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Analysis of the Effectiveness of the Physical Elements of Rural Housing in West Gilan on the Functional Efficiency Using Space Syntax Method*

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ABSTRACT

The architecture of the temperate and humid climate of Iran has features that evolved uniquely over many years and under the influence of environmental factors. These features led to using the particular patterns in the architecture and housing architecture in particular. The rural houses of the north of Iran were uniquely created under the influence of environmental factors such as geography, climate, economy, culture, and social conditions. The architecture of this region is a response to the behavioral and climatic needs of the local people by relying on the regional and natural facilities. The case study was the rural houses of West Gilan that were studied in four geographical classifications of coastal plain, plain, foothill, and mountain. The research method was the analytical-descriptive method. The results were presented using the statistical data analysis extracted from the software. Therefore, the samples were selected non-random sampling method, considering the purposive method and consideration. The components of the functional efficiency in the structure of the rural houses were studied using the Space Syntax method and Igraph software. The results indicate that the pattern of rural housing of Gilan has a single layer structure and enjoys a shallow depth. The maximum connection between the house and the outdoor is through the porch. Also, access to other spaces is through the porch and then telaar. The porch is the shallowest and the most connected space element that is responsible for connecting the outdoor spaces and the other spaces, and telaar is the second element. The porch and telaar increase the connectivity degree and better connection between the yard space and other internal spaces, resulting in improving the function between the spaces generally.

Keywords: Rural Housing, West Gilan, Functional Efficiency.

* This paper is derived from the Ph.D. thesis of the first author entitled "Explaining the housing design model compatible with the climate of West Gilan with the approach of social interactions" under the supervision of the second author and advise of the third author conducted in the Islamic Azad University, Central Tehran Branch.

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1. INTRODUCTION

The vernacular housing in any part of the world is mostly influenced by four geographical and natural conditions of the earth, the climate and weather conditions, economic and livelihood of the residents, and the cultural characteristics of the local people. Indeed, other factors affect the formation of housing in some regions, the effect of which is not permanent and must be investigated based on a case study. The historical records and providing security for the residents of a region are among these cases. However, these factors originated from geographical, climate, and economic conditions. In the housing architecture of Gilan, where the most prominent climate feature is the moderate temperature, high humidity, and long precipitations, the house must prevent the high humidity beyond the human comfort besides meeting the basic needs, i.e., providing a shelter and preventing the natural dangers. That is to say, the building must reduce the humidity around the human body in a way to make the possibility of evaporation and sweating through the skin, resulting in a reduction in the human body temperature. The easiest way to achieve this purpose is to create a draft in the building and eliminate the humid air by the wind. Also, another way is to create spaces with many openings and minimum wall surfaces that lead to the easier direction of the wind flow to the living spaces on the hot days of the year. The porch is useful in this regard many times of the year. The formation of the porch and thorough telaars around the building indicate the significant need for this element. The porch on the second or the third floor is called telaar. Telaar is few stairs higher than the porch and is located under the barn of the stables. Also, the beneath of the telaar is empty in some cases. The room behind the telaar is called Balakhaneh (attic or upstairs) (Gorji & Daneshvar, 2010).

As mentioned, the porch and telaar provide the possibility of easier air movement on the residential floors. Therefore, ventilation occurs not only in the environmental walls of the building but also in its different levels of layers through the wind flow. Also, the porch and telaar connects the open space of the yard to the closed space as semi-open spaces and play a significant functional role in forming the spatial hierarchy as the interface space. Therefore, this mediating space can play a considerable role in the spatial connections as well as the movement patterns from the open space to the closed space and vice versa. On the other hand, given the definition of the functional efficiency presented in the following, the efficiency of a space increases in the whole space configuration of a building when the mentioned space has many spatial connections with other spaces in the complex. It provides accessibility and the use of different spaces for different classes of people. The current study analyzes the effectiveness of the physical elements such as porch and telaar in the functional efficiency of the rural housing of Gilan using the space syntax method.

2. RESEARCH QUESTIONS AND HYPOTHESES

In the present paper, the housing of West Gilan is studied as the independent variable, and the functional efficiency is investigated as the dependent variable. Therefore, the main research questions are as follows:

- What is the role and characteristics of the different types of rural housing in West Gilan in the functional efficiency of the architectural body?
- What is the effectiveness of the physical elements of the porch and the telaar in improving the functional efficiency?

Accordingly, the research hypotheses are presented as follows:

- Each type of rural housing in West Gilan has its own physical characteristics and functional efficiency.
- Physical elements, especially porches and telaar, have a direct effect on the functional efficiency of spaces.

3. RESEARCH LITERATURE REVIEW

As mentioned, some functional efficiency indicators are introduced to perform the process proposed in this study and to prove the hypothesis.

3.1. Functional Efficiency of Space

Functional efficiency in a system is directly associated with the efficiency of that system for the users. Functional efficiency in a system has a direct relationship with the efficiency of that system for the users. In this regard, Bill Hillier, in his book "Space is the Machine" defines functional efficiency as follows: efficiency means minimizing the influence of unrelated groups and properly organizing related spaces together so that their efficiency depends on proper services with each other. This type of spatial organization leads to the formation of efficient social relationships (Hillier, 2007, p. 229). Therefore, it can be stated that the functional efficiency of a space has a direct relationship with the extent and type of activities done in that space. This concept can be investigated from three perspectives in the literature related to the architectural space. The first perspective defines the functional efficiency of space in providing the comfort conditions of the space users, including the heating, cooling, providing light, ventilation, and alike. In this approach, the more space provides the comfort conditions for the human, regarding the mentioned variables, the more will be the efficiency. The second perspective studies the functional efficacy in behavioral science. In this approach, the functional efficiency of an environment is its ability to meet various mental and physical needs of its users, including security, peace, vitally, sense of belonging, and alike (Altman, 2003; Neman, 2015).

The third approach that studies the concept of the functional efficiency of an environment is the physical

approach (Mostafa & Hassan, 2013). This approach that addresses the structure of the space layout introduces the efficiency of micro-space in a space configuration system in its applicability by users. In this regard, indicators, such as the position of the considered space in the general structure of the building, its connection and relationship with its adjacent spaces, the access to the considered space, and alike are among the factors that affect the efficiency of the considered space. The current study has been conducted based on the physical approach.

