptual model (figure 7 and 8).

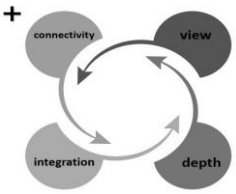


Fig.7. Reinforcement loop diagram with counterclockwise rotation direction.

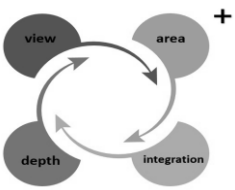


Fig.8. Balance loop diagram with clockwise rotation direction.

In these loops, a variable having the ability to increase was selected, and by increasing it, its effect on the rest of the loop components was examined. Since that the selected variable strengthened the system or balanced it, these rings are called strengthening and balancing rings. The combination of the explained loops formed the feedback loop, which was the conceptual model of the research (Figure 9).

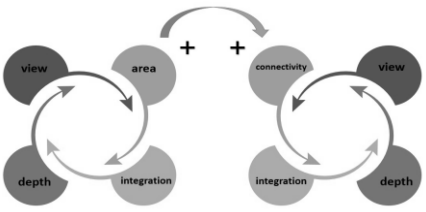


Fig. 9. Feedback loop - conceptual model of the research

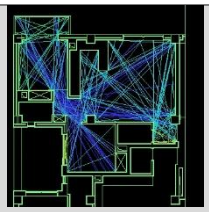
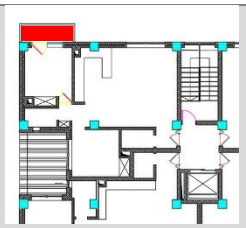
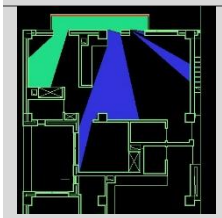
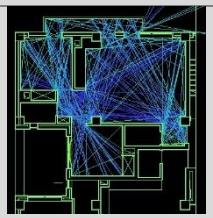
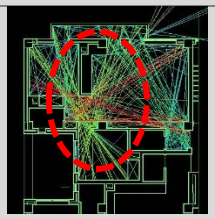
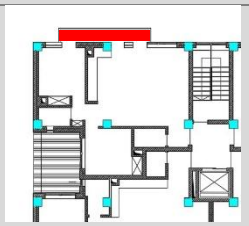
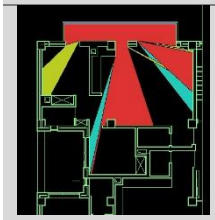
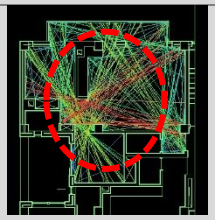
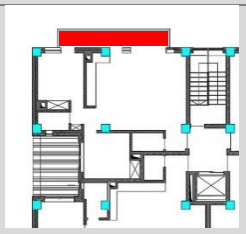
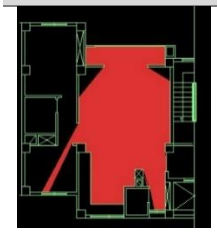
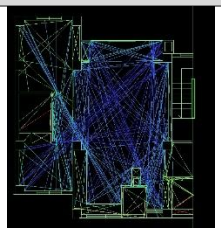
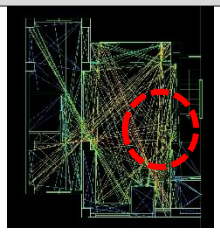
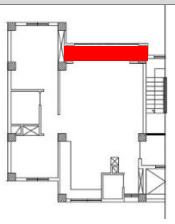
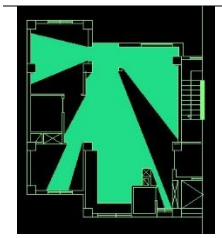
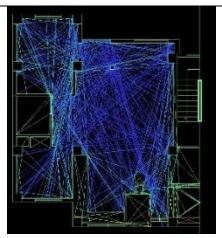
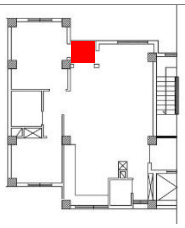
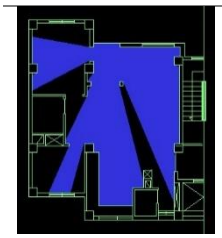
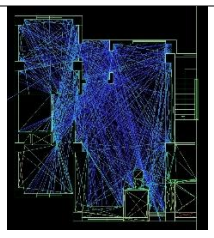
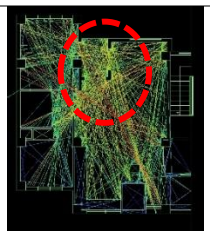
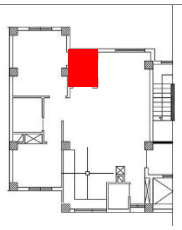
Now, according to the determination and explanation of the changeable variables and carefully considering that the current research had practical goals in order to improve the efficiency of the residential space; which specifically investigated the balcony space, the target community under investigation were residential buildings. In order to investigate the variables discussed in the statistical population of the research, the residential buildings of Gilan province in the last decade were selected and investigated in two categories of mass construction by government and private organizations as the case samples. In the selection of the samples examined by government bodies, three samples from the national housing action projects in Rasht, Anzali and Langrod, Mehr housing were selected in phase 2, and in the private sector, three samples were selected randomly from licensed residential apartments in Rasht city.

