International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 3821-3835

https://doi.org/10.70517/ijhsa464504a

Research on the Protection of Cultural Heritage of Folk Houses and Architecture and the Improvement of Living Environment Based on Sustainable Development

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Abstract The accelerated development of urbanization has caused residential buildings with high historical and cultural value in suburban and remote areas of cities to face the problem of being "renewed" by modernization and urbanization. In order to realize the sustainable development of the protection of residential architectural cultural heritage, this paper chooses GS province as the study area, and analyzes the spatial distribution characteristics and balance of the residential architectural cultural heritage through the nearest-neighbor index, the grid dimension model and the imbalance index. The factors affecting the spatial distribution of residential and architectural cultural heritage were also investigated by means of geographic probes. The average nearest-neighbor ratio of residential and architectural cultural heritage in GS province is 0.781, and the Z score is -2.316<0, which indicates that its spatial distribution is mainly in the form of overall agglomeration and local disaggregation. The difference between the capacity and information dimension of different types of residential and architectural cultural heritage ranges from 0.206 to 0.327, and the spatial distribution of residential and architectural cultural heritage is mainly affected by natural geography, history and culture, and road traffic factors. Based on the spatial distribution characteristics of the residential architectural cultural heritage, a framework for the revitalization and utilization of residential architectural cultural heritage in a hierarchical manner and a protection and utilization pattern are proposed, and the spatial function of the architectural pattern is refined with the concept of sustainable development, and a method for the sustainability optimization of the living environment is designed. The protection of residential architectural cultural heritage and the improvement of the living environment need to be adapted to the local conditions, and the appropriate amount of development on the basis of preserving the originality of cultural heritage can provide new opportunities for the revitalization and inheritance of residential architectural cultural heritage.

Index Terms residential architecture, cultural heritage, living environment, nearest neighbor index, geodetector, sustainable development

I. Introduction

Cultural heritage is the valuable wealth of a country, a nation or even the whole mankind, and residential architecture is the valuable cultural heritage of the Chinese nation and an important part of the Chinese civilization, which is not only a form of architecture, but also represents history, culture and values [1]-[4]. However, due to the passage of time, natural disasters and human destruction, many residential buildings are facing the disappearance of cultural heritage. Residential buildings carry specific cultural spirits and reflect the values and lifestyles of local people [5]-[7]. By preserving and restoring residential buildings, these cultural spirits can be inherited and carried forward so that they can be revitalized in the modern society [8], [9].

The measures that should be taken to protect and improve the cultural heritage of residential buildings mainly include strengthening publicity and education, strengthening the formulation and implementation of relevant laws and regulations, strengthening the scientific repair of traditional residential buildings, strengthening the maintenance and management of traditional residential buildings, and strengthening the adaptive use of traditional residential buildings [10]-[13]. However, the protection of residential architectural cultural heritage and improve its living environment is not an easy task, at present, this is still a difficult and important task of the times, only by strengthening the regulations and management and maintenance measures are far from enough [14]-[16], more need to be the joint efforts of members of the whole society, only then to ensure that the residential architectural culture is effectively protected and inherited, so that this valuable cultural heritage This is the only way to ensure the effective protection and inheritance of the culture of residential architecture, so that this valuable cultural heritage continues to flourish [17]-[19].

The article innovatively researches the spatial distribution characteristics of the cultural heritage of residential buildings, and proposes specific strategies for the protection of the cultural heritage of residential buildings and the improvement of the living environment based on the influencing factors. Residential buildings are the main places for villagers' production and public activities, displaying the residents' customs, recording the bits and pieces of village public life, and carrying the historical culture and emotional memory of the village. Taking GS province as the research object, this paper explores the spatial distribution characteristics of the residential architectural cultural heritage through the nearest neighbor index, and analyzes the spatial distribution equilibrium of the residential architectural cultural heritage by using the imbalance index and the lattice dimension model. The influencing factors of the spatial distribution of residential architectural cultural heritage were also investigated by combining the geodetector model. Based on the spatial distribution characteristics of the residential architectural cultural heritage, strategies for the protection of the residential architectural cultural heritage and the improvement of the living environment were designed.

II. Data sources and study area overview

As an important part of the human habitat environment, the architectural cultural heritage of residential buildings is a projection of the relationship between people and land in traditional Chinese society in physical space, and carries and embodies the traditional civilization of the Chinese nation. However, with the rapid progress of industrialization, urbanization and agricultural modernization, a large number of residential architectural cultural heritages have been damaged and are on the verge of extinction. In today's rapid economic and technological development, how to realize the sustainable development and protection of residential architectural cultural heritage, and better enhance the living environment of residential architecture has become an urgent problem to be solved, and it also helps to innovate the mode of revitalization, utilization and inheritance of residential architectural cultural heritage.

II. A.Data sources and study area overview

II. A. 1) Overview of the study area

GS Province is located in the northwest of China, between latitude 32°32′-42°58′N and longitude 92°14′-108°45′E, bordering SX, QH, XJ, etc. The overall topography is high in the northwest and low in the southeast, with a length of about 1,660 kilometers from east to west, and a width of 532 kilometers from north to south, with a total area of 453,800 square kilometers, which is 4.73% of the country's land area. As of 2023, the province has a resident population of 25.687 million, with 12 prefectural-level cities and 2 autonomous prefectures under its jurisdiction.GS has a unique geographic location in the center of China, located in the upper reaches of the Yellow River, centrally located, and at the same time situated in the three natural regions of China, the diversity of geographic features determines the differences in the architectural cultural heritage of the dwellings of the different regions of the GS province.

II. A. 2) Data sources

The research sample of this paper comes from the list of the first five batches of national-level residential architectural cultural heritage published by China's Ministry of Housing and Urban-Rural Development, and the census list of provincial-level typical residential architectural cultural heritage with historical protection value screened by GS Province in 2015, totaling 305 residential architectural cultural heritage. Among them, national-level residential architectural cultural heritages are villages with important conservation value, as recognized by the Expert Committee on the Protection and Development of Residential Architectural Cultural Heritage, including residential architectural cultural heritages announced in different batches.

The census list of GS Province's residential architectural cultural heritage is traditional villages with traditional residential buildings with large geographical differences in morphology and with regional or ethnic characteristics, including the Hexi Region, Longzhong Region, Longdong Region, Ethnic Region, and Longdong South Region. The coordinates of residential architectural cultural heritage were obtained through the coordinate picker of Gaode map, and the spatial basic database of residential architectural cultural heritage in GS province was constructed by using ArcGIS software. The digital elevation model (DEM) is ASTER GDEM global digital elevation data, which comes from the geospatial data cloud platform. The river data are from the National Center for Basic Geographic Information, and the population, economic, and road network data are from the statistical yearbook published by the GS Provincial Bureau of Statistics and the data of the National Economic and Social Development Statistical Bulletin of each city.

