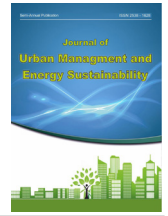# Journal of Urban Management and Energy Sustainability (JUMES)

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ORIGINAL RESEARCH PAPER

Discovering the language of the residential architectural pattern of the emerging cities of western Iran based on graph and Isovist theory (Case study: Ilam City)

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ARTICLE INFO

A B S T R A C T

Patterns, texture and architecture play a significant role in understanding the culture and life of a region, so knowing the customs of the residents of a region is part of the group of knowing the architectural patterns of that region. Architects have used many methods to recognize architectural patterns, such as graph and isovist theory, space layout approaches, spatial configuration. In this research, the application of this theory has been investigated in residential contexts (old, new, rural) of Ilam province. The current research is applied and exploratory in terms of purpose. To carry out this research, using the method of field studies, three old, new and rural textures of Ilam province (new texture) were identified, taken and drawn. The simulation of house maps is by using computer drawings and by means of specialized software for space layout and syntax, i.e., Space Syntax plugin in Depthmap software. Based on the detailed analysis of three types of houses - old houses, rural houses and newly built houses - different features and spatial configurations can be observed. Each type of house reflects different cultural values, lifestyle preferences and design approaches. In summary, the spatial configuration of old houses, rural houses and newly built houses show distinct characteristics and reflect different cultural values and lifestyle preferences. Understanding these spatial configurations provides valuable insights for architects, designers, and researchers in creating homes that harmonize with specific cultural contexts and meet the evolving needs of residents in diverse environments.

Running Title: Language of the residential architectural pattern of the emerging cities of western Iran based on graph and Isovist theory

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
27	11	00

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INTRODUCTION

Patterns, texture and architecture play a significant role in understanding the culture and life of a region, so knowing the customs of the residents of a region is part of the group of knowing the architectural patterns of that region. Architects have used many methods to recognize architectural patterns, such as graph and isovist theory, space layout approaches, spatial configuration, which have had many achievements and advantages in architectural spaces. In the late 1970s, Professor Bill Hare together with Julian Hansen presented the theory and method of space arrangement to understand the spatial structure and configuration of the city, and based on that, they analyzed the interaction effect of space configuration and social organization of cities. From the point of view of this theory, the relationship between activity and space can be understood and defined in the existing relationships between spaces or spatial organization, as well as relationships between contacts and social interactions, rather than being defined in the characteristics of the space individually. (Siyadtan and Pourjafar, 2013: 29; Bahraini and Tagaban, 2015: 6). In fact, in the analysis of spatial configuration, the way spaces are arranged next to each other and their mutual relationship is discussed. In other words, any change in the map and structure of the city (adding or subtracting a space such as a street, open space, etc.) will create changes in the relationships of the spatial configuration of the whole city. Such changes can change the probability of occurrence of activities and events (Abbas-Zadegan, 2011: 67). In the theory of space arrangement, first, the city is a discrete system consisting of the longest visual-motor channels for analysis. More advanced ones are shown with a line and in the next step, based on mathematical and graph analysis, the intersection of these lines with each other is examined. Thus, any line that has more intersections with other lines will be connected to more elements in the network and will be more accessible as a result (Rismanchian and Bell, 2010: 73).

For the first time, Levin proposed the idea of using graphs for architectural design modeling, and after that many researches were conducted in this field. One of the most important advantages of using a graph to model the architectural design problem is that it allows the designer to present a representation of the design problem that only includes the essential features of the design, and on the other hand, using Graph theory provides a principled method for architectural design, which can be used to reach an optimal plan from the given information and the necessary connections between spaces. As it was said, the graph can be a cognitive method of architecture; Therefore, it can be a factor to identify diversity in an architectural dialect. The ancient cities of Iran have achieved a single language since long ago, which can be obtained by examining the city map and building plans, its architecture and urban planning based on graphs. However, about growing cities or areas that have grown as cities in the contemporary period; A comprehensive study has not yet been carried out. It is expected that in the cities of western Iran, especially those cities that have been developed in the last fifty years, despite being in the category of cities with the background of Iranian culture, in the form and tone of modernization. acquired. Among these cities, Ilam province is due to the rapid changes in the nomadic to monogamous context, which probably requires maintaining the culture of creating a nomadic environment; It is studied. In other words; The significant presence of pre-urban customs, the strong presence of the village in front of the city in the province and the culture related to nomadic life in the province, which gives rise to the expectation that the presence of non-traditional pre-modern life in the construction of Shatab period houses in a Substitution observed. This research seeks to investigate the methods of creating a new space based on local mental perceptions in the form of a cultural and anthropological studies method. It is hoped that in this direction, a dialect of Iranian architecture can

