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Residential Space Organization of the Inner Mongolia Earth Dwellings around the Yellow River Basin

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Abstract: The living spaces within vernacular dwellings undergo continuous adjustments in response to evolving lifestyles, society, and cultural shifts. Residents, guided by their understanding, integrate newly emerging functional spaces within the framework of traditional living environments. While appearing rough and A disorganized, this spontaneous and evolving arrangement of living spaces can reflect how residents incorporate contemporary lifestyles into the framework of traditional dwelling spaces. The research focuses on the traditional earth dwellings in the Inner Mongolia section of the Yellow River basin, aiming to explore the contemporary spatial organization within these local residences. The research uses typology to classify the plans and analysis as the spatial syntax theory to organizational characteristics of residential spaces. With the assistance of the Depthmap X software, Integration and Control Value parameters are computed. Combining the calculated results with the parameters' meaning determines the following: (1) the plan organization is related to basic functional space types; (2) the stove, used for heating in functional spaces, serves as the center of the plan organization, and the basic functional spaces are typically arranged around this center; (3) both of these space types have extremely high Control Values over directly adjacent spaces and become the core spaces for daily living and activities. Researching the characteristics of local residential space organization and concretely showcasing local residential culture can provide a foundation for future construction that respects residents' preferences and supports the sustainable development of local residential culture.

Keywords: earth dwellings; space organization; residential culture

Citation: Song, J.; Zhao, S.; Kong, J. Residential Space Organization of the Inner Mongolia Earth Dwellings around the Yellow River Basin. *Sustainability* **2023**, *15*, 15027. https://doi.org/10.3390/su152015027

Academic Editor: Aliakbar Kamari

Received: 27 August 2023
Revised: 24 September 2023
Accepted: 27 September 2023
Published: 18 October 2023

1. Introduction

Culture is classified as one of the three pillars of sustainable development under the social category [1]. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines architecture as material culture, a concrete performance of local culture and values accumulated over many years [2]. Traditional dwellings, constructed by non-professionals using limited resources, were built to meet usage needs and value orientations influenced by local culture [3]. With the development of the contemporary economy and technology, the safety and ability to contain modern life have improved, posing a threat to traditional dwellings [4]. Protective research on recording the forms and styles of traditional dwellings has been extensive. However, Oliver points out that "Tradition by itself is not enough" to solve the impending housing crisis [5] (p. 381). Housing is adapted to living needs, and residents will spontaneously adjust their spaces to create the most suitable living environment when demands change [6] (p. 15). Residents' construction behaviors are often unconscious, but by observing these methods, we can learn how natives combine cultural awareness with contemporary needs, inspiring the sustainable development of local dwelling cultures.

In China's rural areas, many locally distinctive dwellings have faced demolition and renewal since 2010 due to aging and residential safety issues. Earth dwellings, a traditional local residence of Inner Mongolia, accounted for 35.9% of 2011 survey research but declined dramatically during 2014–2017 [7]. In 2018, national agricultural census data indicated that the proportion of earth dwellings in Inner Mongolia had decreased to 6.74% [8]. Within the section of the Yellow River Basin, where there is a significant presence of loess soil, the ratio of earth dwellings was slightly higher than the overall average, around 8.99% (Calculated as the average ratio of earthen dwellings in cities within the Inner Mongolian segment of the Yellow River Basin [8]: Wuhai 1.46%, Bayannaoer 15.9%, Baotou 5.91%, Hohhot 8.1%, Ulanqab 15.8%, Ordos unknown). Hasty updates of new housing often result in vacancies or renovation phenomena, demonstrating a mismatch with local residential culture. The construction and use of living spaces are prerequisites for a deeper understanding of housing forms and culture [9]. The research aims to analyze the living spaces of traditional earthen dwellings, observe the current use of space, and concretely extract the influence of culture on local residential space usage habits.

The research focuses on earth dwellings in the Inner Mongolia region. Given the elongated and narrow expanse of Inner Mongolia, which spans multiple cultures, it is unsuitable for a unified overview. Meanwhile, based on the historical background of earth dwellings and the concentrated number of surviving examples in the Yellow River Basin of Inner Mongolia, this study will focus solely on researching the earth dwellings located within this geographical boundary. The Yellow River Basin is China's birthplace of earth dwellings [10]. The Inner Mongolia section of the Yellow River Basin is located in the middle and upper reaches of the Yellow River Basin, about 151,200 square kilometers [11], surrounded by deserts to the southwest in the central part of Inner Mongolia (Figure 1). The sedimentation of the river and aeolian deposits have led to loess deposition, forming a loess layer [12]. The soil in the region has high viscosity [13] and is suitable for constructing dwellings [14]. Archaeological excavations have shown evidence of using raw earth for constructing dwellings as early as 4500 BC [15,16]. Until 1500 BC, many residential plans were discovered with single-room and suite-style layouts. In the earlier stages, stoves were often located at the center, while in later constructions, they tended to be positioned toward the edges of the living spaces. Around the 3rd century BC, the northern Mongolian people migrated southward [17] (pp. 85–93), and the Inner Mongolia section of the Yellow River Basin became a borderland between Mongolia and ancient China. Under the influence of both cultures, rammed earth dwellings went through three phases (Table 1): (1) Latent Period: Influenced by Mongolian culture, mobile dwellings such as Gers (yurts) became a predominant residential style. Based on Mongolian customs, the stove is set in the plan's center, with the sides divided into spaces for male and female use. The opposite side of the entrance was used for bedding, while a shrine was nearby. (2) Adaptation period: In the mid-17th century, as Han Chinese people migrated northward, they built rammed earth dwellings in Inner Mongolia, including structures like "liubaan" (building frames made of bundled sand willows covered with mud), Yao-style (a cave-type including digging under the ground, on the cliff or build on the land), and house-style dwellings (using rammed earth or adobe to construct the walls and single-pitch or double-pitch roof frames on top of the walls). After acquiring the construction techniques from the Han Chinese, the Mongolian people built fixed Gers with earth adobe [18,19]. As the plans show, the combination of the earth-built sleeping area known as "Kang" and the stove was utilized in various dwellings during this period. (3) Stability period: In the 20th century, various types of rammed earth dwellings gradually integrated, and the contemporary styles of homes include Yao-style and house-style designs. The stove's functionality was divided into cooking and heating, sometimes serving both purposes concurrently. Alongside universal furniture and appliances, functions such as laundry and dining were separated, resulting in distinct spaces. Reflecting on the historical development of the plans of earth dwellings in the Inner Mongolia section of the Yellow River basin, one can observe that these dwellings continuously adapted to changing environments and cultural shifts, leading to a lifestyle taking the Kang-Stove system as a basic functional space.

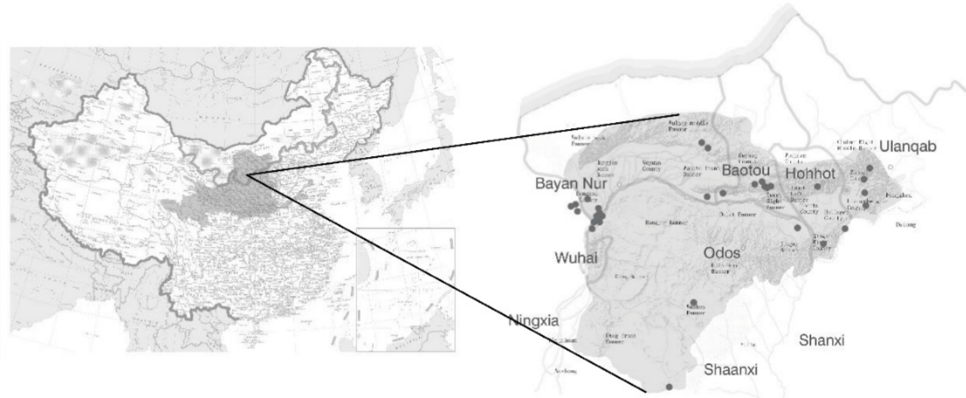
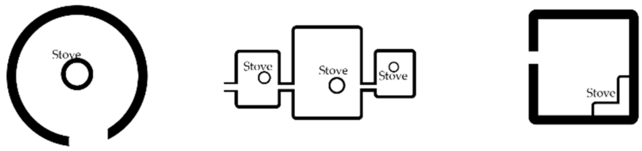
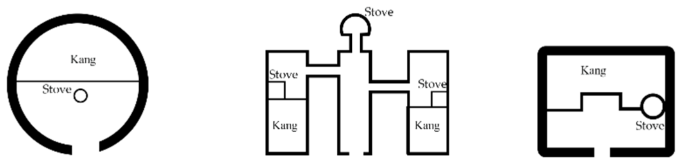
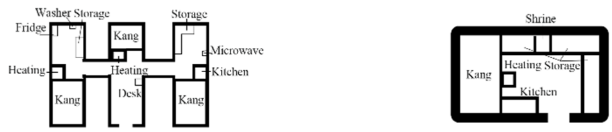


Figure 1. Research scope and sample distribution.

Table 1. Earth dwellings' plan evolution history.

Prehistory (4500–1500 B.C.)	 Semi-Subterranean House; Ground House
Latent period (400 B.C.–1650S)	Earth dwelling: Only written records;  Ger
Adaptation period (1650S–1900S)	 Fix Ger; Yao; House
Stability period (1900S~)	 Yao; House

The research will analyze the current usage of living spaces, observe how traditional earthen dwellings organize traditional and contemporary spaces, and excavate local residential culture from the usage relationships within the areas. The study initially employs typological methods to categorize plans from two perspectives: by spatial structure into four categories and basic functional space types into another four categories. Moreover, we describe the surface characteristics of residential space from survey research data. Subsequently, space syntax is utilized for computational analysis. Features of plan organization are scrutinized through Mean Depth and Integration values, aiding in selecting relevant classification methods for plan organization. The study analyzes the specific impacts of classification methods on plan organization and examines the organizational characteristics of different functional spaces within dwellings. Furthermore, the analysis is conducted based on Integration and Control Value to understand the relationship between the organizational center in the plan and the practical living center (Figure 2). Through this research, the study aims to address the following questions: (1) Do earth dwellings in the Inner Mongolia section of the Yellow River basin exhibit similar spatial organizational patterns? (2) What distinctive characteristics are manifested in these spatial organizational patterns? The research is now expanded beyond providing an overview of the characteristics of traditional dwelling styles but shifts its focus toward how dwellings spontaneously adapt to modern life. Exploring contemporary spatial organization features aims to uncover local culture's influence on residential behavior.