II. B.Selection of methodology for analyzing research data

The closest neighbor index in ArcGIS software is applied to discriminate, and then the imbalance index and the grid dimension model are used to judge the degree of balance in the distribution of the residential architectural cultural

heritage of GS province. Based on the overall to local spatial distribution characteristics of the residential and architectural cultural heritage of GS province, the index system of influencing factors is established by quantifying the influencing factors, and the degree of influence of the factors is analyzed by using the geodetector model as a way to analyze the correlation between the spatial distribution characteristics of the residential and architectural cultural heritage and each influencing factor.

II. B. 1) Nearest Neighbor Index

Mean Nearest Neighbor Index analysis was performed using the Mean Nearest Neighbor tool in ArcGIS software, which is used by the Mean Nearest Neighbor algorithm to compute the mean distance between each element and its nearest neighboring elements, which is then compared to the mean distance of a random distribution [20]. If the average distance between nearest neighbor elements is greater than the average distance of the random distribution, the pattern of element distribution is considered to tend towards diffusion. If the average distance between the nearest neighbor elements is smaller than the average distance of the random distribution, it is considered that the pattern of element distribution tends to aggregate. The formula is as follows:

$$ANN = \frac{D_0}{D_E} = \frac{\frac{1}{n}\sum_{i=1}^{n} d_i}{0.5^{*}\sqrt{\frac{A}{n}}} \tag{1}$$

where D_0 is the average distance between each element and its nearest neighbor, D_E is the expected average distance between elements in the stochastic model, d_i is the distance between an element and its nearest neighbor, and A is the area of the smallest outer polygon or the area of the study area for all elements.

II. B. 2) Grid Dimensional Modeling

The grid dimension model is used to represent the complexity of the spatial distribution of residential and architectural cultural heritage. In the networked analysis of the whole space, the number of network grids N(r) occupied by the residential and architectural cultural heritage will change with the change of the network scale r, and if the residential and architectural cultural heritage is scale-free, the relationship between the two satisfies the following equation:

$$N(r) \propto r^{-a} \tag{2}$$

where $a = D_0$ refers to the capacity dimension. In a network with row and column numbers i and j, where the number of residential built cultural heritage distributions is assumed to be N_{ij}, the total number is N, and the probability P_{ij} is the quotient of N_{ij} and N, Eq:

$$I(r) = -\sum_{i}^{k}\sum_{j}^{k} P_{ij}(r)\ln P_{ij}(r) \tag{3}$$

where, $k = 1/r$, refers to the number of segments on each side of the space, and the unit of the side length is 1. If the spatial distribution of residential architectural cultural heritage is in fractal form, there is:

$$I(r) = I_0 - D_1 \ln r \tag{4}$$

where I_0 is a constant and D_1 refers to the information dimension.

Generally speaking, the larger the values of $0 \le D \le 2$ and D are, the more balanced the spatial distribution of residential and architectural cultural heritage is. When $D = 0$, all the residential and architectural cultural heritage is concentrated in one point, when $D = 2$, it is uniformly distributed, when D is close to 1, there is a tendency to gather the distribution on a certain line, and when $D_1 = D_0$, it is distributed with medium probability in the spatial network.

II. B. 3) Imbalance index

The imbalance index is an important index to measure whether the distribution of the research objectives is balanced or not. The study of the distributional balance of residential architectural cultural heritage is calculated using the formula of the Lorentz Curve Equilibrium Index [21]. Namely:

$$S = \frac{\sum_{i=1}^{n} Y_i - 50(n+1)}{100n - 50(n+1)} \tag{5}$$

where n is the total number of municipalities in GS province, Y_i is the cumulative ratio of the proportion of built heritage in each municipality in each region in descending order to i. The value of S ranges from 0 to 1. When $S = 0$, it indicates that the residential and architectural cultural heritage is evenly distributed in each municipality, and when $S = 1$, it indicates that all residential and architectural cultural heritage is concentrated in one municipality. In general, a larger value of S indicates a less balanced distribution of residential and architectural cultural heritage.

II. B. 4) Geo-detectors

Geodetector reveals the driving force behind the spatial differentiation by detecting the spatial differentiation, which consists of four parts: factor detection, interaction detection, risk area detection and ecological detection. Among the influencing factors of the spatial distribution of residential architectural cultural heritage, its influencing factors involve many aspects, and in this study, we choose the factor detection and interaction detection model to analyze the influencing factors of the spatial distribution of residential architectural cultural heritage [22].

(1) Factor detection. Factor detection is mainly through the comparison of a factor in a specific region and the spatial changes of geographic things whether there is consistency, if there is consistency, it means that this factor has influence on the changes of geographic things, the size of the degree of influence is usually expressed by q value. That is:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} \tag{6}$$

In the formula, the value of q indicates the degree of influence of the influence factor on the spatial differentiation of the residential and architectural cultural heritage, and the range of the value is [0,1], and the larger the value of q indicates that the influence of the factor on the spatial differentiation of the residential and architectural cultural heritage is larger, and vice versa, the smaller it is. L is the number of samples of the influencing factors, N_h and N are the number of units in district h and the whole district, σ_h^2 and σ^2 are the variance of the residential and architectural cultural heritage in district h and the whole district.

(2) Interaction detection. It is used to analyze whether there is an effect on the dependent variable when two factors are superimposed, and if there is an effect, whether the intensity of the effect is weakened or strengthened compared to a single factor. There are five forms of interaction results, as follows:

When the interaction force is less than the minimum of any of the two factors, it is nonlinearly attenuated.

When the interaction force is between the minimum and maximum values of the two factors, it is nonlinearly attenuated by a single factor.

When the interaction force is greater than the maximum value of either of the two factors, there is a two-factor enhancement.

When the interaction force is equal to the one-factor force of each of the two factors, it is independent.

Nonlinearly enhanced when the interaction force is greater than the sum of the one-factor forces of each of the two factors.

III. Characteristics of the spatial distribution of residential buildings and influencing factors

The protection of residential architectural cultural heritage is not a comprehensive “museum” type of protection, but to promote development in protection and protection in development. Analyzing the spatial distribution of residential architectural cultural heritage and the factors affecting it will help to analyze specific problems in the process of protecting residential architectural cultural heritage and provide a basis for the protection and development of residential architectural cultural heritage. The protection of residential architectural cultural heritage requires the concerted efforts of all sectors of society, not only the support of the government, but also the research of the academic community, and more importantly, it requires the participation of the general public, and multi-party cooperation, to promote the protection and development of residential architectural cultural heritage and to promote the preservation and inheritance of traditional culture.