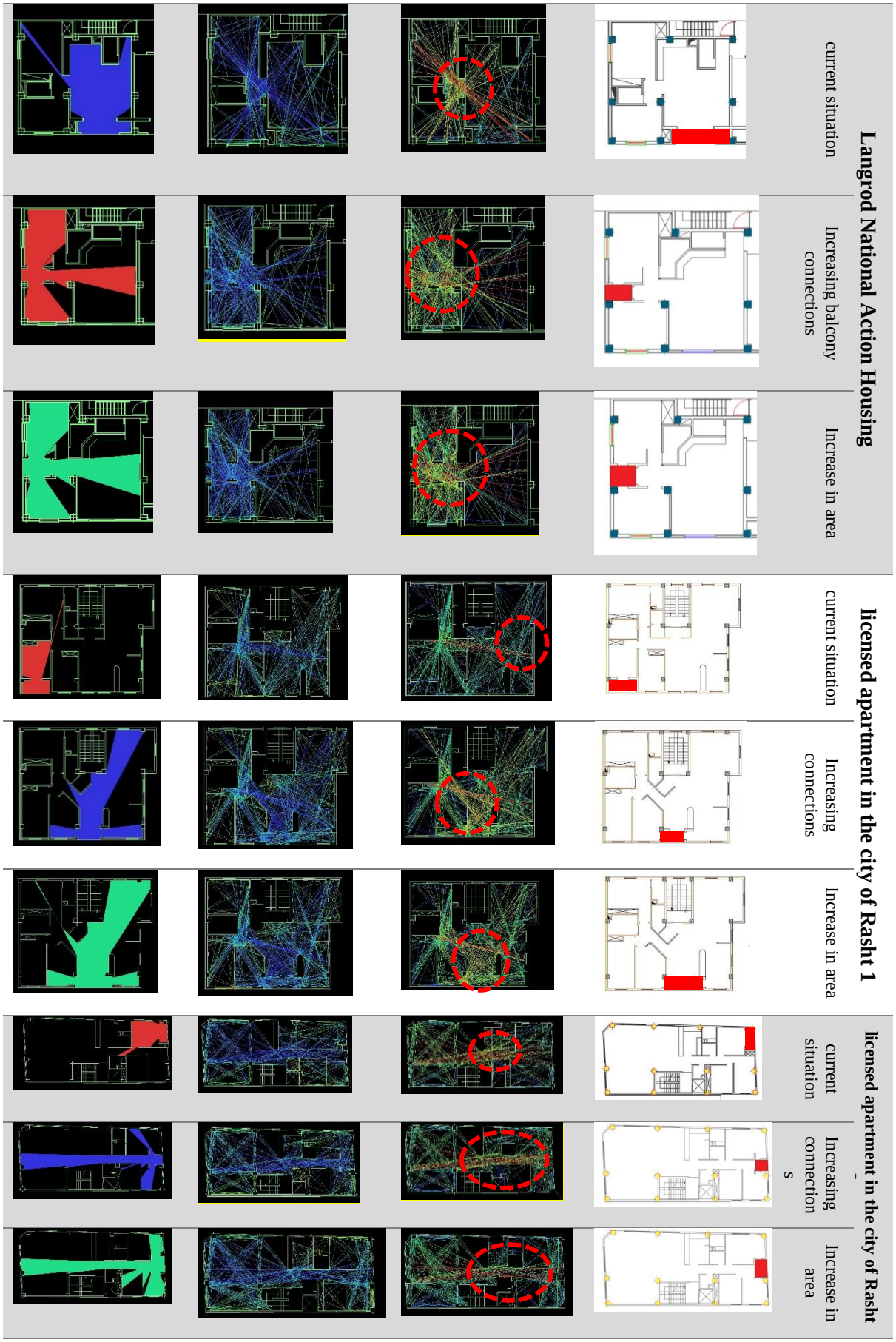
For this purpose, at the beginning, the necessary information was prepared and drawn from the plans of common residential buildings using AutoCad software. Next, using the depthmapx software (0.50), three indices of integration, depth and isovist were obtained for each of the samples to investigate the effect of these indices on improving functional efficiency based on system dynamics preferences (Table 2). The concept of more connectedness in a space means a space that has more integration with other spaces. Depth is defined as the number of steps to pass from one point to another. A point is called deep if there are many steps between that point and other points (Mirakabad, 2018). Spatial isovist is also considered by specifying points as the user's viewing angle (Rahimi, 2014). In fact, this technique specifies the audience's viewing angle in each part of the space by presenting shape graphs. After checking the desired indicators in the existing plans of the samples, according to the system dynamics method, two main indicators were changed, i.e. the degree of connection of the balcony space with other spaces and the amount of its area in the plans. The remarkable thing about the changes made in the plan was that the overall structure of the building did not change and the area of each unit remained constant. Finally, the obtained graphs were compared through logical reasoning, and in the examination of the samples, according to the obtained indicators, the obtained graphs were drawn for each of these changes.