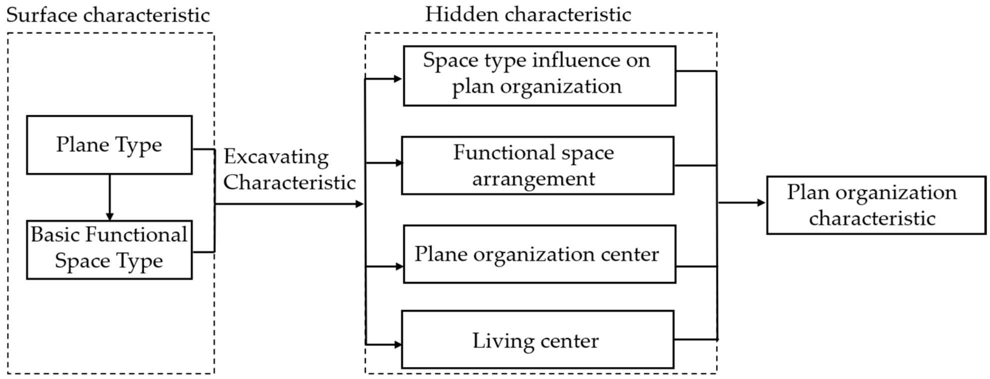


Figure 2. Research structure.

2. Literature Review

Scholars from various fields have highly regarded studying living spaces. Western spatial studies began with analyzing spatial forms [20] and later expanded to analyzing factors from social and humanistic domains that contribute to spatial formation [21]. In China, the study of living spaces began in the mid-20th century, focusing on surveying records of traditional residential types [22]. By the end of the 20th century, research shifted toward analyzing the influence of regional culture on residential spaces [23]. Early approaches often relied on broad and generalized descriptions of existing spatial research methods. The Japanese scholars utilized statistical methods to analyze the characteristics of occupants and deduce corresponding spatial patterns for different types of residents [24]. Bill Hillier's concept of "space syntax," introduced in the 1970s, offered a quantitative means to describe spatial connectivity and define spatial attributes [25]. In contemporary times, space syntax is used to study spatial representations in different cultures [26–30] and document spatial organization methods evolution [31–33].

In Inner Mongolia's history, due to its remote geographical location, the external world has limited awareness of it, and there are only a few textual descriptions regarding the architecture of dwellings. In the 1930s, Wangyun and Yiqian [34] introduced the living conditions of Inner Mongolia to the outside world through sketches. In 1943, Yamada documented the housing forms of farmers and herders through photographs [35]. In 1957, Dunzhen first interpreted the types of indigenous dwellings in Inner Mongolia in his work *An Overview of Chinese Residences* [22] (p. 55). The 1959 edition of *Ancient Architecture in Inner Mongolia* organized the types of dwellings from various eras chronologically [14]. Early research on Inner Mongolian dwellings focused on collecting and summarizing architectural styles. In 2010, Pengju analyzed the evolutionary history of various types of dwellings in *Ancient Architecture in Inner Mongolia* [36]. Guiming studied the spatial evolution of Han ethnic dwellings in the Inner Mongolian section of the Yellow River Basin under the influence of immigration history from the 15th century to the early 20th century [37]. Yushu categorized vernacular dwellings' styles and living spaces in the Alxa agricultural and pastoral area into different periods based on historical and social changes and analyzed their correlation [38]. Research after 2000 focused on the chronological changes in residential styles and spaces and explored the relationship between local factors and changes. Guo examined the characteristics of dwelling spaces under different production modes [39]. In 2019, China proposed exploring regional cultural characteristics embodied in traditional residential spaces in urban and rural housing construction. Several localities in the Yellow River Basin of Inner Mongolia have studied the spatial styles of local earth dwellings [40–43].

Previous studies of Inner Mongolia residents have less of an exploration of whether a broader region's cultural and environmental contexts have resulted in similar impacts on the spatial characteristics of dwellings. In spatial analysis, only spatial forms visible through the observational plan are classified, and there needs to be more analysis on the special reality relationship between organization and usage.

3. Materials and Methods

3.1. Case Selection

In recent years, the number of earth dwellings has sharply declined, and the distribution of existing homes has become more scattered, which has increased the difficulty of investigation. Since traditional earthen dwellings are influenced by terrain and construction methods, they may exhibit different architectural styles. Therefore, we initiated extensive visits to villages in the Inner Mongolia section of the Yellow River Basin. During these visits, we observed a relatively higher number of traditional earthen dwellings in the plain areas. However, in mountainous and hilly regions, most residents have relocated due to recent rural consolidation and centralized residence policies, leaving only a small number of earth dwellings still in use. While various construction styles of traditional earthen dwellings have appeared in the research area, our survey and visits revealed that house-style traditional earthen dwellings dominate the studied region. In contrast, Yao-style traditional earthen dwellings are almost extinct, and other styles are unseen. To ensure the representativeness of our samples, we organized the data collected from samples with complete information. For this purpose, we selected seven samples from mountainous areas, six samples from hilly areas, and 39 samples from plain regions, totaling 52 samples. There are 2 Yao-style residences among these samples, while the rest are house-style.

3.2. Overview of the Data Collected

Before analyzing the characteristics of living spaces, it is essential to categorize the samples. Based on observed floor plans, space types can be divided from structural and functional perspectives. According to these types, a comparison can be made between the terrain and architectural styles, explaining the relationship between the external environment and the selection of space types. Additionally, we describe the usage combinations exhibited by the samples in these two classifications.

3.2.1. Residential Space Classification

Classified by Plan Structure

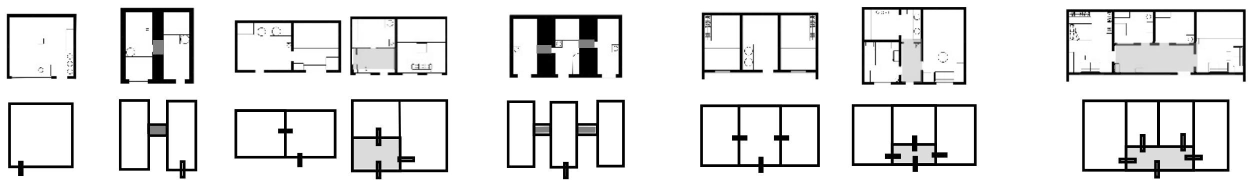
The earth dwellings in the Inner Mongolia section of the Yellow River Basin have formed diverse residential spaces. It can be observed that the plan structure around this section comprises one or more horizontally connected rooms after researching. According to Chinese terminology for traditional architecture, the horizontally expanded rooms are called "bays". Based on the number of "bays", the residential space can be divided into four categories (Table 2a): (a) one "bay", (b) two "bays", (c) three "bays", and (d) four or more "bays". Due to different ways of connecting the rooms, b type is divided into b1, where the rooms are connected via an aisle; b2, where the rooms are directly connected; and b3, connected via a hall; a few samples use composite plan. Similarly, the c type is divided into three subsets. Type d only has one sample, which is classified as d3, as four rooms are connected via a hall. However, with the passage of time, b1 and c1 have become obsolete, and there have yet to be any cases found during the investigation.

Classified by Basic Functional Space

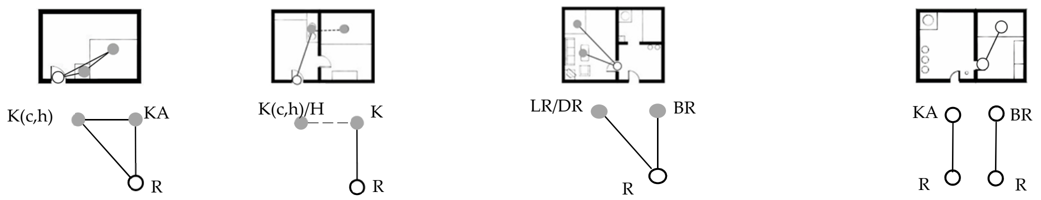
The basic functional space is the original space in earth dwellings. The other spaces are arranged based on the sleeping area, making it the basic indoor functional space. According to the style of sleeping space, the space can be divided into α, β, γ, * (Unique type), and four basic functional space types (Table 2b). Due to the cold climate of the Inner Mongolia section of the Yellow River Basin, the Kang always connected with a stove to make up the sleeping area in early vernacular dwellings. The way to connect the kang and stove can be summarized into two basic functional spaces: α is directly connected; β is connected across rooms. According to local living habits, the daily routines, diet, and household chores are all conducted on Kang, which means the basic functional space fulfills more than sleep functions. With the popularization of furniture, functional spaces can be independently designated. Some vernacular dwellings built later would use a bed instead of the kang, but they are always accompanied by a dining room (DR) or living room (LR) to consist of basic functional space. This has evolved into the third type: γ. Unique basic functional spaces refer to those using a Kang or bed independently and cannot be classified into the three basic functional spaces and are represented by *.

Table 2. Plan classification.

(**a**) Plan structure type

Type	**a**	**b**			**c**			**d**
		b1	**b2**	**b3**	**c1**	**c2**	**c3**	**d3**
Plan / **Plan type**								

(**b**) Basic functional space type

Type	**α**	**β**	**γ**	*
Plan / **Basic functional type**				

Aisle Hall Basic functional space R: Room Kang: KA Kitchen (cooking, heating): K (c, h) H: Heating DR: Dining room BR: Bedroom

3.2.2. The Surface Characteristic of Residential Space

The samples were collected as the background conditions of terrain and residential styles, which were considered potential factors that could impact guiding sample selection. After the classification of residential space types, we compared them with the collection condition. All three types of plan structures, a, b, and c, were used in the mountainous samples. In hilly areas, a and b types of plan structures were used. The largest samples were collected from the plain sites, where all four plan structures were used. Among them, the usage rates of different plan types in mountainous and hilly areas were similar, while in plain regions, type c had the highest usage rate, and type a had the lowest. The only d3 plan was in the plain area.