III. A. Characteristics of spatial distribution of residential buildings

III. A. 1) Spatial distribution characteristics

Based on the selected data in the study area, the average nearest neighbor tool of ArcGIS software was used to calculate the average nearest neighbor summary of the residential architectural cultural heritage in different regions of GS Province as shown in Figure 1, and the spatial distribution types of residential architectural cultural heritage as shown in Table 1. In the table, AOD and EAD represent the average observed distance and expected average distance, respectively.

From the provincial scale, the average observed distance of 305 residential and architectural cultural heritages in GS province is 12.73km, and the predicted average distance is 15.06km, the nearest-neighbor ratio is R=0.781<1, and the P-value is 0.001, which passes the test of significance. The Z-score is -2.316 (to test the statistical significance of the spatial autocorrelation analysis, Z>0 means dispersion, and Z<0 means agglomeration), which shows that the average distribution type of residential and architectural cultural heritage is as follows. It indicates that the overall distribution of residential architectural cultural heritage in GS province is agglomerative. From a city perspective, the average observation distance of Jinchang, Wuwei, Baiyin, Qingyang, Tianshui, Longnan and Gannan Tibetan Autonomous Prefecture is larger than the expected average observation distance, and the nearest-neighbor ratio is larger than 1, which suggests that the distribution of residential architectural cultural heritage in the above regions in GS Province is discrete. In Jiuquan, Jiayuguan, Zhangye, Lanzhou, Dingxi, Pingliang and Linxia Hui Autonomous Prefecture, the average observation distance is smaller than the expected average observation distance, and the nearest-neighbor ratio is less than 1, which indicates that the cultural heritage of dwellings and buildings in the above mentioned areas is distributed in a clustered manner. In conclusion, the spatial distribution of the residential architectural cultural heritage in GS province is characterized by overall agglomeration and local dispersion.

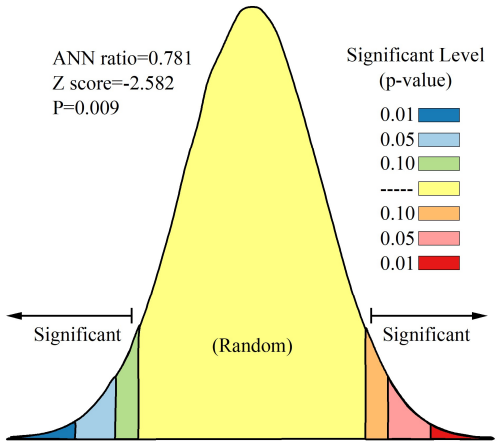


Figure 1: Average recent neighborhood summary

Table 1: Type of residential space distribution

Region	AOD (km)	EAD (km)	Z score	ANN	Distribution type
GS province	12.73	15.06	-2.316	0.781	Agglomeration
Jiuquan	8.52	10.94	-0.003	0.832	Agglomeration
Jiayuguan	6.04	7.85	-0.001	1.514	Agglomeration
Zhangye	6.37	7.32	-0.024	0.238	Agglomeration
Jinchang	8.94	7.53	0.035	1.503	Discrete
Wuwei	7.65	6.43	1.017	1.427	Discrete
Lanzhou	2.41	4.67	-0.016	0.514	Agglomeration
Baiyin	7.18	6.81	0.025	1.013	Discrete
Dingxi	5.06	5.42	-0.001	0.215	Agglomeration
Qingyang	6.32	5.75	0.014	1.328	Discrete
Pingliang	3.64	4.46	-0.057	0.506	Agglomeration
Tianshui	4.48	4.31	0.011	1.015	Discrete
Longnan	5.56	4.93	0.027	1.239	Discrete
Linxia	9.07	9.78	-0.029	0.327	Agglomeration
Gannan	10.29	9.54	0.036	1.358	Discrete

III. A. 2) Balanced spatial distribution

Based on the spatial distribution types in the previous section, this section utilizes the imbalance index to analyze the cumulative percentage of residential architecture within each municipality after sorting its weight in the overall region. Figure 2 shows the Lorenz curve of the distribution space of the cultural heritage of residential buildings in GS province. According to the Lorenz curve of the distribution space of residential architectural cultural heritage, it can be seen that the overall curvature of the curve is larger, which to a certain extent explains the imbalance of the spatial distribution of residential architectural cultural heritage in the municipal area of GS province. And the residential architectural cultural heritage in the municipal area is mainly distributed in the cities and states of Qingyang, Longnan, Gannan, Tianshui, Pingliang and Wuwei, whose total residential architectural cultural heritage has reached 77.71% of the total in the province. The total number of residential architectural cultural heritage of Jiayuguan and Jinchang is less than 1.5%. This fully demonstrates that regions where ethnic minorities are concentrated are more likely to produce residential architectural cultural heritage, which is relatively preserved in terms of ethnic cultural characteristics and has a relatively more suitable living environment with a deep ethnic cultural heritage, thus creating residential architectural cultural heritage.

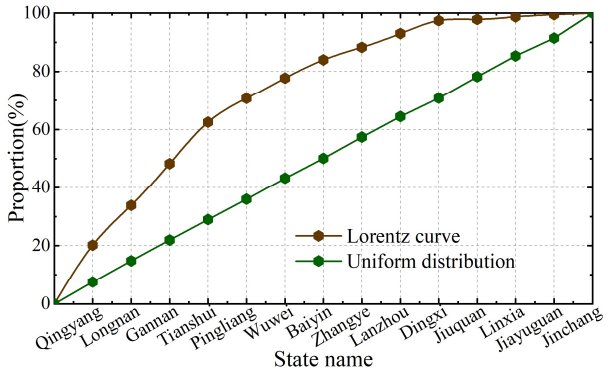
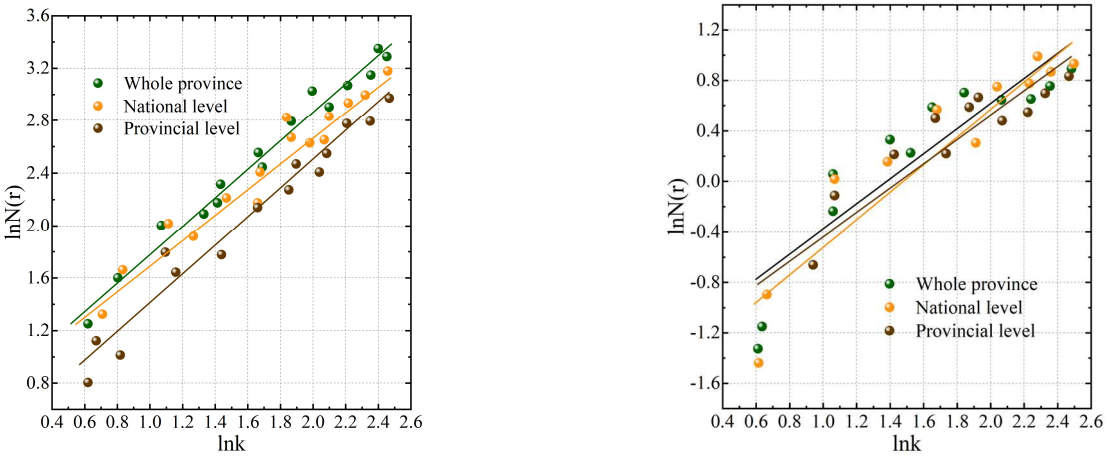


