

Article

# Characteristics and Influencing Factors of Traditional Village Distribution in China

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**Abstract:** Understanding the characteristics of the traditional village distribution contributes to the formulation of relevant protection and development strategies. We adopted a series of spatial analysis methods to investigate the characteristics of the traditional village distribution in China by using the watershed as the research unit. Moreover, we conducted quantitative and qualitative analyses of the relevant influencing factors affecting the distribution pattern using Geodetector and mathematical statistics. The findings indicate that traditional villages are distributed unevenly across watershed units. High–High clusters tend to occur at the boundaries of first-level watersheds. Traditional villages have a clear agglomeration trend in space, with a concentrated and contiguous distribution pattern based on the “core density area–ring-core expansion group–belt area”. The key factors affecting the traditional village distribution are annual precipitation, annual average temperature, and river density. The traditional village number has a clear inverted U-shaped relationship with the annual average temperature, river density, and road density. The study reveals the complex and various characteristics of the traditional village distribution and its influence mechanism and offers scientific advice for traditional villages’ future protection and development.



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**Keywords:** traditional villages; watershed; spatial distribution; influencing factors; Geodetector

## 1. Introduction

According to the definition of relevant documents jointly announced by China’s Ministry of Housing and Urban-Rural Development, Ministry of Culture, Ministry of Finance, and State Administration of Cultural Heritage, traditional villages, also known as ancient villages, usually refer to villages that formed at an early stage, remain relatively intact, and have a rich culture, traditional customs, and natural resources [1–3]. These villages are important carriers of China’s tangible and intangible cultural heritage and have enormous value in history, culture, science, art, society, and economy [4,5]. In 2012, the Chinese government released the first batch of national traditional villages lists. Since then, protecting traditional villages has been raised to a national level and given legal status [6,7]. As of 2019, a total of 6819 national traditional villages have been designated in five batches from the existing 600,000 villages in China [8]. Since the reform and opening up, China has been experiencing rapid urbanization and industrialization [6,7,9,10], but the agricultural-based traditional villages are facing the risk of decline and disappearance. More and more rural populations have been migrating to cities to seek high-paid jobs, resulting in an increasing hollowing in traditional villages [11–13]. In addition, unprecedented urbanization has caused a series of other unavoidable problems for traditional villages, including constructive destruction, ecological degradation, and land resource waste [14,15]. These problems pose considerable challenges to the traditional villages’ protection and sustainable development.

The protection and development of traditional villages have always been the focus of academic circles. A number of researchers have discussed in depth many aspects of traditional villages, such as their values [16,17], vitality [18], vulnerability [19],

hollowing [11,12,20], ecological risk [21], evolutionary characteristics [14], landscape pattern [22–24], tourism development [6,15], protection and development [25–27], sustainable development [5,13,28], pattern and influencing factors [4,7,8,15,24,29–33], etc. The distribution of villages or traditional villages can effectively reflect the relationship between people and the natural environment, society, economy, and politics [4,34,35]. Understanding the characteristics and influencing factors of the traditional village distribution is not only beneficial to the existing traditional villages' protection and development [7], but also to the designation of new official traditional villages. In ancient China, the site selection, layout, and construction of villages in China are deeply influenced by the fengshui theory [36–38]. The ideal village focuses on the harmony between humans and the natural environment [16] and emphasizes closure and defensibility [36]. That is, the natural geographic environment plays a critical role in the traditional villages' formation. In fact, most civilizations in the world were nurtured by rivers or originated in river watershed areas [39,40] and spread along rivers [41]. As one of the main factors influencing the spatial distribution of resources, river systems are not only an important material basis for human production and life, but also the birthplace of various cultural heritage sites [42,43]. In addition, the high availability of water sources promotes population agglomeration, thus forming various unique rural settlements [44]. Therefore, the river condition is essential for the formation of traditional villages, as they are a unique cultural heritage site and a representative model of rural settlement revitalization in China. Previous studies also support it; the traditional village distribution is closely related to rivers, and most traditional villages are distributed close to rivers and have a clear hydrophilicity [8,16,45].