be achieved, which is specific to the western regions and here Ilam province, and to diversify the knowledge of what is called Iranian architecture. Identity is the second element influencing architecture, which refers to a set of factors and aspects that are influential in the design and construction of architectural structures and spaces and help to manifest the culture, beliefs and thoughts of a society. In this regard, we can refer to the study of "Damiar" (2013). In order to organize the factors that make up a kind of architectural beauty, they led to a three-axis model whose axes are "perception of experience" (physical, psychological, social and spiritual), "environment of experience" (natural and artificial) and "time". "Experience" (immediate, lifetime, successive and eternal generations). As a result, even if people don't accept all the human aspects, there were still aspects in the desired architecture that are valid for these people as well. Also, "Rezaei" (2014), investigating the amount of sunny hours, the amount of annual precipitation and the direction of the winds in Ilam province, showed that in order to take advantage of the winter sun, it should be used most in the south direction of the building; On the other hand, by creating a canopy and a small porch and planting small leafy trees, it is possible to reduce the sun's radiation to the building in the summer season. "Akremi and Damyar" (2015), they recognized and investigated the contradictions caused by the difference in the mentality of the designer and the user in the rural housing that the trustees of the field of architecture designed and implemented for the villagers. It was found that the observation of physical changes after exploitation is a relatively reliable tool to discover the factors of physical mentalization and physical, behavioral. But memory factors require the use of the proposed process in full. By examining the components of space syntax in the studied contexts, while explaining the differences and similarities of their spatial structure, we intend to discover a single pattern of their architectural language and accent. Although this pattern is heterogeneous due to the differences in the spatial structure of the studied textures, it can be considered as a basis for the vernacular architectural language in the city of Ilam.

MATERIALS AND METHODS

Methodology

The current research is applied and exploratory in terms of purpose. The field collection method is a survey of research variables in the statistical population of Ilam province, which is determined based on the research topic and the relationship between independent and dependent variables. By referring to the documents and first-hand sources available in Latin and Persian writings related to the theory of space syntax, spatial configuration, graph theory, isovist, theory of patterns/the language of patterns in architecture, as well as the history of Ilam province/native architecture in Ilam province, etc. Items related to the background of the research have been collected. To carry out this research, using the method of field studies, three old, new and rural textures of Ilam province (new texture) were identified, taken and drawn. Izovist tools and graph analysis are efforts that have been made in recent years to express quantitative and measurable spatial quality, and despite the lack of maturity and evolution, they are viewed by researchers with the view of future space analysis tools. Visibility is investigated and analyzed using isovist analysis and graph analysis. Simulation of house maps using computer drawings and space layout and syntax specialized software, i.e., Space Syntax plugin in Depthsmap software. Using simulation and software tools, production data and relationships between variables have been investigated. The method of selecting samples from three contexts, old, new, and rural, is a purposeful cluster. In the software, first, the communication of spaces/micro spaces in each context (house) was modeled, and then, the parameters of space syntax analysis were extracted from it. Analytical and graphic analysis of the maps

was done using the Depth Map software. In this software, by simplifying the maps of the houses and leaving the parts that are related to each other, the investigated parameters are presented graphically at every point of the map space.

Research variables and indicators

Considering that in this research we are looking for the discovery of language and accent in the native architecture of Ilam province, therefore, the indicators that are discussed and analyzed from the space syntax technique, whose analysis leads to interpretation; Understanding and investigating the cultural and social characteristics of the people of Ilam province. Introverted indicators (solitude, privacy, hierarchy, ...) and other components such as connection, control, average depth, and interlinking can be considered spatial syntactic indicators in this research. Finally, the results are presented as mathematical and graphical parameters. Also, in this research, graphs of visibility, access, etc. are also analyzed for the spaces in the studied contexts.

Residential houses under study

In this research, 20 houses have been used from rural houses, old urban houses and newly built urban houses, so these three models have been selected in this research that can help in discovering the language of architectural patterns and have been identified.

DISSCOUSION AND FINDINGS

Spatial syntax analyses

Izovist visual analysis parameters, view level from the whole plan, view compression, visible angle and selected axial analyzes and degree of connection, which we will examine further. The spatial syntax method is a spatial analysis technique used to evaluate how different spatial configurations of buildings affect human behavior. Based on the given information, the analysis of the residential house using this method shows the following findings.

Visual (izovist) and axial (axial) analyzes of rural houses

Izovist analysis of 20 rural samples shows that the maximum number of changes in the maximum and minimum analysis of the visibility level index of the entire plan is 86.48%, the second place in the changes is the mystery index with 66.30%, the third place is the changes in the visibility compression index at the rate of 32.50% and finally, the fourth place is assigned to the visible angle index at the rate of 13.48%. In the axial analysis, the axial connection index has the highest number of changes with 89.85%. All the results show that the rural part of the view level is very different from the whole plan and the connection in the plan, and we cannot expect much similarity in the rural residential plans.
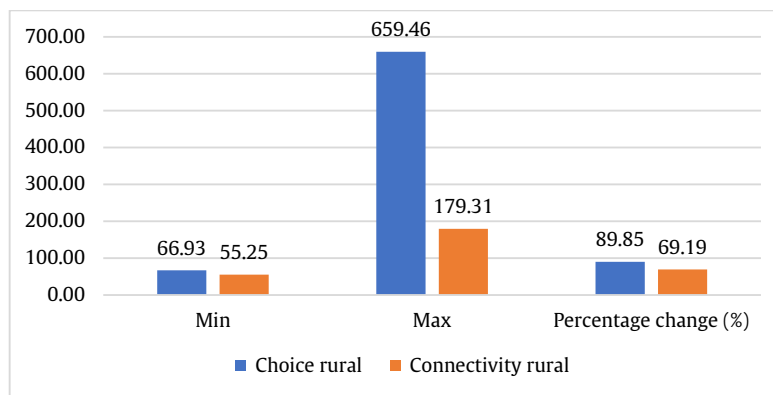