Figure 2: The Lorentz curve of the spatial distribution of residential buildings

In addition, this paper also verifies the balanced characteristics of the distribution of residential architectural cultural heritage in the province, the national level and the provincial level in terms of capacity and information dimensions using the grid dimension model. Figure 3 shows the double logarithmic scatter plot of the lattice dimension of residential architectural cultural heritage, in which Figures 3(a)~(b) show the distribution of the capacity and information dimensions, respectively.



(a) Capacity dimension (b) Information dimension

Figure 3: Grid-dimension double logarithmic scatter plot

At the municipal and state scales, the spatial distribution of the national, provincial and provincial residential architectural cultural heritage conforms to the mathematical significance of the fractal dimension, i.e., there are more significant scale-free zones, which indicates that the distribution of residential architectural cultural heritage is more obvious in terms of its fractal characteristics. Whether it is the province's residential architectural cultural heritage, or the national or provincial level, its capacity and information dimension are not equal, and the difference is between 0.206 and 0.327. This indicates that the fractal characteristics of the residential architectural cultural heritage of GS province are more complicated, among which the difference value is the largest and the fractal structure is the most complicated at the national level. Meanwhile, the capacity and information dimensions are both relatively close to 1, especially the capacity dimension, which indicates that the spatial distribution of the residential architectural cultural heritage is not only more concentrated, but also shows a trend of distribution along a certain geographic line.

III. B. Factors affecting the spatial distribution of residential buildings

The distribution of residential and architectural cultural heritage is affected by many factors, which need to be analyzed comprehensively in the light of regional characteristics, social demographics and history and culture. At present, a common tool for analyzing the influence factors of spatial distribution is the geographic detector, which can be used to explore the influence factors and formation mechanism of the spatial distribution characteristics of the residential architectural cultural heritage. Taking the kernel density index of residential architectural cultural heritage as the dependent variable, and the factors of water system, population and road as the independent variables, the index system of influencing factors on the spatial pattern of residential architectural cultural heritage is constructed from four aspects, namely, natural geography, social and demographic characteristics, history and culture, and road transportation, as shown in Table 2.

Table 2: The influence factors of the spatial pattern

Influencing factor	Index	Code
Natural geography	Elevation	N1
	Grade	N2
	River	N3
	Relief of relief	N4
Social population	Years	S1
	The number of residential buildings	S2
	Population condition	S3
Historical culture	Cultural enrichment	H1
	Unlicored project	H2
Road traffic	National distance	R1
	Channel distance	R2

III. B. 1) Physical and geographic influences

The site selection, layout and construction of the residential architectural cultural heritage in GS Province follow the basic principles of "Tibetan wind gathering, mountains and rivers, and self-reliance" emphasized by Feng Shui and Kanyu Theory, and the construction idea of "taking the mountain as the bone and the water as the source" highlights the importance of the natural environment to the derivation and distribution of the residential architectural cultural heritage. Based on the 35m resolution DEM data, the study area's elevation and slope information are extracted by using the surface analysis method of the spatial analysis module in ArcGIS software, and the elevation data are reclassified into five categories of valleys, low hills, high hills, low hills, and mid-hills based on geomorphological features, and the slope information is reclassified into five categories of flat, flat-slope, gently-sloping, moderately-sloping and steeply-sloping land. In addition, the topographic relief index can reflect the comprehensive geographic information of the target area such as elevation, slope, surface cutting degree, etc., which is an important geographic basis for the site selection and layout of the residential architectural cultural heritage, and the basic principle of the index extraction refers to the existing relevant research results. Based on the window analysis method, combined with the FOCAL function and map algebra operation to get the results of terrain undulation degree, and combined with the actual combination of this paper will be the geomorphological form according to the size of the degree of undulation is divided into four categories, namely, hilly plains, small undulating mountainous areas, medium undulating mountainous areas and large undulating mountainous areas. Table 3 shows the statistical results of the distribution of the cultural heritage of residential architecture under the influence of natural geography.

From the viewpoint of vertical natural environment elements, there are 139 residential architectural cultural heritages distributed in the basin area below 250m, accounting for 45.57%, with a density of 5.52/100km², which are mainly distributed in the east side of Longnan Basin and other low-altitude areas. The low-hill landscape with an altitude of 250~540m is the most extensive, and the number of residential architectural cultural heritages situated therein is more than half, with a density of 2.95/100km², concentrated in the valleys between the major mountain ranges such as Gannan and Qingyang. The number of residential architectural cultural heritages distributed in the terrain above 540m above sea level is only 9, accounting for 2.95%, and the density is only 1.24/100km². Under the element of slope, gentle slopes below 2.2° have the least area and the highest density, and the total number of residential architectural cultural heritage in the terrain area with slope below 5.2° is more than 50%, while the total number of residential architectural cultural heritage in the terrain area above 15.2° is 46, accounting for 15.08%, among which there are only 5 residential architectural cultural heritage distributed above 25.2°. From the point of view of the distribution of topographic relief, there are 129 residential architectural cultural heritages distributed in the hilly plains below 250m, 161 in the small relief mountainous areas, and only 15 residential architectural cultural heritages distributed in the middle relief mountainous areas and above. Considering the great difference in the area of each type of area, it can be found out from the analysis of the density angle, that the value of the density decreases from the area of small relief to the area of high value. It can be seen that the layout and location of residential architectural cultural heritage in GS Province are closely connected with the surrounding terrain, forming a compact and confined space of human environment, showing the vertical zonal distribution characteristics from the bottom to the top.

