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Spatial and Temporal Evolution and Conservation Significance of Traditional Villages in the Yangtze River Basin, China

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Abstract: Traditionally, "ancient villages" are communities that date back to a previous era, possess abundant traditional resources, and hold significant historical, social, cultural, ecological, and economic significance. This study examines the geographical and chronological development of 2957 traditional communities in the Yangtze River Basin and extensively employs GIS spatial analysis, geostatistical analysis, and historical literature review to study the evolution of the locations of traditional settlements under various factors. The study's findings revealed that: (1) From a geographical standpoint, the traditional villages in the study area present a distribution state of "two cores, small aggregation, and many dispersions". The two core clusters are located at the intersection of Hunan, Guizhou, and Chongqing provinces, where the natural geographical advantages attracted people from different dynasties to settle here. (2) From a temporal perspective, the quantity of traditional villages shows a growing trend, and the distribution center of each dynasty shows an east–west direction. Among them, the shift from the Song to the Yuan dynasties marked the period of greatest change in village distribution, which originated from the Song Dynasty's quick economic growth. In addition, the village distribution was clustered in the eastern part of the country, adapting to the needs of commercial trade. When the Song Dynasty fell, the society was in turmoil, and the villages were transferred to the central region to avoid the war. The Yuan Dynasty also laid down the fundamental distribution pattern of conventional villages. (3) From the standpoint of choosing a village location, most of them are distributed in mountainous, hilly, and plain regions; the gentle slopes of 0°~15° are favored by people. Sufficient water sources, abundant precipitation, and a suitable climate are also necessary choices. (4) From the perspective of driving factors, traditional village distribution in the basin is impacted by historical, cultural, social, and ecological factors. Included among these, traditional village distribution is inversely connected with socio-economic variables. Under the interaction of two factors, the distribution will be more affected. To summarize, the complex human geographic factors together create the conventional village dispersal pattern, and examining these elements holds substantial practical importance for comprehending, safeguarding, and preserving traditional villages.

Keywords: traditional villages; Yangtze River Basin; spatial and temporal evolution; influencing factors: conservation value

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1. Introduction

Traditional villages are essential elements of the historical and cultural legacy, carrying rich historical information and cultural connotations. It also maps the social structure, economic forms, and cultural characteristics of different historical periods, which are cultural treasures in the history of human development. Since 2012, the Ministry of Housing and Construction and three other national organizations have organized and carried out the first national mapping survey of villages [1]. There have been six batches of traditional Chinese villages announced [2], totaling 8155. In the Yangtze River Valley, there are a total of 2957 traditional villages. This includes 432 in Guizhou Province, 152 in Yunnan Province, 396 in Sichuan Province, 164 in Chongqing Municipality, 672 in Hunan Province, 406 in Jiangxi Province, 264 in Hubei Province, 179 in Anhui Province, as well as 9 in Zhejiang Province, 58 in Jiangsu Province, and 5 in Shanghai Municipality. In recent years, the urbanization process has accelerated, as well as the growth of traditional villages has become increasingly severe. To ensure that the growth of customary villages continues, guidelines for preserving traditional villages have been introduced in various places [3]. As an early historical form in the course of urban development, traditional villages are vital for maintaining regional culture. Hence, research on traditional settlements has important theoretical and practical significance. So far, preserving customary villages remains a challenging and crucial issue [4].

At present, traditional villages have received extensive attention from scholars in sociology, geography, architecture, history, ecology, tourism, and other disciplines. They are intersecting and interpenetrating each other, together constituting a diversified perspective and a comprehensive framework of traditional village research, which has achieved relatively fruitful results. The research in this paper focuses on the subsequent facets. First, the spatial and temporal evolution process, in conjunction with the spatial GIS analysis method, is used to build a GIS database of traditional villages and analyze the evolution characteristics of traditional villages in the historical process from a macro viewpoint [5]. The second is the influencing factors, which analyze in detail the influence of social and environmental factors on traditional village placement [6]. For example, Wang Wei, Liu Yingjie, and Liu Anqi focus on the impact of the natural environment, social and economic, ecological, climatic, historical, and cultural elements, and policy variables on how the spatial pattern of traditional villages has changed throughout time. Thirdly, this study examines protection significance, as protection policy significantly influences the evolution of villages. So it is imperative to build the traditional village defense system as soon as possible [7].

As one of the important water systems in China and even in the world, the Yangtze River Basin has a unique geographic location, varied and intricate terrain and scenery, an extensive range of water systems, rapid development of socio-economic conditions, and profound cultural values. The traditional villages distributed here also possess rich historical and cultural, both creative and academic, and social and economic diversified values [8], as well as distinctive local customs and folklore. This paper chooses traditional villages as the study subject in the basin and carries out research on the process of the evolution of traditional settlements over time and space and their distribution characteristics. Furthermore, it offers counsel and recommendations on how to preserve ancient villages in the modern day.

2. Research Field and Approach

2.1. Study Area

The Yangtze River Basin comprises 19 provinces, municipalities, and autonomous regions spread across three primary economic regions in eastern, central, and western China [9]. It represents 18.8% of China's overall land area. The Yangtze River flows through this vast area, and with geographic coordinates of the basin ranging from latitude 24°27′ to 35°54′ north and longitude 90°33′ to 122°19′ east. With a total length of about 6300 to 6400 km, the Yangtze River is the world's third-biggest river and the largest in China. It comes from the eastern region of the Tibetan Plateau, specifically the Tanggula Mountain Range. The Basin of the Yangtze River has a variety of climate types, experiencing, in turn, a variety of climate types, such as alpine cold climate, plateau temperate climate, and subtropical monsoon climate. According to the Ministry of Housing and Construction of the People's Republic of China, the method for selecting well-known historical and cultural towns and villages, as well as the index system for evaluating and recognizing traditional villages. As of 2023, there were 2957 traditional villages publicly distributed in the basin. These villages have nurtured a rich cultural heritage and humanistic landscape with high cultural value (Figure 1).

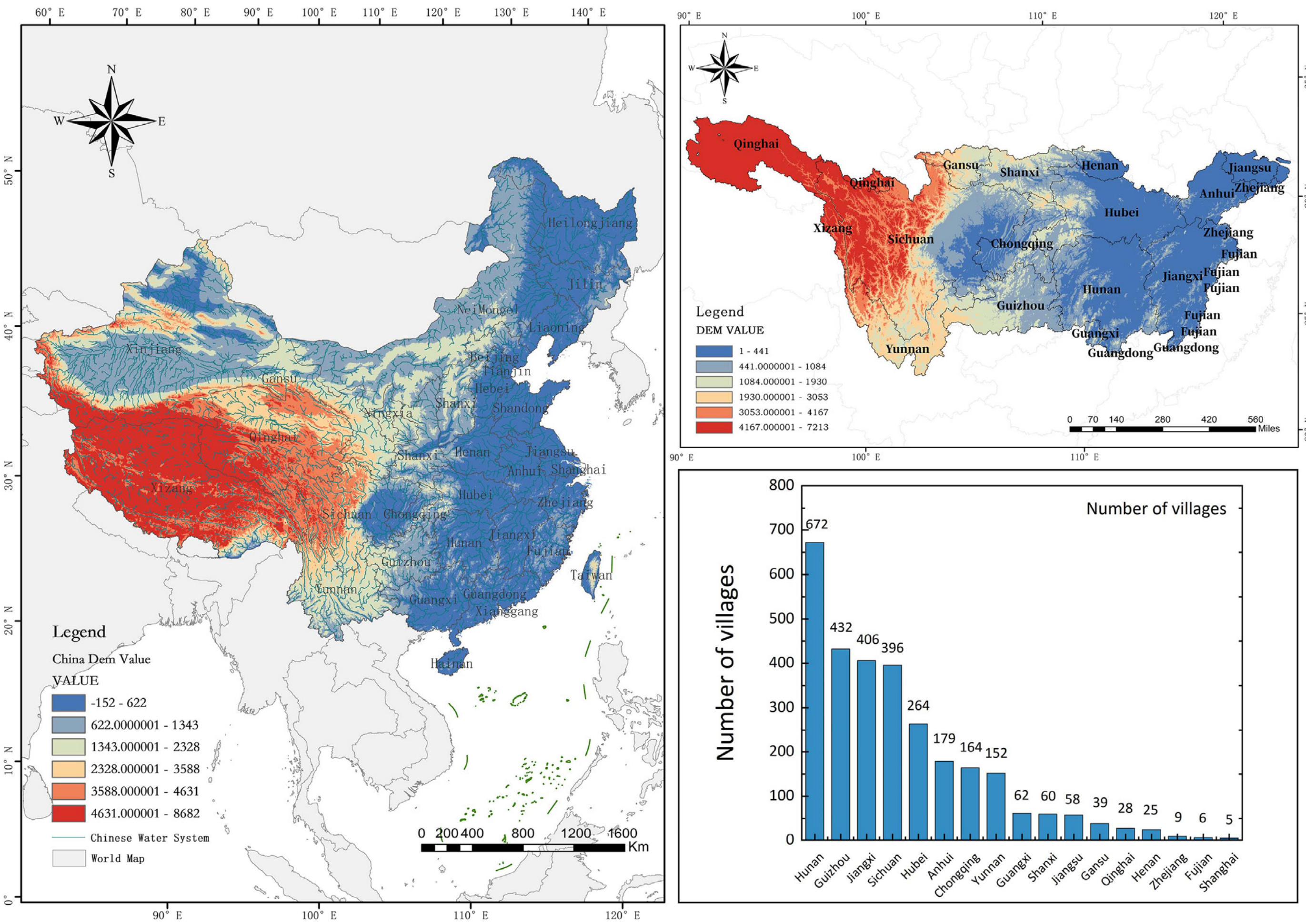

Figure 1. Location of the research area.