Numerous findings have been obtained from previous studies on the characteristics of the traditional village distribution. However, studies that fully consider the relationship between traditional villages and rivers are still lacking, although some studies have proved the hydrophilicity of traditional villages [8,16,45]. In addition, most studies failed to quantify the impact of relevant influences on the traditional distribution. This study aims to introduce the watershed unit as the research unit to analyze the characteristics of the traditional village distribution, which can fully consider the interaction between traditional villages and rivers. Then, we further analyze the influencing mechanisms of relevant factors on the traditional village distribution in a qualitative and quantitative way.

This study's remaining sections are organized as follows. Section 2 provides the literature review. Section 3 describes the research methodology and data sources. Section 4 shows the characteristics of traditional village distribution in China, and a qualitative and quantitative analysis of the relevant influencing factors. Section 5 discusses the relationship between traditional villages and influencing factors and the advantages and limitations of our study and introduces the watershed management model for future traditional villages' protection and sustainable development. Section 6 concludes our findings.

## 2. Literature Review

Few studies have focused only on analyzing the characteristics of the traditional village distribution. For example, Xu et al. [15] used the nearest neighbor index, Lorenz curve, geographic centralization index, Gini coefficient, and kernel density analysis to reveal the distribution characteristics of 323 traditional villages in Shanxi Province. Zheng et al. [24] applied the nearest neighbor index, kernel density analysis, and minimum cumulative resistance model to analyze the distribution pattern of traditional villages in Southwest China. Wu et al. [4] systematically sorted out the traditional villages' spatial patterns and their evolutionary characteristics at the different administrative unit scales using the Gini coefficient, hotspot analysis, and standard deviation ellipse.

Most studies used spatial analysis and statistical analysis to comprehensively analyze the characteristics and influence mechanisms of the traditional village distribution. For example, Jin and Yan [29] performed the nearest neighbor index, kernel density analysis, global spatial autocorrelation, and statistical analysis to study the spatial differentiation and influencing factors of traditional villages in Gansu. Li et al. [30] examined the spatial

distribution and influencing factors of traditional villages (including the traditional villages in the first and second batches, and the national-level and provincial-level famous historic and cultural villages) in Hunan by using the nearest neighbor index, geographic centralization index, imbalance index, and statistical analysis. Tang et al. [31] and Zhang et al. [32] adopted the same methods to explore the distribution characteristics and influencing factors of traditional villages in the previous four batches in Hunan and the cumulative five batches in Guizhou, respectively. Ma and Tong [33] applied ArcGIS and Geoda to investigate the spatial distribution characteristics and influencing factors of 1767 traditional villages in Sichuan, Yunnan, and Guizhou. Only a few researchers have quantified relevant factors' influences on the traditional village distribution. For example, Bian et al. [7] explored the spatial distribution evolution and the influence mechanism of traditional villages by using the nearest neighbor index, geographic centralization index, imbalance index, kernel density analysis, and Pearson's correlation analysis. Gao et al. [8] examined the characteristics and influencing factors of the traditional village distribution in the Yellow River watershed with the help of ArcGIS and Geodetector.

In terms of the existing studies on the characteristics and influencing factors of the traditional village distribution, although some results have been obtained, there are still many limitations. First, most previous studies conducted at the spatial scale have concentrated on administrative units [4,7,8,15,24,29–33], which, to some extent, weakened the influence of the geographic environment, undermined the integrity of natural areas, neglected the similarity of traditional villages in geographical environments and cultural customs, and caused some interference in the study results. To date, however, there are relatively few cross-administrative studies that use geographic environmental units with element similarity characteristics as the research unit. Second, most studies failed to quantify the impact of relevant influences on the traditional distribution.