Horizontally, the number of residential architectural cultural heritage within 280m from the river is 153, accounting for 50.16%, with a density of 11.38/100km², and the number within 1000m is 208, accounting for 68.20%, with the high density occurring in the valleys and alluvial plains along the rivers such as the ancient waterway, Fuzi River, Zhangshui River, Dazhouyuan, etc., and the total number of residential architectural cultural heritage within 1500m accounts for 75.74% of the total. Through further neighborhood analysis, it is found that the distance from rivers in GS province is generally not more than 3500m, which is a significant feature of water-friendly and near-river distribution.

To sum up, the residential and architectural cultural heritage of GS Province is significantly influenced by topography, hydrology and other elements of the natural environment, which can be summarized as the law of zonal differentiation of “living along the basin and the water”.

Table 3: The distribution of cultural heritage of residential buildings

Factor	Level	Type	Area (km²)	Number	Density	Ratio
Elevation	H<250m	Basin	2517.48	139	5.52	45.57%
	250≤H<540m	Low hill	5324.69	157	2.95	51.48%
	540≤H<620m	High hill	631.74	6	0.95	1.97%
	620≤H<1000m	Low mountain	1052.38	3	0.29	0.98%
	H≥1000m	High mountain	232.43	0	-	-
Grade	0°<S≤2.2°	Gentle slope	432.15	57	13.19	18.69%
	2.2°<S≤5.2°	Slow slope	963.58	112	11.63	36.72%
	5.2°<S≤15.2°	Slope	2832.41	90	3.18	29.51%
	15.2°<S≤25.2°	Steep slope	3106.59	41	1.32	13.44%
	S>25.2°	Urgency slope	2423.99	5	0.21	1.64%
River	0<D≤280m	-	1345.24	153	11.38	50.16%
	280<D≤520m	-	841.38	31	3.69	10.16%
	520<D≤720m	-	800.51	12	1.51	3.93%
	720<D≤1000m	-	1123.36	12	1.07	3.93%
	1000<D≤1500m	-	1814.47	23	1.27	7.54%
	D>1500m	-	3833.76	74	1.93	24.26%
Relief of relief	0<R≤250m	Hill flat	1964.51	129	6.57	42.30%
	250<R≤550m	Small and fluctuating mountains	5069.54	161	3.18	52.79%
	550<R≤1000m	Middle and fluctuating mountains	2631.83	15	0.57	4.92%
	R>1000m	Big and rugged mountains	92.84	0	-	-

III. B. 2) Historical and cultural influences

The formation of the residential architectural cultural heritage of GS Province has gone through four main stages of development, each of which exhibits different characteristics. At the same time, GS Province experienced three types of population migration, firstly, the migration of migrants from the south of the Central Plains, secondly, the

migration of eunuchs and scholars followed by their families, and thirdly, the localization of internal settlements. The three large-scale southward migrations and uncountable localized migrations changed the ratio of the population composition of GS Province, which gradually became the main body of GS Province residents. The promotion of an intact clan structure and advanced culture became the spiritual backbone of the cohesion of the ancestors in GS Province.

Along with the growth of population, the saturation of the gathering place is not enough to satisfy the survival and development of the people of GS Province, and the first task of the people of GS Province is to neutralize the overpopulation and open up the gathering place to satisfy the survival and development. The continuous establishment of branches of clan shrines and the marriage of the local and foreign populations have largely solved the problem of where the population is going to be separated from the population, and many new residential buildings have been born as a result of the migration of the people from the vast GS province to the nearby areas. Along with this pattern of migration, new settlements would expand in size and begin to move to another new gathering point. In this series of processes, clan power played an extremely important role, and the various villages and settlements in GS Province were intertwined and connected with each other. With the passage of time, the change of time and the evolution of society, the geographical layout of the cultural heritage of GS province's residential architecture has become more and more stable.

III. B. 3) Socio-demographic influences

Population is the basis for the development of residential architecture, and the larger-scale residential architectural villages are also the areas where the population gathers, and the level of regional economic development also has a certain relationship with the distribution of residential architectural cultural heritage. Table 4 shows the statistical results of population density and GDP per capita in the areas where the cultural heritage of residential architecture is located in GS Province.

89.51% of the residential architectural cultural heritage in GS province is distributed in sparse areas with a population density of 220 people/km², with Gannan Prefecture, Zhangye City, Longnan City and Baiyin City having the largest number. It can be seen that areas with large population bases and dense populations do not necessarily produce a greater number of residential architectural cultural heritage, probably due to the long-time closed environment, unified religious beliefs and group ideologies such as blood relations in clan settlements in the Gannan region, which have gradually formed aggregated residential architectural clusters. The population density in the mountainous area of Longnan is medium, but confined to the small amount of arable land utilized on a large scale and the closed transportation, most of the residential building communities are distributed in a band or point-like manner on both sides of the river valleys with strong cohesion, and such an environment of population aggregation and closed living conditions is also conducive to the formation and development of the residential architectural cultural heritage. In terms of economic conditions, 74.1% of the residential architectural cultural heritage in GS Province is distributed in areas with a per capita GDP of less than 48,000 yuan, which are also traditional farming areas with a lagging level of industrial and service development. The lagging level of economic development has slowed down the urbanization process and infrastructure development in the region, which is less impacted by modern civilization, creating conditions for the preservation and continuation of the residential architectural cultural heritage.

Table 4: Population density and GDP per capita

Population density (Per/km²)	Number	Ratio	GDP per capita (yuan)	Number	Ratio
0~60	103	33.77%	0~12000	3	4.26%
60~120	56	18.36%	12000~24000	46	21.64%
120~160	79	25.90%	24000~36000	37	16.07%
160~220	35	11.48%	36000~48000	68	32.13%
220~320	23	7.54%	48000~60000	25	14.75%
>320	9	2.95%	>60000	14	11.15%

III. B. 4) Road traffic influencing factors

Transportation is the link between residential architectural communities and the outside world, and it also affects the protection and development of residential architectural cultural heritage. Based on the elevation data of GS province, ArcGIS software was used to count its transportation roads, and the statistical results of highway mileage and highway density were obtained as shown in Table 5.

From the table, it can be seen that the distribution of residential and architectural cultural heritage is less in the areas with highway density, and the distribution of residential and architectural cultural heritage is more intensive in

the areas with low highway density, but there are some areas with low highway density where the residential and architectural cultural heritage is less. It seems that the convenience of transportation may be related to the distribution of residential architectural cultural heritage, and regions with developed transportation have close contact with the outside world, faster economic development, and are influenced by foreign cultures, which may bring impacts on the production and life of residential architectural communities, which is not conducive to the preservation and continuation of residential architectural cultural heritage, and thus the number of residential architectural cultural heritage decreases.