Regarding basic functional space selection, mountainous and hilly areas did not show a significant preference, while in plain regions, type β was used the most. Overall, mountainous and hilly terrains did not substantially influence space selection. At the same time, plain areas used multi-bay plan structures and used type β basic functional spaces more. The only two Yao-style samples have c2 plan structures and use the α basic functional space type (Table A1).

Different plan structures show different tendencies when selecting basic functional space types. Among the six samples of type a, five are α type. Type b and type c are used in conjunction with all types of basic functional space. Among type b, the β type is used the most, with six cases, and the combination of b3 and β appears the most, with three cases. Among type c, the β and β + γ are used the most, with seven cases each, mainly in type c3, with five cases each. Except for the α + γ, type c2 is used with all other basic functional spaces. Only one case of d3 uses the α + γ type.

From the perspective of basic functional space, when the plan structure consists of multiple bays directly connected, there is a greater tendency to use α type. When multiple bays are connected through a hall, β type is more commonly used. Among the composite basic functional space types, β + γ combination has the highest frequency and is mostly used in c3 type plans. Seven cases of special basic functional space layouts were used in a, b2, b3, and c2 types with similar usage rates, and no correlation with plan type was observed (Table A1).

3.3. Methods

As mentioned earlier, the plan structures of earth dwellings in the Inner Mongolia section of the Yellow River Basin are simple. Dividing residential space based solely on visual observations cannot tell if the spatial organization is compact, the way the functional areas are arranged, or the relationships between different areas. Space syntax, conceived by Bill Hillier and Julienne Hanson in the late 1970s, is a set of techniques for representing, quantifying, and interpreting spatial configuration in buildings and settlements [44] (p. 106). The convex space method in space syntax analyzes the connectivity between spaces. Therefore, after understanding the surface characteristics of the sample spaces, a further study of spatial features will be analyzed by space syntax based on the classification of residential space types.

3.3.1. Residential Space Division

Since most functional spaces of earth dwellings in the Inner Mongolia section of the Yellow River Basin are concentrated in one bay, using one note to represent a room with a particular function is hard. Hence, two steps need to be completed before calculation, which are outlined in the following instructions. (1) Breakup space refers to the function. Use software A-GRAPH [45] to draw a J-graph (A justified map/graph is one in which a node is drawn at the base, and the all points of depth 1 from that point are aligned horizontally immediately above it, all points at depth 2 from that point above those at depth 1, and so on until all levels of depth from that point are accounted for). First, using one note represents one bay. Then, represent functional space by a note in one bay. Using segments links spatial nodes with direct connections on the plan. If multiple functional spaces exist within one bay, and their depth relative to the directly connected space is the same, use one node to represent (Figure 3). (2) Upon observing the sample plan, it was found that the J-graph with the fewest functional elements is a circular shape composed of three dots, and some parameters cannot be calculated. Therefore, the J-graph must add a yard as an outdoor space on every sample while drawing it and taking it as the root point (Figure 4). When calculating various numerical values, the cases with and without outdoor space are calculated separately to determine whether adding outdoor space will affect the results.

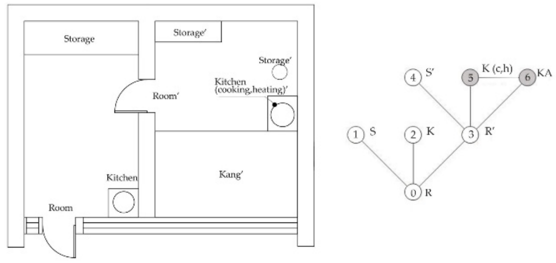


Figure 3. The way to draw J-graph.

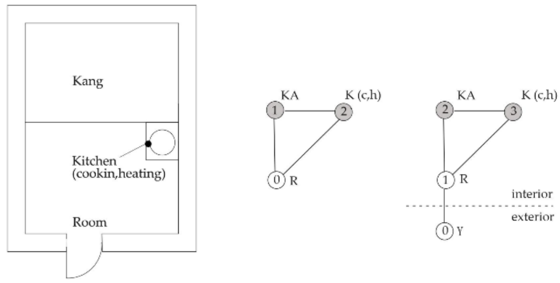


Figure 4. J-graph for calculating S: Storage; Y: Yard.

3.3.2. Parameters and Method

Parameters

After completing the plane partition based on the convex space concept, calculate the parameters Integration (i), Relative Difference Factor (H*), and Control Value (CV). In spatial syntax theory, "depth" explains the distance between one space and another. Mean Depth (MD) refers to the average depth reaching all other spaces from each space within the plan when taken as the center. After drawing a J-graph with each space as the root, calculations yield corresponding values. However, different spaces chosen as the root point can influence Total Depth (TD) within the same plan. The Relative Asymmetry (RA) (2) is introduced to facilitate the comparison of values between spaces. When comparing values between different planes, it is necessary to eliminate differences in the number of elements within the plan and the connectivity between elements. Therefore, Diamond Shape transformation is introduced to obtain Real Relative Asymmetry (RRA) (3). To help understand, taking the reciprocal of RRA yields Integration (i). For spaces, a higher i value indicates greater accessibility, reflecting a space's ability to attract traffic. For a plan, a higher i value indicates a higher level of compactness in the plan's arrangement [46].

$$\text{Mean Depth}(\text{MD}) = \frac{\text{TD}}{(\text{K}-1)} \tag{1}$$

$$\text{Relative Asymmetry}(\text{RA}) = \frac{2(\text{MD}-1)}{\text{K}-2} \tag{2}$$

$$\text{Real Relative Asymmetry}(\text{RRA}) = \frac{\text{RA}}{\text{DK}} \tag{3}$$

$$\text{Integration}(\text{i}) = \frac{1}{RRA} = \frac{DK}{RA} = \frac{DK(K-2)}{2(MD-1)} \tag{4}$$

K: Number of spaces in the system

DK: is the relative Asymmetry of space from a Diamond-Shaped graph.

Hiller and Hanson argue that culture involved in spatial organization can manifest as an inequality genotype and use the Difference Factor (H) (5) to explain. H can then be 'relativized' between ln2 and ln3 to give a relative difference factor H* (6) between 0 (the maximum difference, or minimum entropy) and 2 (the minimum difference, or maximum entropy, that is, all values are equal) [25] (p. 365).

$$\text{Base different factor}(\text{H}) = -\sum\left\lfloor \frac{a}{t} ln\left(\frac{a}{t}\right)\right\rfloor + \left\lfloor \frac{b}{t} ln\frac{b}{t}\right\rfloor + \left\lfloor \frac{c}{t} ln\frac{c}{t}\right\rfloor \tag{5}$$

$$\text{Relative different factor}(\text{H}^*) = \frac{(\text{H} - \ln 2)}{(\ln 3 - \ln 2)} \tag{6}$$

a = Max RRA
b = Mean RRA
c = Min RRA
t = a + b + c.

The Control Value (CV) is found by letting each node give the total value of 1 equally distributed to its connected nodes. It is the degree of local influence it exerts in the graph (7) [47]. The higher the CV value, the easier it is to affect the connected spaces.

$$\text{Control Value}(\text{CV}) = \sum_{\text{D}(\text{a},\text{b})=1} \frac{1}{\text{Val}(\text{b})} \tag{7}$$

Val(b) is the number of connections to a node b.

Using these parameters can help explore the organizational patterns of living spaces and the relative positions of various functional areas in the plan and uncover potential characteristics of actual living behaviors through the distribution and connections of available rooms.

Research Method

The samples are classified based on the floor structure and basic functional space style. Firstly, the spatial organization of different types is analyzed based on Mean Depth and Integration values. Classification methods that have a significant impact on spatial organization are selected. The influence of having an exterior (or not) on the numerical results is also determined.

Then, the parameters of each space within the plan are used to interpret the spatial organization characteristics. In the J-graph, a note is assigned to each bay to express the connection between different functional spaces in other bays. However, the points themselves do not have functional attributes. Therefore, when further analyzing the organizational features of functional spaces, the values representing bays are excluded, and functional spaces are calculated separately. As basic functional spaces are considered a space type, functional spaces will be further classified into basic functional spaces and other spaces. The integration value of functional spaces is used to analyze the relative numerical changes compared to the overall functional space. The correlation between basic functional spaces and other functional spaces is determined. After analyzing functional space categories, the organizational situation of individual functional spaces within the plan is analyzed. Finally, the spatial organization characteristics of traditional dwellings in the Inner Mongolia section of the Yellow River Basin are summarized.

4. Data Analysis

4.1. Analysis of Planar Overall Parameters

The calculation results analyze the organizational features of the plan based on the Mean Depth (MD), Integration (i), and Relative Different Factor (H*) values. The overall MD increases with the number of bays in the plan structure set, and the composite plan form has the highest MD (with the exterior) (1). The MD of the plan structure with connected corridors is lower than that of the planar form with directly connected bays. Usually, the variation pattern of MD (without exterior) is similar to MD (with exterior), and the planar depth is lower when there is no exterior space. Type d3 is unique, with MD values being approximately the same regardless of the inclusion of outer space. Observing the mean i values, the inclusion or exclusion of exterior space has little influence on the i values (4). Type a has the lowest i value, indicating a loose spatial organization. The i values of other types of plans are similar. By analyzing the combination of MD and integration values, we can see that type a has the lowest MD with the shortest mean depth between internal functional spaces but the lowest i value. When the MD of the type c planar form decreases, the i value does not change significantly. Figure 5a indicates that the planar configuration can affect the MD value between functional spaces. Still, the compactness of spatial organization, as noted in the i value, remains relatively the same with different planar forms.