2.2. Data Sources and Processing

The six batches (2012−2023) of Chinese traditional villages published on the People's Republic of China's Ministry of Housing and Urban-Rural Development website (www.mohurd.gov.cn, accessed on 24 July 2024) are the source of all the data for traditional villages recognized at the national level [10]. A total of 2957 conventional villages situated in the Yangtze River Basin were acquired by organizing and removing duplicated villages. The selected 2957 research samples were located at the precise coordinates on Baidu Map and Map Location, and then the coordinates of villages were extracted from them. The information on the target villages was linked to the geographic information system (GIS) software. Utilizing the ArcGIS 10.8 platform, the sample data were analyzed and visualized. The geographic distribution maps of these traditional villages were then generated (Figure 2). The National Earth System Science Data Center provided the Yangtze River Basin river data [11] while the Geospatial Data Cloud Platform provided the DEM (Digital Elevation Model) data with a spatial resolution of 30 m × 30 m.

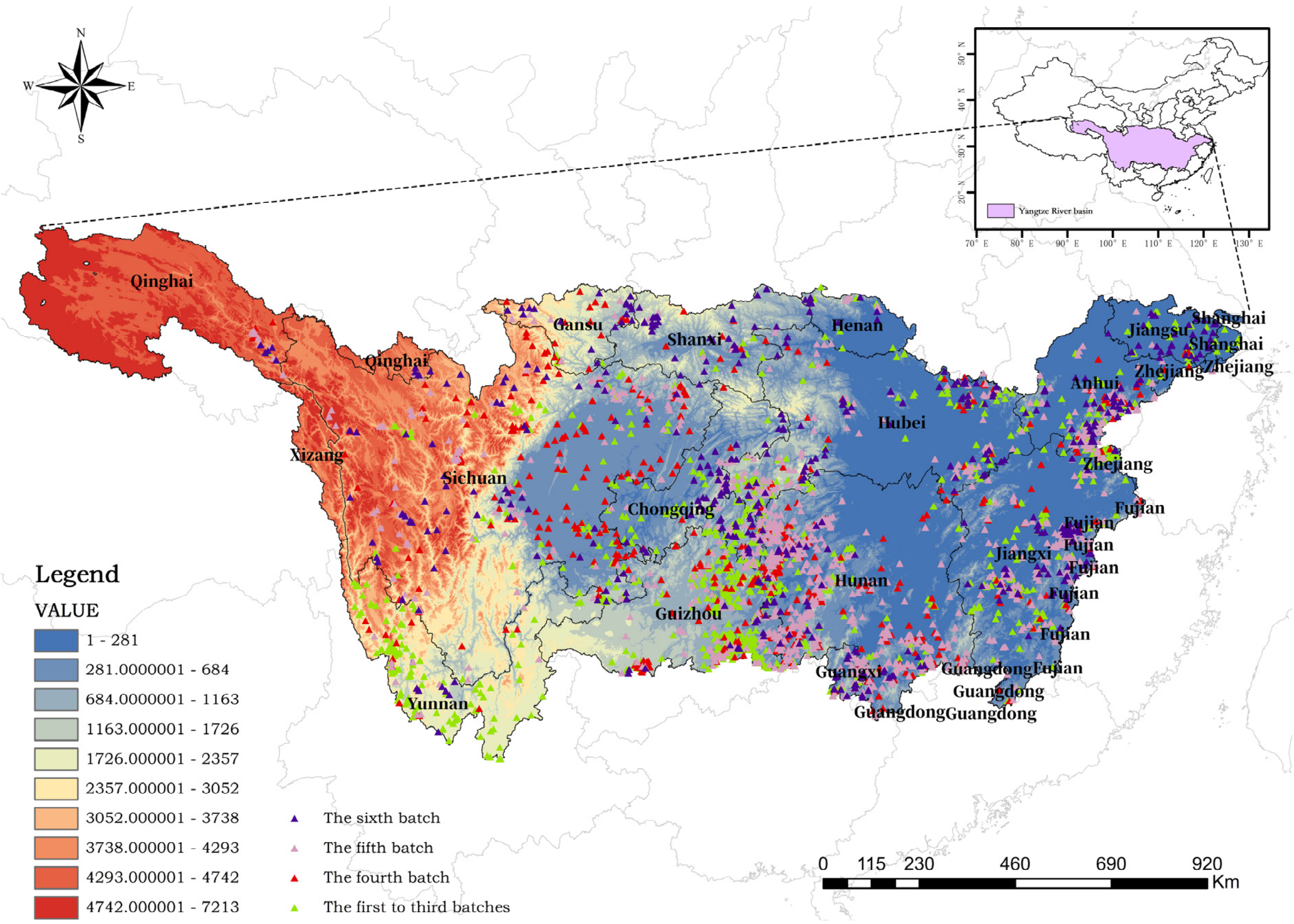

Figure 2. Spatial distribution of traditional villages in the Yangtze River Basin.

2.3. Research Methodology

This research categorizes the geographic spread of traditional villages in the Yangtze River Basin. It considers the impact of practice history development on the evolution of the geographic arrangement of villages utilizing ArcGIS 10.8's spatial analysis features, which include the nearest-neighbor index, kernel density analysis, imbalance index, and standard deviation ellipse. The selection of spatial analysis methods necessitates comprehensive consideration of research objectives, data characteristics, technical feasibility, and overall evaluation. By making reasonable choices, one can precisely uncover the spatial arrangement of villages, evaluate population or resource density hotspots, quantify regional development disparities, and delineate the direction and pattern of village agglomeration and dispersion. Utilizing tools like ArcGIS, in conjunction with methods such as the nearest-neighbor index and kernel density analysis, ensures that the analysis aligns with research requirements, maximizes data utilization, and maintains technical feasibility, thereby yielding scientific and precise spatial analysis outcomes.

2.3.1. Nearest Point Index

The Nearest Neighbor Index (NNI) is the ratio of the actual closest distance to the theoretical closest neighboring distance and illustrates the arrangement of point features within geographic space [12,13]. It is a geographic indicator that quantifies the features of point element spatial dispersion, including aggregated, homogeneous, and random types. It can indicate the degree of aggregation among the research objects within a certain spatial range. It is possible to show the degree of aggregation among traditional villages in the study area. The following is the exact formula for NNI:

$$E = \frac{\overline{r_1}}{r_E} = \sqrt[2]{D} \quad (1)$$

where E denotes the nearest neighbor index (NNI); r_1 represents the average value of the separation of every point from its closest neighbor [13]; r_E indicates the theoretical closest average distance; and D symbolizes the density of points. When E = 1, it indicates that the point elements are dispersed randomly. When E > 1, point characteristics are typically distributed equally. Conversely, when E < 1, It suggests that there is a spatial clustering of the point elements.

2.3.2. Kernel Density Estimation Methods

A nonparametric statistical technique for determining the probability density function of a random variable is kernel density estimation. It is based on data sample points and weighted summation of sample points by kernel function and bandwidth parameter to get the estimation of the probability density function. Kernel density analysis can facilitate the understanding of the clustering of data points within a watershed, including the degree of aggregation between spatial elements. The specific formulas of KDE are as follows:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - X_i}{h}\right) \quad (2)$$

where $f(x)$ represents the density estimate at point x, n denotes the total number of observations [14], h is the Search Radius (Search Radius, h > 0), k() is the kernel function, $\sum$ denotes the summation of all the observations X_i, and $(x - X_i)$ denotes the separation from the estimated village x to the sample village X_i. The center of gravity of the distribution of villages is thus the area with the highest kernel density value [15].

2.3.3. Standard Deviation Ellipse

A standard deviation ellipse is a statistical method used to characterize the guidance and distribution of a set of geographic data. It computes parameters like the mean center and the long and short semi-axes to create an ellipse. And rotation angle of the data to visualize the direction, extent, and dispersion of the data distribution. The minor axis gauges how far the data are dispersed, and the major axis indicates the primary direction of dispersion. The flattening ratio or the directionality of the distribution is determined by the major-to-minor axis ratio. An increased ratio indicates a more pronounced directionality of the distribution. A reduced ratio, closer to a circle, shows a weaker directionality and a wider spread of the distribution. The following is the precise formula used to calculate SDE:

$$tan\theta = \frac{\left(\sum_{i=1}^{n} w_i^2\widetilde{x}_i^2 - \sum_{i=1}^{n} w_i^2\widetilde{y}_i^2\right) + \sqrt{\left(\sum_{i=1}^{n} w_i^2\widetilde{x}_i^2 - \sum_{i}^{n} w_i^2\widetilde{y}_1^2\right)^2 + 4\sum_{i=1}^{n} w_i^2\widetilde{x}_i^2\widetilde{y}_i^2}}{2\sum_{i=1}^{n} w_i^2\widetilde{x}_i\widetilde{y}_i^2} \quad (3)$$

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i\widetilde{x}_i cos\theta - w_i\widetilde{y}_i sin\theta\right)^2}{\sum_{i=1}^{n} w_i^2}} \quad (4)$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{n}\left(w_i\widetilde{x}_i sin\theta - w_i\widetilde{y}_i cos\theta\right)^2}{\sum_{i=1}^{n} w_i^2}} \quad (5)$$

where θ is the rotational angle, and σ_x and σ_y represent the standard deviations for the x-axis and y-axis, respectively. The allocation in centroids of traditional villages of China is studied by using the standard deviation ellipse analysis method in the ArcGIS platform.

