



Application of Traditional Village Spatial Gene Recognition Technology in Conservation Planning

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SUMMARY: *The traditional villages play an important role in the national culture and historical heritage, but their protection and use experience significant pressure in view of the fast urbanization process. This paper uses the spatial gene identification technology, combined with the Ripley K-function and spatial syntax to study the spatial distribution and spatial configuration of traditional villages in Jiangsu Province and based upon this develop strategies to preserve and transmit the spatial patterns of traditional villages. The findings show that the provincial traditional villages in Jiangsu are dispersed in a manner that there are more settlements in the south and less in the north. On the provincial scale, the entire distribution is clustered and the concentration level is decentralized with the level of spatial balance being relatively low. This spatial pattern also has a structure of density in the south and sparse in the north and each of the core areas is slowly decreasing in size. Overall characteristics of traditional villages are formed by the combination of the topography and the water system, and the most connected streets in terms of space and the minimum depth values are mostly located at the center of villages, which tend to be major roads or a highly developed area.*

KEYWORDS: *Ripley's K basic function; spatial syntax; traditional village; spatial gene recognition*

1 Introduction

The territory of China is very large and its history is long. The significant regional cultural diversity has resulted in significant differences in the level of social and economic development, which created a diverse and multi-faceted traditional village culture with unique local characteristics. Since the reform and opening up, China's urbanization has been developing rapidly, and the relatively low productivity level and low labor income in the countryside have led to the outflow of labor from the countryside and the passive change of production relations. And traditional villages due to its own disadvantages, this effect has been further amplified, the destruction of village vernacular culture is serious, according to statistics China's average daily nearly 100 natural villages and 1.5 traditional villages disappeared [1-3]. In addition, the wave of new rural construction has brought a lot of chaos, most people think that the new rural construction is just a simple urban space for hard transportation, the city's way of life and the experience of the landscape imposed on the people in the villages, there are many ridiculous, ambiguous rural landscape style, such as mechanical and rigid modular village houses, etc. [4].

However, at present, the society is undergoing rapid transformation in all aspects, and due to the rapid economic growth, the spatial landscape of traditional villages, which carries rich

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historical and cultural heritage, has been damaged in various degrees [5]. Secondly, due to the lack of a clear understanding of their own system and the deep “homogenization” crisis, the traditional villages blindly follow the wind type of construction, the destruction of tourism resources, some of the precious spatial genes are facing the danger of gradual disappearance [6, 7]. Traditional villages is the great unique color of the Chinese nation, traditional villages and construction and development of the contradictions between the increasingly acute, long-established spatial form, street network, residential architecture and other unique vernacular environment has been damaged, regional integrity is broken [8]. The revival of historical and cultural genes of traditional villages is thus also vital in the success and development of national culture and the problem of spatial gene loss is one that should be handled urgently with coordination and balance between economic development and preservation of these cultural relations.

The study of rural settlements began to be conducted in the 1820s, starting with the examination of geography and mostly focusing on the natural distribution of rural settlements and its relationship with the environment around them. Weng V et al. explored the role rural public spaces play in building rural culture and social order, and discovered that folk beliefs can become an essential vehicle of political communication, which helps to promote the spirit of the population of rural areas and restore the so-called basic cultural order of the countryside. On these grounds, it is believed that the revival of rural culture, the development of regional features, and the extraction of belief-related components are useful incentives to reconstruct the public space of new rural areas [9]. Bian J et al. analyzed the spatial pattern of traditional villages in China based on GIS and spatial analysis, and found that the villages are majorly located in the southeast of China and in general have a cluster-like pattern and spatial imbalance [10]. Yang H et al. chose traditional rural landscapes of the Qing Dynasty as a subject of study and investigated the preferences, values, and conservation attitudes of both landscape professionals and local residents to traditional rural landscapes. As a result they discovered that local residents had higher preferences and were more willing to conserve traditional rural landscapes with cultural attributes than professionals [11]. Edgu, E et al. investigated how village configuration is influenced by boundaries within their current locations by comparing the morphology and syntax of four border villages. It was found that marginal villages along the Green Line demonstrate a controlled spatial development with cul-de-sac and circular patterns, and villages separated by the Green Line exhibit a relatively integrated spatial arrangement [12].

Concerning the spatial research of traditional villages, the history of the research goes back to the middle of the 1840s when the studies have been mostly focused on the general spatial research of the villages, internal organization of space in the villages, characterization and transformation of the spatial patterns of the traditional villages, preservation and exploitation of these patterns, and interrelationships between specific elements of the spatial structures [13, 14]. CHIRIȚĂ, V et al. analyzed the typology of Romanian villages and its sustainability using the G-CL viewpoint, and performed a territorial analysis of village components in Bukovina based on the multivariate discriminant criteria in matrix form to identify the key indicators of cultural villages and classify village types based on various co-cultural landscape patterns [15]. Howey, M and Burg, M pointed out that the connection between human beings and space is a fundamental concept in archaeological studies, and that through multivariate dynamic landscape models built on GIS systems and with the addition of various geospatial methods of cultural process modeling in landscapes, it becomes feasible to investigate visibility modeling and dynamic change in landscapes in combination, which will clarify the evolutionary path of traditional settlements [16]. Cao, J presented a review of the ecological landscape environment of Guanzhong traditional villages in terms of reviving the countryside, and the

results indicated that the most significant factors were given to the village location and the landscape pattern, then architecture and landscape, followed by nature and street views, and finally the intangible cultural landscape along with the conservation of landscape elements [17]. Deng, Y et al. used geographic analysis techniques: Standard Deviation Ellipse Analysis (SDEA), Nearest Neighbor Analysis (NNA) and Source-Destination Analysis (SDA) to explore the nature of geographic centers in traditional villages, concentration and dispersal over time, and functional changes [18]. Chen, X et al. have created a cultural-ecological environment model that examines the stages of the evolution of traditional village space and its pattern characteristics, and according to their studies, the space of traditional villages has experienced an evolutionary process of creation, development, prosperity, decline and revival that has been jointly influenced by the natural, economic and social environment [19].

Spatial genes are distinctive and relatively stable spatial combination patterns created through the interaction between human activity space and the natural environment, history and culture that make up local consensus. These spatial genes do not only represent the intrinsic generative processes and heredity information of places but keep them intact [20, 21]. Cox, M et al. collected genome-wide genetic data and language information of eight villages in Sumba, a remote island in eastern Indonesia, in terms of population genetics theory. They discovered that most of the communities spoke different languages and they could be genetically differentiated; although both languages and cultures can be developed very fast to form social barriers, even intergenerational migration across several generations is enough to retain the genetic link among villages [22]. Wei, X used the concept of biological genetic variation to analyze the characteristics and changes of landscape genes in traditional Qiang villages in Sichuan and suggested that landscape genetic variation is one of the main causes of regional landscape cultural diversity [23]. By extracting the contents and statistically examining 182 publications, Xu, H chose the descriptive indicators of the research of the landscape genes based on the three scales, including rural environment, rural interior space, and vernacular architecture, and illustrated the characteristics and composition patterns of the landscape elements in two traditional villages, Wuli Village and Bayazhong Village, to compare and contrast them [24]. Aguilera, A and Santos, J followed the superimposed-mapping technique in the colonial territory of El Chaparral in Granada and concluded that the successful land-planning model that was implemented to 300 colonial villages in Spain is based on a multiscale and multidisciplinary approach, has a historical continuity, and evolves in such a manner as to take into consideration the characteristics and components of the landscape [25].

Landscape genes are provided as images to enhance the comprehension. Theoretically speaking, landscape gene mapping is the schema system that has been created by the system of the landscape factors that can be represented by visualization, and landscape gene mapping can also analyze epigenetic and cryptic characteristics of landscape genes so that it could be possible to draw the fundamental logic of the development of the traditional settlement site selection [26]. With Geographic Information System software (ArcGIS), Vandergast, A et al. mapped landscape genes and stated that the ArcGIS toolbox can be applied to Landscape Genetics to show the geographic distribution of genetic diversity and assess its correlation with either genetic-diversity distributions or geo-referenced environmental information [27]. Wei, X chose a village called Wangta Village in Sichuan where both the Tibetans and Qiang lived, and applied the idea of landscape gene theory to study the environmental, architectural and settlement-cultural features of Wangta Village and how they are interconnected. This was done on the basis of the study that revealed and extracted the underlying landscape genes to reveal the siting, partition and spatial configuration patterns of the settlement [28]. Jiang, Y et al. took village settlement spatial genes as the entry dimension, adopted spatial texture of genetic information mining as the specific analysis method, and used CityEngine parametric platform, digitization

and three-dimensional visualization as methods to discover the self-organizing principles of traditional village spatial patterns and their applications [29]. Through a logical framework of gene recognition and decoding, Liu, P et al. studied the characteristics and values of residential landscapes in traditional Chinese settlement patterns, and subsequently derived a spatial genome map of traditional villages in settlement patterns based on the cross-regional perspective [30].

Building spatial systems of traditional villages requires the identification and extraction of spatial genes. The researchers Ćurović, Ž et al., used the village of Mrkovi in the Bay of Kotor, Montenegro as an example of spatial gene identification techniques in traditional villages. They assessed individual elements and vulnerabilities based on the natural, cultural, and visual attributes of space after determining the type of landscape and asserted that the initial stage in safeguarding the distinctive features of the landscape is to identify the spatial gene of cultural patterns [31]. A multiscale analytic framework which incorporates various dimensions was developed by Yu, C et al. to identify landscape genes of traditional villages, and they noted that geographic influences play a significant role in influencing architectural patterns and also interactions between geographic, cultural, and economic factors in different dimensions were revealed [32]. C Hui identified the spatial genes of a traditional village, Zhugge Bagua Village, through the lens of landscape genes, using the method of gene identification and settlement-landscape extraction in four aspects: architecture, layout, culture, and environment [33]. Through the spatial gene theory, Yong, F and Xiang, J determined the spatial genes of traditional villages at three levels, i.e. landscape, settlement and architecture and subsequently came up with a networked conservation corridor of traditional villages by using a network-structure model along with a least-resistance model, thus creating a conservation plan of such villages [34]. Wei, K et al. introduced the new two-chain model of the spatial genes of the traditional village landscape of the material-cultural type. This model consists of seven dimensions and twenty-four indicators of spatial genes of traditional villages [35].