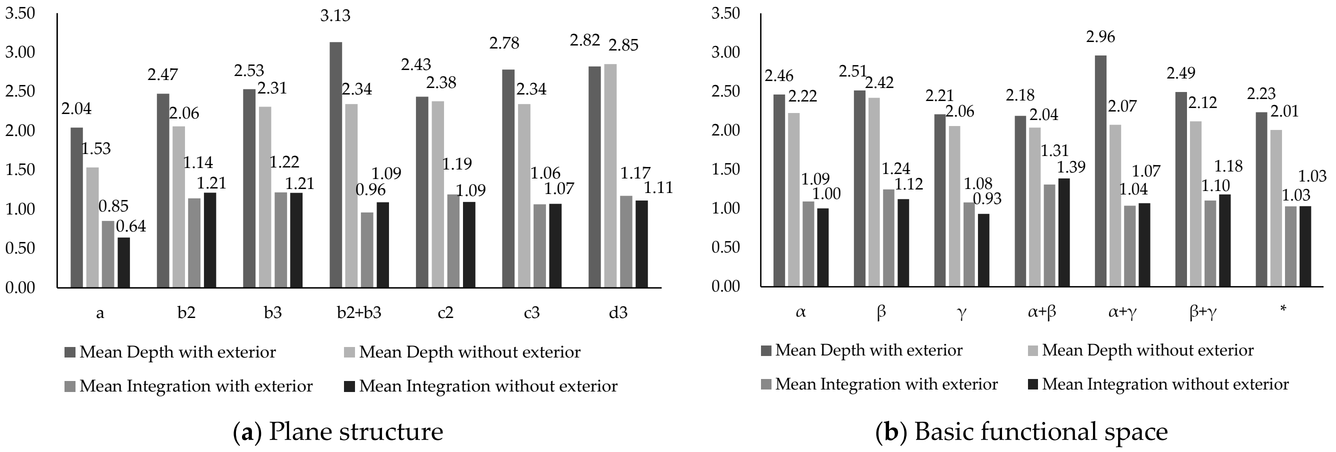


Figure 5. Classification method infection on spatial organization.

The different types of basic functional space had a significant fluctuation in MD (with the exterior), with the $\alpha + \gamma$ type having the highest value. When calculated without outdoor spaces, the mean depth values show less fluctuation, with only the α and β types having higher values, while other types have similar average depths. The i values fluctuate among different functional types. The β type has higher values than others in a single functional type. In composite types, the combination with the β type has a higher plan value than others. The highest value is obtained among all types with the combination of α and β. The pattern of changes in the integration chart for basic functional space shapes approximates the MD trend. However, the $\alpha + \gamma$ shape is unique because it has a high plan depth but loose spatial organization. Overall, the samples show that while calculating with the exterior, the MD value has a significant impact, but the i values remain similar. Therefore, in subsequent analyses, the data will be based on calculations that include outdoor spaces.

After calculations, the Relative Difference Factor results in the sample are close to 1 except for case B9 (Table A2, Appendix A) (6). No significant differences are observed among categories (Table 3), indicating a lack of genotype expression. The H* value of B9 in the samples, with = 0.48 and without = 0.56, significantly differs from the mean. Since the overall genotype of the models is not significant, but there are individuals with distinct differences, the samples are divided into general plans and special plans for further research.

Table 3. Classification method infection on relative different factor.

	Relative Different Factor (H*)									
Plane type	a	b	b2	b3	b2 + b3	c	c2	c3	d3	Total
with exterior	0.87	0.78	0.76	0.76	0.83	0.74	0.71	0.77	0.73	0.78
without exterior	0.94	0.76	0.73	0.76	0.8	0.74	0.71	0.77	0.75	0.8
Basic Functional Space Type	α	β	γ	α + β	α + γ	β + γ	*	Total		
with exterior	0.77	0.73	0.79	0.6	0.78	0.76	0.82	0.75		
without exterior	0.79	0.75	0.78	0.65	0.76	0.74	0.78	0.75		

4.2. Correlation Analysis between Basic Functional Space and Other Space

After computation, it has been determined that the basic functional spatial classification affects the i value of the plane (4). Therefore, further analysis using the i value can be employed to assess the performance of basic functional space within the plan's organization and its impact on other space arrangements. After excluding areas that do not have functional attributes, the spaces can be divided into two sets: basic functional spaces and other functional spaces. Take the mean i of functional areas in different basic functional space types as the baseline compared with the mean i values of the two sets.

As observed from Figure 6, the i values of basic functional spaces in γ and β + γ shapes are similar to those of other functional spaces, showing a balanced layout of functional spaces without a tendency toward centralized distribution. However, in another basic functional space type, the i values are higher, indicating that the basic functional spaces are closer to the center of spatial organization. In the * type, the Kang or BD are located far from the center of spatial organization. In the special plan, under type α + β, the values of basic functional spaces are much higher than those of other functional spaces, which means the plan is closely centered around basic functional space.

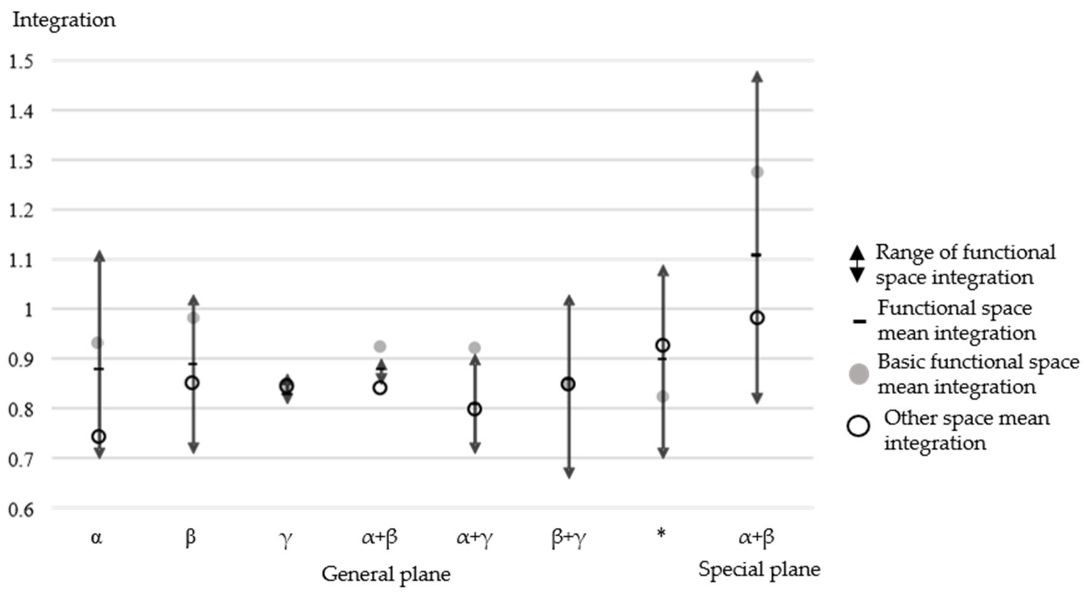


Figure 6. The mean integration of different type.

In different types of planes, the basic functional spatial layout demonstrates a tendency to arrange differently around the plane's center, leading to variations in the arrangement of other functional spaces. Using the Pearson correlation coefficient, we analyzed whether the basic functional space directly influences the organization of other spaces. The coefficient of 0.48 indicates a moderate correlation between the two types of spaces. As shown in

Figure 7, an increase in the mean integration of functional spaces accompanies an increase in basic functional space value. The distribution of other functional spaces tends to be more concentrated as the basic functional space is organized compactly. The sample distribution is mainly within the range of 0.6–1.1, with a lower distribution for the α shapes and a more normal distribution for the β shapes. The β + γ shapes deviate from the axis line and experience a sharp increase when the value of basic functional space is around 0.8–1.1. Few samples were available for the γ, α + β, and α + γ shapes, making it challenging to observe distribution trends within these types. The * shapes are distributed above the axis line, suggesting that the spatial organization revolves around other spaces. The special plan B9 is near the axis line (Figure 7).

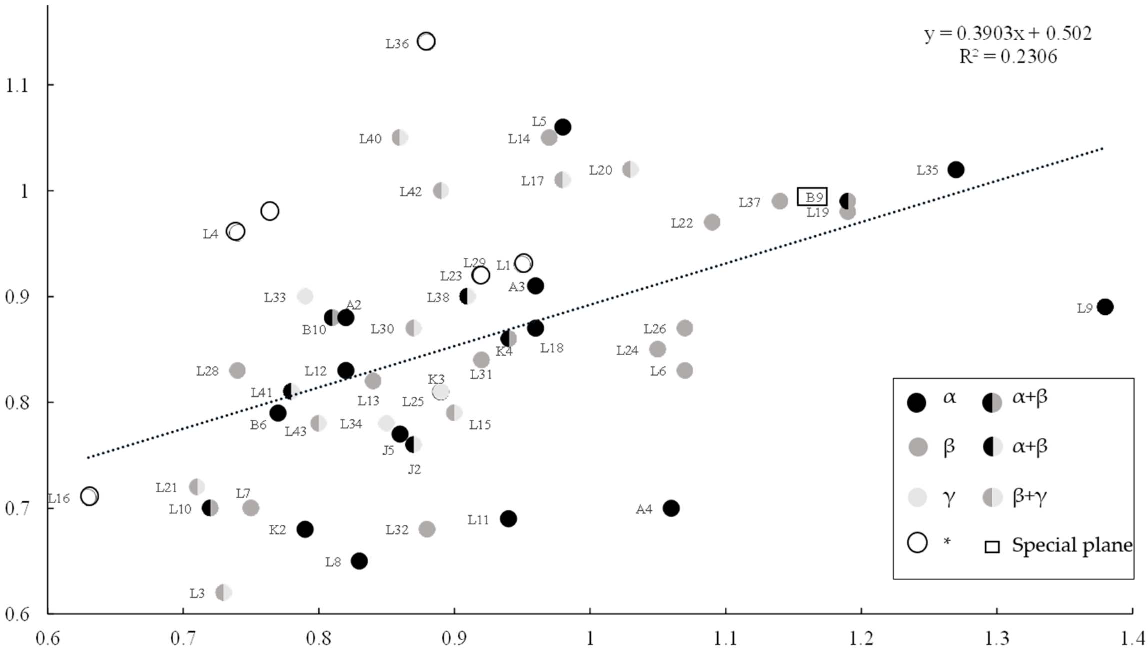


Figure 7. Correlation between basic functional space and other space.