2.3.4. Imbalance Index

The imbalance index is an indicator utilized to gauge the intensity of distribution equilibrium of a phenomenon or data among different regions [16], categories, or levels. To examine the distributional equity of traditional villages, we calculate the imbalance index within the Yangtze River basin [17]. The equation for determining the imbalance index is as follows:

$$S = \frac{\sum_{i=1}^{n} Y_i - 50(n+1)}{100 \cdot n - 50(n+1)} \tag{6}$$

where n represents the total count of provinces within the basin [18], and Y_i indicates the first province is the total proportion of villages in all basin provinces to the overall count of villages within the basin. The provinces are arranged in descending order according to the percentage of traditional villages to the total number. The value of S is generally between 0 and 1, with values nearer 0 signifying a distribution that is more balanced and values closer to 1 indicating a more unbalanced distribution.

2.3.5. GeoDetector Analysis

Geoprobe is a statistical model for spatial analysis. It can test both the spatial dissimilarity of a single variable and the possible causal relationship between two variables by testing the coupling of their spatial distributions. It includes a variety of means, such as nonlinear detection, interaction detection, single-factor detection, and ecological trend detection [19]. This study was used to detect the change in values under the influence of each single factor and two factors. Thus, to explore the significance level of each factor affecting the distribution of traditional villages.

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST}, h = 1, 2, \ldots, L \tag{7}$$

$$SSW = \sum_{h=1}^{L} N_h \sigma_h^2 \tag{8}$$

$$SST = N\sigma^2 \tag{9}$$

where q is a number between 0 and 1, and h = 1, 2,. . ., L indicates how the dependent variable is arranged Y. The more significant the difference in location between traditional villages, the higher the value, q is 0 represents that factor X does not have any relationship with Y. The p-value indicates the degree of significance of the role of every element in the typical village distribution. And $p < 0.05$ indicates that the factor is more significant in how traditional settlements are distributed.

3. Research Results

3.1. Spatial Distribution Characteristics

In this study, the nearest neighbor index analysis was carried out by ArcGIS 10.8, which yielded a nearest neighbor ratio of 0.532882. Consequently, it may be concluded that traditional villages along the Yangtze River follow a unified geographical distribution pattern. This analysis showed that the actual nearest neighbor distance (r_1) had a mean value of 7.969 km, while the expected distance (r_E) is 1.495 km, so the nearest neighbor index ratio (R) is 0.532. A negative Z value (−48.59) and a near-zero P (−48.59) and close to zero values indicate clustering in the 2957 traditional communities' study data.

3.2. Balanced Spatial Distribution

Because of the impact of numerous elements, including the natural geographic environment and socio-economic culture between each province, the distribution of villages will also have differences in distribution equilibrium. Through an examination of the balance in the traditional village distribution within the Yangtze River Basin, the imbalance index S = 0.601 > 0 is determined. That demonstrates an uneven distribution of conventional villages in the area. The Lorenz curve of its traditional villages shows that most of the traditional villages are distributed in Hunan Province, Guizhou Province, Jiangxi Province, Sichuan Province, and Hubei Province (Figure 3).

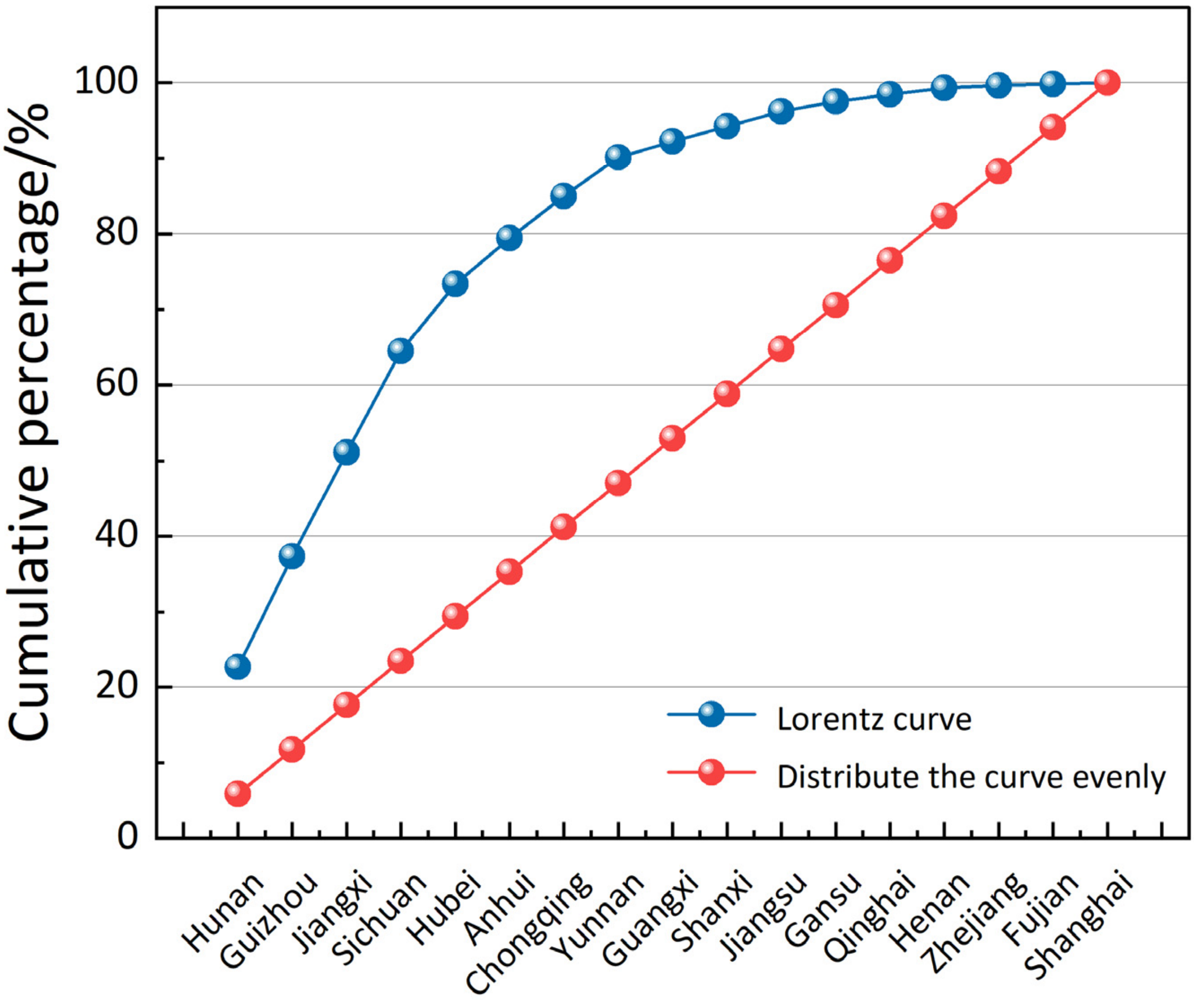

Figure 3. Lorenz curve displaying the spatial arrangement of traditional villages in the Yangtze River Basin.

3.3. Spatial Distribution Density

The Yangtze River Basin's traditional villages' kernel density was examined in this research using the kernel density analysis tool in ArcGIS 10.8 software to determine its kernel density distribution map. The center region of the basin has the core [20,21], a high-density area where traditional village distribution occurs, with kernel density values ranging from 52 to 137. It is most densely distributed at the junction of Chongqing Municipality, Hunan Province, and Guizhou Province [22]. The second high-density area is distributed in the eastern part of the Yangtze River Basin, where the value of core density is between 52~116, the central part of Jiangxi Province. The intersections of Zhejiang and Anhui Provinces, as well as those between Guangdong and Guangxi Provinces, are quite pronounced. The distribution density in the western region is lower and more scattered. Overall, the distribution pattern is demonstrated by the nuclear density of the highest in the central part, the second in the eastern part, and the lowest in the western part. It shows a multi-peaked distribution with multiple concentrations of kernel density values in different regions (Figure 4).

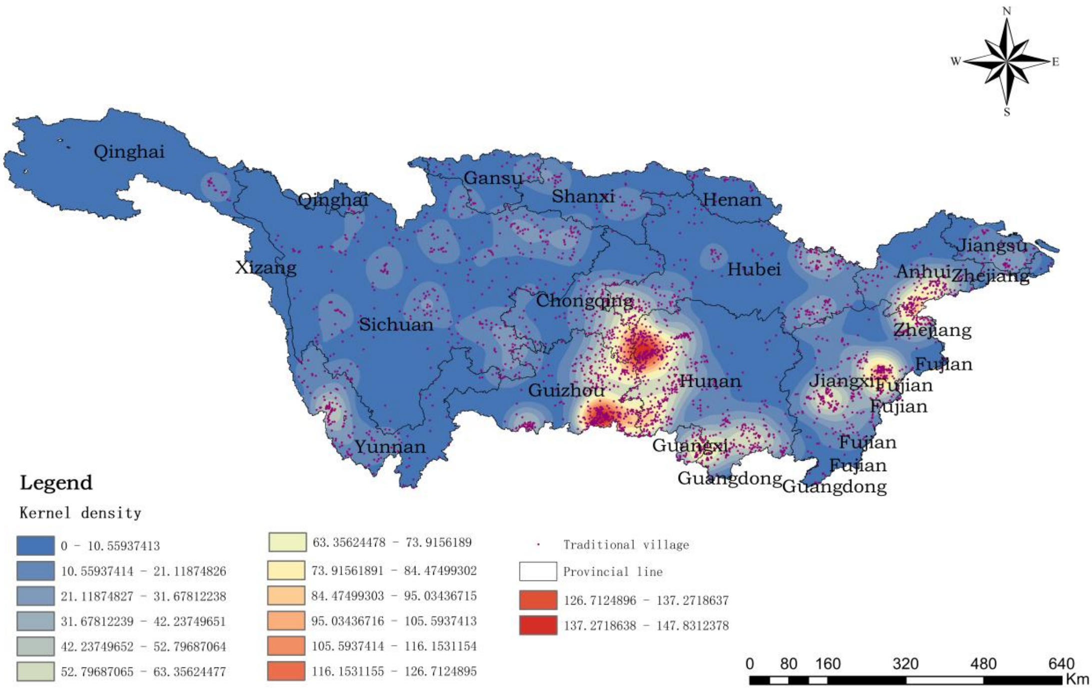

Figure 4. Nuclear Density Evaluation of Historical Settlements in the Yangtze River Basin.