Table 5: Statistical results of road mileage and road density

Name	Mileage (km)	Mileage (km)		Population (*10000)	Highway density	Number
		Province	country			
Jiuquan	801.42	89.45	711.97	107.51	7.45	4
Jiayuguan	2648.61	196.53	2452.08	89.42	29.62	2
Zhangye	3065.34	138.42	2926.92	69.95	43.82	14
Jinchang	1425.06	206.54	1218.52	77.89	18.30	1
Wuwei	1563.48	176.61	1386.87	30.42	51.40	19
Lanzhou	1325.41	203.57	1121.84	35.65	37.18	13
Baiyin	1154.38	189.51	964.87	21.64	53.34	17
Dingxi	3521.64	172.26	3349.38	40.76	86.40	11
Qingyang	4325.48	183.94	4141.54	33.83	127.86	58
Pingliang	4415.34	176.53	4238.81	22.42	196.94	41
Tianshui	1534.79	188.84	1345.95	18.54	82.78	29
Longnan	3895.61	262.53	3633.08	111.63	34.90	52
Linxia	6281.48	395.79	5885.69	83.27	75.44	13
Gannan	3546.42	236.85	3309.57	53.49	66.30	31

III. B. 5) Multifactor intensity detection

Based on the index system of influencing factors on the spatial pattern of the cultural heritage of residential architecture established in the previous paper, this paper utilizes ArcGIS software to transform the numerical type indexes such as river, elevation, slope and so on before importing them into geo-detector for analysis. Table 6 shows the detection results of the influencing factors of the spatial pattern of residential architectural cultural heritage. The bold italics in the table indicate the q-value under the effect of a single factor, and the others indicate the q-value under the interaction of two factors, and * and ** indicate the two-factor nonlinear synergy and indicate the two-factor double synergy, respectively.

As can be seen from the table, the factor with the greatest degree of relevance to the distribution of cultural heritage of residential buildings is the distance from residential buildings to rivers (N3) in the natural geography factor, followed by the distance from provincial highways (R2) in the road transportation factor, then the degree of cultural relics richness (H1) in the history and culture factor, and the weakest influence is the chronological factor (S1). Taken together, socio-demographic factors have much less influence on the formation and development of residential architectural cultural heritage than natural geographic, historical and cultural and road transportation factors.

On the basis of the single factors, further multifactor interaction analysis was conducted to assess the change of influence under the effect of multiple factors. The results show that the q-value of any single factor interacting with other factors increases to different degrees, which shows that the influence of two factors interacting with each other is stronger than that of a single factor. The two-by-two interaction of the influencing factors is mainly a nonlinear synergy, and the interaction of some factors is a double synergy, which indicates that the effect of the influencing factors on the distribution of the cultural heritage of the residential buildings is not a simple addition of two factors, but presents a nonlinear enhancement effect or mutual enhancement effect among the factors. Among them, slope (N2), river distance (N3) and topographic relief (N4) in the natural environment, as well as establishment age (S1) and population status (S3) in the socio-demographic factors, had stronger effects on other factors, and the q value appeared to be increased several times when interacting. This suggests that the socio-demographic factor, although not obvious when acting alone, has an important impact on the distribution of residential architectural cultural heritage when acting in concert with other factors. This shows that the spatial distribution of residential architectural cultural heritage is the result of the joint influence of multiple factors.

Table 6: The influence factors of the spatial pattern of residential buildings

-	N1	N2	N3	N4	S1	S2	S3	H1	H2	R1	R2
N1	0.145	-	-	-	-	-	-	-	-	-	-
N2	0.283	0.104	-	-	-	-	-	-	-	-	-
N3	0.726	0.665	0.493	-	-	-	-	-	-	-	-
N4	0.554	0.463	0.715	0.175	-	-	-	-	-	-	-
S1	0.224	0.672*	0.806	0.594*	0.035	-	-	-	-	-	-
S2	0.358	0.523	0.802	0.803*	0.462	0.211	-	-	-	-	-
S3	0.376*	0.654*	0.995	0.774*	0.385*	0.383	0.085	-	-	-	-
H1	0.603	0.615	0.873**	0.892	0.981*	0.615	0.693	0.411	-	-	-
H2	0.592	0.546	0.716**	0.685	0.584	0.704	0.481	0.733	0.293	-	-
R1	0.503	0.763*	0.835	0.973*	0.442*	0.692	0.502*	0.665	0.484	0.156	-
R2	0.651	0.614	0.872	0.961	0.545	0.753	0.715	0.923	0.561**	0.675	0.337

IV. Strategies for the protection of residential buildings and improvement of the living environment

Residential architectural cultural heritage mainly refers to the traditional village buildings that contain the traditional Chinese farming culture in the process of historical development, which have rich cultural and natural resources, and have certain historical, cultural, scientific, artistic, economic and social values, and should be protected by revitalization and utilization. Based on the analysis of the spatial distribution of residential buildings and related influencing factors, this chapter mainly combines the concept of sustainable development to explore the revitalization and protection of residential architectural cultural heritage and the optimization and improvement of the living environment, with the aim of further enhancing the effective inheritance of residential architectural cultural heritage.

IV. A. Strategies for the Protection of the Cultural Heritage of Habitat Architecture

IV. A. 1) Activation and utilization of residential buildings by graded categories

Residential buildings are the core cells of traditional villages and the main space for villagers' production and life. Residential buildings should not be "rigid" old houses. It is more important to put forward effective repair paths and renovation and upgrading strategies to meet the needs of villagers' modern life, based on their actual needs and potential for protection and utilization of villages. Figure 4 shows the comparison of the classification and grading of the protection and adaptive use of residential buildings.