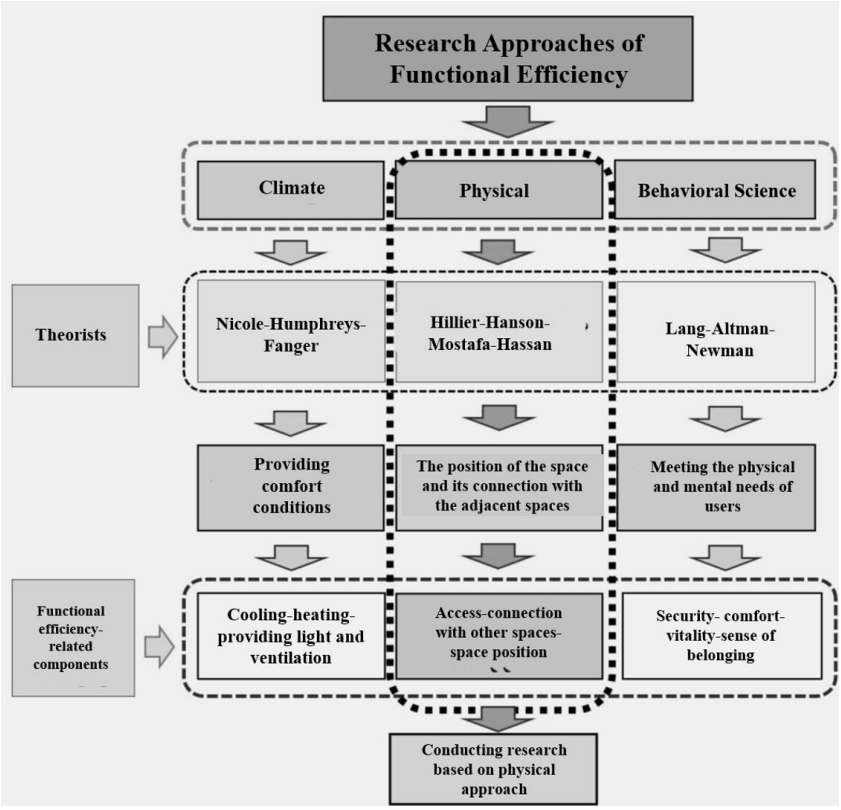


Fig. 1. Research Approaches of the Functional Efficiency

3.2. Analysis of the Spatial Structure in Space Syntax

In the early 1970s, a perspective called space syntax was developed related to the analysis of the human environment- large houses in large cities. The primary origins of the space layout are based on the studies by Christopher Alexander and Philip Steadman, and its theoretical ideas were first presented by Hillier and Hanson. They stated that the relationship between the form and function occurs by accepting and maintaining different patterns of movement in cities and buildings, and faces that are based on its space configuration (Hillier & Hanson, 1984). The purpose of this method was to describe the spatial models and present these models in the form of graphical and numerical figures, resulting in facilitating the scientific interpretations regarding the considered spaces (Mostafa & Hassan, 2013, p. 445). In other words, syntax or arrangement studies the relationship between a spatial unit in a complex with its adjacent spaces, which is precisely similar to the investigation of a word inside a text and its relationship with other words (Memariyan, 2002, p. 8). That is to say, in this method, the space composition pattern and the relationship between them are analyzed by turning it into a graph. Space syntax as a method and measurement tool and not a variable is the link between the body and the components of the functional efficiency.

3.3. Factors of The Functional Relationships Analysis in The Space Syntax Model

A) Relative Asymmetry (RA) (Spatial Level)

Relative asymmetry of space is the visual depth of various spaces in a space structure of the main space, such as the main entrance. If the depth of space in the building is lower than the depth of the sample space in another building, space is, then, called symmetric space. Therefore, spatial separation increases. Also, when the number of visual phases between the existing spaces increases, it leads to a poor functional relationship (efficiency and performance). The maximum efficiency can be achieved in the spatial systems when all the spaces are directly connected to the main space (such as rotting space) (Model A). However, the minimum efficiency is obtained when all the spaces are arranged in a regulated linear sequence away from the main space (Model B). In the first case, the space is symmetric in the system considering other spaces, while in the second case, the space is asymmetric (Hillier, 2007, p. 22).

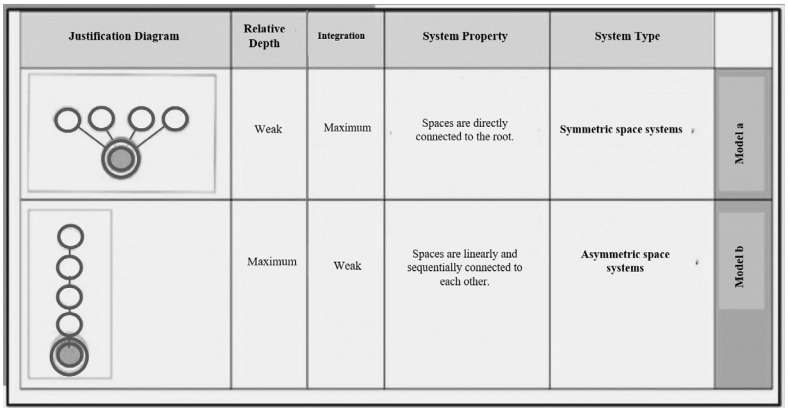


Fig. 2. Types of Spatial Systems and the Justification Diagram

B) Space Configuration

The number of access points can be one of the key factors in organizing, facilitating, and diversity the land uses in a building. In this regard, the spaces are divided into four types of a,b,c, and d. a is a space that is only connected to another space. Generally, these type of spaces leads to increasing the depth and lack of proper access (reducing the considered integration). Space b is spaces that are connected in a minimum of one or two other spaces. The research results show that creating b type spaces in the residential buildings result in connecting the public areas to the private areas. Type c spaces are the spaces that are in a ring, and type d spaces are the spaces that are connected to a minimum of two other rings. Spaces type c and d lead to the reduction in the depth, facilitation of the access and space flexibility (Amorin, 1997).