3.4. Qualities of Evolution in Time and Space

By searching the information, among the 2957 traditional villages with historical records, there are 447 in the Sui Dynasty and before, 251 in the Tang Dynasty, 408 in the Song Dynasty, 170 in the Yuan Dynasty, 689 in the Ming Dynasty, and 992 in the Qing Dynasty and after. Using the standard deviation ellipse (SDE) for spatial distribution analysis, it is possible to see its out-distribution pattern (Figure 5).

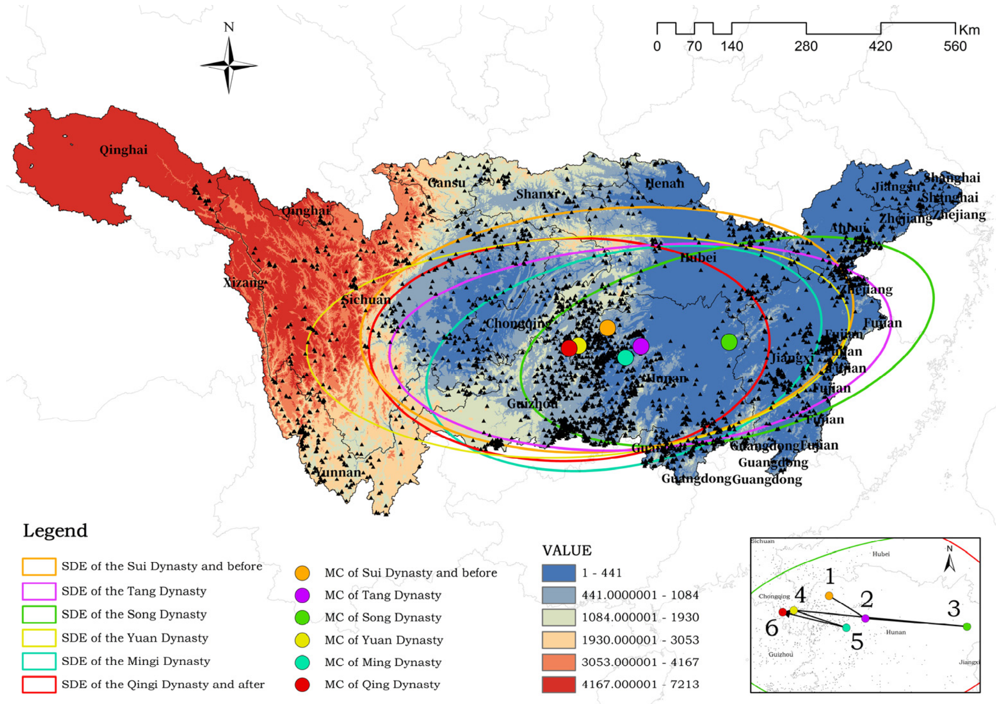

Figure 5. The comprehensive development of traditional village spatial arrangements in the study area.

The Sui Dynasty and earlier periods established the groundwork for the advancement of conventional villages, with larger SDEs, lower axis ratios, and a wider distribution of villages. The Tang Dynasty had smaller SDEs and larger axial ratios, showing a trend toward more concentrated and tightly packed distribution. By the Song Dynasty, with rapid socio-economic development and commercial prosperity, the axial ratios decreased slightly. There was a significant tendency for the center of traditional villages to shift from the central to the eastern part of the country. During the Yuan Dynasty, society was more turbulent, and the political struggle was intense; the center point of traditional villages shifted to the west with a longer axis ratio. During the Ming Dynasty, the axial ratio narrowed, and the distribution center moved to the east again. The Qing Dynasty and thereafter were socially turbulent, and contraction was evident in the SDE, with a tendency for the distribution to be broader and less centralized, and the center of distribution shifted to the west. Influenced by the topography and geomorphology of the Tibetan Plateau and the Hengduan Mountains, the main axis of the SDE has been aligned with the east–west topography within the region. The plains and basins within the region have created a superior natural environment with fertile soil and abundant water sources, ideal for crop growth and human habitation. They offer ideal circumstances for the establishment and growth of communities.

3.5. Factors Influencing Spatial Distribution

This study mainly focuses on natural geographic elements, historical and cultural elements, and socio-economic considerations to develop the narrative. Firstly, to guarantee the validity and scientific integrity of the data, the point data are unified using the official list of six batches of traditional villages. Secondly, the study looks into what influences social changes and the process of establishing spatial patterns in the research area. With that, there are 6 natural geographic factors, 4 socio-economic factors, and 2 historical and cultural factors, for a total of 12 factors. They are selected to examine the distribution pattern of traditional village formation according to each factor's role [23]. Finally, it discusses how to develop and protect traditional villages in the current social situation.

3.5.1. Natural Factors

(1) Topographic factors

Poster, slope, and slope direction data were extracted from the DEM data using ArcGIS 10.8. Combining traditional village data and topographic data, the distribution map of traditional village sites in the basin based on the influence of various topographic factors was obtained (Figure 6). The average elevation value of historical villages in the study field is 742.4 m. 85% of the villages are dispersed in plains, hills, basins, and small mountains with an elevation of 0 to 1000 m. Because of the higher topography of the study area, such as the Tibetan Plateau, the Yungui Plateau, the Hengduan Mountain Range, the Wushan Mountain, and the Xuefeng Mountain, more than 60% of Villages can be found in mountainous, hilly, and plain areas. These areas are prone to the formation of river valleys and flat dams and have fertile soils and sufficient water sources, which support the establishment and growth of villages. The average slope value in the watershed is 5.91 degrees, and 92% of the conventional villages are located within a slope range of 0 to 15 degrees. The count of villages located on slopes greater than 15 degrees has a clear downward trend, constituting merely 7.9% of the total. The percentage of villages distributed in the plains is 7.3%; villages on micro-slopes and gentle slopes account for 23% and 27.8% of the total, respectively. The number of villages on hillsides within a proximity of 5 to 15 degrees accounts for 33.8%.

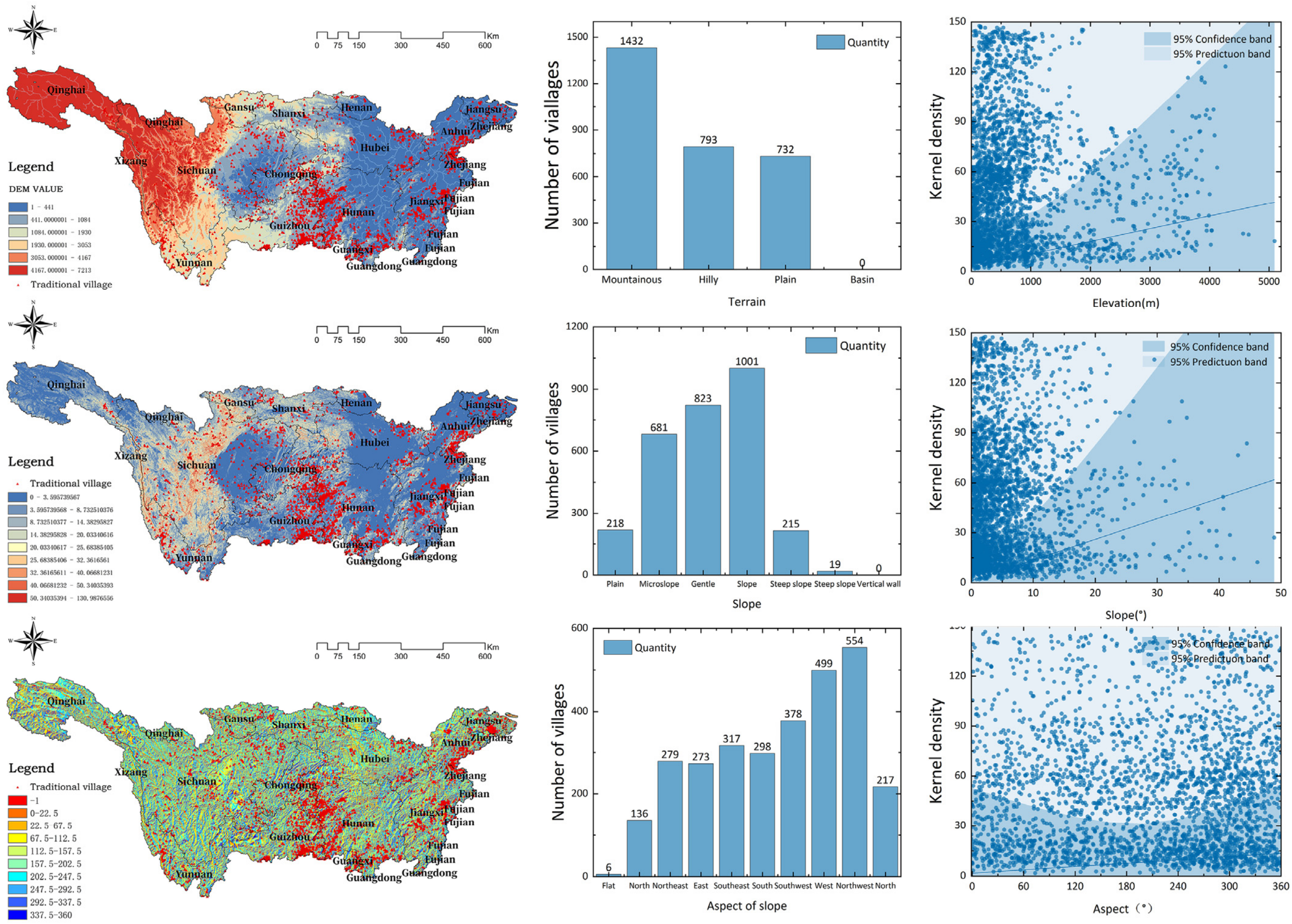

Figure 6. Topographic factors affecting the Yangtze River basin.