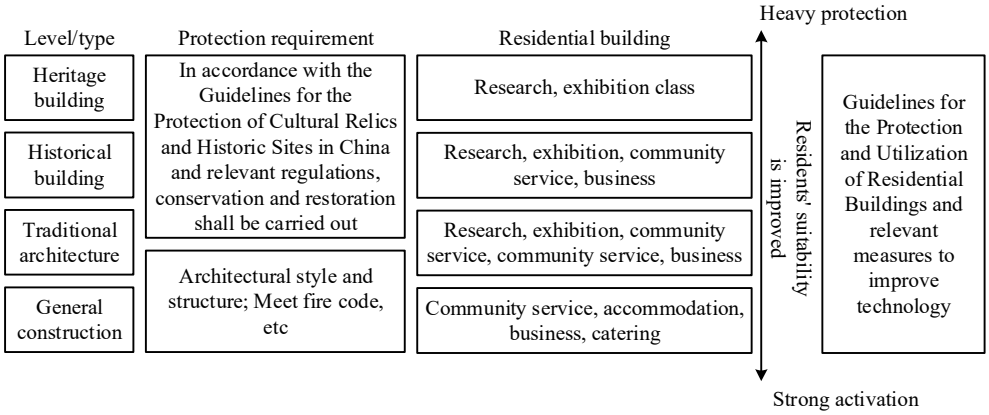


Figure 4: Classification and activation of residential buildings

(1) In-depth research, prioritizing protection and hierarchical control. In order to effectively rescue and protect, it is necessary to carry out special research on the architectural quality of residential buildings. Through data collection, residents' reports, field visits, scoring and evaluation, the cultural heritage of residential buildings is categorized into 3 levels according to the importance of protection. Level 1 is for cultural relics and historical buildings at all levels that have been listed or recognized, Level 2 is for the list of historical buildings to be recommended, and Level 3 is for general traditional residential buildings. On the basis of the grading, the list of traditional buildings to be repaired

is proposed and a repair plan is formulated by integrating the quality of the houses, repair costs, current ownership, and the value of future renovation and utilization, thus significantly controlling the repair costs.

(2) Explore the mode of livelihood protection, low cost and green renovation. Through field visits, villagers reflect that traditional houses generally have problems such as poor lighting, ventilation and waterproofing, making it difficult to meet the needs of modernized life, and that the number of such buildings is large, the transformation is difficult and the construction cost is high. Therefore, the study proposes to explore ways and means of low cost and small intervention in building materials and remodeling modes. First, we should fully listen to the needs of the main users, rationally organize the internal space, and place more emphasis on local transformation. Secondly, in terms of materials, the use of original building materials should be retained as far as possible, or low-cost glass tiles, imitation wood doors and windows should be adopted. The third is to improve lighting and ventilation conditions through skylights or small-scale facade adjustments to avoid affecting the overall appearance.

IV. A. 2) Building a pattern of protection and utilization of residential buildings

Guided by the concept of sustainable development, the sustainable development of the protection of residential architectural cultural heritage requires the dialectical coordination of the three major relationships of protection, utilization and inheritance, and profoundly grasps the new views, new concepts and new methods of the new era, so as to place the residential architectural cultural heritage into the long river of modern historical evolution, development and growth. Through various scientific and technological and humanistic means, it is transformed into a scientific system with multiple values such as “social, economic, and cultural”, and the existing protection model of residential architectural cultural heritage is summarized and compared, and the innovative transformation form of “resources, industry, life, and mode” is constructed, as shown in Figure 5.

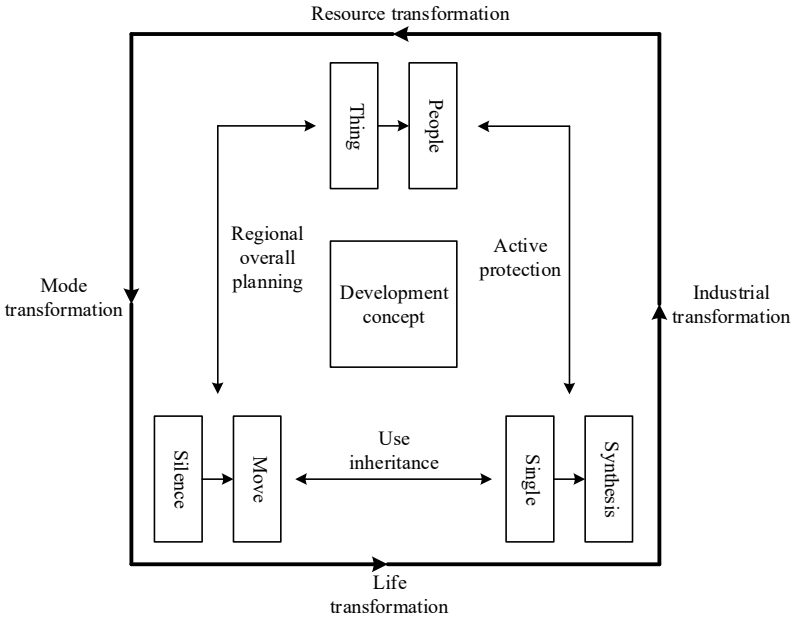


Figure 5: The construction protection mode of residential buildings

(1) Vertical village synergistic development. In order to further build a pattern system for the protection and utilization of residential buildings, vertically, the main starting point is the linked development of cluster units and the synergistic development of villages, promoting the linked development of traditional villages and other general villages, and forming a pattern of synergistic development. In order to effectively form a synergistic development pattern of residential architecture, we should promote the linked development of villages and highlight the systematic value. Firstly, by creating vertical tourism routes of “one-day tour along the route”, planning a series of activities for the concentrated and continuous development of residential buildings, and giving each village a different thematic IP in combination with its characteristics, a vertical pattern of conservation and utilization will be formed. Secondly, it will play the role of hierarchical transmission of each residential building to drive the development of other villages along the vertical tourism routes and form the complementary advantages among residential buildings. Finally, the community of residential buildings is built on three levels, namely, industry, culture and ecology, to form a multifaceted synergistic development pattern of industrial continuity, cultural molding and ecological unity.

(2) Horizontal village development guidelines. Based on the spatial distribution characteristics of residential architectural cultural heritage, development guidelines are provided for residential architectural communities in each region. Through the AHP method, the development advantages of each cluster are determined, and the role of individual residential buildings in the conservation and utilization pattern is given full play. Based on the premise of resource synergy and taking into account the time cost and distance, resources are pooled to highlight the respective development advantages and the systematic value of linkage of the residential and architectural cultural heritage, and to promote the joint protection and development of the residential and architectural cultural heritage.

IV. B. Strategies for improving the living environment of residential buildings

IV. B. 1) Components of the human environment in residential buildings

Habitat environment in residential building communities is a comprehensive manifestation of society, geography and ecology. At the level of humanistic environment, the main body of the habitat environment of residential buildings is the rural residents, and the social network environment of the rural habitat in the suburbs is constructed by the consistent social and cultural background of the farmers with the same characteristics, traditional customs, institutional culture, behaviors, values and so on. From the perspective of regional spatial environment, the content of human environment space of residential architecture includes spatial location and spatial scope, and also covers the natural production of material materials and man-made material wealth in geographic space. From the perspective of natural ecology, human development requires the supply of natural resources and natural conditions, and the natural ecological environment provides a sustainable and survivable material platform for the residential built habitat environment. Figure 6 shows the constituent elements of the built habitat.