4.3. Integration Analysis of Different Functional Spaces

After analyzing the i values of various functional spaces within the plan and comparing them with the mean i values for each type, it is observed that among the 14 functional spaces, there are 11 instances where the i values are higher than the mean i of their corresponding classification (Table 4) (4). The i values do not surpass their type's mean i regardless of the Bedroom (BR), Storage (S), and Study area (ST). S has the highest usage rate within the plan, but its low i value suggests loose connections with other spaces. Lavatory space (LA) is a space that appears after the washing machine is used, which is found in eight plans and located near the center of the plane. Sacrifice space (SA) is a space that only some households will have, and it is usually set far from the center of the plane. Toilet (TO) is rarely found indoors, with only three samples, all located near the center in planes of the β + γ form. Despite Washstand (W) not being used extensively, it exhibits high i values except in * and special plan, which indicates that the W establishes close connections with other spaces once used. Makeup (MU) and Study areas (ST) are rarely used and considered spaces that appear sporadically. Most of the time, they are distributed far from the plan's center. There is only one instance where MU is close to the center in the * type. Both Heating (H) and Kitchen (cooking, heating) (K(c,h)) consistently possess high i values across all categories, whereas Kitchen (K) only exceeds the type's mean i in the α, γ, and α + β types. When used for heating, it is suggested that the stove is sure to form close connections with other spaces. As for special plans, only the mean i of the K(c,h) space is higher than that of functional spaces, indicating that the plan's organization revolves around the K (c,h) space as the center. Other functional spaces are loosely connected and arranged away from the center.

According to the definition of the Integration parameter, it is evident that higher i values indicate a tighter connection with other spaces. The space with the highest i value within the plan will become the central component of the plan's organization. Statistical analysis was conducted on the number of functional spaces with the highest integration values within all plan samples, which is categorized by basic functional space types (Table 5). First, considering basic functional spaces as a whole, in α-type plans, 55% of α spaces had the highest integration values, while in β-type plans, 72% of β spaces had the highest values. In γ-type plans, only one γ space had the highest integration value, accounting for 7% of the total. These results indicate that basic functional spaces are more likely to become the central areas of the plan organization. This pattern is consistent in both general and special plans. When observing independent functional spaces, the heating space had the highest frequency of being the space with the highest integration value within the plan. Among them, eight were basic functional space compositions, while 16 were independent spaces. These data suggest that the heating space, whether used independently or as part of a basic space composition, serves as the central space in the plan organization. In *-type plans, ten different types of spaces had the highest integration values in seven samples, indicating a lack of a core space in the organization of *-type plans.

Table 4. The usage time and mean integration of functional spaces.

Basic Functional Space Type		Number	Functional Space Mean i	Functional Space														
				H	**K(c,h)**	**K**	**KA**	**BR**	**DR**	**LR**	**S**	**LA**	**SA**	**TO**	**W**	**MU**	**ST**	
General plan	α	14	0.88	10	15	7	21	6	5	4	19	-	1	-	6	-	-	**Number**
				1.05	0.88	0.89	0.86	0.81	0.92	0.89	0.81	-	0.71	-	0.92	-	-	**Mean i**
	β	13	0.89	13	2	13	13	8	14	6	28	5	3	2	8	-	-	**Number**
				1.04	0.98	0.85	0.94	0.76	0.87	0.85	0.83	0.92	0.85	0.78	1.01	-	-	**Mean i**
	γ	3	0.83	5	-	2	2	4	2	3	5	1	-	-	-	-	-	**Number**
				0.98	-	0.91	0.75	0.78	0.83	0.77	0.8	0.81	-	-	-	-	-	**Mean i**
	$\alpha + \beta$	2	0.88	2	1	1	4	-	-	1	6	-	-	-	-	-	-	**Number**
				0.88	1.11	1.12	0.83	-	-	0.87	0.83	-	-	-	-	-	-	**Mean i**
	$\alpha + \gamma$	3	0.81	3	1	4	4	4	3	4	6	1	1	-	2	-	-	**Number**
				0.88	0.84	0.76	0.8	0.75	0.75	0.79	0.78	1.2	0.68	-	0.92	-	-	**Mean i**
	$\beta + \gamma$	9	0.86	13	8	4	11	12	8	15	14	-	2	1	2	1	-	**Number**
				0.98	0.95	0.73	0.8	0.8	0.89	0.78	0.85	-	0.51	0.91	0.95	0.8	-	**Mean i**
	*	7	0.91	7	-	6	5	4	5	2	11	1	1	-	4	1	2	**Number**
				1.16	-	0.84	0.81	0.84	0.88		0.86	1.05	0.92	-	0.89	0.92	0.88	**Mean i**
Special plan	$\alpha + \beta$	1	1.11	1	1	-	2	-	-	-	-	-	-	-	1	-	-	**Number**
				0.99	1.47	-	1.04	-	-	-	-	-	-	-	0.99	-	-	**Mean i**

K: Kitchen; SA: Sacrifice; LA: Laundry; TO: Toilet; W Washstand; MU Makeup; ST Study.

4.4. Control Value Analysis of Different Functional Spaces

The Control Value (CV) reflects the ability of a space to influence the connected spaces. A higher CV value indicates that the connected spaces have fewer external connections and a stronger dependence on the original space. The integration value represents the compactness of spatial organization, reflecting the distance relationship between spaces. Conversely, the Control Value (CV) indicates the usage relationship between spaces. Spaces with higher CV values receive more services from other functional spaces. Hence, it can be described that spaces with high CV values are where daily activities are concentrated.

For all samples, the functional spaces are sorted based on their CV values and the highest values for analysis (Table A2) (7). Table 6 shows that among the 45 samples using basic functional space types, the basic functional spaces rank first in terms of CV value in 39 cases, accounting for 87%. The CV values of basic functional spaces in general and special plans exhibit the same pattern. These data indicate that basic functional spaces generally have high control over the surrounding spaces and serve as the absolute core of living spaces. Among the three samples of the γ shape, the basic functional spaces have the lowest CV values in two instances, indicating a weak control over the surrounding spaces. Examining each functional space independently, H has the highest CV value when used alone most often. Eleven functional spaces have the highest CV values in the seven * plan samples. The range suggests that in this category of plan shapes, most functional spaces have similar organizational power over the surroundings, and the living spaces within these residential areas will not be concentrated in one area.

Table 5. The time of the functional space with the highest integration.

Basic Functional Space Type		Number	Functional Space with the Highest i															
			Sleeping Space	H	K(c,h)	K	KA	BR	DR	LR	S	LA	SA	TO	W	MU	ST	
General plan	α	14	10	4 (α2)	8 (α8)	-	8 (α8)	1	-	-	-	-	-	-	-	-	-	Occur number (as basic functional space)
	β	13	9	6 (β4)	1 (β1)	2 (β2)	2 (β2)	-	2	-	-	-	-	-	-	-	-	
	γ	3	1	3		1	-	1 (γ1)	-	1 (γ1)	1		-	-	-	-	-	
	α + β	2	α: 0 β: 2	-	2 (α1,β1)	1 (β1)	-	-	-	-	-	-	-	-	-	-	-	
	α + γ	3	α: 1 γ: 0		1 (α1)	-	1 (α1)	-	-	-	-	-	-	-	-	-	-	
	β + γ	9	β: 7 γ: 0	5 (β2)	4 (β4)	-	1 (β1)	-	-	-	-	-	-	-	-	-	-	
	*	7	-	6	-	3	3 (3)	1(1)	3	1	5	1	1	-	2	1	-	
Special plan	α + β	1	α: 0 β: 0	-	1 (α1)	-	-	-	-	-	-	-	-	-	-	-	-	

K: Kitchen; SA: Sacrifice; LA: Laundry; TO: Toilet; W Washstand; MU Makeup; ST Study.

Table 6. The time of the functional space with the highest control value.

	Basic Functional Space Type	Function Space with the Highest Control Value (CV)														
		H	K(c,h)	K	KA	BR	DR	LR	S	LA	SA	TO	W	MU	ST	
General Plan	α	4 (4α)	9 (9α)	10 (10α)	-	-	-	-	-	-	-	-	-	-	-	Occur number (as basic functional space)
	β	4 (3β)	1 (1β)	3 (3β)	7 (7β)	-	-	-	-	-	-	-	-	-	-	
	γ	2	-	-	-	1 (1γ)	1 (1γ)		1					-	-	
	α + β	2 (2β)	-	-	-	-	-	-	-	-	-	-	-	-	-	
	α + γ	2 (2α)	1 (1α)	-	3 (3α)	-	-	-	-	-	-	-	-	-	-	
	β + γ		3 (2β)	1 (1β)	4 (4β)	1	-	-	-	-	-	-	-	-	-	
	*	5	-	3	-	-	3	1	3	-	1	-	-	1	-	
Special plan	α + β	1 (1 α + β)	-	-	-	-	-	-	-	-	-	-	-	-	-	

K: Kitchen; SA: Sacrifice; LA: Laundry; TO: Toilet; W: Washstand; MU: Makeup; ST: Study.

5. Discussion

Through investigation and comparing residential layouts with the types of residences and the environmental conditions of their locations, we can roughly deduce the following: (1) Local residential space preferences tend to favor flatter terrain and a higher number of open spaces within the floor plan; (2) Features of residential types are independent of spatial preferences. However, the impact of local culture on individuals' behaviors and consciousness in their lives is challenging to articulate.

The results of the Relative Difference Factor (H*) calculations indicate that only one instance in the sample collection exhibits a significant difference. In contrast, the rest of the samples show similar spatial organization patterns but some variation in basic functional space types. This result answers the earlier question regarding whether residential space organization in this region exhibits commonalities. A shared residential culture exists in the adobe houses of the Yellow River Basin in Inner Mongolia. This cultural aspect has a more significant influence on space functionality organization compared to spatial structure. The calculations show that the sampled plans exhibit distinct characteristics of spatial organization around H as central spaces. Components of basic functional spaces are often arranged around the center, indicating that ease of connectivity and closeness to heating facilities are important considerations in residential houses. After the furniture and appliances become populated, LA and W are more prevalent than others, and they are used closer to the plan's center. In the results of the Control Value, basic functional spaces often achieve the highest values, indicating that other spaces primarily serve these types of spaces and thus become the core locations for everyday activities.

With the advancement in construction capabilities and the ability to build on a larger scale, local vernacular dwellings that lack sufficient cultural and historical value are less protected and hard to maintain. Through their developmental history, the earth dwellings in the Inner Mongolia section of the Yellow River Basin demonstrate the remarkable adaptability of spontaneously adjusted living spaces to local culture and environment. The balance between traditional residential culture and contemporary lifestyles present in the local dwelling culture offers a reference for creating living spaces that respect local housing preferences while accommodating modern living needs. The survey research demonstrates that external factors like terrain conditions and architectural styles do not determine space organization. This conclusion will lead to extracting the culture of spatial organization independently of geographical and material constraints. It will open up the possibility of transplanting local residential culture into newly constructed houses during relocation or new construction irrespective of geographical and house style limitations. It contributes to the sustainable development of residential culture.