The watershed usually refers to the river's catchment area surrounded by a water parting [46]. Unlike the man-made administrative units, it is a geographic unit formed naturally. The watershed is also a system that keeps frequent material, energy, and information exchanges with the external world, while maintaining relative closure within a clear physical geographical boundary [47]. In the human–earth system, the watershed is the geographical unit most frequently affected by human activities [48]. Historically, human productive life and economic activities were usually carried out along major rivers [47]. With the dynamic effects of rivers and human activities, diverse local cultural customs have gradually formed in settlements along the rivers [49]. These local cultural customs are the products of long-term human adaptation to local climatic and other natural conditions [16]. The relative stability of various elements in the watershed further promotes the formation of cultural customs areas, which makes the human characteristic of a given watershed have an obvious similarity. In contrast to the fragmented state of elements caused by administrative divisions, this similarity formed by nature reflects the continuity of elements in the watershed. Thus, the watershed can also be regarded as a relatively complete ecological and human system, since there are similar topographical environments, interconnected economies, and co-mingled cultural customs within the watershed. That is, the watershed is not only a hydrological unit, but also a socio–political–ecological unit, even a geographical unit with the earliest imprint of human activity [8,48]. At present, the watershed has become an important geographical unit for achieving sustainable development goals (e.g., resources, environment, ecology, etc.) and earth system science practices in most countries of the world [47,50,51]. It is worth noting that the distribution pattern of China's traditional villages clearly reflects the representative traditional culture and the representative traditional production and lifestyle [2]. Thus, the watershed unit is also important for studying the characteristics of traditional village distribution. To sum up, the watershed is the foundation for traditional villages' formation and organization, which provides convenient conditions for exploring the characteristics of the traditional village distribution and ensures the scientific and reasonable research conclusions.

In view of this, using the watershed as the research unit, we adopt series spatial analysis approaches, including the imbalance index, average nearest neighbor index, kernel density analysis, and spatial autocorrelation, to explore the distribution characteristics of China's existing 6819 traditional villages. In addition, Geodetector and mathematical statistics were used to quantitatively and qualitatively analyze related factors that affected the traditional village distribution. Finally, some suggestions were provided for the future protection and development of traditional villages. The results are expected to provide an important reference for the protection and sustainable development of China's existing traditional villages, as well as the designation of new official traditional villages. What is more, we expect our study to provide a reference for studies on villages and cultural heritage sites in other countries or regions. As discussed above, most cultural heritage sites and villages (including traditional villages) in the world have a high similarity in formation, i.e., their formation is closely related to the rivers.

### 3. Materials and Methods

#### 3.1. Data Sources

We obtained a total of 6819 traditional villages from the Ministry of Housing and Urban-Rural Development of China (<http://www.mohurd.gov.cn>, accessed on 5 June 2022) and used Google Earth to obtain the geospatial coordinates of these traditional villages. The locations of these traditional villages are shown in Figure 1. The National Center for Glacial Permafrost and Desert Science (<http://www.ncdc.ac.cn>, accessed on 5 June 2022) provided the watershed boundary data. According to the watershed system and administrative division, the Ministry of Water Resources of China divided the country into three levels of watersheds [52]: 9 first-level watersheds; 58 second-level watersheds; and 210 third-level watersheds. Given previous studies [7,8,29–33] and the data availability, we selected nine key potential influencing factors to explore the traditional village distribution. The descriptions of these influencing factors are listed in Table 1.