This phenomenon suggests that the gentle slopes and slopes are more suitable for human habitation compared with the plains, craggy slopes, and vertical walls, which provide good conditions for the formation and agglomeration of villages. In addition, from the distribution map of slope direction, it can be seen that the number of dorsal shady slopes in the study area is slightly more than that of sunrise slopes. The ratio of sunrise slopes to dorsal shady slopes is calculated to be 1:2, which indicates that people prefer dorsal shady slopes when they live in the area. In conclusion, the topography of the villages in the region tends to be higher in the mountains and hills, with relatively few plains, probably because this type of terrain has a favorable climate and a large number of rivers, which provides a good environment for agricultural production.

(2) Climate and hydrological factors

There exists a significant relationship between the location of traditional villages and various climatic and hydrological factors. Within the research domain, 94.6% of the villages fall within the 500 to 1500 millimeter range [24,25], and Eighty-five percent of the communities are situated in the 15 to 20 °C. This phenomenon indicates that areas with warm and favorable climates and abundant precipitation are more conducive to village development and population settlement. In particular, when the precipitation exceeds 1500 mm and the temperature exceeds 20 °C, the number of villages decreases sharply, indicating that this environment is not favorable for the establishment and growth of villages. In addition, the majority of traditional communities are found throughout the area close to the river; 90% of the villages are spread out within a river’s 1-km radius [26]. The densest villages are in the range of 0 to 500 m, which shows a strong near-water characteristic. It is worth noting that from the figure, it can be seen that the village settlements show a string of beads-type characteristics. The villages tend to be distributed along the river valley or foothills, and they maintain a relatively close distance to the river, especially in the area within 3 km (Figure 7).

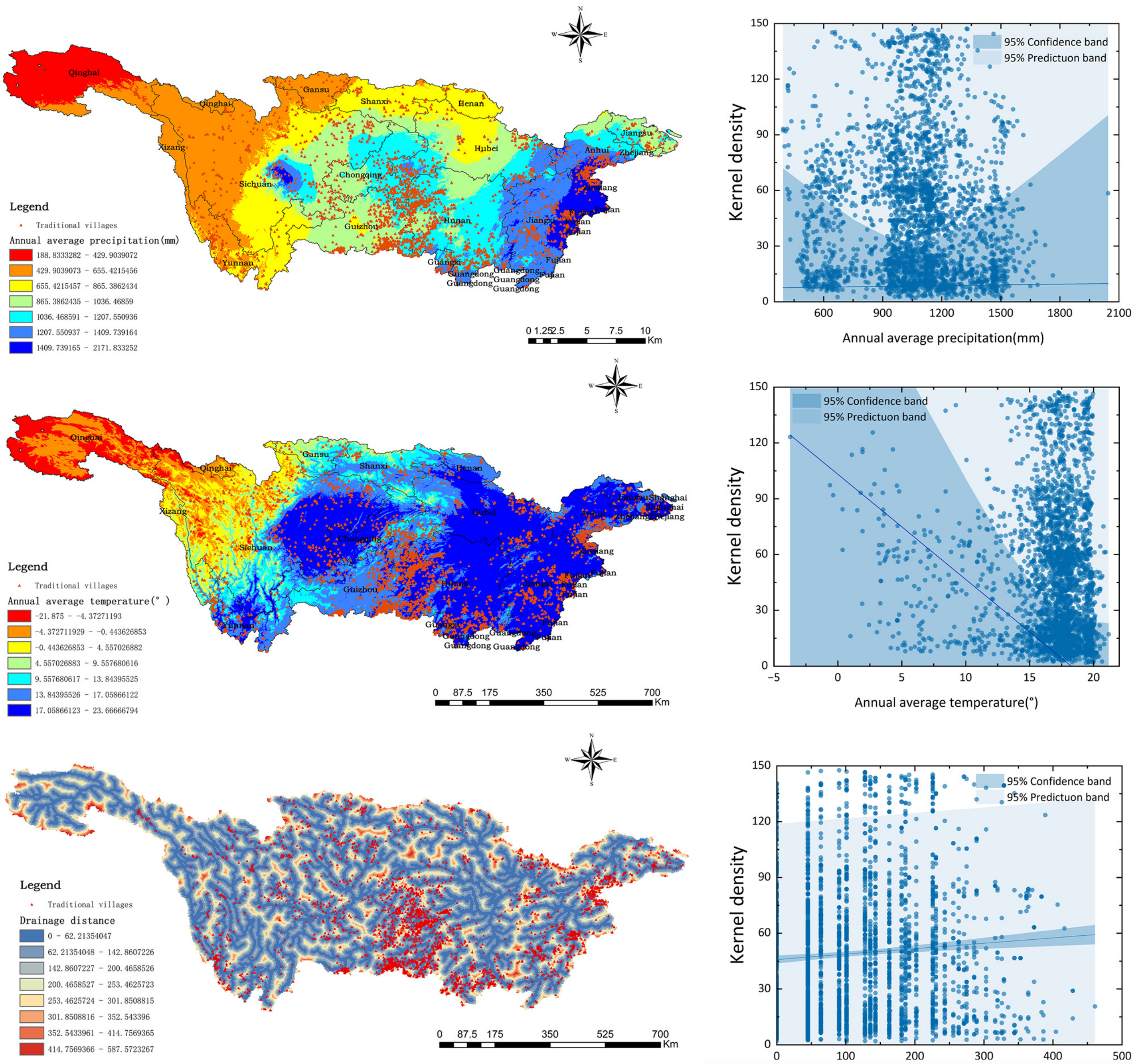

Figure 7. Climatic and hydrological factors affecting the Yangtze River Basin.

(3) Geographical and geological variables that affect the dispersion of traditional villages

In earlier research, it was argued that natural geographic conditions directly influence the layout of villages, with rivers serving as the key element and topography as the important foundation. These factors manifest as constraining guiding forces, while subject choices and social patterns manifest as selective adaptive forces. Economic impetus and policy regimes, on the other hand, manifest as stochastic driving forces, a viewpoint that is more similar to this study's findings.

This research examines the impact pathways of natural elements, such as altitude, slope, slope direction, precipitation, air temperature [27], water system, and other natural factors on the allocation of traditional villages. It is discovered that the natural geographic conditions directly determine the prototype of the village sites. This is mostly evident in the fact that the villages are generally concentrated in the mountainous, hilly, and other topographical features. The villages select sites in the areas with abundant water sources, such as rivers and lakes, to adapt to for domestic use. Agricultural production needs are also taken into account. The factors of temperature and precipitation also fully influence the location of villages and the scale of development. And it can be seen that villages are found in regions with plenty of precipitation and comfortable temperatures, plus the mountainous and hilly areas are easy to form a river valley environment. The fertile soil and sufficient water are favorable for agricultural cultivation, which can improve the yield and quality of crops and are also conducive to the formation of villages and the expansion of their scale.

It is worth noting that the residents of the watershed chose to live more on the shady slopes and closed mountains and hills, an order that may be because people chose the deep and closed areas surrounded by mountains to escape from the war. On the other hand, it may be related to feng shui customs such as "dragon vein feng shui". The layout of villages emphasizes the mountains and water, hiding the wind and gathering the qi, and the villages are intertwined with the water system to create a distinctive village design.

3.5.2. Social Factors

(1) Socio-economic situation

The Yangtze River Basin's typical village distribution interacts with the socio-economy, and it's evident that they have a pattern of negative association (Figure 8). In the research area, the average road network density is 75.76. The data ranges from 0 to 668.539, which indicates that there is a large gap between the villages within the research area regarding road network density. A total of 82.9% of the settlements are spread across regions that have a road network density of less than 100. When road network density exceeds 100, the number of villages distributed decreases rapidly. That suggests that the dispersion of traditional villages is more favorable in areas where transportation is inconvenient, and the infrastructure is relatively backward. To a certain extent, such areas can also protect the original appearance and the natural surroundings of traditional villages.

In addition, the GDP, population density, and urbanization rate within the region also affect the distribution of traditional villages. In the research area's eastern region, cities exhibit the highest GDP levels [28], and traditional villages are primarily found in central areas like Guizhou and Hunan [29,30]. And the per capita annual income of 72% of the traditional villages is not more than 60,000 yuan. When the population density exceeds 200 persons per square kilometer, and the urbanization rate exceeds 60%, the number of villages distributed decreases significantly. It indicates that factors such as economic underdevelopment, low population density, low level of urbanization, and inconvenient transportation are favorable to the creation and growth of traditional villages. The density of villages decreases gradually with the improvement of socio-economic level.

(2) Impact of socio-economic factors on the distribution of traditional villages

By examining the geographical arrangement of traditional villages in the Tibet–Qiangyi Corridor and the factors affecting them [31], an inverse relationship between transportation accessibility and the degree of development of the economy regarding the spatial arrangement of traditional villages is found. They noted that these villages tend to be relatively few and far between in regions characterized by advanced economies and efficient transport systems. Other research believes that the cities and towns with a higher population density, a higher economic development rate, and a higher rate of urbanization make it more difficult for villages to be preserved. In contrast, in some areas, the small number of villages has little to do with the poor living environment and then die out. In some areas, the small number of villages has little to do with the population density. If the local living conditions are unfavorable, the villages will face the dilemma of being uninhabited and then dying out.