An overview reveals that, in the existing literature in the field of space genetics of traditional villages, there is a relative paucity of works that focus on spatial genetics as the central theme in modern academia and the entire course of research has a tendency towards dispersion. Despite the widespread use of spatial genes as an analysis instrument in rural settlement landscapes, the theoretical background and research methodology have not been systematically developed. Furthermore, the studies of traditional villages in the world are also inadequate in the context of the landscape genetics, particularly in its systematical character and comprehensiveness. The current debates are mostly focused on the Anhui, Hunan, and Sichuan provinces, whereas studies of landscape genetics in the traditional villages are insufficient in other areas, and this indicates obvious disparities in scholarly interest.

The paper focuses on the planning of protection of traditional villages and incorporates spatial gene identification methods such as Ripley's K-function and spatial syntax. Analysis is made to explore the spatial distribution features, agglomeration pattern, spatial pattern, distribution balance, and the intensity and scale of major agglomeration areas of 554 provincial traditional villages in Jiangsu Province using ArcGIS 10.8 and Excel, and spatial gene data analysis of these villages is done. Lastly, based on the principles of protecting the genes of integrity, originality, and continuity and principles of inheritance of stability, transmissibility, and variability, the present research suggests ways of preserving and inheriting space shapes of traditional villages.

2 Overview of the study area

This paper selects Jiangsu Province as the case region. It is situated on the eastern coast of China, in the Yangtze River Delta, bordering Anhui, Shandong, Shanghai, and Zhejiang. With an area of 107,200 square kilometers, the province has a level surface and a well-developed network of rivers and lakes. The plains cover over 80 percent of the territory, including the vast northern Jiangsu plain and Yangtze delta plain. Its water system is very advanced: rivers and lakes are closely linked, the Beijing-Hangzhou Canal flows from north to south, the Yangtze River runs across from west to east and many others such as the Qinhuai River and the Tongyang Canal are spread far and wide. Moreover, the third and fourth largest freshwater lakes in China are Lake Taihu and Lake Hongze. There are also numerous traditional villages in Jiangsu. Of them, 79 villages were listed in the Chinese Traditional Villages List, and as of the end of 2024, the province had listed seven batches of the provincial traditional villages. Due to its long cultural background, favorable geographic environment, and economic-social structure, Jiangsu offers a favorable environment to the development and spatial arrangement of traditional villages, which are valuable both historically and culturally, socio-economically and scientifically. On the one hand, these villages exhibit bright aspects of the local culture and conserve a wealthy tradition. On the other hand, there is no doubt that the special socio-economic situation of Jiangsu not only facilitates the formation and distribution of these villages but also presents certain obstacles to their survival, preservation, and further development.

3 Data sources and research methodology

3.1 Data sources

The information and data related to the traditional villages in the province of Jiangsu, which have been used in the research, come mostly in the form of authoritative publications issued by departments of provincial and national governments and fall into three groups.

(1) The list of six tranches of national-level traditional villages published jointly by the Ministry of Housing and Urban-Rural Development (MOHURD), the Ministry of Culture (MOC) and the Ministry of Finance (MOF) since 2012.

(2) The list of Chinese historical and cultural villages issued by the Ministry of Construction and the State Administration of Cultural Heritage since 2003.

(3) The documentation of eight batches of provincial traditional villages of the Department of Housing and Urban-Rural Development of Jiangsu Province up to the year-end of 2024.

The result of the screening, de-duplication and aggregation of the aforementioned sources was data on 554 traditional villages in Jiangsu Province. Since the study area is large and the size of each village is relatively small, point data were applied to indicate the spatial distribution of the individual villages. OSpider, Baidu Maps and similar applications were used to get geographic coordinates, followed by importing the traditional-village point data into ArcGIS 10.8 to produce a vector map that was used to visualize and display, hence generating a map depicting the spatial distribution of traditional villages in Jiangsu Province. The socio-economic data were mostly based on the most recent Statistical Yearbook 2024 published by the Provincial Bureau of Statistics of Jiangsu.

3.2 Research methodology

3.2.1 Ripley's K basic function

The Ripley K-function is one of the most popular ways to analyze spatial point patterns and it

allows evaluating spatial distribution features of the traditional village at various spatial scales. The particular equation is presented here:

$$K(D) = \frac{A}{n^2} \sum_{i=1}^n \sum_{j \in J_D} I_{ij} \quad (1)$$

where D denotes the spatial scale, A refers to the area of the study region, n is the number of traditional villages within the study area, J_D represents the set of traditional villages taking i as the circle center and D as the neighborhood distance, and I_{ij} indicates the number of traditional villages contained in that set.

In order to represent more fully the spatial organization of traditional villages in Jiangsu Province, the paper examines two types of spatial distribution patterns, including the locations of the traditional villages and the village sizes. As Equation (1) only serves to estimate the extent of clustering or dispersion of traditional-village locations, the above equation may be changed further when the object of investigation is shifted to village size as follows:

$$K(D) = \frac{\sum_{i=1}^n y_i \sum_{j \in J_D} y_{ij}}{\sum_{i \neq j, j=1}^n y_j} \times \frac{1}{\sum_{i=1}^n y_i / A} \quad (2)$$

where y_i and y_j denote the populations of traditional villages i and j , respectively, and y_{ij} refers to the village size within set J_D . This equation contains two components: the first part represents the expected size of traditional villages within neighborhood range D centered on any village point, whereas the second part describes the density of village size.

Theoretically, when the significance level is determined, in case the value of K is much higher than πD^2 , traditional villages have a strong clustered spatial distribution and an increase in K value indicates a high level of clustering. Conversely, in the case where K is significantly lower than πD^2 , the villages take on a clear dispersive pattern, and the lower the K value, the more dispersed the spatial configuration will be. Only when K approaches the expected value πD^2 can the traditional villages be regarded as randomly distributed in space. In order to test the statistical significance of K values under different scales, the statistic t obeying the Poisson distribution can be constructed, and under the significance level α , the t statistic is expressed as:

$$t = \frac{\bar{K} - \pi D^2}{\delta / \sqrt{n}} \quad (3)$$

where \bar{K} and δ represent the mean value and standard deviation of the empirical distribution of traditional villages, respectively, and the confidence interval of t is $|t| \geq t_{\frac{\alpha}{2}}(n-1)$. In

practice, it is not easy to measure the mean value and confidence interval of the hypothetical distribution of traditional villages directly. Then, Monte Carlo simulation needs to be used to find the range of variation in K values and to check their statistical significance.

3.2.2 Space syntax

Spatial syntax, as a research method, emphasizes the ontology and self-organizing ability of space, which together with human activities influence the evolution of social space. Spatial syntax analyzes the structure of human living space through quantitative analysis, and uses professional software to reveal the intrinsic connection between spatial form and human behavioral activities and social culture. Currently, spatial syntax consists of three analytical methods such as the convex-space approach, the axial-analysis approach and the visual-field analysis approach. The spatial syntax indicators that are most commonly used are integration, depth, connectivity, control, and comprehensibility.

(1) Connection value

The connection value reflects the amount of linkage between a spatial point and the neighboring points. The larger the connection value, the easier it is to connect the point to the neighboring spaces.

$$C_i = \sum c_{ij} \quad (4)$$

where C_i represents the i -space connection value and c_{ij} represents whether the i -space is connected to the j -space, and if so, it is assigned a value of 1, and if not, it is assigned a value of 0.

(2) Control value

The control value is the extent to which a spatial point can act upon its surrounding environment. It is usually applied to assess the effect of one point on the visibility and accessibility of another point, and it shows the strength of the impact of a spatial point on the surrounding space, thus, its position in the spatial network.

(3) Depth value

Depth value measures the “distance” required for one spatial point to reach other points. Total depth represents the accessibility relationship among all nodes in a spatial network. It is the sum of the shortest path lengths from one spatial point to all other spatial points. In a way, the magnitude of the total depth is inversely proportional to the reachability of a node in space. The total depth expression is given below:

The total depth expression is shown in equation (5) below:

$$D_i = \sum_{j=1}^n d_{ij} \quad (5)$$

where D_i denotes the total depth value of i space, n denotes the total number of spaces in the system, and d_{ij} denotes the depth value of j space for i space.

Depth value mean is derived by adding up all depth values within a space and then dividing the total by the number of spatial elements to reflect the distance relationship between spaces.

The average depth value is shown in equation (6) below:

$$\bar{D}_i = \frac{D_i}{n} \quad (6)$$

where \bar{D}_i denotes the average depth of space i , and n represents the total number of spaces in the system.

(4) Integration degree

The level of integration is the measure of accessibility of a spatial point to the entire spatial

network. The larger the integration value, the closer it is to the average depth required to get the point to another spatial point and thus the point is at a more central location in the network.

Integration is traditionally categorized as global integration and local integration. The level of global integration indicates how much one space is grouped with every other space in the whole system, whereas the concept of local integration refers to a clustering relationship between adjacent spaces that is often evaluated at topological distances of three ($R = 3$) or five ($R = 5$).

The integration degree expression is shown in equation (7):

$$I_i = \frac{n \left[\log_2 \left(\frac{(n+2)}{3} \right) - 1 \right] + 1}{(m-1) |\bar{D}_i - 1|} \quad (7)$$

where I_i denotes the integration of i space, n denotes the total number of spaces in the system, and \bar{D}_i denotes the average depth value of i space.

(5) Intelligibility

The intelligibility of a spatial layout refers to its complexity and comprehensibility. Comprehensibility in spatial syntax has been frequently assessed by analyzing how various indicators are related, including the relationship between overall global integration and individual local integration.

The most usual form of the bivariate linear regression is carried out when the local integration is taken as the Y-axis ($R=3$) and the global integration as the X-axis ($R=HH$). The result is a two-variable scatter plot and the coefficient that is used to indicate the confidence level of the scatter plot is $R^2 \leq 0.2$. When $R^2 \leq 0.2$, it is low intelligibility. $0.2 < R^2 < 0.4$, it is medium intelligibility. $R^2 \geq 0.4$ is considered highly comprehensible.