6. Conclusions

The local residential space organization characteristic is summarized based on the sample by analyzing the residential space of earth dwellings in the Inner Mongolia section of the Yellow River Basin. The research conclusion is the special part from two levels. From the surface characteristics, we can see the following:

1. Regional topographical conditions manifest in the selection of plan spatial structures, where flatter terrains tend to have more bays. However, topography did not significantly impact the choice of basic functional space categories.
2. Regional geological conditions influence the construction form of residential buildings. Still, the samples included in the study, such as Yao-style and house-style dwellings, did not exhibit differences in spatial structures.

The hidden characteristic found through quantitative analysis reveals that the integration value, which reflects the compactness of the layout organization, varies with different basic functional space types. When classified according to basic functional space types, the following was found:

(1) The type of basic functional space has a more decisive influence on spatial organization than spatial structure. The β type and the planar organization containing the β type are the most concentrated.

(2) Within the layout of sleeping-type plans, the basic functional space serves as the central organizing element. In contrast, in non-sleeping-type plans, other functional areas are closer to the center of the layout. Different types of basic functional spaces positively correlate with the organization of other functional areas.

(3) When considering the basic functional space as a whole, they exhibit the highest frequency of occurrence for the i value; within independent spaces, H has the highest frequency of the i value, making it the most conveniently connected space with other regions and making it the most convenient spaces to connect with other areas.

(4) Basic functional spaces exert significant control over surrounding spaces in most layouts, serving as the central living area of the plan.

(5) As H serves as both the central element of spatial organization and easily becomes the hub of daily activities, it indicates that the stove holds significant importance in the layout of local residential spaces while used as heating facilities or heating equipment.

Despite the apparent lack of structural divisions and the seemingly disorderly and crowded nature of the interior spaces of earth dwellings in the Inner Mongolian section of the Yellow River Basin, this study shows that there is, in fact, order. Analyzing the connections between spaces and their use patterns reveals how residents, driven by local cultural awareness, ingeniously combine traditional living spaces with contemporary lifestyle needs. Interpreting the cultural significance embedded in living spaces and understanding the residential mindset of local communities provides a reference to construct living spaces that respect and adapt to the local social and cultural environment and protect the sustainable development of local culture. The study's only analysis is based on the sample objects. Due to the limited sample size, some plans cannot be explained. Future studies will add more samples to clarify the space arrangement characteristic.

Author Contributions: Data curation and analysis, J.S.; writing—original draft, J.S.; writing—review and editing, S.Z.; funding acquisition, J.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Natural Science Foundation of Inner Mongolia of China: "Research on the Construction Wisdom and Renewal of Earth Dwellings in the Western Region of Inner Mongolia", grant number 2019MS05048; Inner Mongolia Autonomous Region science and technology plan project "Research on the Green Building Model and Technology System of Inner Mongolia Region Based on Multiculturalism", grant number 2019GG142; Natural Science Foundation of Inner Mongolia of China "Research on the types and characteristics of traditional villages in Inner Mongolia", grant number 2021MS05063.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Acknowledgments: The authors gratefully acknowledge the help of the Human Environment Research Institute of Inner Mongolia University of Science and Technology for assistance during the survey in China.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The details of the cases.

Plan Type		Code	Year	Dwelling Type	Topography	Basic Functional Space Type
a		A4	1900	House	Plain	α
		K2	1900	House	Hill	α
		B6	1960	House	Hill	α
		B10	1960	House	Mountain	α
		L35	1980	House	Plain	α
		L30	1980	House	Plain	*
b	b1	-	-	-	-	-
	b2	J4	1950	House	Hill	α
		J5	1950	House	Hill	α
		B9	1960	House	Mountain	α + β
		L9	1970	House	Plain	α

Table A1. *Cont.*

Plan Type		Code	Year	Dwelling Type	Topography	Basic Functional Space Type
b	b2	L11	1980	House	Plain	β
		L24	1980	House	Plain	β
		J2	1980	House	Plain	β + γ
		L16	1980	House	Plain	*
		L23	1980	House	Plain	*
	b3	L42	1970	House	Plain	β + γ
		L19	1980	House	Plain	β
		L28	1980	House	Plain	β
		L37	1980	House	Plain	β
		L4	1980	House	Mountain	*
		L36	1980	House	Mountain	*
	b2 + b3	L25	1980	House	Plain	β
		L13	1980	House	Plain	γ
		L10	1980	House	Plain	α + γ
c	c1	-	-	-	-	-
	c2	A2	1900	Yao	Plain	α
		K3	1900	House	Hill	α + β
		K4	1900	House	Hill	α + β
		L1	1960	House	Mountain	*
		L5	1970	House	Plain	α
		L8	1970	House	Plain	α
		L12	1980	House	Plain	α
		A3	1980	Yao	Mountain	α
		L22	1980	House	Plain	β
		L26	1980	House	Plain	β
		L33	1980	House	Plain	γ
		L34	1980	House	Plain	γ
		L17	1980	House	Plain	β + γ
		L20	1980	House	Plain	β + γ
		L29	1980	House	Plain	*
	c3	L40	1970	House	Plain	β + γ
		L43	1970	House	Plain	β + γ
		L41	1970	House	Plain	α + γ
		L18	1980	House	Plain	α
		L6	1980	House	Plain	β
		L14	1980	House	Plain	β
		L7	1980	House	Plain	β
		L31	1980	House	Plain	β
		L32	1980	House	Plain	β

Table A1. *Cont.*

Plan Type		Code	Year	Dwelling Type	Topography	Basic Functional Space Type
c	c3	L21	1980	House	Plain	β + γ
		L15	1980	House	Plain	β + γ
		L3	1990	House	Mountain	β + γ
d	d3	L38	1990	House	Plain	α + γ

Table A2. The calculating result of the cases.

General			Mean Integration					Highest Control Value	Relative Different Factor (H*)
Basic Functional Space Type	Code	Plan Type	Plan	Functional Space	Basic Space	Other Space	Functional Space	Functional Space	
α	A4	a	0.70	0.94	1.06	0.7	KA 1.06=K(c,h)1.06>S 0.7	KA 1.06=K(c,h)1.06	0.91
	K2	a	0.93	0.71	0.79	0.68	KA 0.79=K(c,h) 0.79>LR 0.73=S 0.73>DR 0.65=K 0.65=S 0.65	KA 0.7=K(c,h)0.7	0.86
	B6	a	1.01	0.76	0.77	0.79	KA 0.85=K(c,h)0.85>W 0.79=S 0.79>KA′ 0.65=K(c,h)′ 0.65	KA′0.83=K(c,h)′0.83	0.81
	B10	a	1.08	0.84	0.81	0.88	KA 0.95=K(c,h) 0.95>H 0.88=W 0.88=S 0.88>KA′ 0.66=K′(c,h) 0.66	KA′ 0.83=K′(c,h) 0.83	0.75
	L35	a	0.89	1.12	1.27	1.02	KA 1.27=K(c,h) 1.27>DR 1.02=W 1.02=K 1.02	KA 0.67=K(c,h) 0.67	0.96
	J4	b2	1.16	0.79	0.79	0	KA 0.85=K(c,h) 0.85>KA′ 0.73=K′(c,h) 0.73	KA′ 0.83=K′(c,h) 0.83	0.74
	J5	b2	1.17	0.81	0.86	0.77	KA′ 0.86=K′(c,h) 0.86>K 0.77=S 0.77=S′ 0.77	KA′ 0.75=K′(c,h) 0.75	0.79
	L9	b2	1.46	1.05	1.38	0.89	H′ 1.77>KA′ 0.99>K 0.89=W 0.89=DR′ 0.89=S′ 0.89	H′ 0.9	0.75
	A2	c2	1.13	0.85	0.82	0.88	BD 0.98=S 0.98>KA1 0.82=K1(c,h) 0.82=KA2 0.82=K2(c,h) 0.82>S1 0.78=S2 0.78	KA1 0.75=K1(c,h) 0.75=KA2 0.75=K2(c,h) 0.75	0.75
	L12	c2	1.09	0.82	0.82	0.83	K 1.12>DR 0.98>H1 0.82=KA1 0.82>LR1 0.78>S2 0.71=SA2 0.71>K 0.65	K 1.2	0.69
	L5	c2	1.08	1.04	0.98	1.06	H 1.38>K 1.18=LR 1.18=W 1.18>H2 0.98=KA2 0.98>S2 0.94=BR2 0.94>BR1 0.84=S1 0.84	H2 0.7=KA2 0.7	0.68
	L8	c2	0.88	0.7	0.83	0.65	H1′ 0.99>K1 0.83>KA1′ 0.67=BR2 0.67>H1′ 0.65>BR1″ 0.59>KA2′ 0.51	H1′ 0.95	0.77
	A3	c2	1.22	0.94	0.96	0.91	KA 1.14=K(c,h) 1.14>DR 1.07>KA1 0.87=K1(c,h) 0.87=KA2 0.87=K2(c,h) 0.87>S1 0.83=S2 0.83	KA1 0.75=K1(c,h) 0.75=KA2 0.75=K2(c,h) 0.75	0.72
	L18	c3	1.13	0.89	0.96	0.87	H 1.24>H3 0.98>KA3 0.94>LR3 0.87=S3 0.87>BR2 0.81=H2 0.81=S2 0.81>W1 0.76=S1 0.76	H3 1.2	0.74
β	L11	b2	1.17	0.81	0.94	0.69	H 1.02>KA′ 0.85>K 0.73>S′ 0.64	H 0.75	0.69
	L24	b2	1.28	0.92	1.05	0.85	H 1.11>KA′ 0.99>W 0.89=S 0.89>DR′ 0.81=S′ 0.81	KA′ 0.75	0.72
	L25	b2 + b3	0.97	0.82	0.89	0.81	K 1.01>DR 0.95=LA 0.95=W 0.95=S 0.95>S′ 0.81=LA′ 0.81>KA1 0.77>LR1 0.73=S1 0.73>K1′ 0.62=H1′ 0.62	KA1 0.75	0.80
	L19	b3	1.29	1.02	1.19	0.98	KA2 1.22>H1 1.16>W 1.1=S 1.1=LA 1.1>DR2 0.95=LR2 0.95=S2 0.95>K1 0.87=S1 0.87	H1 0.75	0.86
	L28	b3	0.94	0.82	0.74	0.83	H1′ 1.27>S′ 0.99=LR′ 0.99>W 0.88=S 0.88>LA1′ 0.82=S1′ 0.82=DR1′ 0.82=K1′ 0.82>BD2′ 0.81=S2′ 0.81>H1 0.74=KA2 0.74>DR1 0.7=K1 0.7=S2 0.7=LR2 0.7>BD3′ 0.68=S3′ 0.68	H1′ 0.78	0.72
	L37	b3	1.34	1.03	1.14	0.99	KA1 1.33>S1 1.02=SA1 1.02=H1 1.02=DR1 1.02>K2 0.95>H 0.88	K2 1	0.75
	L22	c2	1.31	1	1.09	0.97	H 1.3>K 1.14=S 1.14=W 1.14>KA1 0.87=H2 0.87=BR2 0.87=S2 0.87>DR1 0.79	KA1 0.83	0.64
	L26	c2	1.23	0.92	1.07	0.87	K(c,h) 1.21>S 1.04=W 1.04>KA2 0.92>DR2 0.82=S2 0.82>S1 0.75=BD1 0.75	KA2 0.75	0.68
	L6	c3	1.17	0.89	1.07	0.83	H1 1.07=KA3 1.07>W 1.01>SA1 0.83=K1 0.83=LR3 0.83=S3 0.83>S2 0.67	H1 0.75=KA3 0.75	0.70