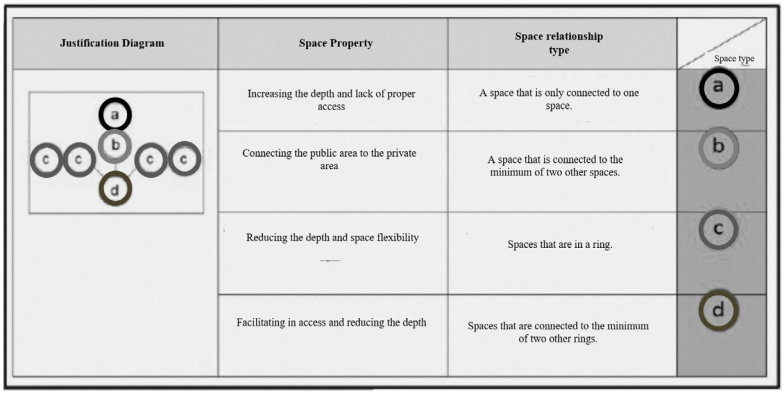


Fig. 3. Hypothetical Justification Diagram and Representation of Different Spaces

C) Integration and Connectivity

Connectivity means the number of connections of each space with other spaces. Also, the integrated space is a space that has a low relative depth and is connected with a relatively high number of spaces (Hillier, Hanson, & Peponis, 1987, p. 364). Integration of a point indicates the integration or the separation of a point from the whole or the lower system (Memariyan, Feyzi, Kamalpoor, & Moosaviyan, 2012, p. 4). Therefore, the more the value of integration in the physical space of a building, the more its functional efficiency is, and the more the spaces are separated from each other and have lower connections, the lower is the functional efficiency.

D) Depth

The space depth or the mean relative depth means the space phase that a part of the space has to the other parts and is related to the flexibility and integration of the space (Hanson, 2003, p. 82). If the spaces (servicing and distrusting spaces such as porch in particular) are in a lower depth to the entrance space, the space function becomes efficient. Then, it eventually leads to improving functional efficiency.

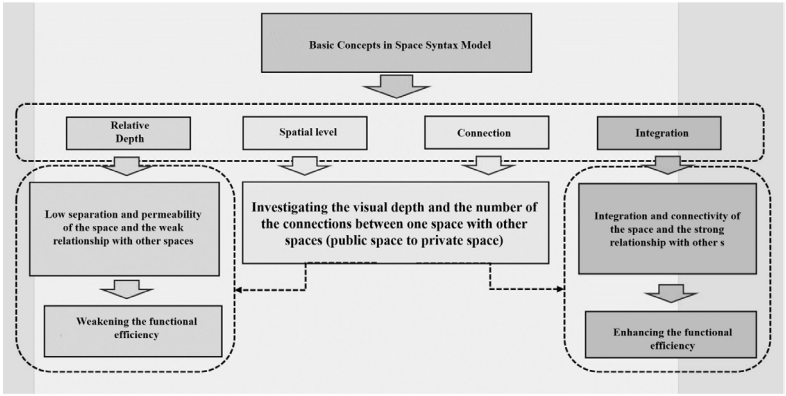


Fig. 4. Basic Concepts in Space Syntax Technique

As mentioned, space syntax can be used by four components of integration, space configuration (access), spatial level, and relative depth in identifying the spaces. The relative depth measures the weakening or enhancing the social relation by recognizing the depth of the spaces, and by identifying the spatial separation and permeability in the body, and eventually specifies the function of the space. Integration is another component of the space syntax that provides the ground for social relations by emphasizing the measurement of the connectivity and depth of space. Regarding the type of the considered space, space configuration and spatial levels measure the integration or the depth of the considered space. Eventually, these components emphasize the effectiveness of the physical elements on the functional efficiency of the space by turning in to depth and integration.

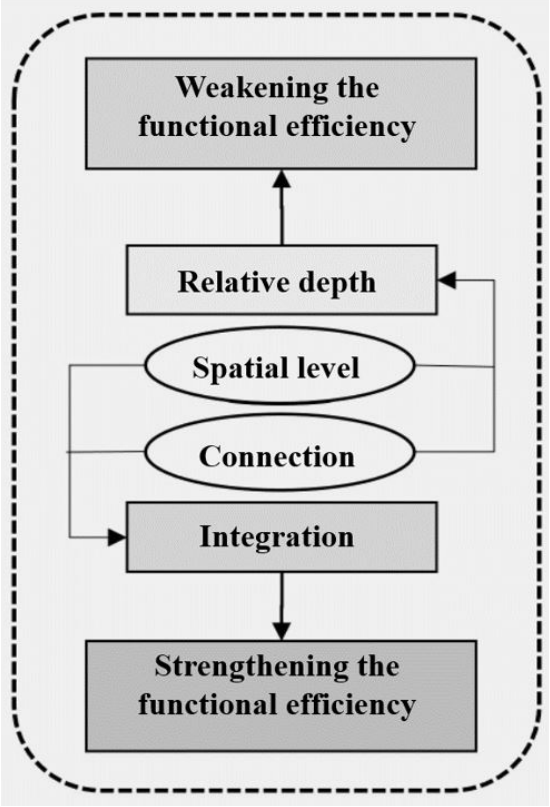


Fig. 5. The Effect of the Basic Concepts of the Space Syntax on the Functional Efficiency

3.4. Research Background

Many studies have been conducted on functional efficiency using the space syntax method. For instance, Mostafa et al. studied various types of mosque patterns, and considering the dome as a variable and introducing the components of the space efficiency, evaluated the functional efficiency of these types. In another study on these components, the space configuration and the functional efficiency were analyzed in different patterns of house and business centers. In Iran, Abbas Zadegan and Memariyan were the first researchers who introduced the space syntax approach, and by using this approach, Yazdanfar, Rismanchian, and Mollazadeh have conducted studies in the urban contexts in Iran. In a paper entitled "the review of Space Syntax, a solution in architecture and urban design, case study: Brojerdiha House in Kashan", Hamedani Golshani reviewed the intellectual foundations and principles of the space syntax theory and updating the developments that occurred in the recent years in the concepts and applications of this theory (Hamedani, 2015). Azadbakht studied the interrelationship between the space configuration and the system of activities and showed that the types of housing have different configurations. However, despite the change in the space configuration, the system of activities has not changed, and the residents adopted themselves with the considered spaces (Azadbakht & Noortaghani, 2017). In a paper entitled" the analytical approach to the space syntax in understanding the space configuration of the vernacular housing of Qesham (case study: Laft Village), Tabatabaee Malazi used the analytical method of space syntax to study the relationships between the spaces of the vernacular housing of this region (Tabatabaee, 2016). Analysis of the space system hidden in the vernacular housing architecture of Mashhad based on the space syntax theory is the title of the study conducted by Rokni (Rokni & Ahmadi, 2017). Khakbour, Taleghini, Mousavi, Azimi Dobakhshari, Gorji, and Rahnemai are among the researchers who conducted studies on the architecture of Gilan.