4 Characteristics of spatial distribution of traditional villages in Jiangsu Province

In this chapter, traditional villages are abstracted as prime points in space, and the spatial distribution characteristics, spatial agglomeration pattern and distribution balance, spatial distribution pattern, intensity and scale characteristics of major agglomerations, and spatial morphology of traditional villages in Jiangsu Province are analyzed with the help of ArcGIS 10.8 and Excel tools.

4.1 Characterization of spatial distribution

4.1.1 Distribution characteristics of traditional villages in Jiangsu Province

(1) Provincial quantity distribution characteristics

Using the geographic coordinates of the traditional villages in Jiangsu Province and having loaded this information to ArcGIS 10.8, the spatial distribution map of the traditional village points in Jiangsu Province was derived (see Figure 1). With regard to the provincial spatial view, the traditional villages are mostly found in the central and southern regions of Jiangsu Province, whereas the northern region has a less dense population and the trend is denser population in the central and southern regions and sparser population in the northern region.

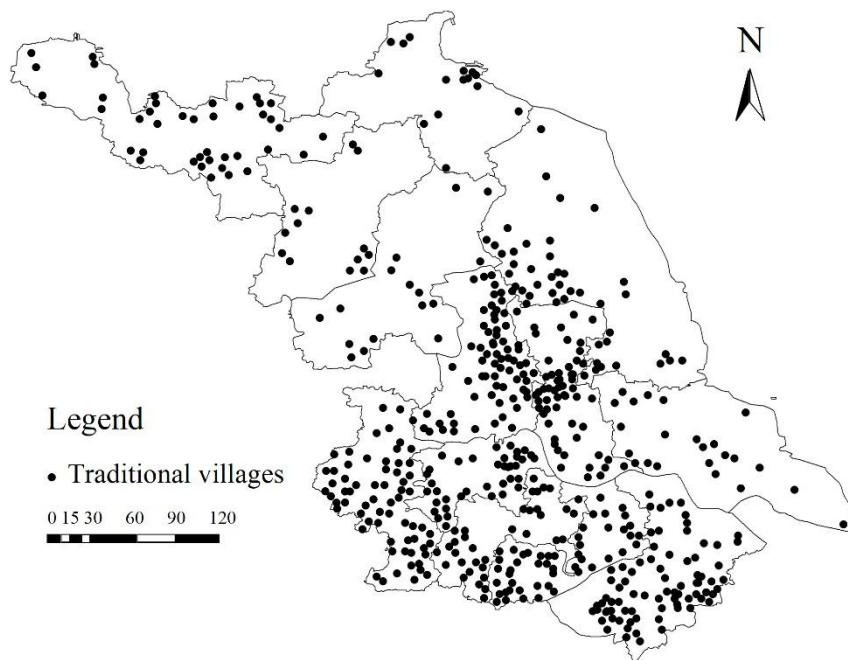


Figure 1: Spatial distribution of traditional villages in Jiangsu province

(2) Municipal quantity distribution characteristics

Information on the number of conventional villages in each city of the Jiangsu Province is given in Table 1. The visualization of the quantity distribution of traditional villages was done through the use of ArcGIS 10.8, and the spatial distribution of villages in the cities in Jiangsu Province is depicted in Figure 2. If we consider Table 1 and Figure 2 in conjunction, the municipal distribution of traditional village is obviously not even. Of all the cities, Suzhou, Yangzhou, and Nanjing have the highest number of traditional villages with a relatively dense pattern whereas Suqian, Lianyungang and Huai an have the lowest and are relatively sparse.

Table 1: Statistics of the number of traditional villages in Jiangsu province

Region	Prefecture-level city	The number of traditional villages
Southern Jiangsu	Nanjing	65
	Wuxi	55
	Suzhou	78
	Changzhou	35
	Zhenjiang	39
Central Jiangsu	Yangzhou	71
	Taizhou	58
	Nantong	23
Northern Jiangsu	Xuzhou	41
	Lianyungang	15
	Suqian	13
	Huai'an	17
	Yancheng	44

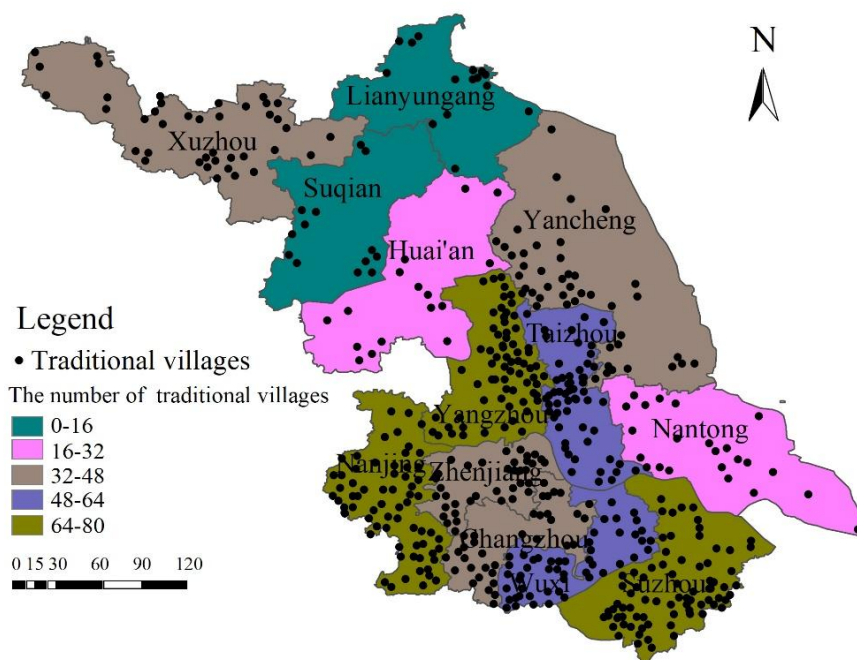


Figure 2: Distribution of traditional villages in Jiangsu province

4.1.2 Types of spatial distribution

A macroscopic view of the traditional village may be represented as an element in a point-like form. In space, their locations in nature and society are classified according to three categories: random, even and agglomerated. The present paper will identify these types using the nearest neighbour distance and the nearest neighbour index in ArcGIS 10.8. If the nearest neighbour ratio $R=1$, the point pattern is random; if $R>1$, the elements are evenly distributed; if $R<1$, they cluster; and if $R=0$, the distribution is fully concentrated.

(1) Provincial spatial distribution type

The geographical coordinates of 554 traditional villages were inserted into ArcGIS 10.8 and the spatial statistics analysis tool was used to compute nearest-neighbor distance and nearest-neighbor indices in order to establish the provincial-level spatial distribution of traditional villages in Jiangsu Province. Figure 3 shows the summary results of the nearest-neighbor spatial analysis and table 2 reports the confidence level of the nearest-neighbor index.

One may infer that the nearest-neighbor ratio of the point elements of traditional villages in Jiangsu Province is $R = 0.596243 < 1$, which indicates that, on the scale of the province, the spatial distribution of traditional villages in Jiangsu Province is clustered. The figure shows that the Z-score is a measure of statistical significance and the p-value is the probability with which the decision to reject the null hypothesis is made. Combined, the expected value, Z-score, and p-value allow establishing whether the null hypothesis can be rejected or not. Based on the result of the nearest-neighbor index confidence, $z=18.542615 < -2.58$, and $p=0.00000 < 0.01$. The confidence level of this test is 99 percent, which means that the result is not random and that the results found are trustworthy.

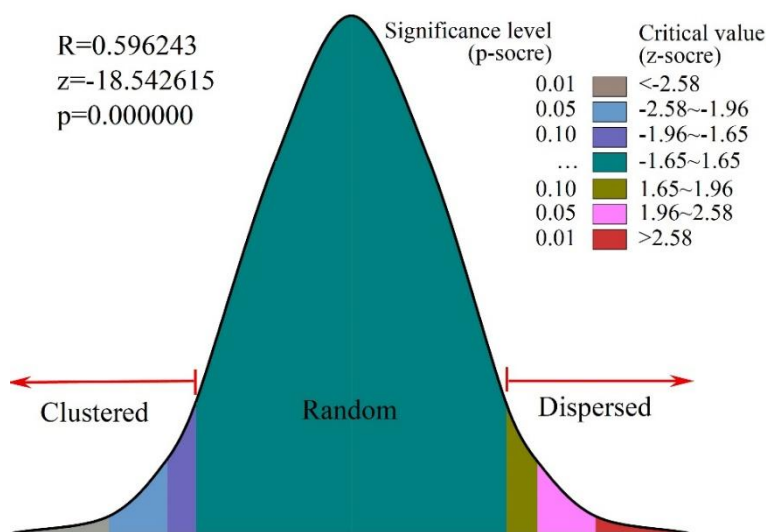


Figure 3: Spatial nearest neighbor summary analysis

Table 2: Nearest neighbor index confidence

Z-score (standard deviation)	P-value (probability)	Confidence level
<-1.65 or >+1.65	<0.10	90%
<-1.65 or >+1.65	<0.05	95%
<-1.65 or >+1.65	<0.01	99%

(2) Municipal spatial distribution types

The spatial connection tool has been used to connect all the traditional village points under the administrative areas of 13 prefecture-level cities to enable them to find the nearest-neighbor index of traditional villages in every city of Jiangsu Province and determine the spatial distribution pattern in every city, as it is presented in Table 3. As per the table, ten cities have the nearest-neighbor indices between (0,1) indicating an agglomerated distribution pattern. Nantong, Lianyungang, and Huai an are three cities that have nearest-neighbor indices larger than 1 indicating a uniform distribution type. The nearest-neighbor index of Zhenjiang is 0.99, a number that is closest to 1, implying that its agglomeration pattern approaches randomness.