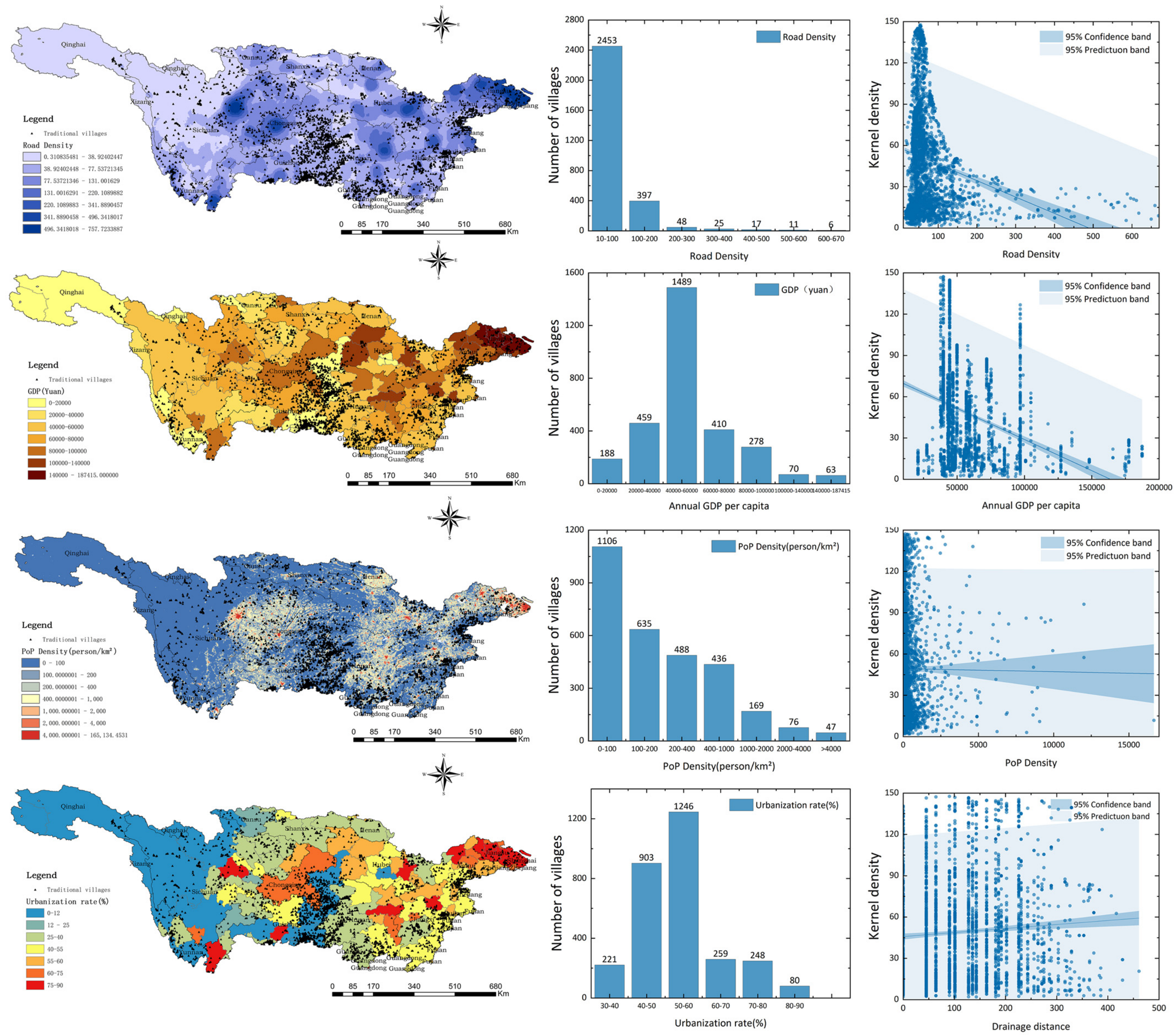

Figure 8. The relationship between traditional village distribution and road density, GDP, population density and urbanization rate.

In this study area, there is a large gap in socio-economic conditions. Overall, traditional villages are primarily situated in areas characterized by sparse road networks [32], a low rate of urbanization, low population density, and low GDP. These areas have formed a stable human–land relationship and can better protect the original appearance of the villages from the impacts of urbanization and construction. However, individual economically developed areas, such as the coastal areas of Shanghai and Zhejiang, have also formed a smaller distribution of clusters. Consequently, it can be concluded that in regions with advanced economies [33], the government will invest more resources in the maintenance and enhancement of historic villages. It also formulates relevant protection regulations for the villages and provides financial support to better strengthen the clustering and development of the villages.

To summarize, socio-economic considerations have a complex and wide-ranging impact on the allocation of traditional villages with different levels of development in different places, different topographical features, and different levels of policy support. The distribution pattern of today's traditional villages has been formed under the mutual influence of various factors, which is a cultural property worthy of our study and enhanced protection.

3.5.3. Historical and Cultural Factors

The research area of traditional villages demonstrates different distribution features in each dynasty, and their centers of gravity shifted. The figure shows the density pattern of village distribution under the effect of historical and cultural factors in each dynasty. During the Sui Dynasty and before, northern China was repeatedly attacked by nomadic peoples, such as the Yongjia Rebellion and the Five-Hu Rebellion. It resulted in many Han Chinese individuals moving southward to flee the conflicts. Jiankang (modern-day Nanjing) served as the capital of both the Eastern and Southern Jin Dynasties, and the Grand Canal's construction significantly increased trade and cultural interactions between the Yangtze River Valley and other areas. As a result, the Yangtze River Valley gradually become a new center of politics, economy, and culture. And with that, the village was born. After the Anshi Rebellion of the Tang Dynasty, the economy of the north was hit hard, while the south was relatively stable. The Yangtze River Valley gradually became the center of economic gravity of the whole country because of its exceptional environmental circumstances and abundant resources [34]. Many cities in the valley became important commercial centers and trading ports, which also laid the conventional village dispersal pattern shifting to the south.

The Song Dynasty was a peak of China's economic development, with an active commodity economy and the government encouraging overseas trade. It led to remarkable achievements in politics, economy, culture, and other aspects, and villages were mostly distributed in the more economically developed areas. The Song Dynasty's traditional villages were focused in the eastern coastal regions (Figure 9). However, with the Shame of Jingkang, the Peasants' Revolt, the war between Liao and Jin, and the attack of the Yuan army on the Song Dynasty, the Song Dynasty also faced the dilemma of gradual extinction. That led to the return of the typical village distribution center of gravity in the Yuan Dynasty to the core region of the research zone.

The socio-economic situation of the Yuan Dynasty had great development in agriculture, handicrafts, commerce, transportation, etc. In terms of wars, the Yuan Dynasty carried out several unification wars and foreign wars and also faced internal wars and political turmoil, which led to a dispersed arrangement of traditional villages. In the Ming Dynasty, the number of villages dramatically rose from the socio-economic development of agricultural technology, handicrafts, and commercial networks. On the other hand, due to the wars around the world, people avoid wars and settle in a suitable area. The number of traditional villages in the watershed increased during the Qing Dynasty and later, thanks to its superior natural environment and rich river network resources. However, the later wars and social unrest, the western area became the village distribution's center of gravity.

Compared with the previous dynasty, the Song and Ming Dynasties are the two dynasties with the largest increase in the allocation of traditional villages within the basin, with 53.33% of the villages built in these two dynasties. The distribution of villages has changed, and this indicates that socio-economic and historical-cultural processes have a direct impact on village distribution [35], and people migrate to areas with safer social environments to avoid wars. In traditional Chinese society, the concept of family and clan is very strong, and in the process of migration, villages are often formed and developed based on families or clans. This form of social organization provides a strong guarantee for the stability and growth of villages, forming the current layout of historical villages.

In conclusion, the arrangement of villages within the Yangtze River Basin is shaped by a confluence of natural landscapes, socio-economic conditions, and historical-cultural elements. These influences are interconnected and collectively contribute to the formation and development of traditional villages.