4. RESEARCH METHOD

The current research is applied in terms of purpose, and the research method is a descriptive-analytical method based on the case study. Library studies and field observations were used for collecting the required information for the research. The information collection tools used in this study are documentation studies and field observations, including sampling, photography, roleve and architectural sketches.

In the present study, the method of data analysis, library review, and review of the subject texts is collected by field information and data analysis to determine whether there is a systematic relationship between the variables being measured or not? Also, the space syntax method and the statistical-analytical software of Igraph were used for data analysis that includes four phases:

First phase: it includes the documentation and library studies on rural housing and the influential factors on functional efficiency.

Second phase: defining the components of the functional efficiency and the physical elements of the rural housing requires the review of the relevant texts and field observations that include identifying, photography, sketching, roleves, and architectural, climatic, and environmental studies.

Third phase: research model, data analysis, and collection.

Fourth phase: presenting the research conclusions and introducing the findings and confirming or rejecting the hypotheses.

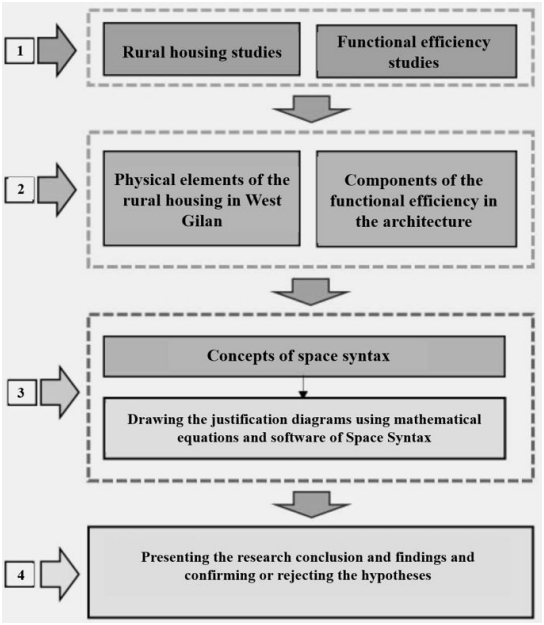


Fig. 6. Research Phases

4.1. Theoretical Framework

This section concludes and presents the theoretical framework of the research. In the research literature, the indicators of functional efficiency were introduced and analyzed. Also, the effect of changes in each of these components on the formation of the functional efficiency of space was mentioned. According to the characteristics of these components, the relationship between each of these indicators and their effect on the functional efficiency of Telar in rural housing of Gilan will be evaluated. In the current research, evaluating the abovementioned will be done using the mathematical equations of the space syntax.

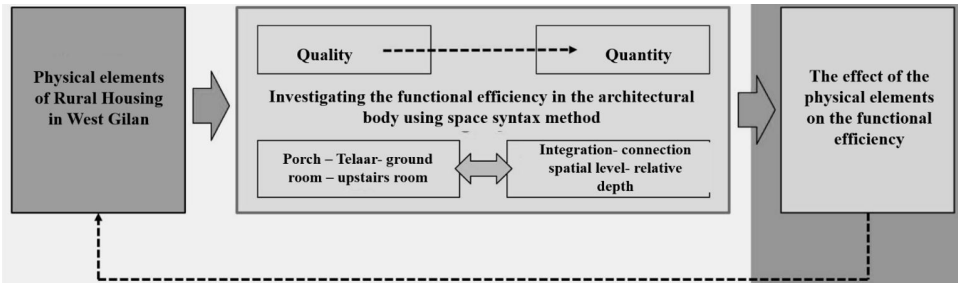


Fig. 7. Research Conceptual Model

4.2. Research Area

In the physical plan of Gilan and Mazandaran, approved in 1994, Gilan province has been divided into three parts of East Gilan, West Gilan, and Middle Gilan. In this division, the capital of the middle district is Rasht City, the capital of the east district is Lahijan, and Fuman has been selected as the capital of the west district. According to the results of the studies of the Rural Heritage Museum of Gilan Province Project, the architectural-cultural area of Gilan has been classified into nine architectural-cultural areas, disregarding the state and political divisions. The classification of these areas is based on the environmental factors (Topography, climate, and alike), type of agricultural activity, culture, religion (dialect, language, and so on), and the type of rural vernacular architecture. These nine architectural-cultural zones include two zones of the west and east branches with four sub-branches of the coastal, plains, submontane, mountainous, and central plain zones.

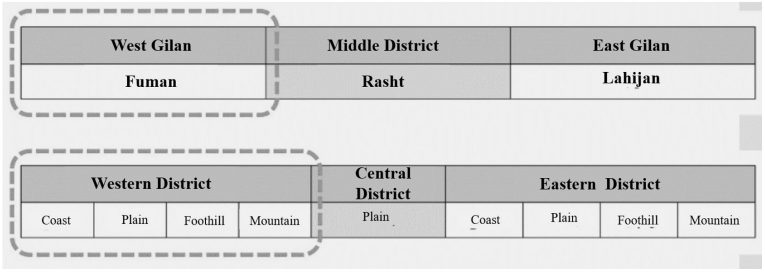


Fig. 8. Division of Gilan Province

5. FINDINGS

As mentioned, the geography of Gilan province has been divided into four geographical zones of mountain, foothill, plain, and coast. These geographical zones do not have the same conditions in terms of climate, and each one of them has its particular climate components that their effect on the diversity of the architectural body is evident.