Table 3: Analysis of spatial distribution types of traditional villages in the municipal area

Prefecture-level city	Quantity	Nearest neighbor index	Distribution type
Nanjing	65	0.85	Agglomeration type
Wuxi	55	0.81	Agglomeration type
Suzhou	78	0.88	Agglomeration type
Changzhou	35	0.78	Agglomeration type
Zhenjiang	39	0.99	Agglomeration tends to follow the type
Yangzhou	71	0.81	Agglomeration type
Taizhou	58	0.80	Agglomeration type
Nantong	23	1.24	Uniform type
Xuzhou	41	0.79	Agglomeration type
Lianyungang	15	1.17	Uniform type
Suqian	13	0.92	Agglomeration type
Huai'an	17	1.36	Uniform type
Yancheng	44	0.91	Agglomeration type

4.2 Spatial agglomeration patterns and distributional balance

4.2.1 Level of concentration

The geographic concentration index is used in order to test the concentration of traditional villages in every municipal area. The so-called geographic concentration index (G) can be defined as any index that indicates the extent of centralization of spatial distribution of geographic objects in some particular region. It has the following formula:

$$G = 100 \sqrt{\sum_{i=1}^n \left(\frac{x_i}{T} \right)^2} \quad (8)$$

In this formula, G denotes the geographic concentration index of traditional villages, n represents the total number of municipalities in Jiangsu Province, that is i , the number of prefecture-level cities in the province, and T is the total number of traditional villages in Jiangsu Province.

The average geographic concentration index \bar{G} represents the value obtained when geographic elements are evenly distributed across each regional unit, and its formula is:

$$\bar{G} = \frac{T}{n} \quad (9)$$

The value of G ranges from 0 to 100; the larger the value of G , the stronger the concentration.

Assuming that the average distribution of traditional villages in Jiangsu Province is $G = \bar{G}$, then when $G > \bar{G}$, the distribution of traditional villages in Jiangsu Province is considered concentrated; otherwise, it is regarded as decentralized. From Equation (8), $\bar{G} = 34.8571429$, and from Equation (9), $\bar{G} = 34.8571429$. Since $G < \bar{G}$, the distribution of traditional villages in Jiangsu Province is relatively decentralized at the municipal level.

4.2.2 Level of balance

Imbalance index can also be used to assess the level of balance in the spatial location of the traditional villages between the cities of Jiangsu. It has the following formula:

$$S = \frac{\sum_{i=1}^n Y_i - 50(n+1)}{100n - 50(n+1)} \quad (10)$$

where n denotes the quantity of prefecture-level cities in Jiangsu and Y indicates the summative percentage of the traditional village in every prefecture-level city as compared to the overall number of traditional villages in Jiangsu, sorted in a descending manner, with the i th position being ranked in decreasing order, with the i th position ranked from largest to smallest. The range of S values is (0,1). If S tends to 0, then it implies that the traditional villages are more uniformly spread; if S tends to 1, they tend to be more clustered.

As per the Formula (10), $S=0.38$. In absolute equilibrium, $\bar{S} = 0$, and as a result $S > \bar{S}$, the spatial distribution of the traditional villages in this region is poorly balanced. The software Microsoft Excel was employed to create the Lorenz curve as presented in Figure 4, which is a

more intuitive representation of the discrepancy between the actual distribution curve and the hypothetical uniform-distribution line of every city in Jiangsu. As it can be seen in the figure, the difference between the two curves is significantly varying and the enclosed region is large enough; thus, traditional villages in Jiangsu Province have an unbalanced distribution pattern.

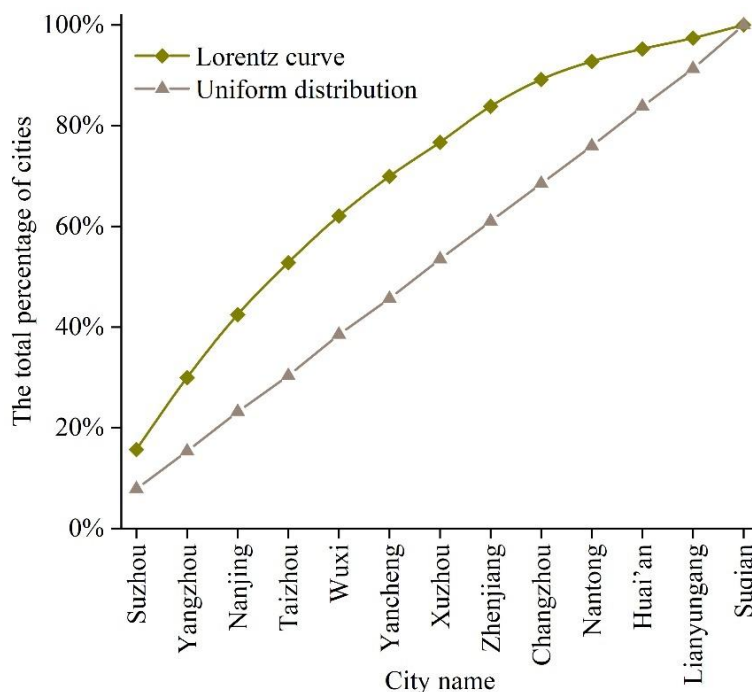


Figure 4: Lorentz curve of spatial distribution of traditional villages in Jiangsu province

4.3 Spatial distribution patterns

The coordinates of the traditional villages of Jiangsu Province were entered as input points in ArcGIS 10.8 and the search radius was selected as 50 km and then the result of the kernel-density distribution is shown in Figure 5. As can be seen, the results show that in the province of Jiangsu, traditional villages are mainly situated in central and southern Jiangsu, and there are two core areas which serve as centers and a slowly reducing trend towards the outside. All this indicates that this is a spatial structure of high density in the south and low density in the north, with obvious differences in the spatial differentiation pattern between the north and the south. Among them, Yangzhou-Taizhou City in Central Jiangsu Province and Suzhou City in South Jiangsu Province are high-density agglomeration areas, and their spatial distribution density can reach up to 114.02-138.55 per 10,000 km². Nanjing, Wuxi, and Zhenjiang City are the three secondary high-density distribution areas. Most of northern Suzhou is a low-density agglomeration area, except for Xuzhou and southwest Yancheng, which have a slight tendency to agglomerate.

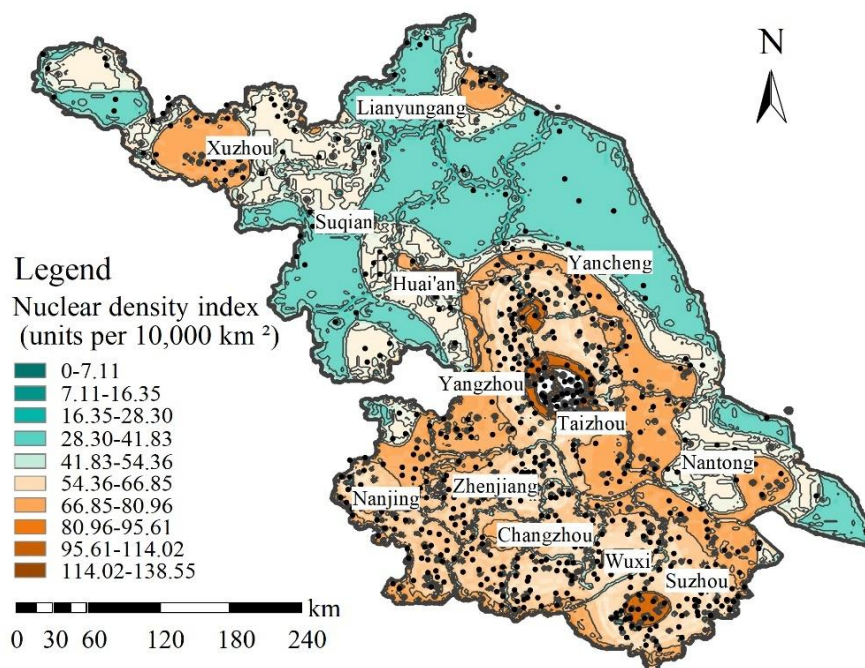


Figure 5: Distribution of core density of traditional villages in Jiangsu province

4.4 Characteristics of agglomeration intensity and size

As stated in Eq. (1) and Eq. (2), Ripley's K-function was analyzed per cluster and it was found to be significant. The outcomes of the Ripley K-function are given in figure 6 with regard to the main agglomeration regions. Panels (a) - (c) refer to the three agglomeration regions in Southern Jiangsu, Central Jiangsu and Northern Jiangsu respectively.

All three clusters have L(d) curves higher than the highest value of the confidence interval at any spatial scale following the first distance, indicating that the spatial distribution of traditional villages in these three agglomeration regions has a high degree of cluster formation. The result is similar to the kernel-density analysis discussed previously. Besides, the L(d) curves of the three clusters also have the pattern of an inverted U, implying that the intensity of their agglomeration is subject to the pattern of increasing and subsequently decreasing. Nevertheless, there are still obvious differences in the form of the scale and intensity of agglomeration. Namely, the characteristic spatial scales of Southern Jiangsu, Central Jiangsu, and Northern Jiangsu agglomerations are 14.15 km, 23.24 km, and 7.3 km, respectively, and the maximum L(d) values are 7.57, 9.23, and 4.71, respectively, and there are significant differences in the scale and intensity of agglomeration among the agglomerations, and the scale of agglomeration in each agglomeration is basically positively proportional to the intensity of agglomeration. From the point of view of agglomeration scale, the agglomeration scale of South Jiangsu agglomeration area is the largest, followed by Central Jiangsu agglomeration area, while the agglomeration scale of North Jiangsu agglomeration area is the lowest. From the point of view of agglomeration intensity, the agglomeration intensity of Central Jiangsu agglomeration area is the largest, followed by South Jiangsu agglomeration area, while the intensity of North Jiangsu agglomeration area is still the lowest. It can be seen that, both in terms of agglomeration scale and agglomeration intensity, the South Jiangsu and Central Jiangsu agglomeration areas are much higher than the North Jiangsu agglomeration area, which once again confirms the spatial distribution pattern of "dense in the South and sparse in the North" of the traditional villages in Jiangsu Province.