Diagram 1: the maximum, minimum and percentage changes of the visual indicators of rural analysis

Visual (izovist) and axial (axial) analyzes of old houses

Izovist analysis of 20 old samples shows that the maximum number of changes in the maximum and minimum analysis in the visibility level index of the whole plan is 93.39%, the second place in changes is the mystery index with 78.92%, the third place is the changes in the index Visibility is 54.84% and the fourth place is assigned to the visible angle index at 13.13%. In the axial analysis, the axial connection index has the highest number of changes with 93.81%. All the results show that the old part of the view level is very different from the whole plan and the connection in the plan, and like the rural context, we cannot expect much similarity in the old residential plans.

Visual (izovist) and axial (axial) analyzes of newly built houses

Izovist analysis of 20 new samples shows that the maximum number of changes in the maximum and minimum analysis of the visibility level index of the entire plan is 95.24%. At the rate of 48.15% and finally, the fourth rank is assigned to the visible angle index at the rate of 15%. In the axial analysis, the axial connection index has the highest number of changes with 95.85%. All the results show that the newly built part of the view level is very different from the whole plan and the connection in the plan, and like the two types of rural and old, we cannot expect much similarity in the old residential plans.
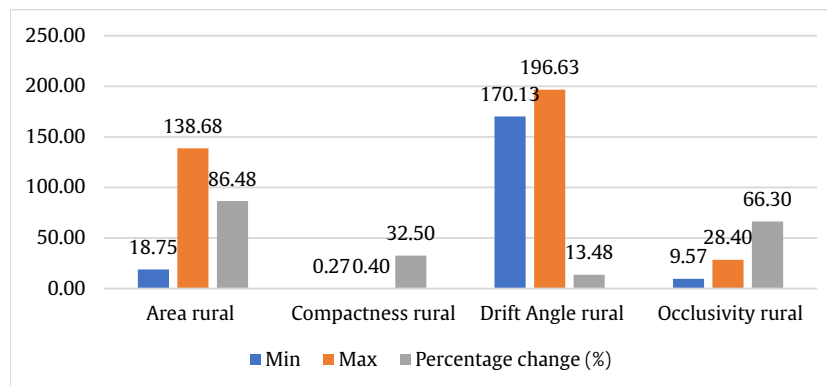

Diagram 2: the maximum, minimum and percentage changes of the key indicators for rural analysis
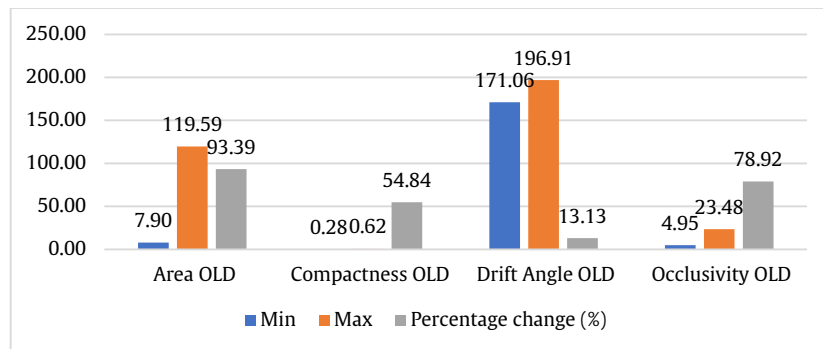

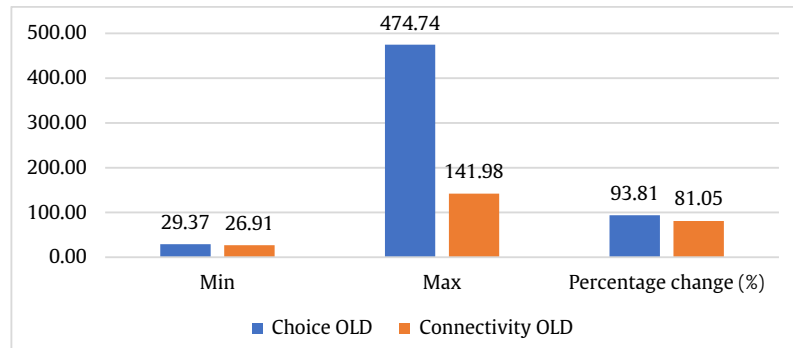Diagram 3: The maximum, minimum and percentage changes of the old analyzed visual indicators