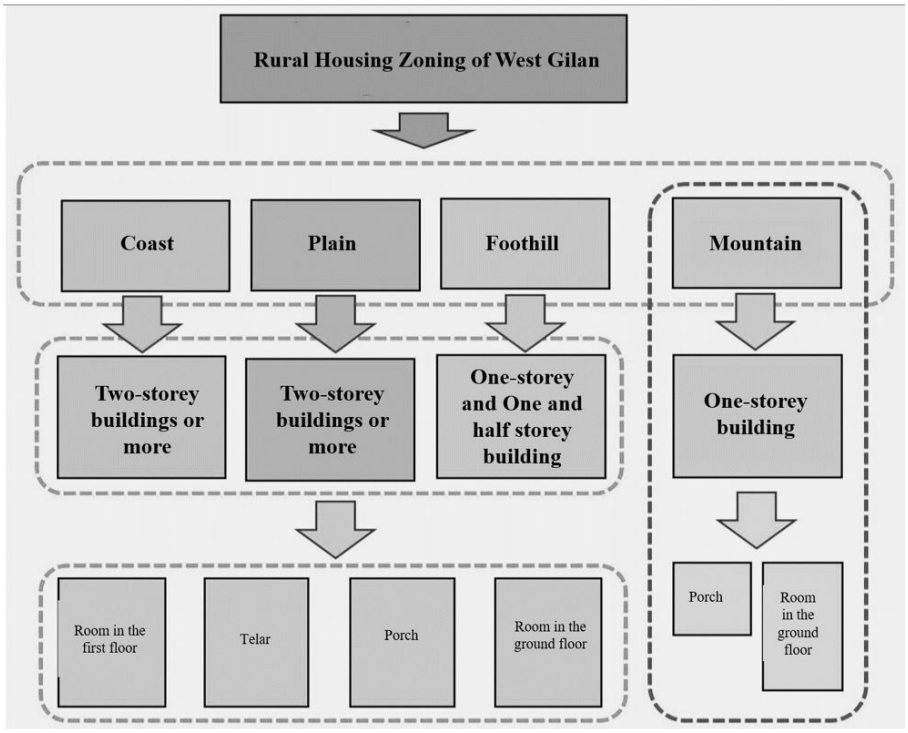


Fig. 9. Rural Housing Zoning of West Gilan

The spatial structure of the rural house in this type of architecture includes a porch, telar, korsar (a covered porch along the main façade that connects the rooms), kotoom (a wooden porch), Varkotoom, Davakeh, Balakhaneh, Barn, and so on. The arrangement of objects in each part is affected by the particular function of each one of these spaces and is in line with providing the needs of the residents.

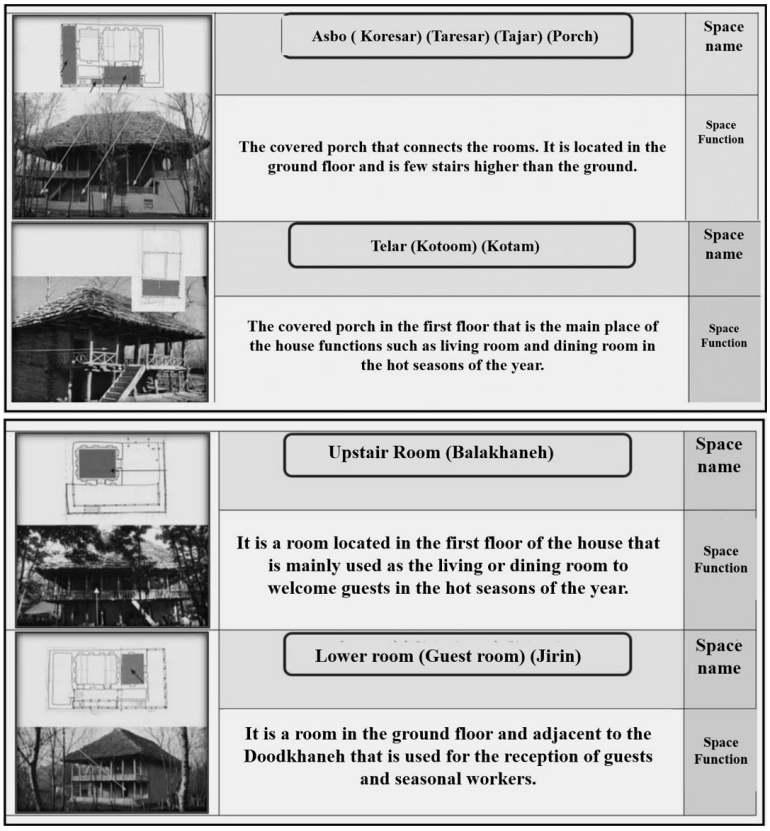


Fig. 10. Naming the Physical Elements of the Rural Housing with the Common Dialect in West Gilan

Due to the climate effects and the temporary nature of the housing in some parts of the coast, parts of the mountain and foothill, the buildings did not have the spatial diversity of the plain regions. Also, in many cases, the building does not have a porch. Besides, telaar is observed with the summer function in some cases. Therefore, in the present study, the samples were selected from the architecture of foothill, plain, and coastal plain of Gilan.

Fig. 11. Mountain Rural Housing Type

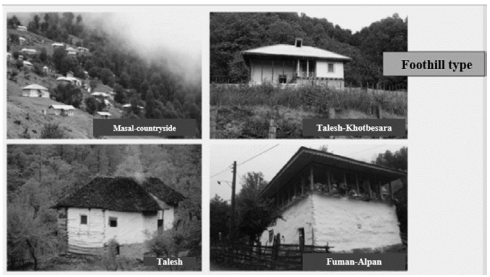


Fig. 12. Foothill Rural Housing Type

Fig. 13. Plain Rural Housing Type

Fig. 14. Coastal Rural Housing Type

The plain architecture has the perfect spatial diversity among the vernacular houses of Gilan due to the climate reasons and being in the geographical region with long summers, short cold season, and higher relative humidity.

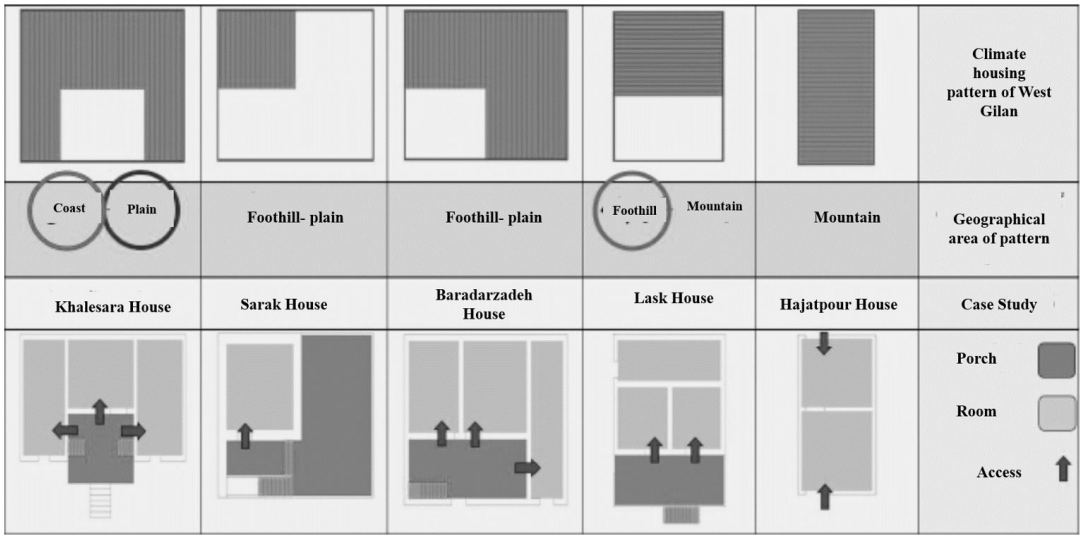
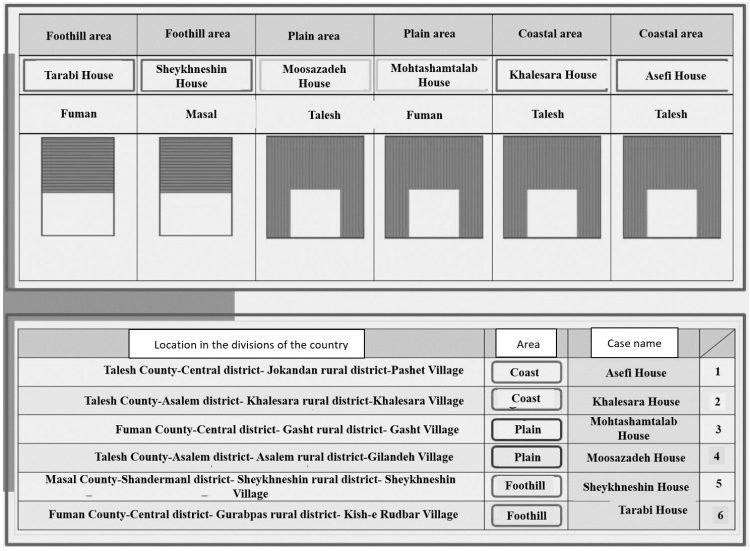