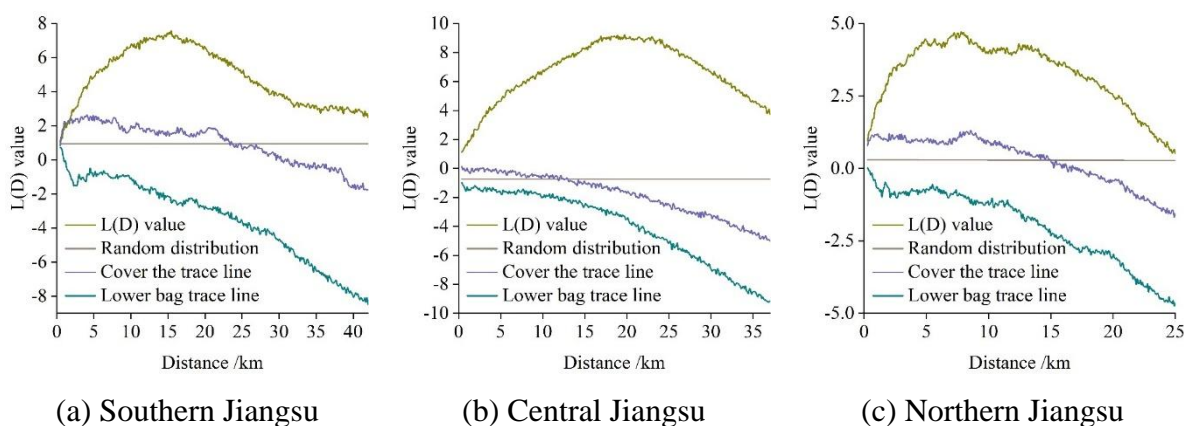


Figure 6: Ripley's K function in the main agglomeration area

4.5 Spatial pattern measurement

The present section is based on the concept of spatial syntax to assess the total space and linear street space of the old villages of Jiangu Province quantitatively, and summarize the general characteristics that can be seen in the spatial morphology of the villages and offer a much-needed background to future plans of preserving the villages.

4.5.1 Measurement of the overall spatial pattern of the village

To further investigate the overall spatial pattern of traditional villages in Jiangu Province, this paper employs comprehensibility to examine the characteristics of village spatial patterns. After the relevant data are imported into DepthMap software, the comprehensibility values of the overall layouts of several villages can be obtained, as shown in Table 4.

The comprehensibility of Xigang and Yangqiao villages as well as Longshan village is relatively high, reaching 0.589, 0.895 and 0.593 respectively. Except for Kaixinbow Village, Dafangqiao Village, and Jiaoxi Village, which have comprehensibility levels of 0.103, 0.165, and 0.184, the comprehensibility levels of Luxiang Ancient Village, Mingyuewan Village, Dongbang Village, Xiemaqiao Village, Zhuling Village, and Jiu Li Village are between 0.2 and 0.4, which is located in the medium comprehensibility category, indicating that the spatial perceptions of these villages are better.

The analysis of village comprehensibility can help determine that most villages in Jiangu Province have medium or relatively high comprehensibility values. It implies that the total spatial perception of these villages is quite intense and that there is no likelihood of easy disturbances to their development by the outside world. Combined with the DEM analysis, it is found that the reason for the strong comprehensibility of these villages is that most of these villages are located in less rugged places, with wider distribution of roads, dense ancient buildings, and concentrated distribution of water flow.

Table 4: Village understandability

Village name	Global integration degree	Local integration degree	Understandability
Luxiang ancient village	0.537	1.129	0.384
Mingyuewan village	0.584	1.386	0.226
Xigang village	0.482	1.064	0.589
Kaixiangong village	0.299	0.961	0.103
Dongbang village	0.407	1.173	0.319
Xiemaqiao village	0.462	1.141	0.343
Dafangqiao village	0.284	0.923	0.165
Zhuling village	0.379	1.088	0.226
Jiaoxi village	0.308	0.977	0.184
Yangqiao village	0.939	1.499	0.895
Longshan village	0.446	1.143	0.593
Jiuli village	0.364	1.157	0.207

4.5.2 Internal Street Spatial Morphology Measurement

The paper uses connection values and average depth values as a measure of quantification of the linear street-space pattern in villages and explores the causes of its emergence.

(1) Connection value

Table 5 presents the connection values of the villages. Some villages are relatively high in average connection level, such as Luxiang Ancient Village (2.636), Mingyuewan Village (2.948), Dongshan Village (2.569), Xiemiaoqiao Village (2.587), Yangqiao Village (3.324) and Jiu Li Village (2.518). These numbers suggest that the general street-space connectivity of these villages is fairly high. In contrast, the rest of the villages have lower levels of connectivity compared to the ones discussed previously. As an illustration, Kaixinbow Village has the least connection value (2.147) of all the samples, whereas Dafangqiao Village and Jiaoxi Village have connection values of 2.236 and 2.221 respectively, which indicate that the street spaces of these villages are simpler and the spatial permeability is weaker. The reason for this is that the villages are more restricted by the water system and hilly terrain in their development, and the expansion of buildings is more limited.

Table 5: Village connection value

Village name	Minimum value	Average value	Maximum value
Luxiang ancient village	1	2.636	8
Mingyuewan village	1	2.948	12
Xigang village	1	2.404	6
Kaixiangong village	1	2.147	8
Dongbang village	1	2.569	10
Xiemaqiao village	1	2.587	8
Dafangqiao village	1	2.236	5
Zhuling village	1	2.483	6
Jiaoxi village	1	2.221	6
Yangqiao village	1	3.324	15
Longshan village	1	2.497	8
Jiuli village	1	2.518	9

(2) Average depth value

The depth value represents the degree of convenience within which movement is possible between two spaces. The lesser the depth value, the higher the accessibility of village streets. Spatial syntax theory uses the term integrated zones to describe spatial nodes that have high accessibility and discrete zones to describe ones that have low accessibility.

The analysis reveals that the areas of least depth values in Luxiang Village, Mingyuewan Village, Xigang Village, Xiemaqiao Village, Jiaoxi Village, and Yangqiao Village are all situated near the major roads, the entrance of village streets, and at the boundaries linking the village to the external area. These areas are congested with pedestrians and constitute the most convenient places that are connected to the other parts of the village starting with the center. In Kaixinbow Village, Donghama Village, Dafangqiao Village, and Zhuling Village, however, the areas with the least depth values are clustered in the public spaces in the villages as well as the areas where activity in the villages is most active. To put it another way, the regions with the smallest depth values are the ones with the highest traffic volumes of both humans and vehicles as well as the highest traffic activity throughout the whole village.

5 Spatial gene construction and data analysis of traditional villages in Jiangsu Province

5.1 Spatial Gene Construction and Analysis of Traditional Villages

This section extracts the spatial genes associated with the external natural setting and the internal architectural environment of traditional villages in Jiangsu Province. These genes are expressed through the mountain-water-forest-field gene, the overall spatial gene of the settlement, the street-and-alley spatial gene, and the courtyard gene. On this basis, by examining the stability and in-situ characteristics of the associative combination patterns among core elements, the formation mechanism is further revealed.

5.1.1 Mountain-water-forest-field genes

(1) Stabilizing spatial characteristics

1) Mountain as the nucleus, living along the hills

As the birthplace of farming culture, most of the traditional villages revolve around the farmland, but under the influence of hill topography, high, medium and low hills are scattered, and will also enclose a more gentle area, so the traditional village buildings in Jiangsu Province show a linear development with the hills, and gradually enclose the situation.

2) Harmonization of Mountain Residence

Due to the impact of the complicated terrain and geographical features, combined with a great number of mountains and water bodies scattered throughout the river systems, the majority of rural settlements in Jiangsu Province demonstrate a similar landscape pattern whereby mountains, rivers, forests, and fields are interwoven, producing a charming environmental mood.

3) Relationship between mountains and fields

There is a strong relationship between mountains and cultivated areas on the natural territory of the traditional villages in Jiangsu Province. Taken together, the villages present the characteristic of a vernacular landscape, where mountains, forests, and farmland are interlaced into each other.

4) “Mountain-Field-House” Sequence

Since Jiangsu Province has a well-developed water network and rather big river systems, there is a specific organizational pattern that has developed where water takes the central place in organizing the landscape space. Concurrently, this sequence adds up to the general hierarchy

of the landscape of the settlement, it is an organized sequence of spaces.

(2) Village locality

The “mountain as the core” is a kind of centripetal gene, which is a spatial characteristic of the traditional villages in Jiangsu Province, but it is expressed in different forms in different geographical environments, which is mainly affected by the intermingling of local natural and human factors, and finally reflected in the morphological layout of the villages, which forms a mountainous landscape with the back of the mountains and the river, with farmland interspersed with the mountainous landscape, with farmland interspersed with the mountainous landscape. The spatial gene sequence of mountain-water-forest-field is interspersed with farmland.

5.1.2 Overall spatial genetics of the colony

(1) Stabilization of spatial characteristics

1) Development along the edge

The built environment of traditional villages is mostly developed along the contour of mountains, roads and riverbanks, etc., and the settlement as a whole shows a planar pattern of development along the edge. Traditional villages in Jiangsu Province as a whole are gradually expanded from architectural clusters along the edge into strips, enclosures or linear settlements.

2) Center Diversity

The core of settlement development is the center of village space, which concentrates the spatial elements such as public space for daily activities of traditional villages, traditional buildings and other historical elements. The center of traditional villages in Jiangsu Province is mainly concentrated in the public space nodes. Since most of the historical elements such as ancient trees, wells and bridges are not well protected, they are generally open spaces surrounded by traditional buildings and the surrounding natural environment.

3) Adapting to the local conditions and following the mountainous terrain

Most of the traditional villages in Jiangsu Province are characterized by flexible layout and site selection, mainly based on the landscape environment for the selection of site and shape creation, and at the same time by the influence of roads and rivers, but also shows a linear layout, centralized distribution, as well as a large number of scattered, small concentration of the layout characteristics.

(2) Localization of villages

The “development along the edge” of the settlement is the individualized layout of the village in order to protect the farmland and retain more production factors. Therefore, in areas with gentle terrain, the villages are arranged linearly along roads or mountains, while the foothills form a landscape of terraced fields. As the architectural layout rarely intrudes into the fields or hills, it also does not form a systematic landscape structure, but is mostly a public space enclosed by roads and paths or courtyards, creating a free and flexible idyllic landscape.

5.1.3 Street network genes

(1) Stabilization of spatial characteristics

1) Conformity to topography

Jiangsu Province has a complex and varied topography and landscape, and most of the traditional villages are located between the mountains and the water, which determines that the topography has become an important factor limiting the development of the settlements, but at the same time, it also guides the development of the settlements and changes in architectural form, creating a mountainous structure and texture of the mountain streets that conform to the mountainous terrain, which is manifested in the form of the main streets conforming to the contour, and the secondary streets and alleys interspersed with the perpendicular contour.