Diagram 4: the maximum, minimum and percentage changes of the old analyzed key indicators
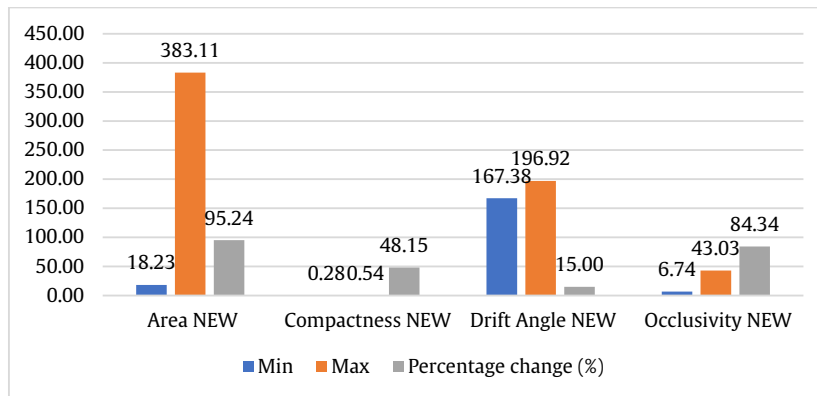

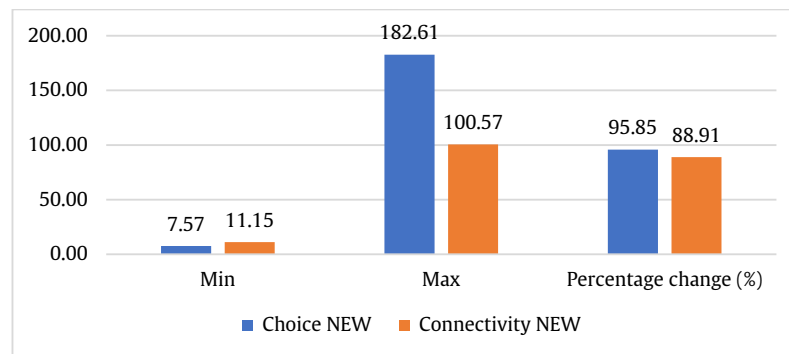Diagram 5: The maximum, minimum and percentage changes of the visual indicators of the new analysis

Diagram 6: The maximum, minimum and percentage changes of the key indicators under the analysis of new ones

Comparison of three types of rural residential houses, old and newly built

From the comparison of all three types of textures analyzed in this research, it can be concluded that there is a harmonious pattern between all three textures in such a way that this pattern is repeated in all three, and the ranking pattern of changes in visual indicators includes: 1- plan view level index 2- index Mysteriousness 3- the visibility compression index and finally 4- the visible angle. Also, the ranking pattern of changes in the central analysis is that the first rank is the selection index and the second rank is the connection index. In the indicators measured in

all three cases, newly built residential buildings have the greatest number of changes in the plan view level index, old residential buildings have the greatest percentage of changes in the visibility compression index, newly built residential buildings have the greatest visible angle, and newly built residential buildings have the most changes in the mystery index. are assigned to themselves. Also, the results of the comparison of the three analyzed contexts in the axial analysis show that the old residential houses have the highest percentage of changes in the selection index and the newly built houses have the highest changes in connection.

Reading the spatial pattern of the analyzed houses

In this section, the indicators of access hierarchy, public and private spaces of the house, readability in the plan, communication and visual privacy, visual access and visual orientation respectively with the help of indicators of the degree of axial connection, axial selection, level of visibility from the entire plan, flexibility. mystery), vision compression and visible angle are measured. "Degree of axial connectivity" refers to the preference or use of axial lines or paths in a spatial configuration. By identifying the main routes or corridors that provide higher levels of connectivity and access within a space, it can be
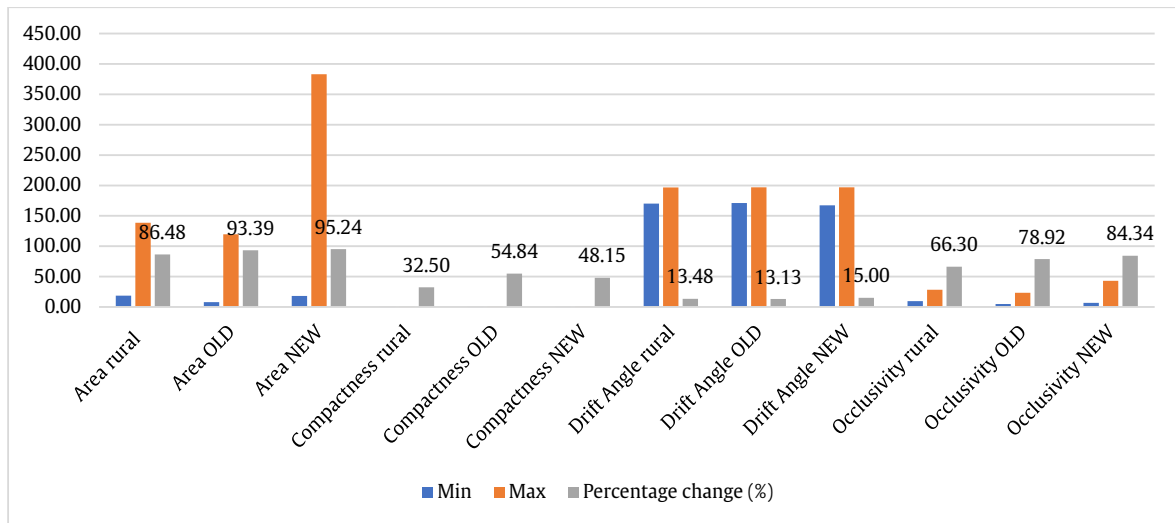