Table A2. *Cont.*

General			Mean Integration					Highest Control Value	Relative Different Factor (H*)
Basic Functional Space Type	Code	Plan Type	Plan	Functional Space	Basic Space	Other Space	Functional Space	Functional Space	
	L7	c3	0.89	0.71	0.75	0.7	DR 0.9>DR′ 0.77=TO′ 0.77>K1(c,h) 0.75=KA3 0.75>SA1 0.69=S3 0.69>BR2 0.65>K2′ 0.58=S2′ 0.58	K1(c,h) 0.83=KA3 0.83	0.81
	L14	c3	1.32	1.03	0.97	1.05	H1 1.6>DR 1.1=W 1.1>KA2 0.99>K1 0.95>BD3 0.9=S3 0.9=LA3 0.9>LR2 0.87	K1 0.83	0.75
	L31	c3	1.14	0.86	0.92	0.84	DR 1.01>K1 0.96>KA2 0.87>H1 0.83=W1 0.83>BR3 0.79=S3 0.79=TO3 0.79	KA2 1	0.76
	L32	c3	1.04	0.75	0.88	0.68	K1 0.88=KA2 0.88>S1 0.7=DR2 0.7>S3 0.66=BR3 0.66	K1 0.83	0.75
γ	L13	b2 + b3	1.04	0.82	0.84	0.82	H1 1.38>S′ 0.84=BR′ 0.84=LR′ 0.84>LA 0.81=K1 0.81>BR1′ 0.65>KA2 0.62=LR2 0.62	H1 0.75	0.82
	L33	c2	1.14	0.87	0.79	0.9	H 1.01=K 1.01>H1 0.87=DR1 0.87=KA1 0.87=S1 0.87>DR2 0.79=BR2 0.79=H2 0.79	DR2 0.25=BR2 0.25=H2 0.25	0.76
	L34	c2	1.11	0.81	0.85	0.78	S 0.85=S1 0.85=H1 0.85=BR1 0.85=LR1 0.85=S2 0.58	S2 0.5	0.76
α + β	K3	c2	1.14	0.85	0.89	0.81	K(c,h) 1.11>S 0.95>KA2 0.83=H2 0.83>KA1 0.78=S2 0.78>S1 0.7	KA1 0.83	0.71
	K4	c2	1.17	0.9	0.94	0.86	K 1.12>S 0.98>H2 0.92=KA2 0.92>S2 0.87=LR2 0.87>KA1 0.78>S1 0.71	KA1 0.83	0.72
α + γ	L10	b2 + b3	0.86	0.71	0.72	0.7	KA′ 0.84=K′(c,h) 0.84>L 0.82=S′ 0.82>DR1′ 0.68=BR1′ 0.68=SA1′ 0.68=S1′ 0.68>LR2 0.65=BR2 0.65=S2 0.65>KA1 0.63=K1 0.63	KA′ 0.7=K′(c,h) 0.7	0.88
	L41	c3	1.08	0.8	0.78	0.81	W 1.01>KA2 0.83=H2 0.83>S2 0.79>DR1 0.73=K1 0.73=LR3 0.73=BR3 0.73	KA2 0.75=H2 0.75	0.73
	L38	d3	1.17	0.91	0.91	0.9	LA 1.2>BR3 0.92=H3 0.92=S3 0.92=LR3 0.92>KA4 0.9=H4 0.9>LR4 0.87>K1 0.83=DR1 0.83=K2 0.83=S2 0.83	KA4 0.75=H4 0.75	0.73
β + γ	J2	b2	0.97	0.82	0.87	0.76	K(c,h) 0.98>DR 0.91=BR 0.91=TO 0.91>BR′ 0.86>LR′ 0.81=H′ 0.81=S′ 0.81>KA1 0.75>LR1 0.71=S1 0.71>K1′(c,h) 0.62	K1′(c,h) 1	0.81
	L42	b3	1.23	0.94	0.89	1	K(c,h) 1.11=H 1.11>H2 1.02>BR2 0.88=LR2 0.88=S2 0.88>KA1 0.7	KA1 1	0.71
	L17	c2	1.31	1	0.98	1.01	K(c,h) 1.3>H 1.14=S 1.14=DR 1.14>KA1 0.87=LR2 0.87=BR2 0.87=S2 0.87>LR1 0.79	KA1 0.83	0.64
	L20	c2	1.30	1.03	1.03	1.02	K(c,h) 1.31>W 1.18=S 1.18=H 1.18>KA1 0.94=DR2 0.94=BR2 0.94=S2 0.94=H2 0.94>LR1 0.87=S1 0.87	KA1 0.75	0.71
	L40	c3	1.16	0.94	0.86	1.05	H1 1.52>KA3 0.91>K3 0.87>BR2 0.83=DR2 0.83=S2 0.83>LR3 0.79	K3 0.83	0.73
	L43	c3	1.07	0.79	0.8	0.78	KA3 0.92>K1(c,h) 0.82>DR3 0.78=S3 0.78>LR2 0.75=BR2 0.75=DR2 0.75	K1(c,h) 1	0.79
	L21	c3	0.87	0.72	0.71	0.72	H1 0.85>MU′ 0.8>KA2 0.73>K1(c,h) 0.72>BR3 0.71=LR3 0.71=S3 0.71=K1′(c,h) 0.71>LR2 0.7=H1′ 0.7=KA2′ 0.7>S1′ 0.65=LR2′ 0.65	K1(c,h) 0.83	0.88
	L3	c3	0.82	0.66	0.73	0.62	H1 0.76=H1′ 0.76>KA2 0.7=KA2′ 0.7>K1 0.67=K1′ 0.67>LR3 0.65=BR3 0.65=LR3′ 0.65=BR3′ 0.65>SA1 0.51=SA1′ 0.51	K1 1.33=K1′ 1.33	0.84
	L15	c3	1.03	0.84	0.9	0.79	H1 1.04>DR1 0.92=KA2 0.92>LR3 0.85=H3 0.85=DR3 0.85=S3 0.85=BR3 0.85>BD2 0.75>W4 0.72=K4 0.72=S4 0.72	KA2 0.83	0.81
*	L30	a	0.56	0.87	0.87	0.87	BR 0.87=K 0.87=H 0.87=S 0.87	BR 0.2	0.97
	L16	b2	0.85	0.7	0.63	0.71	K 0.8=W 0.8=S 0.8>S′ 0.75=K′ 0.75>S1 0.64=KA1 0.64=DR1 0.64>H1′ 0.61=KA1′ 0.61=S1′ 0.61	S′ 0.25=K′ 0.25=S1 0.25=KA1 0.25=DR1 0.25=H1′ 0.25=KA1′ 0.25=S1′ 0.25	0.88
	L23	b2	1.28	0.92	0.92	0.92	K 0.92=SA 0.92=S 0.92=KA′ 0.92=DR′ 0.92=H′ 0.92=S′ 0.92	K 0.2=SA 0.2=S 0.2=KA′ 0.2=DR′ 0.2=H′ 0.2=S′ 0.2	0.78
	L4	b3	1.18	0.92	0.74	0.96	H1 1.48>DR 0.99>BR2 0.74=W2 0.74>K1 0.63	H1 1.08	0.73
	L36	b3	1.31	1.09	0.88	1.14	H1 2.4>K1 1.05=S1 1.05=W1 1.05=LA1 1.05>LR 1.01>BR3 0.88=ST3 0.88=BR2 0.88=ST2 0.88=S2 0.88	H1 0.79	0.82

Table A2. *Cont.*

General			Mean Integration					Highest Control Value	Relative Different Factor (H*)
Basic Functional Space Type	Code	Plan Type	Plan	Functional Space	Basic Space	Other Space	Functional Space	Functional Space	
*	L29	c2	1.28	0.92	0.92	0.92	S 0.92=LR 0.92=KA1 0.92=DR1 0.92=H1 0.92=MU1 0.92	S 0.2=LR 0.2=KA1 0.2=DR1 0.2=H1 0.2=MU1 0.2	0.65
	L1	b2	1.18	0.93	0.95	0.93	W′ 0.95=KA′ 0.95=S′ 0.95=DR′ 0.95=H′ 0.95>K 0.88=S 0.88	K 0.25=S 0.25	0.78
Special			Mean Integration					Highest Control Value	Relative Different Factor (H*)
Basic functional space type	Code	Plan type	Plan	Functional space	Basic space	Other space	Functional space	Functional space	
α + β	B9	c2	1.46	1.11	1.19	0.99	K(c,h) 1.48>KA 1.27>H 0.99=W 0.99>KA′ 0.81	K(c,h) 1.17	0.48

Plan mean integration is the average integration value of all the spaces in the plan. Functional space mean integration is the average value of every functional space, excluding rooms that accommodate functional spaces. The basic value is the mean integration of all the spaces that comprise the basic functional space type. Other space mean integration is the average value of functional space without those makeup basic type. Underline represents the functional space form the basic functional space.