2) Receiving and releasing

Mountainous terrain will change with the mountain, some places are steep, some places are gentle, so in the place of gentle terrain, the layout of the building will be more regular, the street space will be more open, the street texture will be relatively sparse. In the direction perpendicular to the contour line, the terrain will be relatively narrow, and the street scale will be more compact and the texture will be more dense.

(2) Village topography

Different villages have different topography and history and culture, which affect the layout of the settlement and the shape of the buildings. For example, in Xigang Village, which is “built along the river with the back of the mountain and facing the water”, the village is developed along the riverbank and contour line. In addition, because the village is built on the river terrace, the buildings are built in the form of hanging footstools to prevent dampness, and there are fewer courtyards in terms of floor plan, so the texture of the streets and lanes is relatively more coherent, with many corridors, which makes the texture and structure more permeable.

5.1.4 Courtyard genes

(1) Stable spatial characteristics

Because of the demand for flood control, the building complexes are built on the terrace, and the buildings are mostly in the form of footstools, mostly developed along the riverbanks, and the dwellings are mostly in the form of zigzag or zigzag in plan, with very few buildings in the form of courtyards, generally ancestral halls.

In the hilly and flat dam areas, the building groups are relatively decentralized, and the layout is also very flexible, mostly in the form of relatively independent compound, so the form of triad and quadrangle is predominant, which is used to form independent residential groups, and the Wo ping or courtyard dam in front of the compound forms a group of its own.

Generally speaking, although the architectural forms of traditional villages in Jiangsu Province are different, they all retain their simple and original styles, and are integrated with the local landscape environment.

(2) Localization of villages

Influenced by topography, climate, history and culture, in areas where the landscape environment and local society and culture are relatively unique, there will be a clear difference between the architectural forms of other areas.

5.2 Interpretation of architectural genetic data of traditional villages

5.2.1 Area disorder index

This paper, based on the building unit area data of 30 traditional villages in Jiangsu Province, draws the average building unit area dispersion distribution map as shown in Figure 7, with the order of villages sequentially distributed from north to south. From this figure, it can be seen that the building unit area as a whole is located under 350m², and the data are concentrated in the range of 100~250m², in addition, from the north to the south, the overall trend of the data is gradually decreasing, and in the middle of the partially increasing, then decreasing changes. And the further south, the building unit area is mostly gathered within 150m².

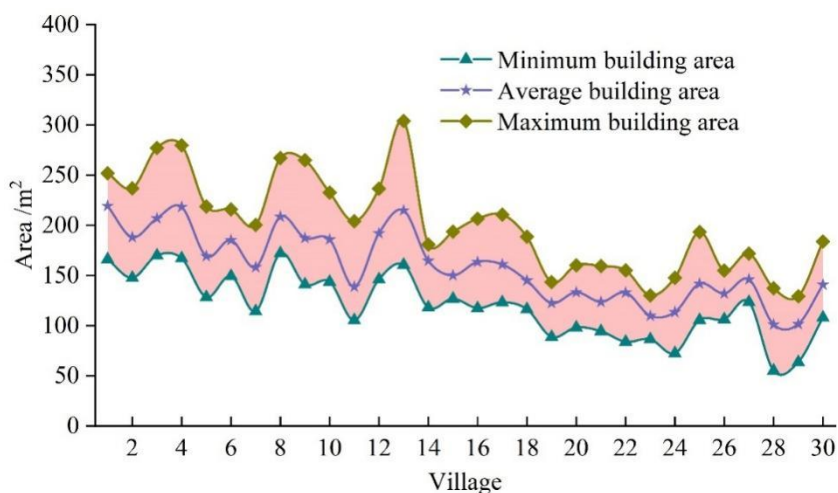


Figure 7: The area of individual buildings in traditional villages is distributed sparsely

In addition, according to the calculated area disorder index of building units, the average disorder index of 30 traditional villages is shown in Figure 8.

The lowest point, highest point, and mean value of the area disorder index were 0.20, 0.58, and 0.33, respectively. As a whole, the data fluctuated from the north to the south, maintaining an equilibrium trend in the central-southern part of the area, followed by a sudden increase and steep decline. In addition, 83.3% of the data were in the range of 0.2-0.4, which determined that the disorder index of the building unit area of traditional villages in the study area was between 0.2 and 0.4, indicating that the undulation of the building unit area of the villages varied greatly.

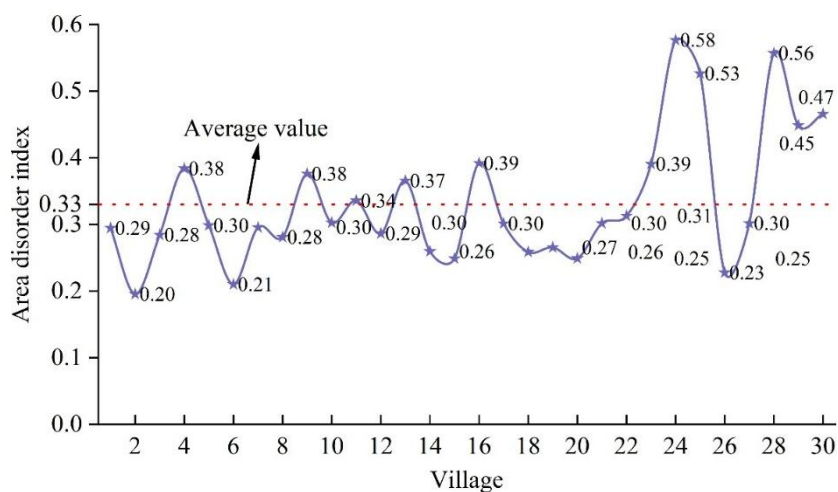


Figure 8: Disorder index of individual building area

The traditional villages with the largest, moderate and smallest disorder indexes are extracted, and the schematic diagram of the disorder index of the building unit area is shown in Figure 9. It can be seen that the larger the building unit area disorder index is, the more the village architectural texture appears to be broken and chaotic, and the smaller the index is, the more coherent it appears.

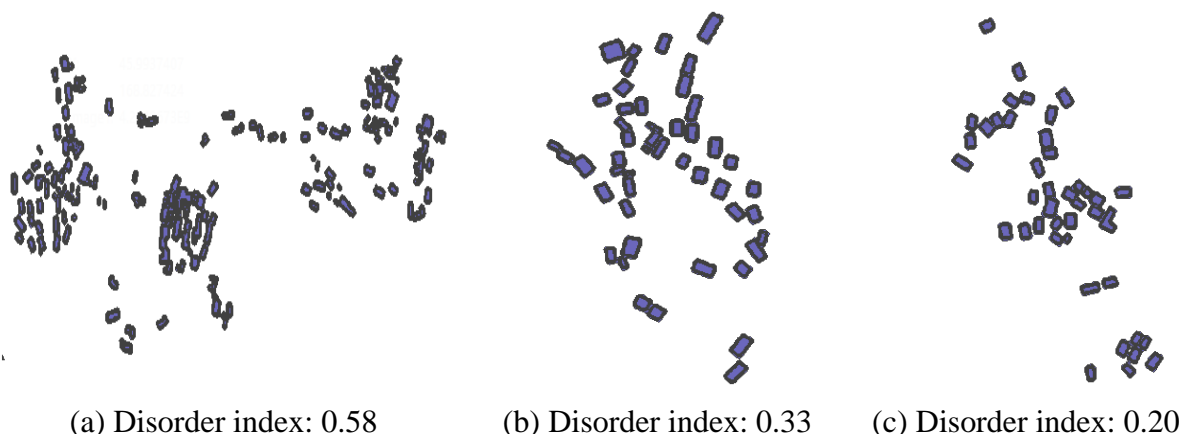


Figure 9: Disorder index of the smallest, moderate and largest single building areas

5.2.2 Angular Disorder Index

With the calculated building unit angle data, this paper draws the building unit angle dispersion distribution map as shown in Figure 10. The overall data has little ups and downs, most of the data is concentrated between $5^{\circ}\sim 40^{\circ}$, and there is no obvious difference between north and south, and locally there are data concentrated in the range of $5^{\circ}\sim 25^{\circ}$, so this paper believes that the building angles of the 30 traditional villages in Jiangsu Province are mostly in the east of north-south or west of north-south by $5^{\circ}\sim 40^{\circ}$. In general, the magnitude of the variation of the building angle is large, the vast majority of the buildings are not located in the north-south direction, and most of the traditional villages have a large angular bias angle, which is mainly due to two aspects, one is the risky natural environment, the mountainous terrain does not exist too much of the south and suitable for habitation. The second is the basic food needs, people need to survive farming, food crops need good lighting conditions, people in order to survive most of the habitable places to food farming.

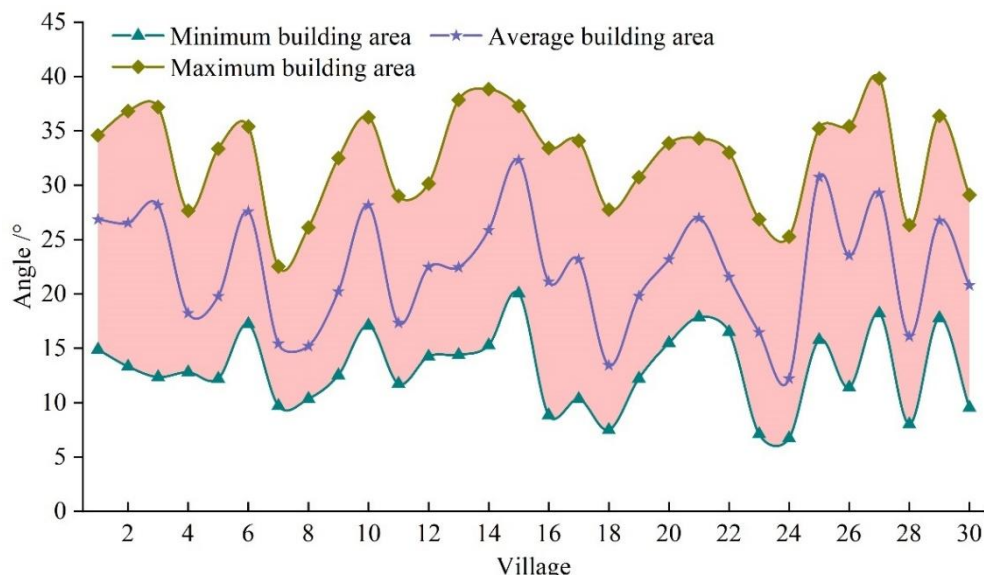


Figure 10: The angular distribution of individual tendons

In this paper, the Building Unit Angle Disorder Index is calculated based on the building unit angle data, in order to measure the disorder of the building unit angle of each traditional village, and ultimately to realize the overall analysis of the traditional villages in the whole

study area, and to observe their significant features. The building angle disorder index is shown in Figure 11. The overall angular disorder index is relatively large, and the undulation varies greatly from north to south, and there is a steep drop in the local situation, with the lowest value, the highest point, and the average value of 0.20, 0.58, and 0.41, respectively, of which 60% of the data are located in the range of 0.3-0.5.