Diagram 7: the maximum, minimum and percentage changes of the analyzed visual indicators in all three investigated fabrics
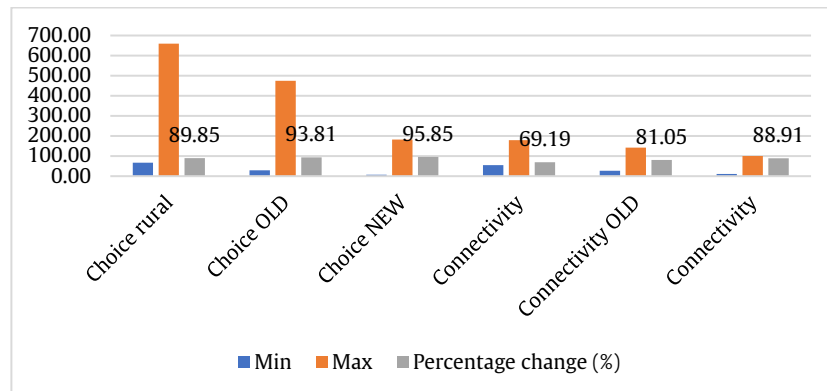

Diagram 8: the maximum, minimum and percentage changes of the analyzed key indicators in all three investigated fabrics

linked to the 'access hierarchy'. This index refers to the degree to which spaces are connected along specific axes or paths in a spatial configuration. It measures the ease of movement and access along these axes or paths. A high degree of axial connectivity indicates strong connectivity and ease of movement, while a low axial connectivity indicates limited connections and potential barriers to movement.

 "Axial choice" can also be related to the distinction between public and private space. This helps to identify paths or lines that are more public and commonly used compared to paths that are more private or have restricted access and can be considered equal to "public and private spaces of the house". The "view level from the whole plan" index also measures the visible area from a certain point in space. It can be related to "legibility" in the plan by showing the amount of visual information available from different locations, which can help the legibility and understanding of a spatial arrangement. "Flexibility" determines the amount of compression or flexibility in the visible area. By evaluating the level of visual accessibility or visual privacy offered by a space, it can be related to "visual communication and privacy". More flexibility indicates more privacy, while less flexibility allows for more visual communication. "View compression" quantifies the shape compression of the visible area. It can be related to "visual accessibility" by evaluating how easily a space can be visually accessed or seen from different points of view. Tighter isovist shapes may indicate higher visual accessibility. Architects often analyze and design spaces by understanding how people move and interact in them. They consider factors such as symbols, signs, and visual cues that affect people's movement and spatial perception. By studying how humans react to directional signs in their environment, architects can create spaces that increase legibility, navigation and overall user experience. Understanding the relationship between visual signs, direction perception and human behavior

can determine design decisions related to circulation, spatial organization, and creating focal points in architectural and urban contexts. In the field of architecture, a concept equivalent to the orientation of the visible area, as described by the "viewable angle", can consider "visual orientation" and its effect on human perception and movement in the environment. are made.

Village House

In the analysis of the overall architectural pattern and spatial arrangement of rural houses, we can observe a coherent design approach characterized by linear and repetitive organization with common elements and a clear hierarchy of spaces. The houses show a linear pattern that follows a certain arrangement along a central axis, creating a sense of order and continuity.

The spatial arrangement can be described as follows:

1. By examining the degree of connectivity in the studied rural houses, it was found that in the vast majority of the rural houses, in terms of the "hierarchy of access" of the living and reception areas of the houses, they have scored the highest points, and in cases where this pattern is repeated in the plan There is no living space on that floor, or it is replaced by a residential entrance. Corridor and entrance spaces are also assigned the next ranks. Also, the bathroom in these houses includes the lowest level of access hierarchy, and the porch, bathroom and storage spaces have the next ranks in terms of frequency. 2. Regarding the "public and privateness of spaces" visually, after the analysis of the study cases, it was found that a high percentage of the houses have the advantage of a more public living space, followed by the porch. Also, internal corridors include visual private space in most houses. In some houses, depending on how the living room is connected to the porch, the porch is also placed in the private part. 3. It can be seen that the yard in rural residential houses has the highest amount of "legibility" among the study samples, and the rooms and porches are relatively more frequent in spaces with low

houses. They have allocated more to themselves. 4. In order to determine "visual communication and privacy" in residential houses, the visual mystery index was used, and the results showed that the internal corridors of the houses have a higher level of privacy and communication, and spaces such as the yard, living room, communication and privacy are less. Three have been assigned to themselves. 5. Examining the amount of "visual accessibility" in the plans showed that the rooms have a higher frequency of visual accessibility, and the kitchen occupies the next rank, and spaces such as the yard, living room, and reception are accessible. It has a higher visual and sometimes the bathroom also has a high visual access. 6. In terms of "visual orientation", after analyzing all the samples of the study, it was found that the courtyards have the highest frequency among the spaces of a

residential house due to the high level of visual orientation inside the plan and the bathroom. It has the most repetition in spaces with low visual orientation. (Fig. 1)