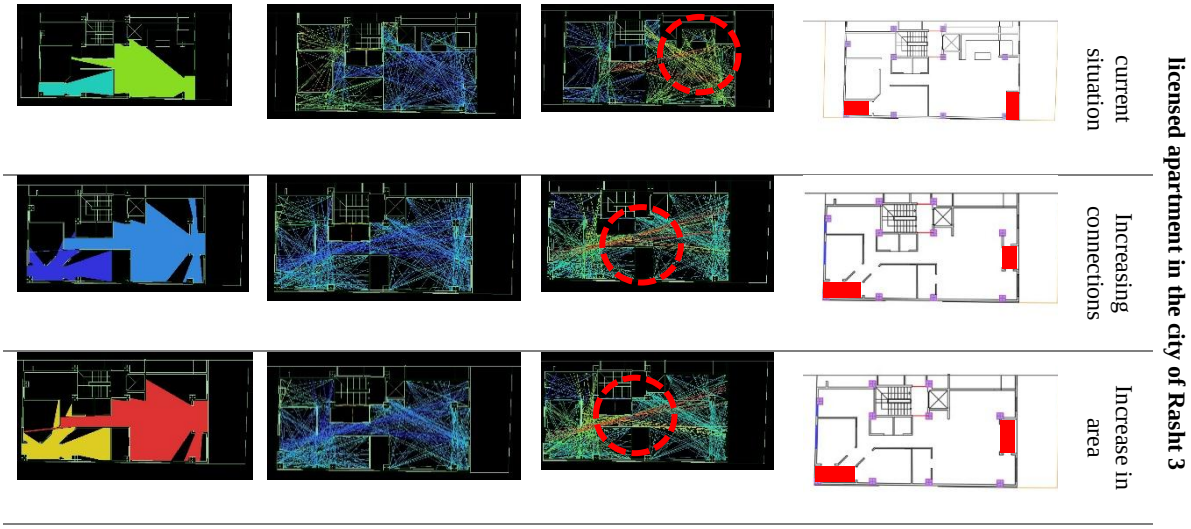
5. Results and Discussion

Since the current research had practical goals to improve the functional efficiency of the residential space, it specifically examined the balcony space, and the target community under investigation was residential buildings. In order to investigate the variables discussed in the statistical population of the research, the residential buildings of Gilan province in the last decade were selected and investigated in two categories of mass construction by government and private organizations as the case examples. In the selection of samples examined by government bodies, three samples from the national housing action projects in the three cities of Rasht, Bandar Anzali and Langrod have been examined, and in the private sector, three samples of licensed residential apartments in Rasht city have been selected. Regarding the examination of the samples according to the indicators obtained in the theoretical basics section, the graphs obtained for each of these changes have been provided in Table 2.