Fig. 15. Rural Housing Pattern in Quadruple Zones

The statistical population of the research is the rural housing of West Gilan that studied in three geographical classifications of coastal plain, plain, and foothill. Therefore, the samples were selected as non-random and purposive. It is noteworthy that due to the climate diversity and geographical dispersion, two samples were selected from each geographical zone and the research was conducted based thereon.



Location in the divisions of the country	Area	Case name	
Talesh County-Central district- Jokandan rural district-Pashet Village	Coast	Asefi House	1
Talesh County-Asalem district- Khalesara rural district-Khalesara Village	Coast	Khalesara House	2
Fuman County-Central district- Gasht rural district- Gasht Village	Plain	Mohtashamtalab House	3
Talesh County-Asalem district- Asalem rural district-Gilandeh Village	Plain	Moosazadeh House	4
Masal County-Shandermanl district- Sheykhneshin rural district- Sheykhneshin Village	Foothill	Sheykhneshin House	5
Fuman County-Central district- Gurabpas rural district- Kish-e Rudbar Village	Foothill	Tarabi House	6

Fig. 16. Statistical Population of the Research Area

After layering and transforming the plan form to the justification diagrams, using the analytical software of Igraph, the physical elements of space were analyzed based on the basic concepts of the space syntax in the form of a diagram and then turning them into the numerical values.

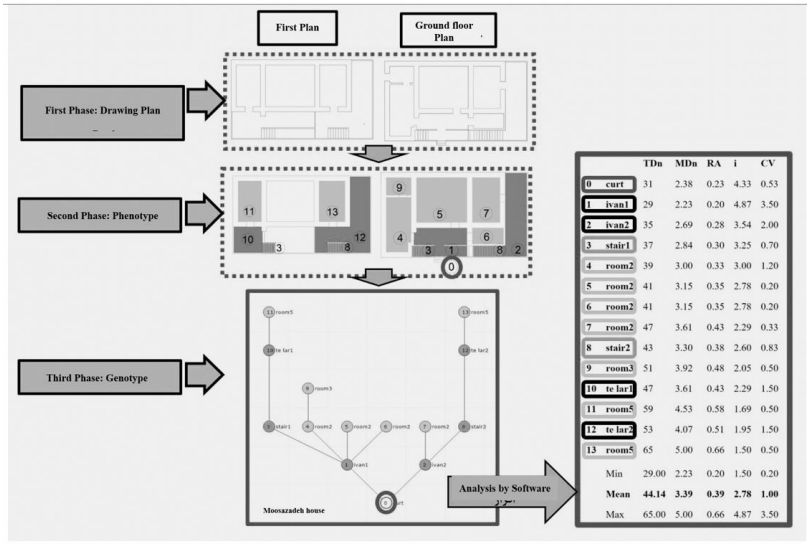


Fig. 17. The Analysis Process of Igraph

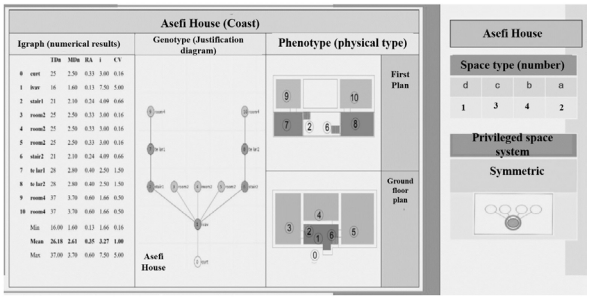


Fig. 18. Software Analysis of Asefi House (Coastal Type)

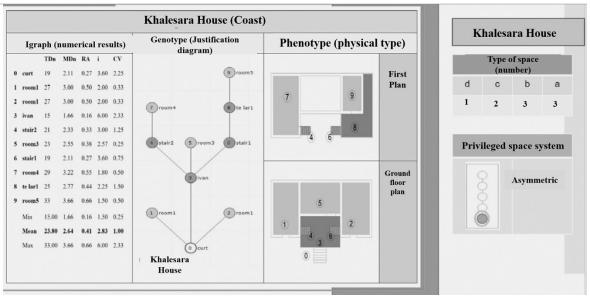


Fig. 19. Software Analysis of Khalesara House (Coastal Type)

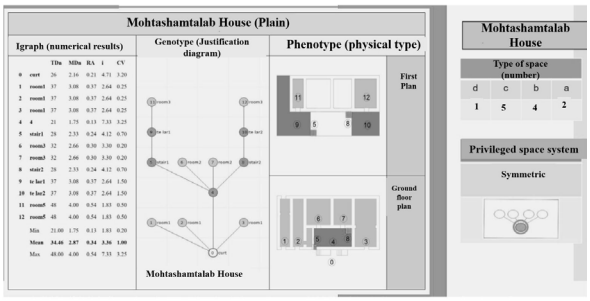


Fig. 20. Software Analysis of Mohtashamtalab House (Plain Type)