References

1. Katriina, S.; Inger, B. Exploring the scientific discourse on cultural sustainability. *Geoforum* **2014**, *51*, 213–223. [CrossRef]
2. Axelsson, R.; Angelstam, P.; Degerman, E.; Teitelbaum, S.; Andersson, K.; Elbakidze, M.; Drotz, M.K. Social and cultural sustainability: Criteria, indicators, verifier variables for measurement and maps for visualization to support planning. *Ambio* **2013**, *42*, 215–228. [CrossRef]
3. Marcel, V. Encyclopedia of vernacular architecture of the world. *Bijdr. Tot Taal Land Volkenkd.* **2001**, *157*, 442–446.
4. Pardo, J.M.F. Challenges and Current Research Trends for Vernacular Architecture in a Global World: A Literature Review. *Buildings* **2023**, *13*, 162. [CrossRef]
5. Oliver, P. *Built to Meet Needs: Cultural Issues in Vernacular Architecture*; Elsevier Ltd.: Amsterdam, The Netherlands, 2007; ISBN 9780750666572.
6. Oliver, P. *Dwellings: The Vernacular House Worldwide*; University of Texas Press: Austin, TX, USA, 1987; ISBN 0292715552.
7. Zhou, T.G.; Duan, W.Q.; Mu, J.; Zhao, X.P.; Du, G.C. Statistical analysis and survey on the aseismatic performance of the raw-soil Building Status in China's rural areas. *J. Xi'an Univ. Archit. Technol. Nat. Sci. Ed.* **2013**, *45*, 487–492. [CrossRef]
8. The Forth Agricultural Census Data. Available online: http://www.stats.gov.cn/sj/pcsj/ (accessed on 5 June 2023).
9. Amos, R. *House Form and Culture*; Prentice-Hall: Englewood Cliffs, NJ, USA, 1969; ISBN 970133956733.
10. Oupu, J. The past and current situation of China's raw earth architecture. *Archit. Knowl.* **1982**, *1*, 2–7.
11. The Yellow River Basin. Available online: http://www.yrcc.gov.cn/hhyl/lydt/ (accessed on 5 June 2023).
12. Fuchu, J.; Shubing, W.; Jianli, F.; Hao, Y. On Study of Lacustrine Formation and its Meaning in the Togtoh platform, Inner Mongolia. *Quat. Sci.* **2012**, *32*, 931–937.
13. Yiya, W.; Fuyao, S. Urban Geography Research on Baotou City. *Geogr. J.* **1937**, *1*, 1–27.
14. Inner Mongolia Architectural History Editorial Committee. *Inner Mongolia Ancient Architecture*; Cultural Relics Publishing House: Beijing, China, 1959.
15. Dang, Y. The History of Architectural Technology from Neolithic Age to Bronze Age in Inner Mongolia. Ph.D. Thesis, Inner Mongolia Normal University, Hohhot, China, 2016.
16. Tianyi, W. The Archaeological Study of Prehistoric House Sites in the Loess Plateau Region. Ph.D. Thesis, Northwest University, Xi'an, China, 2020.
17. Wang, M. *The Choice of Nomads: Facing the Northern Asian Nomadic Tribes of the Han Empire*; Lianjing Publishing House: Taipei, Taiwan, 2009; ISBN 9789860170054.
18. Suiyuan Tongzhi Hall (Ed.) *Suiyuan Tongzhi*; Inner Mongolia People's Publishing House: Hohhot, China, 2007; Volume 50, pp. 17–25.
19. Suiyuan Tongzhi Hall (Ed.) *Suiyuan Tongzhi*; Inner Mongolia People's Publishing House: Hohhot, China, 2007; Volume 51, pp. 157–160.
20. Jianfei, Z. Some Topics in Contemporary Western Architectural Space Research. *Archit. J.* **1996**, *10*, 42–45.
21. Dunzhen, L. *Overview of Folk Houses in China*; China Architecture & Building Press: Beijing, China, 1957.
22. Zhihua, C. Present State of the Native Buildings of China—An Interview with Chen Zhihua. *China Anc. City* **2010**, *4*, 53–56.
23. Xiaofeng, L. Analysis and Rethink of the Mode of Preservation and Renewal of Vernacular Building. *Archit. J.* **2005**, *7*, 8–10.
24. The Japanese Society of Life Science (Ed.) *Housing and Local Communities*; Domesu Publisher: Tokyo, Japan, 1978.

25. Hillier, B.; Julienne, H. Ideas are in things: Applying the space syntax method to discovering house genotypes. *Environ. Plan. B Plan. Des.* **1987**, *14*, 363–385. [CrossRef]
26. Seo, K.W.; Mimi, Z.A.G.; Yazid, S. Relocating home activities: Spatial experiments in Malaysian apartment houses to accommodate the vernacular lifestyle. *J. Asian Archit. Build. Eng.* **2022**, *21*, 311–325. [CrossRef]
27. Seo, K.W. Space puzzle in a concrete box: Finding design competence that generates the modern apartment houses in Seoul. *Environ. Plan. B Urban Anal. City Sci.* **2007**, *34*, 1071–1084. [CrossRef]
28. Chen, Y.; Xu, K.; Liu, P.; Jiang, R.; Qiu, J.; Ding, K.; Fukuda, H. Space as a sociocultural construct: Reinterpreting the traditional residences in jinqu basin, China from the perspective of space syntax. *Sustainability* **2021**, *13*, 9004. [CrossRef]
29. Huang, B.X.; Chiou, S.C.; Li, W.Y. Study on courtyard residence and cultural sustainability: Reading Chinese traditional Siheyuan through Space Syntax. *Sustainability* **2019**, *11*, 1582. [CrossRef]
30. Xingkang, C.K.; Ruyu, J.; Yu, C. Quantitative Comparison of Space Syntax in Regional Characteristics of Rural Architecture: A Study of Traditional Rural Houses in Jinhua and Quzhou, China. *Buildings* **2023**, *13*, 1507. [CrossRef]
31. Toshihiro, H.C.; Masahiko, S.M.; Yamazaki, S.; Ito, S.; Sasaki, M.; Watari, K.; Uekita, Y. The Transition of Japanese Multi-Family Dwellings Using Space Syntax Analysis-Transition from the Private room aggregation Type to the Living room centered Type. *J. Hous. Res. Found.* **2007**, *34*, 173–184.
32. Zhang, X.; Cui, T. Evolution Process of Scientific Space: Spatial Analysis of Three Groups of Laboratories in History (16th–20th Century). *Buildings* **2022**, *12*, 1909. [CrossRef]
33. Arslan, A.; Uraz, T.U. Small House Spatiality: A Comparative Space Syntax Application. *Open House Int.* **2017**, *42*, 58–67. [CrossRef]
34. Inner Mongolia Library. *Zhao Wangyun's Sketchbook on Saishang Chasui Simon's Sketchbook*; Inner Mongolia Yuanfang Publishing House: Hohhot, China, 2013; ISBN 9787555500339.
35. Yamada, T. *Mongolian Rural Village*; Kinjo Publish Company: Osaka, Japan, 1943.
36. Pengju, Z. *Ancient Architecture of Inner Mongolia*; China Architecture & Building Press: Beijing, China, 2016; ISBN 9787112181759.
37. Rengui, M. Research on the Evolution of Residence of Han Nationality in Hetao Region in Inner Mongolia under the Background of Migration. Master's Thesis, Hua Qiao University, Xiamen, China, 2018.
38. Yushu, L.; Ling, Z. From Nomadicity to Sedentariness: Spatial and Social Changes in Vernacular Dwellings in Alxa League, Inner Mongolia. *Archit. J.* **2020**, *6*, 34–39. [CrossRef]
39. Guo, J. The Study on the Spatial Characteristics of Courtyard Houses in Midwest Area of Inner Mongolia. Master's Thesis, Dalian University of Technology, Dalian, China, 2018.
40. Songjing, Y. Study on the Earth Dwellings in the Yellow River Basin of Inner Mongolia. Master's Thesis, Inner Mongolia University of Science and Technology, Hohhot, China, 2019.
41. Wang, V.; Yangya, X. Study on the Constituent Elements and Space Regeneration Strategy of the Adobe Dwellings—A Case of the Traditional Dwellings in Meidaiqiao Village. *Urban. Archit.* **2020**, *35*, 139–141. [CrossRef]
42. Xuebin, Z.; Pengtao, L. Research on Architectural Space Forms of Raw Soil Residential Buildings of Guanglian Village in Wuyuan County, Bayannur City, Inner Mongolia. *Urban Archit. Space* **2022**, *1*, 68–71.
43. Hongwei, Y.; Lipeng, T.; Feng, P. Research on Architectural Form Characteristic of Raw Soil Residential Building in Liangcheng County, Ulanqab City, Inner Mongolia: Taking Guanniuju Village as an Example. *Urban. Archit.* **2023**, *30*, 90–92.
44. Hillier, B.; Julienne, H. *The Social Logic of Space*; Press Syndicate of the University of Cambridge: Cambridge, UK, 1984; ISBN 9780511597237.
45. Manum, B.; Rusten, E.; Benze, P. AGRAPH, Software for Drawing and Calculating Space Syntax Graphs, presented at the 5. Space Syntax Symposium, Delft, June 2005. Available online: https://www.ntnu.no/ad/spacesyntax/ (accessed on 26 August 2023).
46. Mustafa, F.A.; Hassan, A.S.; Baper, S.Y. Using space syntax analysis in detecting privacy: A comparative study of traditional and modern house layouts in Erbil city, Iraq. *Asian Soc. Sci.* **2010**, *6*, 157. [CrossRef]
47. Michael, J.O.; Michael, J.D. *The Mathematics of the Modernist Villa: Architectural Analysis Using Space Syntax and Isovists*; Kim, W., Ed.; Kim Williams Books: Torino, Italy, 2018; ISBN 978-3-319-71645-9.