Old houses

In analyzing the general architectural pattern and spatial arrangement of old houses, we can observe a design approach that is characterized by the organization of common elements and a clear hierarchy of spaces. The houses show a pattern that follows the arrangement and creates a sense of order and continuity. The spatial arrangement can be described as follows:
1. By examining the degree of connection in the studied old houses, it was found that in the vast majority of the old houses, in terms of the "hierarchy of access" of the corridors, the hall houses have won the highest score. Also, the bathroom in these houses includes the lowest level of
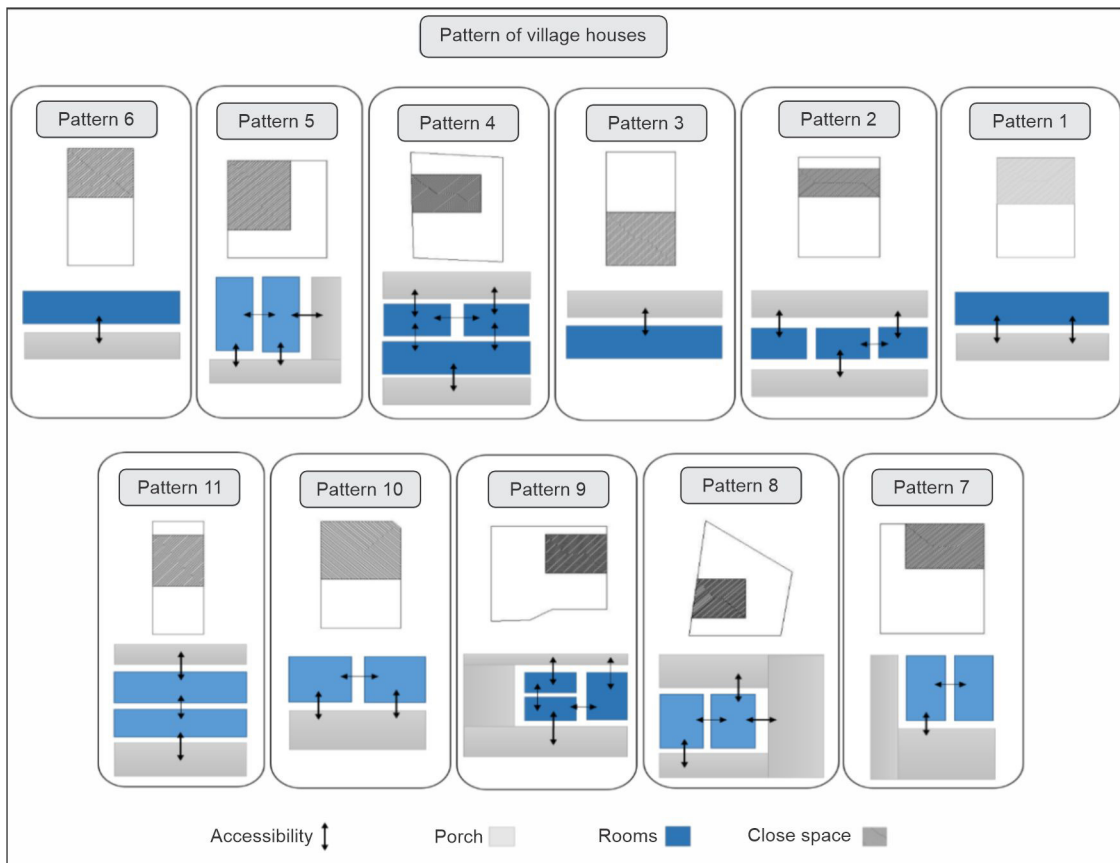

Figure1: The pattern of rural analyzed houses

access hierarchy, and the porch, bathroom and storage spaces have the next ranks in terms of frequency. 2. Regarding the "public and private-ness of the spaces" visually, after the analysis of the study cases, it was found that a high percentage of houses, halls and receptions have the advantage of a more public space, followed by the porch. Also, the kitchen includes a visual private space in most homes. 3. It can be seen that the residential entrance hall and courtyard in old residential houses have the highest amount of "legibility" among the study samples, and the kitchen, rooms are relatively more frequent in the spaces with legibility. They have assigned the lower one. 4. In order to determine "communication and visual privacy" in residential houses, the visual mystery index was used, and the results showed that the entrance and the dividing space of the houses have a higher level of privacy and communication, and spaces such as the kitchen, rooms and They have less privacy. 5. Examining the amount of "visual accessibility" in the plans showed that the rooms, parking lots have a higher frequency of visual accessibility and spaces such as the hall, reception, kitchen have a higher visual accessibility. 6. In terms of "visual orientation", after analyzing all the samples of the study, it was found that the hall and the reception area of the houses have the highest frequency among the spaces of a residential house due to the high level of visual orientation inside the plan and the entrance and the front entrance, toilet, bathroom has the most repetition in spaces with low visual orientation. (Fig. 2)