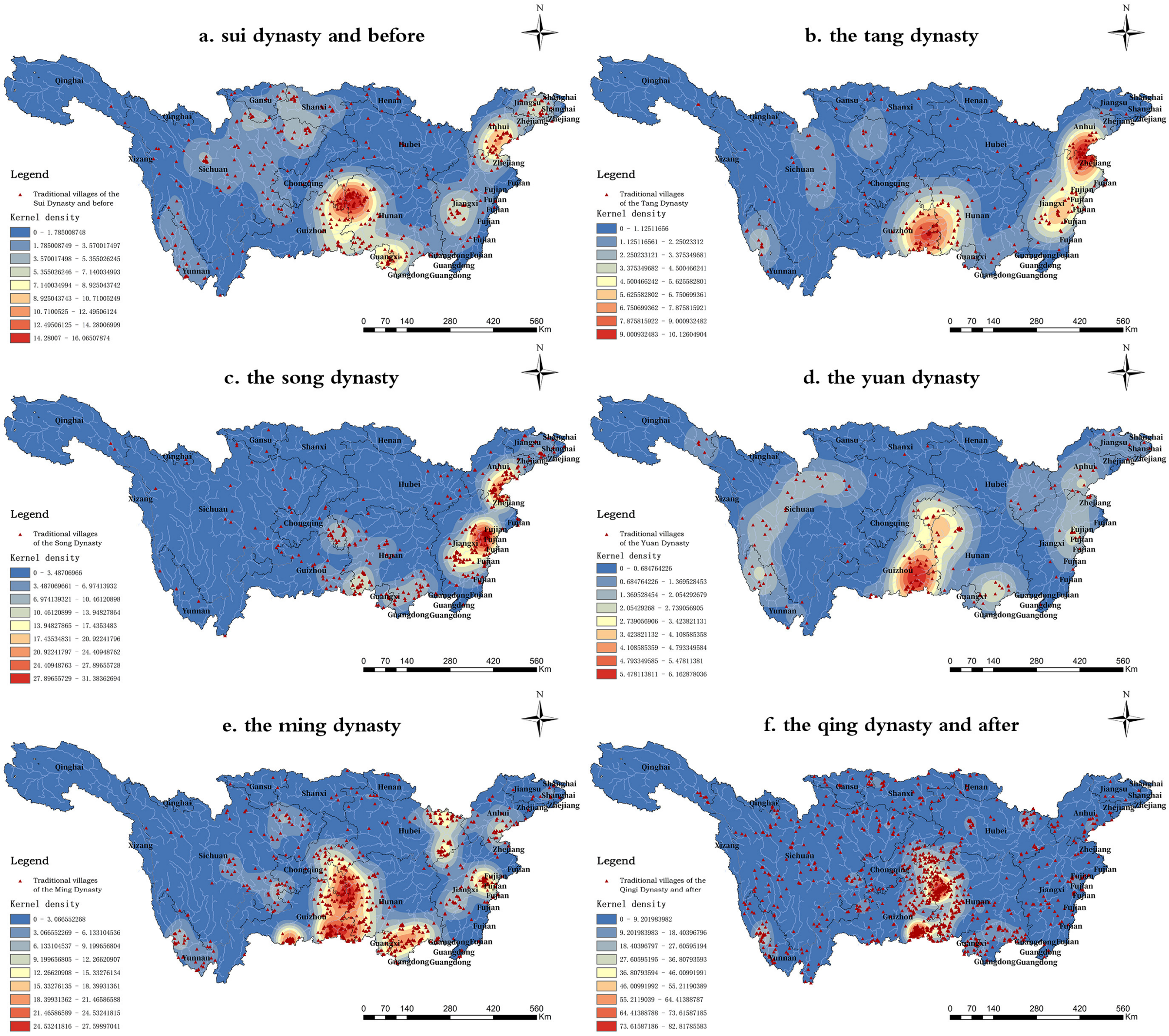

Figure 9. The spread and development of historic villages in the basin across various dynasties.

3.6. Main Impact Mechanisms

In this research, the influencing factors were examined using Geodetector [36], and the single-factor detector data (Table 1), which influenced the distribution of traditional villages in the basin, were listed. And the statistical data of the interaction detector were listed (Table 2). The single-factor detector data show that the primary factor influencing traditional village distribution is the road network density (q = 0.998), followed by population density (0.985) and slope direction (0.985). The least influential factor is the distance between the village and the water (0.042). The distribution was found to be more impacted by road density, GDP, population density, and urbanization rate than by natural causes based on the significance data. The interaction detector data demonstrated the distribution of villages under the impact of two elements, which can be derived from 38 two-factor augmented data and 7 nonlinear augmented data. This indicates that a two-component interaction has a far bigger effect on conventional village distribution than a single factor does. The interaction detector data show that the most important effects are reflected in the road network density ∩ elevation (1), population density ∩ road network density (0.999), population density ∩ elevation (0.999), GDP ∩ road network density (0.999), and urbanization rate ∩ road network density (0.999). Analyzing the data, it can be found that the most critical factor is reflected in the road network density, and the location of communities is more significantly influenced by social factors than by natural factors.

Table 1. Factor detector data.

Factor Detector	Geo-Detection Analyses			Rankings
	Name	qv	pv	
X1	Elevation	0.47308075	1	9
X2	Slope	0.917652829	1	4
X3	Aspect	0.985153108	0.7248017	3
X4	Precipitation	0.840995566	1	5
X5	Temperature	0.339144824	1	8
X6	Drainage	0.042729241	0.04700539	10
X7	Road	0.998721422	0	1
X8	GDP	0.758146372	0	7
X9	population	0.9852538	0.000	2
X10	Urbanization	0.760938045	0.000	6

Table 2. Interactive detectors analyze the data.

Interactive Detectors Analyze the Data										
Factor	**Elevation**	**Slope**	**Aspect**	**Precipitation**	**Temperature**	**Drainage**	**Road**	**GDP**	**Population**	**Urbanization**
Elevation	0.47308075									
Slope	0.99225902	0.91765283								
Aspect	0.99236360	0.98858136	0.98515311							
Precipitation	0.99433863	0.9943938	0.9943938	0.84099557						
Temperature	0.99117624	0.99414314	0.99414314	0.99185948	0.3391448					
Drainage	0.93680801	0.99486261	0.99984447	0.98458844	0.8709825	0.04272924				
Road	1	1	1	1	1	1	0.99872142			
GDP	0.96833068	0.99789117	0.99877036	0.9944089	0.9685367	0.81827712	0.99995266	0.75814637		
population	0.99996217	0.99999950	0.99999969	0.9999997	0.9999791	0.99923412	0.99997959	0.98994455	0.98525379	
Urbanization	0.98437784	0.99816647	0.99904566	0.99646302	0.9752135	0.84792110	0.99995266	0.81754712	0.98910598	0.76093804

The study also used Origin to conduct a correlation heat map analysis of the 10 influencing factors, and the results showed that GDP and urbanization rate had the strongest correlation, followed by precipitation and temperature, road network density and GDP, elevation, and slope. In summary, natural factors and socio-economic factors act together in traditional villages, and they work together and influence each other to establish the features of traditional villages' spatial dispersion (Figure 10).

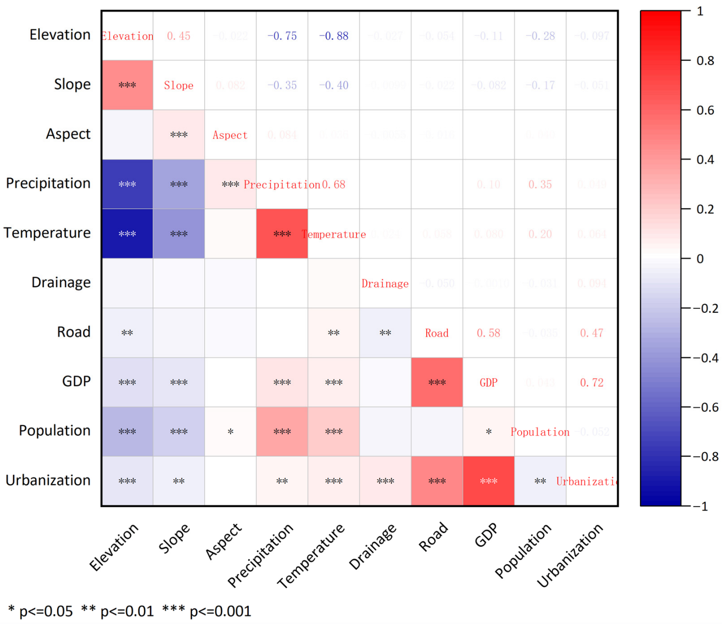

Figure 10. The correlation analysis among the factors affecting the spread of traditional villages.

4. Conservation Significance and Strategy Research

4.1. The Importance of Safeguarding Traditional Villages

The traditional village is a symbol of deep historical and cultural accumulation, which highlights the regional characteristics and local customs, as well as the nostalgia of the children of China. It is a crystallization of culture and art with profound historical and cultural value, and it is also a channel for us to promote and pass on the essence of traditional Chinese culture. Nowadays, its development has been threatened to a certain extent. We have to think about how to realize the transformation of the relationship between protection and inheritance so that traditional villages can be better inherited.

In the course of the development of modern civilization, the lack of awareness of conservation and the constant pursuit of economic interests in many areas has led to the overdevelopment of many villages. It destroys their primitive cultural characteristics and natural ecological environment, leading, in turn, to their decline and even extinction. Traditional villages also suffer from the problems of "hollowing out", "aging", and "industrial homogenization", and their development is subject to many difficulties. Therefore, the defense of customary villages should not be delayed.

4.2. Conservation Strategies of Traditional Villages

Given the complexity and diversity of the situation in different areas of the basin, the reasons for the dispersion of traditional villages are also different [37]. Therefore, the preservation of heritage villages requires the establishment of a scientific protection system, which should be tailored to local conditions and targeted to protect traditional villages.

The upper reaches of the Yangtze River are characterized by great topographical undulations and disparities in elevation, with a large proportion of mountains and plateaus. The complex terrain may lead to inconvenient transportation and marginalize traditional villages. Based on this problem, infrastructure construction should be increased to improve road network density and transportation conditions. The uneven distribution of precipitation within the year and climate variability in the upper reaches may lead to disasters such as floods and landslides. An ecological compensation mechanism should be implemented to encourage farmers to protect the ecological environment, and ecological restoration and protection efforts should be strengthened. In the economically backward areas in the west, the economic income level of traditional villages can be improved through the development of special agriculture, tourism, and other industries. Cultural protection should be strengthened in response to the possible gradual disappearance of traditional cultural features. By formulating laws and regulations and strengthening publicity and education, villagers' awareness of cultural protection should be raised. With the acceleration of urbanization, many young people are leaving traditional villages for cities. This may lead to the aging of the population of traditional villages and the intensification of the hollowing-out phenomenon. The government should provide policy support and start-up funds to attract young people to return to their hometowns.