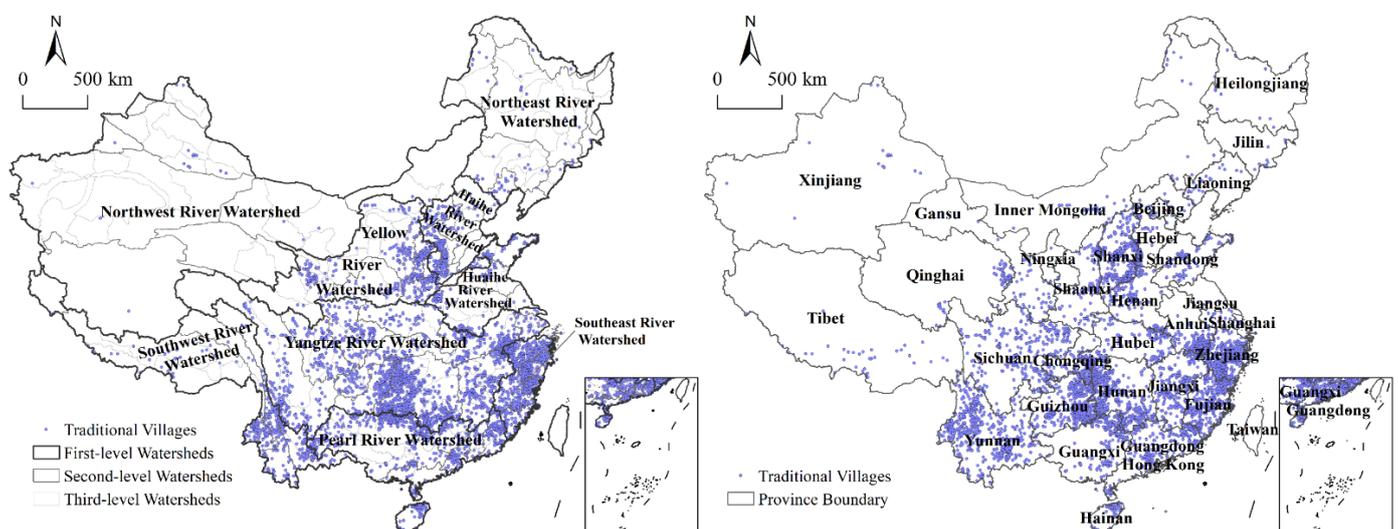


Figure 1. Distribution map of traditional villages in China.

**Table 1.** Descriptions of influencing factors.

Influencing Factors	Descriptions	Sources
Road	It includes China's primary, secondary, tertiary, and fourth roads	The National Earth System Science Data Center ( <a href="http://www.geodata.cn">http://www.geodata.cn</a> , accessed on 5 June 2022)
River	It includes first-class rivers and major rivers	Geographic Data Sharing Infrastructure, College of Urban and Environmental Science, Peking University ( <a href="http://geodata.pku.edu.cn">http://geodata.pku.edu.cn</a> , accessed on 5 June 2022)
Elevation Topography relief	Spatial resolution of 250 m	
Population density Gross Domestic Product (GDP) density	The data with a spatial resolution of 1 km in 2015	The Resource and Environmental Science Data Center of the Chinese Academy of Sciences ( <a href="http://www.resdc.cn">http://www.resdc.cn</a> , accessed on 5 June 2022)
Annual precipitation Annual average temperature Normalized Difference Vegetation Index (NDVI)	2006–2015 dataset with a spatial resolution of 1 km	

### 3.2. Methods

#### 3.2.1. Imbalance Index

The imbalance index has been frequently used to assess the balance of quantitative distribution for point elements across regions [53]. In this study, we used the imbalance index to measure the balance of quantitative distribution for traditional villages in China and each first-level watershed. The imbalance index was calculated as follows.

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

where  $n$  represents the number of three-level watersheds;  $Y_i$  represents the cumulative percentage of traditional village numbers in the top  $i$  three-level watersheds; the value of the imbalance index ( $S$ ) ranges from 0 to 1, and the higher  $S$  value indicates that the traditional villages have a more imbalanced distribution in the three-level watershed.