Newly built houses

By examining and analyzing 20 examples of newly built houses in Ilam city, we found a general pattern in the field of architecture and inspired by the spatial arrangement of these houses, which presents a coherent and
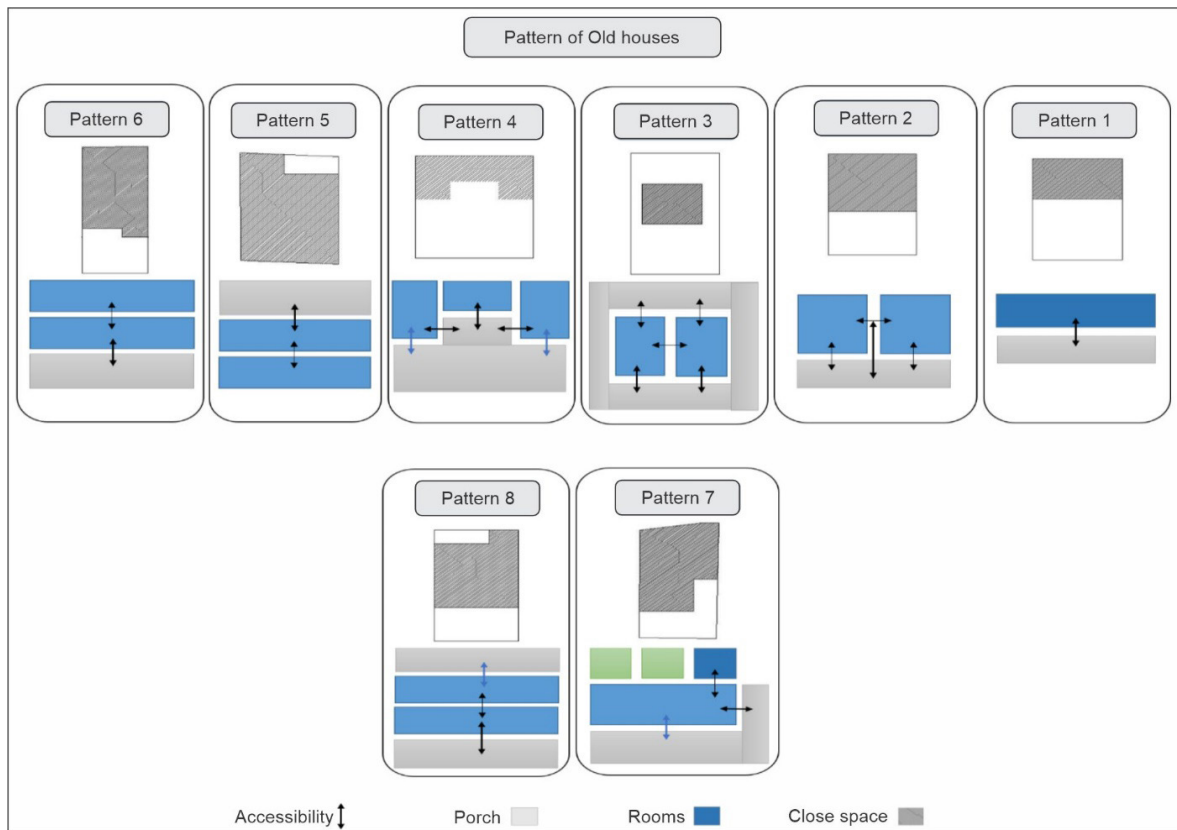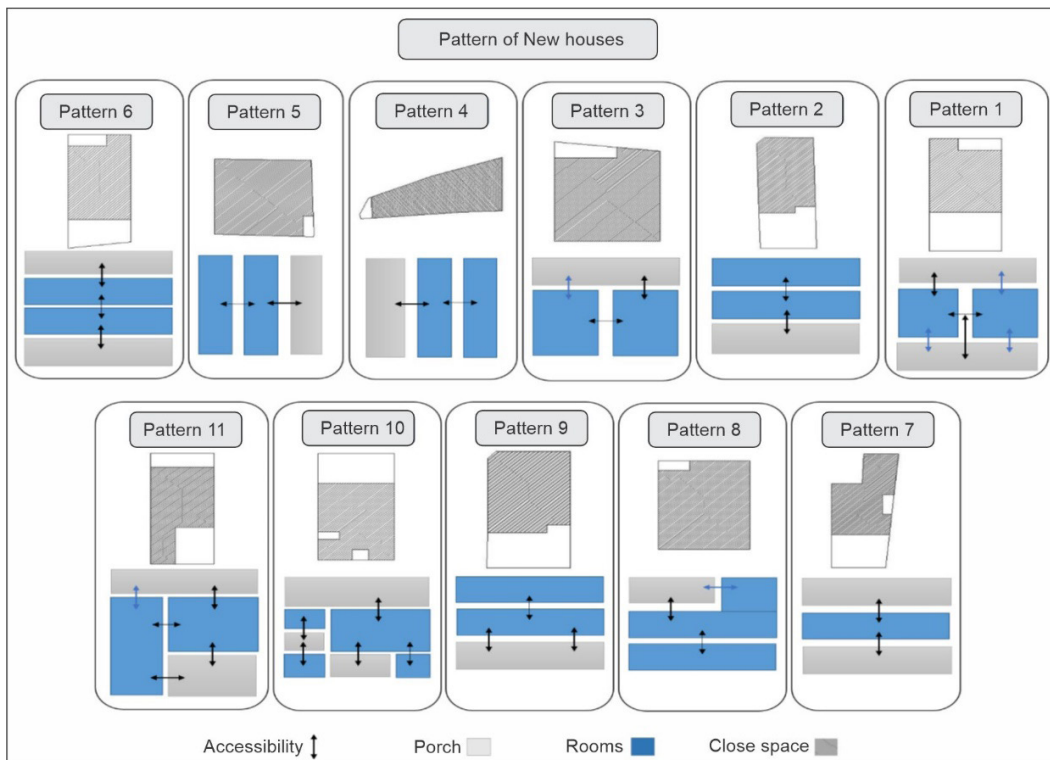