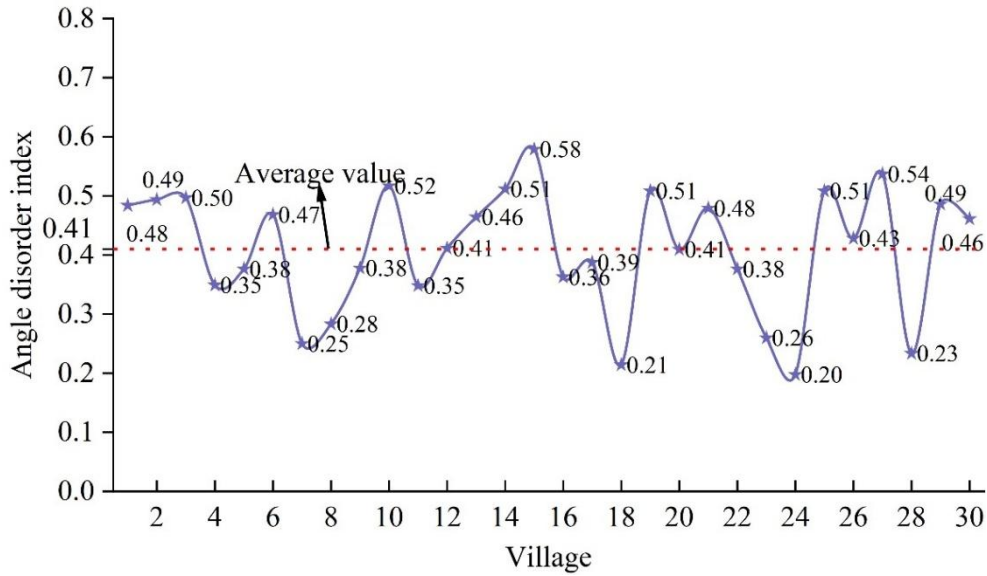
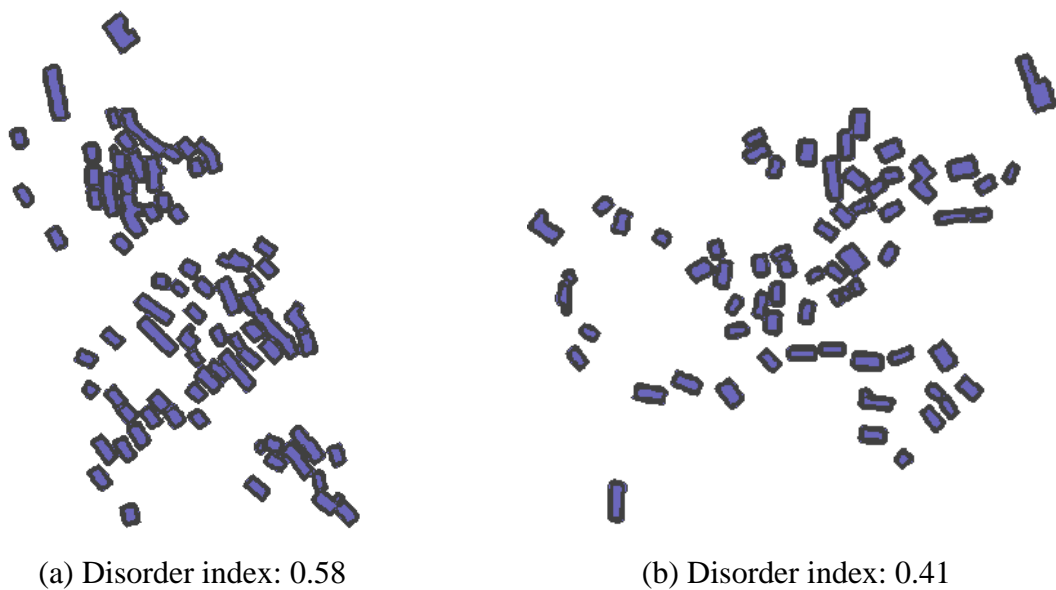


Figure 11: Disorder index of individual building angles

Figure 12 displays the architectural textures of traditional villages in relation to the maximum, intermediate and minimum values of the angular disorder index of the building units. One may observe that the lower the angular disorder index of the building unit, the higher is the directional consistency along the north-south axis. However, this should not lead one to conclude that greater angular disorder index always means worse order. The traditional village architecture with the largest angular disorder index is not chaotic, but rather has some sense of order, in comparison to the architecture of traditional villages in the direction associated with 0.41, which seems more disorganized.





(c) Disorder index: 0.20

Figure 12: Minimum, moderate and maximum individual building angle disorder index

5.2.3 Spacing disorder index

Based on the building unit spacing data, the author drew the distribution map of building unit spacing concentration and dispersion of 30 traditional villages samples in Jiangsu Province as shown in Figure 13. The overall ups and downs of the data are relatively gentle, and not much change is seen from north to south, but from the degree of concentration of the data, most of the data are located between 20 and 80m.

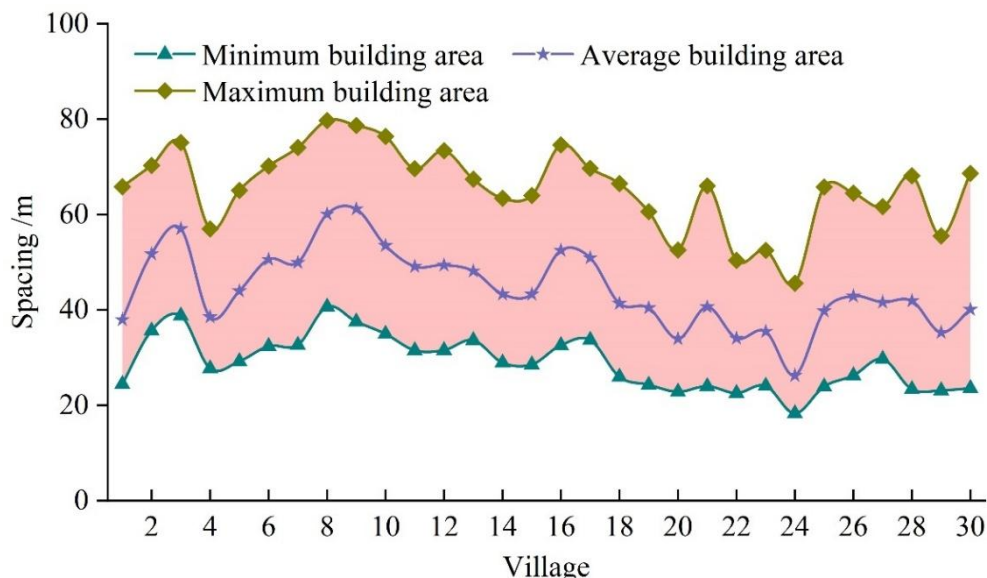


Figure 13: Spacing of individual buildings

According to the building unit spacing data, this paper measured the building unit spacing disorder index of each traditional village as shown in Figure 14. Overall, it seems that the data fluctuates greatly, from north to south first decreases, then increases tends to level off, then decreases, then rises tends to level off growth, in a sudden step increase and steep decline, level off and then rises in the decline. In addition, 90% of the data are concentrated in the range of 0.30 to 0.60, the maximum, minimum and mean values are 0.71, 0.25, 0.41, respectively,

therefore, this paper believes that most of the villages in the study area of the building unit spacing disorder index are within the range of 0.30 to 0.60.

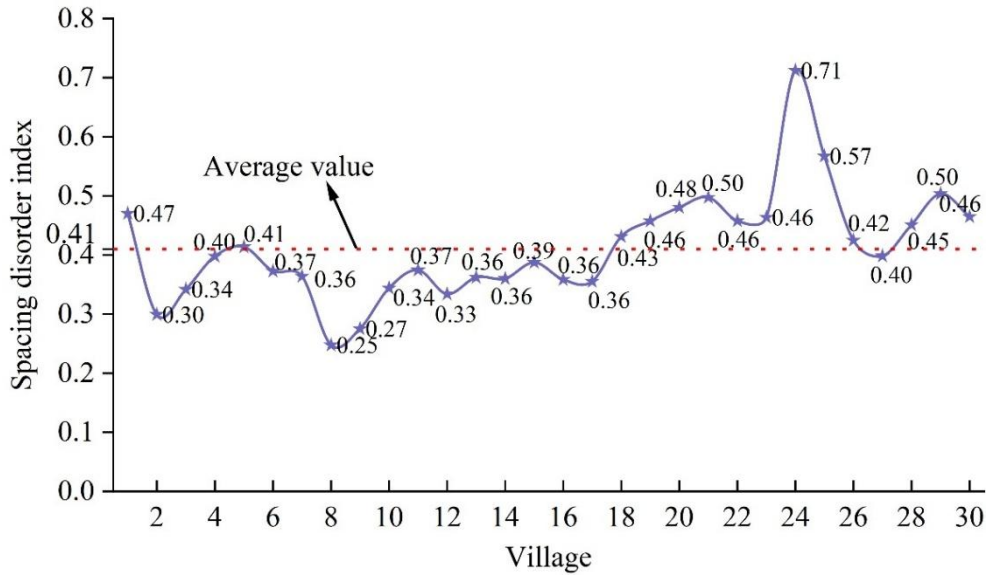


Figure 14: Disorder index of the spacing between individual buildings

The maximum value, the moderate value, the minimum value, the average value of the three data of the representative villages are extracted, and their single building disorder index is shown in Figure 15. Observation can be seen, for the building unit spacing disorder index represented by the village architectural muscle characteristics of the performance is very obvious, the greater the disorder index, the closer the building between, and vice versa.