#### 3.2.2. Average Nearest Neighbor Index

The average nearest neighbor index is a common indicator used to determine the overall distribution type of point elements in a geospatial area [54]. The average nearest neighbor index was used to investigate the overall characteristics of the traditional village distribution in China and each first-level watershed. The index calculates the actual average distance divided by the theoretical nearest neighbor distance [55].

$$R = \frac{r_i}{r_E} \quad (2)$$

$$r_E = \frac{1}{2} \sqrt{n/A} \quad (3)$$

where  $R$  represents the average nearest neighbor index;  $r_i$  represents the average observed nearest neighbor distance;  $r_E$  represents the theoretical nearest neighbor distance;  $n$  represents the number of traditional villages;  $A$  is the area of the study area;  $R > 1$ ,  $R = 1$ , and  $R < 1$  in the calculation results indicate that the distribution types of traditional villages are dispersed, random, and agglomerated, respectively.

#### 3.2.3. Kernel Density Analysis

Although the quantitative relationships of traditional village distribution patterns in the whole country and the nine first-level watersheds can be reflected by the change in the average nearest neighbor index values, they do not reflect their specific degree of

agglomeration or dispersion. The kernel density is a non-parametric estimation method that examines the regional variation in point element density to study point elements' spatial distribution patterns [56,57]. Regional point elements' spatial agglomeration and dispersion patterns can be revealed intuitively from the findings of kernel density analysis. The specific calculation formula is as follows [41,58].

$$f(x) = \frac{1}{nh^d} \sum_{i=1}^n K\left(\frac{x-x_i}{h}\right) \quad (4)$$

where  $f(x)$  represents the kernel density estimate;  $h$  represents the bandwidth (spatial distance);  $n$  represents the traditional village number in the bandwidth range;  $d$  represents the data dimensionality;  $K()$  represents the kernel function;  $x-x_i$  represents the distance between the estimated point and point  $i$  within the bandwidth range.

### 3.2.4. Spatial Autocorrelation

Spatial autocorrelation is one of the most important characteristics of geographic phenomena. It can describe the degree of correlation between the observation unit and adjacent unit attribute values or geographic phenomena [59]. Global spatial autocorrelation and local spatial autocorrelation form a comprehensive spatial autocorrelation analysis.

The global spatial autocorrelation describes the overall trend of traditional villages in the whole space, which can be measured by the global Moran's  $I$ . The global Moran's  $I$  is expressed as follows:

$$I = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2} \quad (5)$$

where  $n$  represents the number of watersheds (here, the third-level watershed);  $x_i$  ( $x_j$ ) represents the traditional village number in the watershed  $i$  ( $j$ );  $\bar{x}$  represents the average of the traditional village number in the total watershed;  $w_{ij}$  represents the selection weight between watersheds  $i$  and  $j$ ; the global Moran's  $I$  ranges from  $-1$  to  $1$ ; a positive  $I$  represents the positive spatial correlation, the larger the  $I$  value, the more obvious the spatial correlation; a negative  $I$  represents the negative spatial correlation, the smaller the  $I$  value, the larger the spatial difference; the  $I$  value  $0$  means that there is no spatial correlation.

Local spatial autocorrelation results can reveal specific spatial patterns, as well as the existence of spatial clusters and isolated areas, which can be measured using the Geoda's LISA tool.

$$LISA_i = \frac{(x_i - \bar{x})}{S_i^2} \sum_{j=1, j \neq i}^n w_{ij} (x_j - \bar{x}) \quad (6)$$

where  $LISA_i$  represents the local Moran's  $I$  of watershed  $i$ ;  $S_i^2$  represents the variance of the traditional village number in the third-level watershed; the other symbols are the same as above.