Figure2: The pattern of old houses analyzed

respectable design approach, which in the continuation of each of the indicators The examined items are subject to detailed interpretation. 1. The analysis of newly built houses in terms of the degree of connection showed that spaces such as internal corridors, partition, living and reception spaces have the highest degree of connection in the newly built residential plans of Ilam city, as well as the kitchen spaces. Rooms and restrooms obtained the lowest degree of connection in the analysis of spatial syntax. 2. In the analysis of the public and private spaces of residential units, in terms of visual indicators, after the analysis of the spatial structure of the corridor, rooms, the entrance to the parking lot are the roads with a higher level of publicness, and the living room, kitchen and reception are in These plans are more private. 3. In terms of legibility in newly built houses, it can be seen that the living room and reception area have the highest level of legibility in the spaces of these units. Spaces such as rooms, bathrooms and warehouses have the least readability in this type of plans. 4. In terms of communication and visual privacy in the modern context of the city, spaces such as the entrance partition space have a higher level of mystery and, as a result, privacy and a higher connection with other spaces of residential units. It can also be said that the rooms and the kitchen in this type of plan have less privacy and communication with other parts of the house, which shows the isolation and privacy of these spaces. 5. The visual accessibility index states that in the newly built houses of Ilam, the rooms have a higher visual accessibility than all other spaces in the investigated residential units. But the kitchen, living room, and internal corridors occupy the least amount in terms of visual access to other parts of the residential units, respectively. 6. In terms of visual orientation inside the plans, the analysis of these houses showed that the rooms have the most orientation and superiority and the living room has the least amount. (Fig. 3)

Figure3: The pattern of new houses analyzed

CONCLUSION AND RESULTS

Based on the detailed analysis of three types of houses - old houses, rural houses and newly built houses - different features and spatial configurations can be observed. Each type of house reflects different cultural values, lifestyle preferences and design approaches.

Old houses, which are characterized by their traditional nature, show a spatial organization that follows hierarchical patterns. Communication, generality and privacy, readability, visual privacy, visual accessibility and visual orientation in these houses show a balanced distribution between public and private spaces. Corridors and living rooms are placed at a higher level of the hierarchy and as more public spaces, they offer higher connectivity, legibility and visual orientation. On the other hand, service spaces such as kitchens, bathrooms, and storages are a lower level of hierarchy and with lower connection, readability, and visual accessibility, which represent more private areas. This spatial configuration reflects the cultural values and lifestyle of the residents and emphasizes the importance of social interaction and individual privacy.

Country houses, common in villages, follow the same hierarchical pattern as old houses, but with some variations. Connection, generality and privacy, legibility, visual privacy, visual access and visual orientation in rural houses also show the hierarchical organization of spaces based on their public and privacy levels. Living rooms and courtyards act as more public areas and show higher communication, legibility and visual orientation. On the contrary, bedrooms, kitchens and bathrooms show more private spaces that have less communication, legibility and visual access. Unlike old houses, yards take on this role in country houses. In addition, living rooms can also function as private spaces in some cases depending on their connection to the courtyards. Spatial configuration in rural houses aims to balance social interaction and individual privacy, adapting to the cultural values of social life and social communication in extended families and neighbors.

On the contrary, newly built houses, which represent the principles of modern design and contemporary lifestyle, show a different spatial configuration. Connection, publicness and privacy, legibility, visual privacy, visual access and visual orientation in modern houses emphasize the division and controlled access between spaces. Corridors, separating spaces and living rooms function more as public areas and have higher connectivity, legibility and visual orientation. Bedroom, kitchen and bathroom, despite showing more private spaces, face less connection, legibility and visual access. It is worth mentioning that bedrooms have more visual access to other spaces compared to the kitchen and living room. This spatial arrangement emphasizes greater separation between public and private areas, which reflects modern cultural values that prioritize people's privacy. The design approach in modern homes promotes controlled flow and access and enhances privacy through visual and physical means. Diagram (13), in summary, the spatial configuration of old houses, rural houses and newly built houses show distinct characteristics and reflect different cultural values and lifestyle preferences. While traditional and rural houses prioritize a balance between public and private spaces with varying degrees of separation, modern houses emphasize partitioning and controlled access to increase privacy. Understanding these spatial configurations provides valuable insights for architects, designers, and researchers in creating homes that harmonize with specific cultural contexts and meet the evolving needs of residents in diverse environments.

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