Table 2
Three indices of integration, depth, and isovist obtained for each of the samples

Isovist graph	Depth graph	Integration graph	Plan		
				current situation	**Rasht National Action Housing**
				Increasing balcony connections	
				Increase in area	
				current situation	
				Increasing balcony connections	**Anzali National Action Housing**
				Increase in area	


Langrod National Action Housing
current situation
Increasing balcony connections
Increase in area
licensed apartment in the city of Rasht 1
current situation
Increasing connections
Increase in area
licensed apartment in the city of Rasht
current situation
Increasing connections
Increase in area



Examining the graphs presented in Table 2, showed that the increase of the two variables of connection and area had a direct relation with the variable of integration and isovist, and as a result of the increase of these two variables, the degree of integration of balconies and their spatial isovist increased. In addition, it seems that by changing the area and connections, it became possible to significantly increase the access to the balconies and get a better viewing angle from the balcony, and increase the relation between inside and outside. This is while the relation between these two variables was opposite to the depth variable, and by increasing the two main variables, the depth of the balconies decreased, and by reducing the depth, better access could be obtained to the balconies. The combination of the obtained factors helped to connect the indoor and outdoor space of the house through the balcony. Comparing the numerical value of the variables clearly showed this issue. Numerical values obtained from Depthmap software for the integration variable could be observed in Table 3.

Table 3
numerical amount of integration for the balcony

Title	Balcony	current	Increase connection integration	Increase area integration
Rasht National Action	Maximum	10.06	12.46	13.35
	Minimum	3.87	4.83	5.75
	Average amount	6.96	8.42	9.55
Anzali National Action	Maximum	7.15	11.88	13.84
	Minimum	2.8	7.2	7.75
	Average amount	4.97	9.54	10.61
Langrod National Action	Maximum	15.24	17.43	18.06
	Minimum	4	7.4	7.66
	Average amount	9.62	12.41	12.8
Apartment in Rasht 1	Maximum	7.9	11.57	12.01
	Minimum	3.3	6.96	7.3
	Average amount	5.6	9.26	9.65
Apartment in Rasht 2	Maximum	6.5	10.32	12.04
	Minimum	2.5	4.54	5.3
	Average amount	4.5	7.43	8.67
Apartment in Rasht 3 Right	Maximum	9.37	15.41	15.46
	Minimum	4.58	5.34	5.9
	Average amount	6.97	10.37	10.69
Apartment in Rasht 3 left	Maximum	5.52	9	9.12
	Minimum	2.15	4.44	5.01
	Average amount	3.83	6.72	7.06

As it is observed in Table 3, the integration of the balcony space was measured in three steps. In the first stage, the integration of the existing balcony was measured, then the layout of the balcony space was changed in AutoCAD software according to the principles mentioned in the research method section in two stages. In the first stage, the connection of the balcony space with the rest of the spaces was increased and the integration was measured again, and then the area of the balcony in the modified plan was increased again in the AutoCAD software, and its integration was measured for the third time. As can be seen in the numerical values, with the change applied in each stage, the degree of integration of the balcony space has increased. The numerical values obtained from the Depthmap software for the integration variable can be observed in Table 2. For example, in Anzali's National Action Housing, the highest rate of integration in the current situation was 7.15; By increasing the number of balcony connections, it reached 11.88 and by increasing the area of the balcony, it reached 13.84, or in Apartment 3 in Rasht, the highest number of integration in the current situation was 9.37; By increasing the number of balcony connections, it reached 15.41 and by increasing the area of the balcony, it reached 15.46. The same measurement steps have been carried out for the numerical value of depth and isovist. Table 4 shows the numerical values related to the depth variable.

Table 4
Numerical amount of depth for the balcony

Title	Balcony	current	Increase	Increase
Rasht National Action Housing	Maximu	2.31	2	1.93
	Minimum	1.51	1.42	1.42
	Average	1.91	1.71	1.67
Anzali National Action Housing	Maximu	2.87	1.83	1.8
	Minimum	1.73	1.51	1.43
	Average	2.3	1.67	1.63
Langrod National Action Housing	Maximu	2.42	1.70	1.69
	Minimum	1.32	1.31	1.31
	Average	1.87	1.50	1.50
Apartment in Rasht 1	Maximu	2.48	1.90	1.88
	Minimum	1.60	1.54	1.54
	Average	2.04	1.72	1.70
Apartment in Rasht 2	Maximu	2.78	2.16	2.07
	Minimum	1.91	1.58	1.51
	Average	2.34	1.87	1.79
Apartment in Rasht 3 Right	Maximu	2.23	2.08	1.99
	Minimum	1.62	1.41	1.39
	Average	1.92	1.74	1.69
Apartment in Rasht 3 left balcony	Maximum amount	3.46	2.40	2.25
	Minimum	2.04	1.67	1.65
	Average	2.85	2.03	1.95