### 3.2.5. Geodetector

The Geodetector is a spatial statistical method widely used to reveal the driving forces behind geographic objects [60,61]. Its advantages include few assumptions, a wide range of applications, and clear physical meaning. In this study, we used Geodetector to identify the factors influencing the traditional village distribution in China. The calculation formula is as follows.

$$q = 1 - \frac{\sum_{h=1}^L N_h \sigma_h^2}{N \sigma^2} \quad (7)$$

where  $L$  represents the number of strata divided by a certain factor;  $N_h$  and  $N$  represent the traditional village number in stratum  $h$  and the whole region, respectively;  $\sigma_h^2$  and  $\sigma^2$  represent the variance of the traditional village kernel density value in stratum  $h$  and the

whole area, respectively; the  $q$  value ranges from 0 to 1; a higher  $q$  value indicates that the factor has a stronger explanatory power on the traditional village distribution.

## 4. Results

### 4.1. Watershed Distribution Differences

Table 2 lists the imbalance index of traditional villages in China and each first-level watershed. The imbalance index for the entire country is 0.75, indicating that traditional villages are unevenly distributed in the three-level watersheds, showing a clustered distribution pattern. In addition, there are significant regional differences in the imbalance index of traditional villages. Except for the Huaihe River watershed, every first-level watershed has an imbalance index between 0.45 and 0.85. The Huaihe River watershed has the lowest imbalance index and the most balanced distribution of traditional villages; the Haihe River watershed has the highest imbalance index and the most imbalanced distribution of traditional villages. Thus, we can conclude that traditional villages tend to cluster in some particular watersheds.

**Table 2.** Imbalance index of traditional villages in China and each first-level watershed.

Region	Number	Proportion (%)	Imbalance Index
Northwest River watershed	26	0.38	0.80
Northeast River watershed	72	1.06	0.68
Huaihe River watershed	211	3.09	0.11
Haihe River watershed	472	6.92	0.82
Southwest River watershed	525	7.70	0.64
Yellow River watershed	681	9.99	0.73
Pearl River watershed	1020	14.96	0.57
Southeast River watershed	1309	19.20	0.48
Yangtze River watershed	2503	36.71	0.57
Total	6819	100.00	0.75

Traditional villages exist in all nine first-level watershed units, although the number varies. The Yangtze, Southeast, and Pearl River watersheds are the top three first-level watersheds in traditional village numbers, each having more than 1000, accounting for 36.71%, 19.20%, and 14.96% of the total, respectively. Only 26 traditional villages exist in the Northwest River watershed, accounting for 0.38% of the total. The Northeast River watershed has the second-fewest traditional villages, with 76, accounting for 1.06% of the total; furthermore, traditional villages in the Northeast River watershed are usually located near China's borders.

There are traditional villages in 54 of the 58 second-level watersheds, covering every second-level watershed in China except the Ussuri, Suifen and Heilonggang watersheds, and the Qaidam inland flow area watershed. However, only 7 second-level watersheds have more than 300 traditional villages. These are the Dongting Lake watershed (999, 14.65%), Poyang Lake watershed (370, 5.43%), and Yangtze River mainstream watershed (336, 4.93%) in the Yangtze River watershed; Xijiang River watershed (610, 8.95%) in the Pearl River watershed; Qiantang River watershed (509, 7.46%), and Oujiang watershed (349, 5.12%) in the Southeast River watershed; Yellow River mainstream watershed (478, 7.01%) in the Yellow River watershed. The traditional village number in the top 7 second-level watersheds reached 3651, accounting for 53.54% of the total. In contrast, there are 20 second-level watersheds with less than 10 traditional villages, forming a significant gap.

Traditional villages are unevenly distributed at the third-level watershed scale. In total, 41 of the 210 third-level watersheds have no traditional villages, 22 of which are in the Northwest River watershed, and 11 are in the Northeast River watershed. The top 6 third-level watersheds with the most concentrated traditional villages are the upper Yuanjiang Pushi Town watershed (278, 4.08%), lower Yuanjiang Pushi Town watershed (426, 6.25%), and upper Xiangjiang Hengyang watershed (214, 3.14%) in the Yangtze