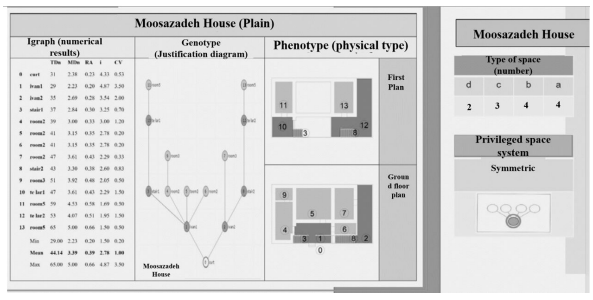


Fig. 21. Software Analysis of Moosazadeh House (Plain Type)

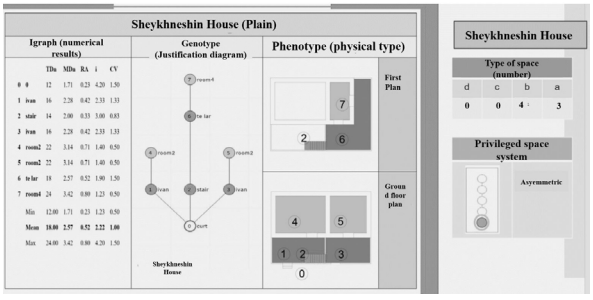


Fig. 22. Software Analysis of Sheykhneshin House (Plain Type)

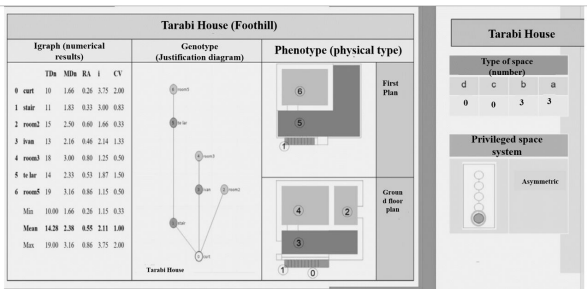


Fig. 23. Software Analysis of Tarabi House (Foothill Type)

6. ANALYSIS AND DISCUSSION

The obtained results on the components of the functional efficiency show that in the patterns of the case study, the percentage of the type a spaces that have the depth is low, and the maximum percentage is allocated to the type b, connective spaces. They all indicate the layer structure of the houses, high connective space, and architecture with low depth in the climate housing of Gilan.

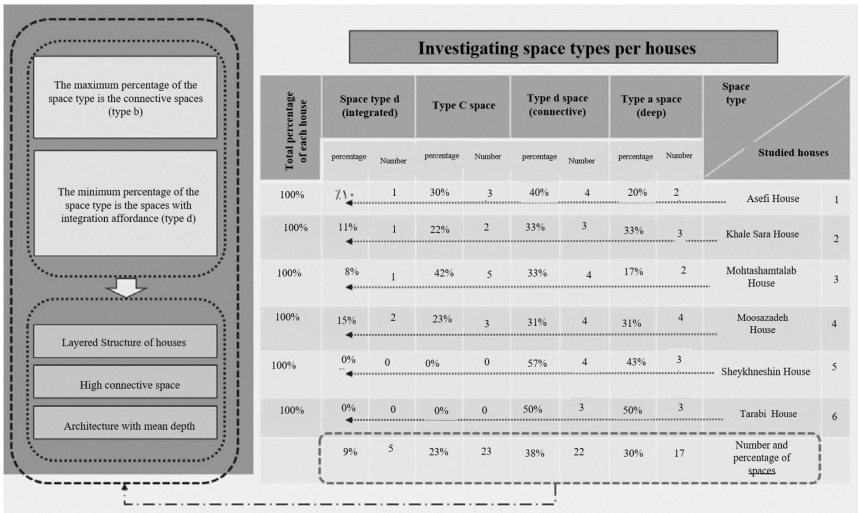


Fig. 24. Investigating the Number of Type a, b, c, and d Spaces in the Houses

Based on the analysis of the statistical data, it can be concluded that among the architectural elements of this type of vernacular housing, the porch has the lowest space depth. It is also the best interface between the open public spaces and the private and semi-private internal spaces, resulting in the highest functional efficiency. After the porch, telaar is the connecting element between the floors and other spaces that has higher security and more features to the porch by being in the mean depth. In the second rank, there are spaces with high integration that leads to maximum functional efficiency.

The study of the obtained results regarding the type of physical space shows that in the studied models, the highest percentage of spaces is of type c (spatial level) and the integrated spaces of type d are in the next stage. Plain houses have the best association, and the foothill species do not have any type d space. In terms of connection and spatial level, plain types are in the first place. The depth (type a space) is approximately the same in all three patterns. And the coastal houses are a little shallower. The conclusion of this section shows that plain houses with physical relationships, congestion, and medium depth, have a better socialized body than other species, which provides the basis for the possibility of proper functional efficiency.

Percentage of Space type d	Percentage of Space type c	Percentage of Space type b	Percentage of Space type a	Space type / Climate area	
40%	22%	32%	30%	Coastal Type	1
60%	78%	36%	35%	Plain Type	2
0%	0%	32%	35%	Foothill Type	3

Among the studied patterns, the plain houses have the strong connectivity among the physical elements and spaces with higher integration and functional efficiency.

Fig. 25. Investigating the Number and Analysis of Types a, b, c, d Spaces in the Climate Areas

The vernacular housing pattern of Gilan has a one-layer structure and low depth. The maximum connection between the house and outdoor space is through the yard, and then the porch and the access to other spaces is through the porch and then telaar. It indicates that the effect of the porch regarding spatial connection and functional efficiency of this type is higher than the telaar.

The porch has a low depth and is the most integrated spatial space that connects the outdoor space (yard) to the other spaces and has the best functional efficiency. Telaar is placed in the second rank. By being in the medium depth and less connection with other spaces, telaar provides a semi-private space and suitable for social interactions and affairs.

Connection	Integration	Spatial level	Space syntax / Porch	
3.66	6.67	0.14	Coastal type	1
3	4.26	0.18	Plain type	2
1.33	2.23	0.44	Foothill type	3

The best functional efficiency is observed in both physical elements of porch and telaar in the coastal climate area.