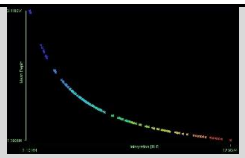
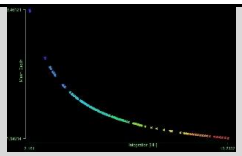
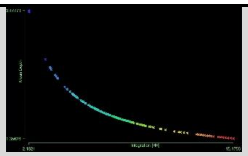
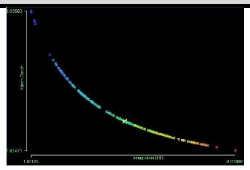
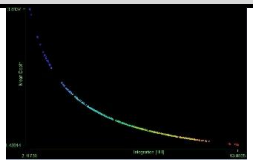
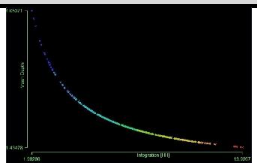
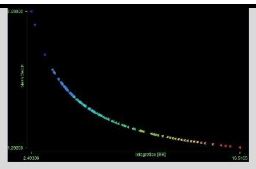
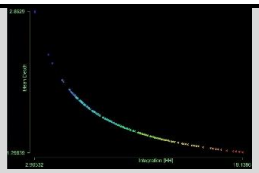
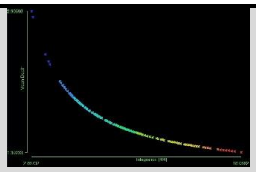
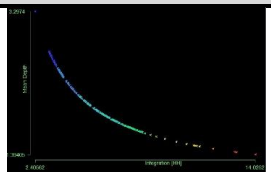
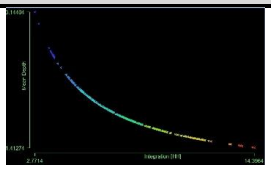
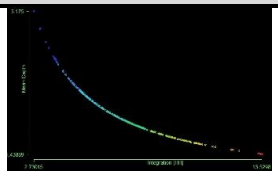
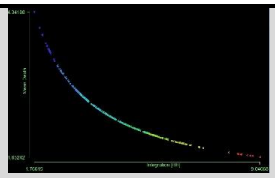
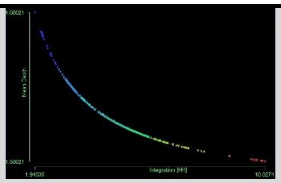
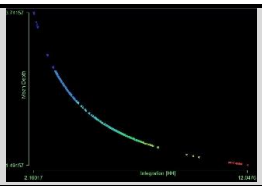
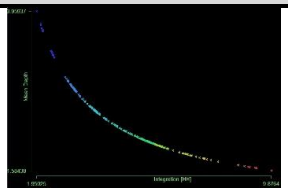
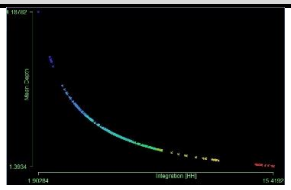
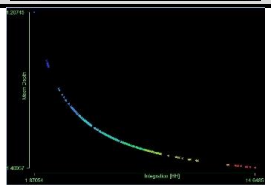
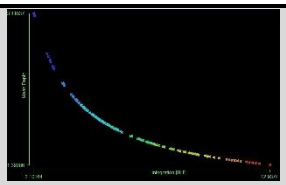
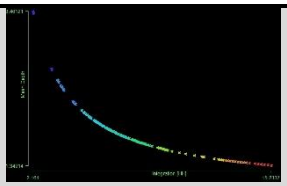
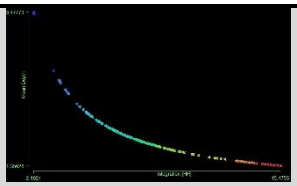
During the observations, the relationship between the depth variable and the two main variables of area and connection had an inverse relationship, and with the increase of these two variables, the spatial depth of the balconies has decreased. For example, in Anzali National Action Housing, the maximum depth in the current situation was 2.87; By increasing the number of balcony connections, it reached 1.83 and by increasing the area of the balcony, it reached 1.8, or in the National Action Housing of Langrod, the maximum depth in the current situation was 2.42; By increasing the number of balcony connections, it reached 1.7 and by increasing the area of the balcony, it reached 1.69. Also, in Table 3, numerical values related to Izovist can be seen, which have increased during the phase of the research and had a direct relation with the main variables. For example, in Rasht Apartment 1, the numerical data of Isovist was currently 14.08; By increasing the number of balcony connections, it reached 38.18 and by increasing the area of the balcony, it reached a significant number of 51.32, or for example in Rasht Apartment 2, the numerical data of Isovist in the current situation was 15.46; By increasing the number of balcony connections, it reached 41.65 and by increasing the area of the balcony, it reached a significant number of 46.38. (Table 5)