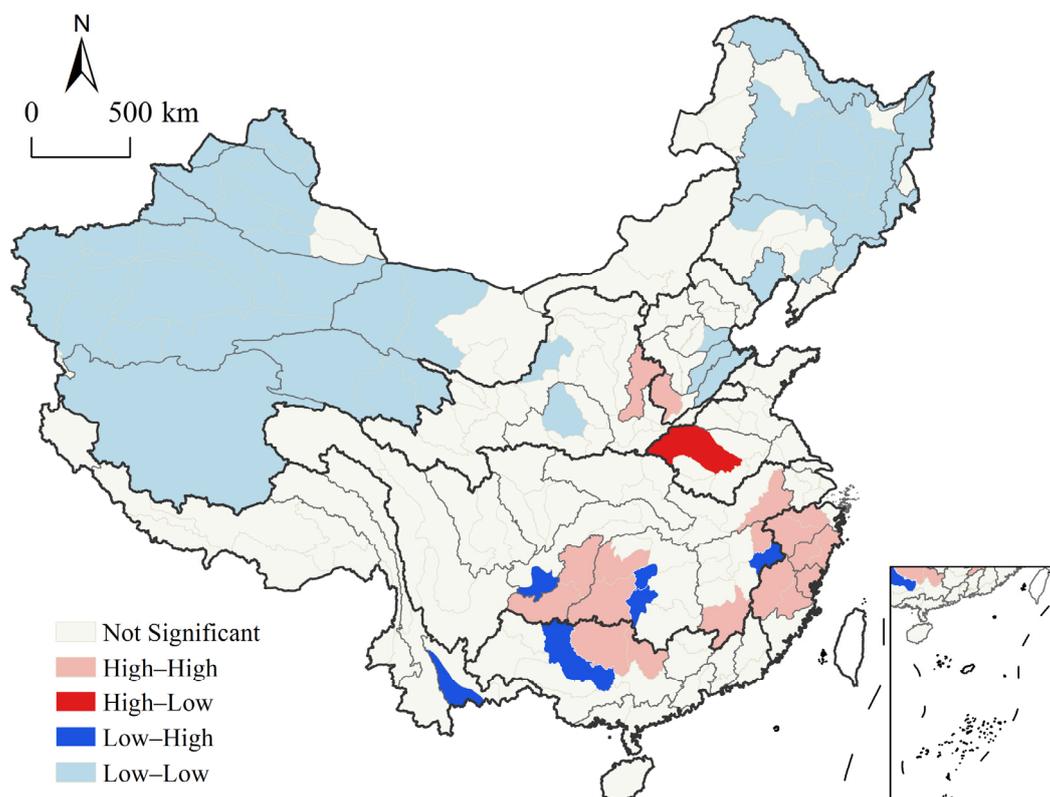
River watershed; the lower Fuchun River Reservoir watershed (405, 5.94%) and upper Oujiang Wenxi watershed (249, 3.65%) in the Southeast River watershed; Liujiang River watershed (325, 4.77%) in the Pearl River watershed. These three-level watersheds have 1897 traditional villages, accounting for 27.82% of the total. In comparison, the number of third-level watersheds with traditional village numbers in the range of 0, 1–10, 11–50, 50–100, and 101–200 is 41, 73, 60, 15, and 15, respectively. A “pyramid” distribution can be seen in the number of third-level watersheds with different traditional village number scales. Most third-level watersheds have a limited scale of traditional village numbers; the bigger the scale of traditional village numbers, the lower the number of corresponding third-level watersheds.

In summary, traditional villages are unevenly distributed at different watershed scales. Most traditional villages (70.86%) are concentrated in China’s southeastern watersheds, which are rich in water resources and account for more than half of the total water resources (<http://www.data.ac.cn/table/tba84>, accessed on 5 June 2022). In contrast, the Northwest River watershed has the fewest water resources (less than 5% of the total) (<http://www.data.ac.cn/table/tba84>, accessed on 5 June 2022) and the fewest traditional villages (0.38% of the total). This indicates that the traditional village distribution may have a watershed-based characteristic in China.