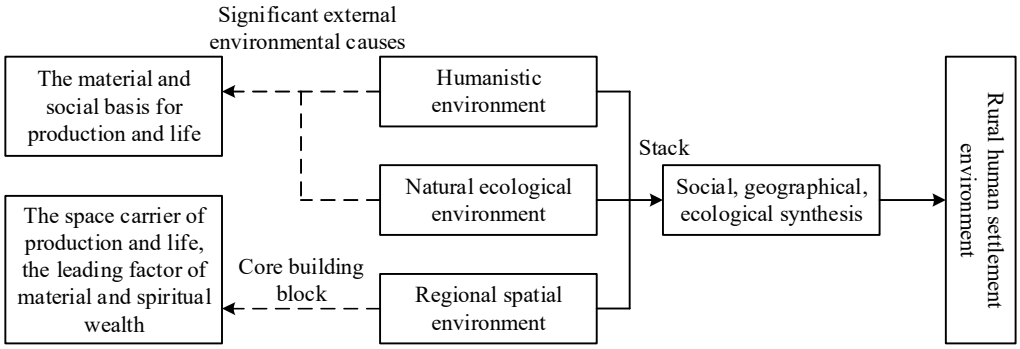


Figure 6: The elements of the living environment of residential buildings

To summarize, the humanistic environment, regional spatial environment and natural ecological environment are the basic elements constituting the habitat environment of residential buildings, and their internal mechanisms are logically related. The material and social basis of villagers' production and life in suburban rural areas cannot be separated from the natural ecological environment and humanistic environment, which are important external environmental factors for villagers' production and life. The regional spatial environment embodies the main status of the human environment, and is the spatial carrier for the production and life of rural residents in suburban areas and the dominant factor in the creation of material and spiritual wealth, thus constituting the core component of the human environment in suburban rural areas.

IV. B. 2) Focus on architectural patterns to refine spatial functions

In the process of improving the living environment of residential buildings, it is necessary to fully follow the theory of sustainable development, and to fully recognize the landscape value and cultural value of residential buildings. Through sorting out the overall spatial pattern of residential buildings, inheriting and continuing the traditional regional culture of the village, combining with the transformation of the external spatial environment of the village and so on, promoting the revitalization and utilization of the cultural heritage of residential buildings, and then giving full play to the functional value of traditional residential buildings.

On the one hand, the natural patterns and ecological landscapes such as terraces, woodlands, rivers and mountains around the residential buildings are protected to form landscape resources with ecotourism value. On the other hand, the existing road flow lines and spatial nodes in the village are sorted out, and the functional spaces in the village are connected to create a dynamic flow line that integrates scenic tourism, agricultural experience, and leisure and sightseeing.

In addition, starting from the integration of the functional space of residential buildings, the original spatial layout is summarized and organized, and the spatial functions are refined according to local conditions. In the renewal and reconstruction of streets and roads, the three main roads in the village were widened and hardened. It also opened up the previously unsuitable side streets and constructed drainage facilities for the low-lying sections to enhance the village's rainwater drainage capacity. Further optimize the road network of streets and lanes, create green and comfortable streets and lanes and road landscapes, and improve the convenience of villagers' travel and the livability of the residential building environment.

IV. B. 3) Optimized design for sustainability in the human environment

At present, most traditional villages are still littered with garbage, seriously damaging the living environment of the villages. The living space of residential buildings is no exception. There are government-placed garbage cans in the old streets, but they are insufficient to meet the daily needs of villagers due to their small number. The first step is to increase sanitary facilities such as garbage collection and disposal points and garbage cans. On the basis of this completion, effective garbage sorting and recycling can be established. Secondly, in the setting of the garbage collection point, there is a total of one garbage collection in the residential area about 4 households. Smaller areas are equipped with simple household garbage cans, and in larger areas 2 to 3 large recycling points can be set up for more garbage sorting and convenience for residents. In neighborhoods and visitor areas, trash cans should be equipped appropriately, which can effectively protect the living environment of residential buildings. In visitor areas, trash cans can be simply categorized into recyclable and non-recyclable trash. The implementation of effective local sustainable design can contribute to the sustainable development of residential building tourist areas.

V. Conclusion

Starting from the spatial distribution characteristics of residential architectural cultural heritage, the article analyzes the spatial distribution characteristics and equilibrium of residential architectural cultural heritage with GS province as the research object, and explores the specific factors affecting the spatial distribution of residential architectural cultural heritage. Based on the results of the analysis, specific strategies for the protection of residential architecture and the improvement of the living environment are proposed under the guidance of the concept of sustainable development.

(1) The nearest-neighbor ratio of residential architectural cultural heritage in GS province, $R=0.781<1$, the P-value passes the significance test, and the Z-score is $-2.316<0$. It indicates that the spatial distribution of residential architectural cultural heritage is of the overall aggregation and the local discrete type.

(2) For the residential architectural cultural heritage of GS province, no matter it is at national or provincial level, the difference between the capacity and information dimension is between 0.206 and 0.327. It indicates that the fractal characteristics of the residential architectural cultural heritage of GS province are more complicated, among which the difference value at the national level is the largest and the fractal structure is the most complicated.

(3) The residential architectural cultural heritage is mainly highly influenced by natural geography, history and culture, and road transportation, while the influence of social population is relatively small.

Based on the results of the above analysis, the protection of residential architectural cultural heritage and the improvement of the living environment are mainly based on the following aspects:

(1) To carry out the revitalization and utilization of residential architectural cultural heritage in a hierarchical manner, and to build the protection and utilization pattern of residential architectural cultural heritage in combination with the spatial distribution, so as to realize the sustainable development of residential architectural cultural heritage.

(2) Starting from the constituent elements of the living environment of residential buildings, and guided by the concept of sustainable development, optimize the architectural pattern and refine the spatial functions to meet the needs of the villagers' life and production, so as to realize the sustainable optimization of the living environment while preserving the original characteristics.

Acknowledgements

"Ridge of China - Research on Qinling Cultural Heritage and Environmental Aesthetics" 2022 Humanities and Social Sciences General Project of Ministry of Education of the People's Republic of China (22YJA760045);

Shaanxi Province Youth Innovation Team Building Scientific Research Project: "Research on Chinese Traditional Construction System and Contemporary Environmental Art Design" (21JP091);

Special Project of Xi'an Academy of Fine Arts: "Traditional Buildings Conservation and Environmental Construction in Shaanxi Guanzhong Area" (2021ZX);

Discipline construction Project of Xi'an Academy of Fine Arts "Ecological community construction and innovation practice" (XK202415).

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