Connection	Integration	Spatial level	Space syntax / Telaar	
1.50	2.38	0.41	Coastal type	1
1.50	2.37	0.42	Plain type	2
1.50	1.89	0.52	Foothill type	3

Fig. 26. Comparison and Analysis of the Components of the Functional Efficiency by Spatial Elements

Among the studied models, Mohtasham Talab house from the plain has the best functional efficiency and Asefi house from the beach plain has the lowest functional efficiency due to the type of communication space and great depth created in the plan.
Plains houses have great depth due to extensive plans. However, due to the spatial relationship, type of spatial system and good physical access, and high integration between physical elements, they have the best functional efficiency among the types, which among the studied models, Mohtasham Talab is introduced as the best example.

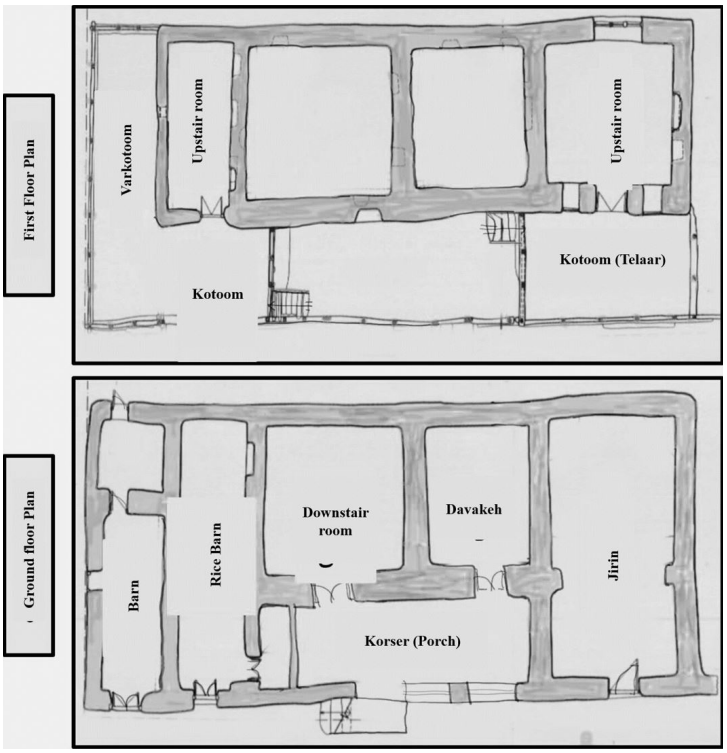


Fig. 27. Mohtasham Talab House Plan (Based on the Map of Gilan Rural Heritage Museum)

In terms of spatial depth and sociability, the porch is the most integrated spatial space and the best interface between the open public space and the internal private and semi-private spaces with high depth, resulting in the maximum spatial relation. By being in the medium depth, proper access, and high integration, telaar is a suitable place for semi-public social interactions. Among the studied patterns, porch and telaar in the Asefi house from the coastal plain area, have the highest functional efficiency among the studied types.

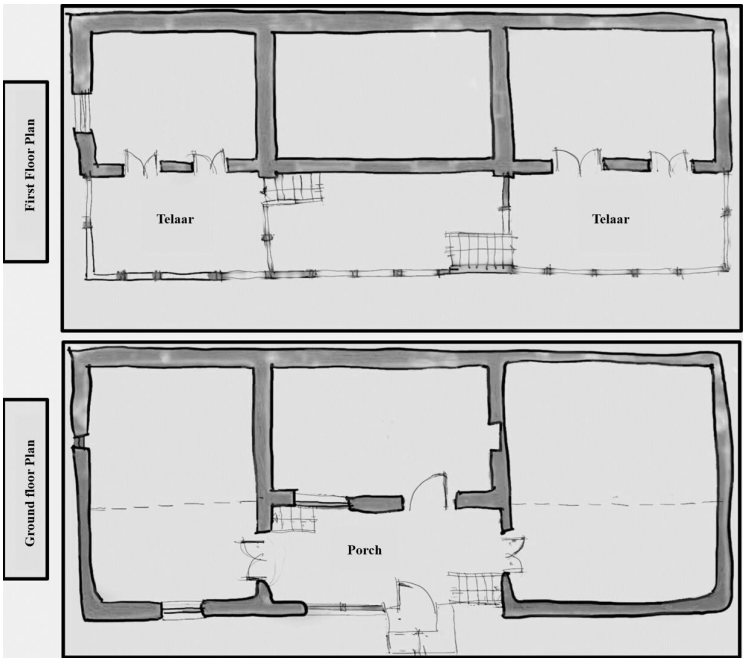


Fig. 28. Asefi House Plan (Based on the Map of Gilan Rural Heritage Museum)

7. CONCLUSION

The conclusion of the study are as follows:
- The climate housing in the geographical area of West Gilan has a low-depth body, low layer, and spaces with the maximum permeability at its most external level.
- The houses in the mountain are more than one floor, closed, and have the minimum openings and the minimum semi-open spaces.
- Houses of the foothill houses have one or a maximum of two floors with limited openings.
- In the plain and coastal area, the plans are linear, non-centralized, and are built in two floors or more with the maximum openings and contact with the outdoor space through the physical semi-open spaces such as porch and telaar.
- The porch and telaar on one side to the four sides of the building are the most significant social and climate spaces.
- Placement of the limited and enclosed space in the center of the building (porch) increases the functional efficiency.
- The best integration (congestion and increase in the functional efficiency) is seen in the plain, coast, and foothill areas.
- The best connection and spatial access are seen in the plain, foothill, and coast, respectively.
- The houses of the plain area have the highest depth due to the extensive plans. However, due to the spatial relation, type of spatial system and proper physical access, and high integration between the physical elements, it is the most sociable type among the other types. Therefore, the best functional efficiency is formed in the houses of the plain area.
- Porch is the most integrated physical element that is the most sociable space because of the high crowd. Porches with three-closed sides with access from the inside of the porch to the telaar have the most proper functional conditions.
- The best terms for the functional efficiency in the samples of porches have been seen in the coastal area and then the plain area.
- By being in the medium depth, suitable climate body, and proper access and high integration, telaar is an appropriate place for semi-public social interactions.

8. RESEARCH RECOMMENDATIONS

Designing the linear, decentralized along with the openings for the draft and natural ventilation and creating the semi-open spaces such as porch and telaar in the building and considering other climate considerations.

Designing a centralized with three-sided closed porch with access to other spaces on the ground floor and access to the higher floors from inside the porch to increase the functional efficiency.

Design of a three-sided open telaar with access from inside the porch, which should be considered in the form of a telaar on the dripstone side. This space will be the most important physical element for social interactions and increasing functional efficiency due to the favorable climatic conditions, the type of proposed design, and high interactivity.

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