Table 5
Izovist numerical data for the balcony

Title	Izovist numerical data for current situation integration	Izovist numerical data for Increasing connection integration	Izovist numerical data for Increasing area
Rasht National Action Housing	13.41	17.61	23.96
Anzali National Action Housing	42.38	47.93	48.26
Langrod National Action Housing	37.86	41.34	42.25
Apartment in Rasht 1	14.08	38.18	51.32
Apartment in Rasht 2	15.46	41.65	46.38
Apartment in Rasht 3 Right balcony	21.99	54.88	63.58
Apartment in Rasht 3 left balcony	11.10	23.5	28.43

Finally, in Table 6, the graphs related to the degree of dispersion and the relation between the integration index and the depth were presented, and in all these stages, the corresponding graphs showed the inverse relationship between these two variables.

Table 6
The graphs for the relation between the integration index and the depth

Title	current situation	Increasing connection	Increasing area
Rasht National Action Housing			
Anzali National Action Housing			
Langrod National Action Housing			
Apartment in Rasht 1			
Apartment in Rasht 2			
Apartment in Rasht 3 Right balcony			
Apartment in Rasht 3 left balcony			

6. Conclusion

After analyzing and comparing the data and output graphs, what was considered as improving the functional efficiency of the balcony from the beginning of the research path can be received. This meant that the best efficiency of the balcony space could be achieved using the system dynamics method. As a result of examining the interaction of variables in the system dynamics method, following the increase of the two main variables of connection and area, by examining its effect on other variables, the results indicated a positive change in the integration variables, isovist and a decrease in the depth variable. This indicated an increase in integration, isovist, and also a decrease in depth, practically increasing the efficiency of the balcony space, and as a result, it led to better functional efficiency.Thus , according to the system dynamics method, the effect of the variables on each other in the

feedback loop could be seen in the diagram below, which confirmed the hypothesis of the research (Figure 10).

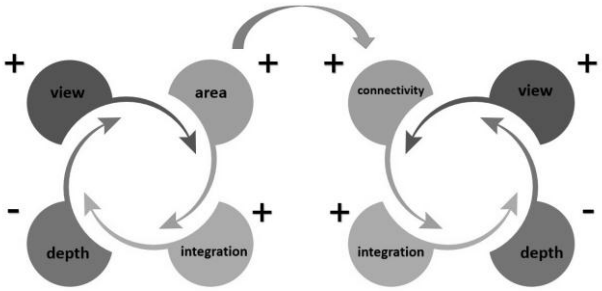


Fig.10. Feedback loop – final result

During data analysis, the results obtained from the software graphs showed that for the samples examined in the design of common housing in Gilan province, the spaces were arranged in such a way that due to the observed spatial arrangement, the most important part of the house (according to integration criterion), was in the area near the bathrooms and bedrooms. This is while it seems that according to the changes applied based on the system dynamic diagrams on the variables regarding the internal arrangement of the architectural plans, balconies could be the heart of a house if more connection with spaces are obtained and its area is managed in such a way that it is not observable in the surface of the facade rather it is extended into the plan so that it has the most access to all internal spaces. In this way, all the interior spaces are placed at the lowest depth compared to the balcony, and the most important part of the plan remains as the area related to the Based on the results of this research, the future research can examine the dimensions, appropriate form, the best amount of area and the optimal orientation regarding the balconies and other interior spaces of the house, so that in the end it can be a suitable model for the design of common housing.

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