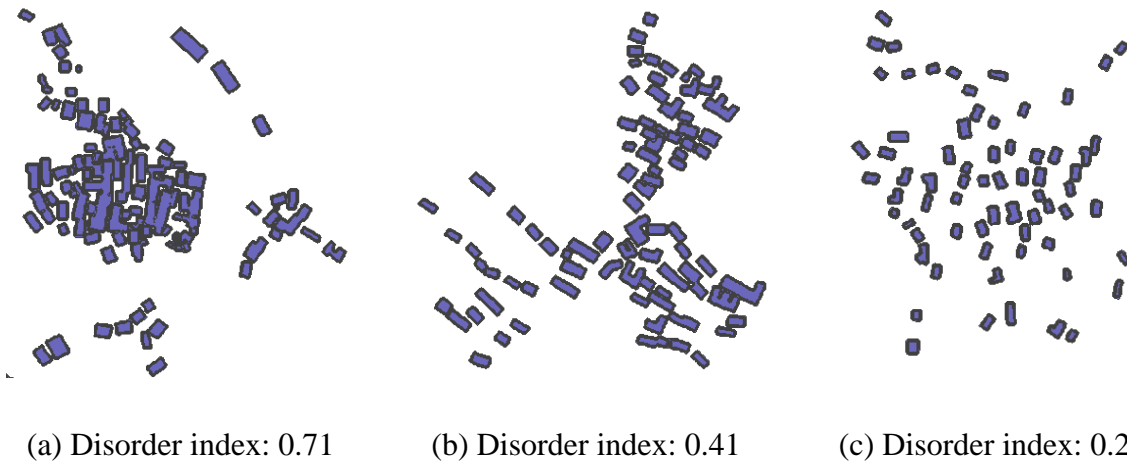


Figure 15: The disorder index of the minimum, moderate and maximum spacing of buildings

5.2.4 Genetic Measurement Data Correlation Analysis

In order to explore the interconnectedness of the traditional village architectural genetic measurement data, this paper carries out Pearson correlation matrix analysis on the building unit area disorder index, the building unit angle disorder index, and the building unit spacing disorder index, and the results of the correlation analysis are shown in Table 6. Where ** indicates significant correlation at p less than 0.01 level.

It can be seen that the area disorder index and angle disorder index of traditional village

building units show insignificant negative correlation, but with the spacing disorder index shows significant positive correlation ($p < 0.01$), which means that when the area disorder index of traditional village building units increases, the spacing disorder just will also have a significant increase. In addition, there is no significant negative correlation between the angle disorder index and the spacing disorder index.

Table 6: Correlation analysis of architectural gene measurement data

	Area disorder index	Angle disorder index	Spacing disorder index
Area disorder index	1		
Angle disorder index	-0.215	1	
Spacing disorder index	0.518**	-0.206	1

6 Strategies for the conservation and inheritance of traditional village spatial form genes

Using the spatial distribution features of traditional villages of Jiangsu Province and the interpreted findings of genetic data, this chapter compiles and constructs a data repository of spatial elements in traditional villages using digitalization technology, and based on this, it proposes some measures to protect and inherit the genetic components of the spatial structure of traditional villages by combining gene-transmission properties with the needs of the three principles of cultural heritage protection.

6.1 Genetic Conservation Strategies for Traditional Village Spatial Forms

Based on the principles of integrity, authenticity, and continuity, this paper suggests a genetic conservation approach to the spatial form of traditional villages.

(1) Integrity protection strategy

The preservation of the traditional village spatial morphogenetic features must consider the integrity of the spatial elements, such as the material structure, the view, and the functionality of the villages.

In the course of protection, data on the spatial environment of traditional villages must be gathered, such as mountains, water bodies, roads, buildings, and any other element, but the historical and cultural heritage of villages should also be registered, like the colors and ornaments of architecture, clan culture events, and traditions. Ecological balance and integrity of natural-environmental factors around the village can be maintained to preserve the spatial setting of the village, which will help achieve the inherited value of the village history and culture and ensure a long-term transfer of the essence of the village. In addition, this method reflects the structural, planned, and functional memory of space development in traditional villages at various historical stages, retains the initial spatial organization, order, and space-functional properties of villages, and allows inheriting all the regional space properties and functions of villages.

Also, street space, architectural courtyard space, and identification node space are the most significant elements to preserve the spatial arrangement and stylistic identity of villages. The safeguarding of these elements must be based on the original historical features of spatial elements and permit suitable transformation of these elements in line with the requirements of modern life so as not to adopt a monolithic protection strategy.

(2) Original Protection Strategy

It is necessary to return to the original spatial situation of the prototype of the traditional

village spatial form at every historical stage and preserve the genuine expression of the genetic elements of village spatial form. In the macro-spatial context, the initial village spatial-environment pattern and the historical-cultural meaning of it must be conserved. With these premises in mind and with the use of the spatial pattern and landscape features of the village at different stages of history, the protection and restoration of the genetic elements of village spatial form should be maximized, since this would maximize the authenticity of the genetic elements of the spatial form of the traditional village. At the same time, it should be noted that the space of the village streets, the space of the architectural courtyards and identification space nodes should be preserved and exhibited both in the form and design, materials and textures, functions and skills, as well as in the spiritual and emotional aspect under the conditions of retaining the spatial structure, order, and functions of the village.

(3) Continuity protection strategy

The genetic parts of the traditional village spatial form are significant carriers to maintain the village spatial environments and historical and cultural continuity. The spatial structure, order and functions of the village are among these elements that symbolize the continuation of the inner order and organization of the village, but they also express the external manifestation of the inherited spatial logic of the village. As per village history and culture, the street space, building space, courtyard space, identifying nodes and other spatial forms, along with socio-economic development reflected in material elements collectively contribute to the continuity of village spatial functional attributes and cultural value.

Consequently, the continuity-protection approach concerning traditional villages must be based on maintaining a sense of integrity and authenticity of the genetic aspects of the village space form, as well as understanding the joint development between traditional villages, their spatial setting, historical and cultural background, and socio-economic progress. By doing so, the spatial structure of Suzhou traditional villages will still be able to inherit and pass down over time.

6.2 Traditional Village Spatial Formation Gene Inheritance Strategy

The internal and external genetic factors of the traditional villages are subject to evolution with the development of the villages. Consequently, their preservation and legacy ought to be considered in terms of stability, continuity, and variability of genetic factors.

(1) Stability inheritance strategy

The traditional village site layout spatial environment and cultural meanings are in line with the traditional philosophy concepts and are consistent with the natural, humanistic and social environment. This compatibility is the foundation of the origin and formation of the traditional village space form, so the issue of inheritance must be examined more closely to understand the humanistic value that it represents.

The spatial order, regional structure, and spatial functions of the village are the external manifestation of the regional features of traditional village spatial form, but also represent the transmitted internal logic of village form. The constant transmission of the village street space, architecture courtyard space, and identifying node space enables village spatial form to keep its inherent functional purpose, historical value, and cultural significance, which can offer genuine value information and identity indicators to traditional villages.

(2) Inheritance inheritance strategy

The spiritual meaning and space features of old villages are the core of the continuation and passing on of the villages. When designing the spatial patterns of the village, the historical and cultural value of villages, as well as their natural connection with spatial patterns, have to be thoroughly investigated to understand the inner cultural value and history of traditional villages in Suzhou.

At the same time, spatial structure, spatial order, and spatial function are important vehicles of inheriting the regional features of village spatial form. Understanding the combined value as well as the current value of the spatial components of traditional villages can help enhance village spatial functions. Besides, street space, architectural courtyards, and identification of node spaces are intrinsic spatial elements that define the regional spatial features of traditional villages, and the way to inherit these is based on having a clear understanding of the original spatial pattern, function and importance.

(3) Variation inheritance strategy

The traditional village spatial form has inherited and adaptive genetic elements, which change over time depending on the social development and changes in lifestyle. The villagers synthesize the traditional culture and traditions with the contemporary world to form a culture that is not only responsive to the current social demands but also preserves the features of the traditional way of life, so as to revitalize the historical culture of the traditional village and continue developing it in line with the social evolution and the spiritual meaning of the village.

Moreover, spatial characteristics of traditional villages are also evolving due to the social environment and family structures to suit the social and economic development. Simultaneously, architectural compounded space is the spatial component of the traditional village form that alters the easiest. It changes as building methods, materials, and environmental conditions change but traditional street space and identifying node space change as a result of changes in the overall spatial context of the village.

7 Conclusion

The given paper will choose 554 traditional villages in the province of Jiangsu as the research population. It studies the spatial morphology and gene construction of traditional villages using spatial gene-recognition technology and offers a general strategy that can be used to protect and inherit the spatial morphology genes of traditional villages.

Conventional villages in the Jiangsu Province are predominantly located in the middle and southern sides of the province whereas the Northern part is relatively less densely populated, creating a spatial arrangement of high-density in the centre and south and low-density in the north. Meanwhile, the distribution across municipalities is not even. At the provincial scale, the agglomeration pattern is clustered, focused on two core regions of Central Suzhou and Southern Suzhou, and progressively decreases towards the outside, indicating an overall spatial organization of density in the south and sparsity in the north. Also, the majority of the villages in Jiangsu Province have a strong overall perception of space. It has to do with the fact that most of them lie within not very mountainous territories, have quite extensive road networks, are tightly populated by old buildings, and have compact water bodies. Village center has the highest level of street-to-street connection and least depth value and is also the region with the highest pedestrian and motor vehicle traffic and the most intensive traffic in the village.

The area disorder index, angular disorder index and spacing disorder index of each building in traditional villages in the Jiangsu Province are all within the corresponding ranges indicating that the spatial form of the village has a certain inner order and demonstrates regional and adaptation differentiation.

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