The terrain in the middle reaches of the Yangtze River is complex, and some villages are located in mountainous or hilly areas with large slopes, which increases the difficulty of village protection. It is necessary to rationally plan the layout and architectural style of the villages according to the characteristics of the topography and landscape. Given the season of abundant precipitation, effective drainage and moisture control measures should be taken to improve the village living environment and building safety. Based on the data analyzed by geodetectors, the density of the road network is a major factor in determining the distribution of villages, regardless of whether it is influenced by a single factor or the interaction of two factors. Therefore, the infrastructure of villages should be improved, and the infrastructure of roads, sewage, and garbage should be actively remedied to improve the environment's livability and the overall image of villages. The middle reaches of the region are more densely populated, and the road network is well developed, so it is necessary to reasonably control the population density and optimize the layout of the road network. It is also necessary to prevent the destruction of traditional villages by over-development and disorderly construction. At the same time, it is necessary to strengthen the publicity, education, and training of villagers and raise their awareness of conservation.

The northern bank of the lower reaches of the Yangtze River is an alluvial plain, while the southern bank is mostly mountainous and hilly, with great relief. The annual precipitation is high, which can easily lead to flood disasters. The high-temperature and humid environment is prone to the erosion of traditional buildings and facilities in the villages. Flood control and drainage facilities should be improved by constructing levees, drainage ditches, and other infrastructure to increase flood control capacity. The area has a high population density and a relatively developed economy, so water quality testing should be strengthened, and industrial and domestic sewage discharge should be strictly controlled. A comprehensive census and registration of traditional buildings should be carried out, and a protection program should be developed.

Finally, traditional villages thrive on the principle of prioritizing protection while allowing development to play a supporting role. This method emphasizes the essential relationship between these villages and the immediate surroundings, fostering a balanced coexistence. By safeguarding natural resources and promoting a sustainable way of life, the villagers collectively embrace the ethos of green living, ensuring the preservation of their pristine landscapes.

5. Discussion

One of the areas where Chinese culture originated is the Yangtze River Basin, which has nurtured a rich and colorful Yangtze culture and is the largest river in Asia and China. The basin has formed a number of important city clusters, such as the Yangtze River Delta City Cluster [38], which includes many cities of prefectural level or above. And it has become an important economic region and transportation hub in China. It is not only abundant in both natural resources and cultural heritage but also rich in mineral resources and an industrial base. It has an important status in China, covering a wide range of fields such as geography, economy, society, ecology, and culture. Traditional villages are a significant legacy of China's agricultural civilization, which can respond to regional characteristics and social development styles and are of high research value. In addition, the watershed has a wide range, and economic development is not balanced enough. So, the traditional villages also show different distribution characteristics in the case of large differences in natural and socio-economic conditions. Consequently, this research focuses on the Yangtze River Basin to examine the features of traditional villages' temporal and spatial evolution within their humanistic context. It investigates how to view the significance of preservation under the conditions of contemporary socio-economic development and formulate a strategy for its preservation to enable the inheritance and continuation of these valuable cultural heritages.

In conclusion, the Yangtze River Basin has an irreplaceable position in China. After fully understanding its topography, socio-economic conditions, ethnic history, and culture, it is of unique research significance and value to choose it as a research object to explore the pattern of geographical dispersion and causes of villages.

Geographic information technology is primarily used in this study to analyze data regarding several factors impacting the traditional village distribution in the Yangtze River Basin. To increase the study's scientific validity, six natural factors, four socio-economic factors, and two historical and cultural factors were chosen. The data were processed using ArcGIS 10.8 to determine each influencing factor's quantitative value, and they were then qualitatively examined in light of the actual circumstances. To precisely ascertain the impact of the variables, the study analyzed ten single-factor values and interaction coefficient values using geodetectors. The results show that there is an obvious nonlinear link of amplification between the two-factor interaction and the traditional village density pattern, and the interaction factor has a stronger influence than the single factor. This approach breaks through the previous research method that only focuses on the influence of a single factor and provides more possibilities for research. This paper also uses a correlation heat map to analyze the correlation between factors, which shows the strongest link between GDP and urbanization rate and its stronger impact on the traditional village movement. The study offers different research methods and perspectives, which are uniquely significant to the study of traditional village distribution.

From the distribution map, we can see that the traditional villages in the Yangtze River Basin are mainly located at the borders of Chongqing, Guizhou, and Hunan provinces, and some of the villages are clustered in economically developed areas such as Jiangsu, Zhejiang, and Shanghai. However, a handful of these villages can also be found clustered in more affluent regions, such as Jiangsu, Zhejiang, and Shanghai. This difference mainly stems from the different government policies and levels of economic development in different places. From a macroscopic point of view, the basin has complexity and variety in topography and landscape, as well as uneven levels of economic development in each province. Traditional villages are unevenly dispersed and are characterized by small settlements and much dispersion. In another study, it was discovered that environmental factors primarily influence village distribution, while socio-economic factors have two sides, showing a negative correlation as a whole and a positive correlation in local areas. This point of view is more in line with the findings of this investigation. In the overall view, the economically backward areas of the village may be affected or even gradually disappear due to the lack of funds, infrastructure imperfections, and other reasons. On the other hand, the governments of economically developed areas will actively introduce relevant policies. They can invest more resources to repair and protect the villages, thus forming a cluster development of villages. Of course, some areas rely on their unique cultural charms and vigorously develop tourism, which can also result in the development of clustered villages.

In this study, single- and two-factor interactions were employed to examine their impact on traditional village allocation. The results of the study demonstrate that the two-factor interaction has substantially more relevance than the single-factor interaction. For example, the interaction between road density and elevation is the highest, which increases by 0.01 and 1.12 times, respectively, compared with their influences. Because the road density itself has a high influence on traditional villages, and its increase is low compared with the value of the interaction effect. Overall, the Yangtze River Basin's traditional village distribution is impacted by both natural and socio-economic forces.

To summarize, three main elements affect the dispersion of villages: natural, socio-economic, historical, and cultural. All of them play a unique role and together shape a rich and diverse range of distinctive villages. It is important to recognize the tension that exists between the preservation of traditional villages and the advancement of modern society. This challenge calls for a collaborative effort among the government, businesses, and individuals to cultivate a mindset that balances progress with conservation. By ingraining this principle into their daily practices, everyone can contribute to safeguarding traditional villages as vital pieces of our cultural heritage.

In the midst of modernization, rural areas around the world face conservation challenges similar to those of traditional villages. The rapid advance of industrialization and urbanization has led to a series of problems, such as the depopulation of ancient villages, the fading of cultural characteristics, and the deterioration of land quality. These problems not only affect the survival of the ancient villages themselves but also reflect the general predicament of rural conservation worldwide. Therefore, preserving the ancient villages in the Yangtze River Basin is not only a way to cherish the cultural heritage but also a key link to promote the sustainable development of the global rural areas. Through scientific planning and management, strengthening cultural heritage, and implementing ecological restoration, these challenges can be effectively mitigated, and the organic integration of ancient villages with modern society can be promoted, providing valuable experience and inspiration for global rural conservation.

6. Conclusions

The distribution of traditional villages in the study basin has undergone temporal and spatial evolution, showing different development patterns in various dynasties. That also maps the process of Chinese civilization's historical development. By exploring the traits of traditional village transformation in the basin in time and space and the reasons for their distribution and analyzing them through the methods of human geography, the conclusions listed below can be made.

(1) From the standpoint of geographic dispersion, traditional villages show a characteristic pattern of "two cores, small aggregation, and many dispersions". And two major cores of villages at the intersection of Guizhou, Hunan, and Chongqing, which is due to the many mountain ranges and rich river network resources in the region. Such as Xuefeng Mountain, Wuling Mountain, Dalou Mountain, the Qingshui River, Youshui River, etc. Those can provide water for residential and agricultural production. In the eastern part of the basin, there is also a smaller tendency of aggregation and distribution, and it can be found that the traditional village distribution is directly impacted by natural environmental variables. The border between Anhui Province and the lower and middle sections of the Yangtze River is home to Zhejiang Province in the plain area. There is Wuyi Mountain Range on the border between Jiangxi Province and Fujian Province, which creates a good environment for the distribution of the villages.

(2) When considering the allocation of time, it's evident that the incidence of traditional villages has experienced a general upward trend, particularly with a notable surge during the Ming and Qing Dynasties. The Yuan and Ming Dynasties laid down the fundamental model of traditional village allocation. In the Qing Dynasty period, due to war and social unrest, the aggregated clusters of villages became much less obvious, especially the transient disappearance of the agglomeration pattern in the eastern area. At the same time, the junction of those three provinces in the middle of the basin was still the agglomeration cluster of the spread of traditional villages. This stems from the impact of economic development, policies, and wars after the Song Dynasty, which produced a substantial amount of immigrant villages in this area, spreading to the periphery centered on Yousei and Jishu urban areas.

(3) Regarding driving factors, natural, socio-economic, historical, and cultural factors interact together to promote the pattern of geographical dispersion, with environmental factors significantly influencing the selection of village locations. From the research data, 85% of villages are mainly distributed in lower plains, hills, basins, and small mountains, and 92% of the traditional villages favor gentle slopes of $0°$~$15°$ in slope selection. While road network density, GDP level, and urbanization rate are secondary factors, developed socio-economics in ancient times would have attracted villages to gather. Nowadays, less developed areas may preserve the original appearance of villages better. This also reflects the differentiation of driving influences on the village distribution under different eras, while the orientation of national policies is also important.

This study explores Space-time evolution characteristics of the spread of villages in the area and determines the traits and variables that affect the distribution of villages in the basin [39]. However, there are still some shortcomings in the study, such as the limitation of the information from traditional villages and the sample size may be incomplete. Regarding historical and cultural elements, it is difficult to find the specific distribution pattern and production environment of each village in different dynasties due to the relatively long period and the limitation of the existing information. Future studies must be conducted to analyze the influence of each factor in a more thorough and specific manner. Also, more attention needs to be paid to how to protect and inherit traditional villages [40], fully explore the charm of culture, and promote its co-development with modern civilization.

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visualization, Y.Z.; supervision, Y.G.; project administration, Y.G. All authors have read and agreed to the published version of the manuscript.

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