#### 4.2. Spatial Autocorrelation Analysis

The global Moran’s  $I$  of traditional villages for the three-level watersheds is 0.42, with a  $p$ -value less than 0.05, passing the 1% significance level test. This shows that traditional villages between third-level watersheds have a strong positive spatial correlation; that is, watersheds with a high traditional village number are adjacent to each other, as are watersheds with a low traditional village number.

The results of LISA analysis (Figure 2) show five distribution types, namely, HH-type (High–High-type) distribution, LL-type (Low–Low-type) distribution, LH-type (Low–High-type) distribution, HL-type (High–Low-type) distribution, and non-significant (Not Significant).



**Figure 2.** LISA cluster map of traditional villages in China.

A total of 18 third-level watersheds belong to the HH-type distribution, and approximately 45% of total traditional villages are located within these watersheds. There are two apparent clusters of watersheds with HH-type distribution at the junction of the first-level watersheds. The first cluster is located at the junction of the Yangtze and Pearl River watersheds, with 6 third-level watersheds and 1340 traditional villages. These third-level watersheds are the upper and lower Sinan watersheds, the upper and lower Yuanjiang Pushi Town watersheds in the Yangtze River watershed; and the Liujiang and Guihe River watersheds in the Pearl River watershed. Another cluster is located at the junction of the Yangtze and Southeast watersheds, with 1401 traditional villages. The third-level watersheds in this cluster are the Rao and Qingyi River watersheds, the upper Ganjiang Dongbei watershed in the Yangtze River watershed; and most third-level watersheds in the Southeast River watershed, except for the Southeast and Zhedong Coastal River watersheds, and the Zhoushan Island watershed. This distribution slightly occurs at the junction of the Haihe River watershed (the Zhangwei River mountainous watershed) and Yellow River watershed (the Fen River watershed), which has 322 traditional villages. Third-level watersheds with HH-type distribution generally have more traditional villages than their surrounding third-level watersheds; they are also areas with high traditional village number homogeneity.

The LL-type distribution occurs in most third-level watersheds (23.9% of the total), but these watersheds have only 76 traditional villages (1.11% of the total). Among these, 79.41% of third-level watersheds in the Northwest River watershed and 60% in the Northeast River watershed belong to the LL-type distribution. This distribution occurs slightly in the Yellow and Haihe River watersheds. The third-level watersheds with LL-type distribution have a small number of traditional villages, similar to the surrounding third-level watersheds; in general, they also have a contiguous distribution pattern in space.

Most third-level watersheds with LH-type distribution are adjacent to the HH-type distribution clusters. These watersheds are the upper and lower Zishui Lingshui River watersheds, Xin and Chishui River watersheds in the Yangtze River watershed, and the Hongshui River watershed in the Pearl River watershed. It is worth noting that the Lixian River watershed in the Southwest River watershed also belongs to the LH-type distribution. These watersheds have a significantly different number of traditional villages compared to their surrounding third-level watersheds. Third-level watersheds with LH-type distribution have few traditional villages, but their surrounding third-level watersheds have a greater number. We refer to these third-level watersheds as “depressed inequality watersheds”.

The HL-type distribution is only observed in the Wangbeng Interval North Bank watershed of the Huaihe River watershed. This watershed has the most traditional villages (51, 24.17%), compared to other third-level watersheds in the Huaihe River watershed. However, its surrounding third-level watersheds have a low number of traditional villages. It can be seen that the third-level watersheds with HL-type distribution show a negative correlation with their surrounding third-level watersheds; that is, the high traditional village number in the middle and the low number in its surrounding third-level watersheds. This type of watershed is also usually a watershed rich in traditional village resources in a given area. Therefore, we refer to these third-level watersheds as “raised inequality watersheds”. The remaining third-level watersheds appear as non-significant areas in the LISA map.

#### 4.3. Spatial Agglomeration Characteristics

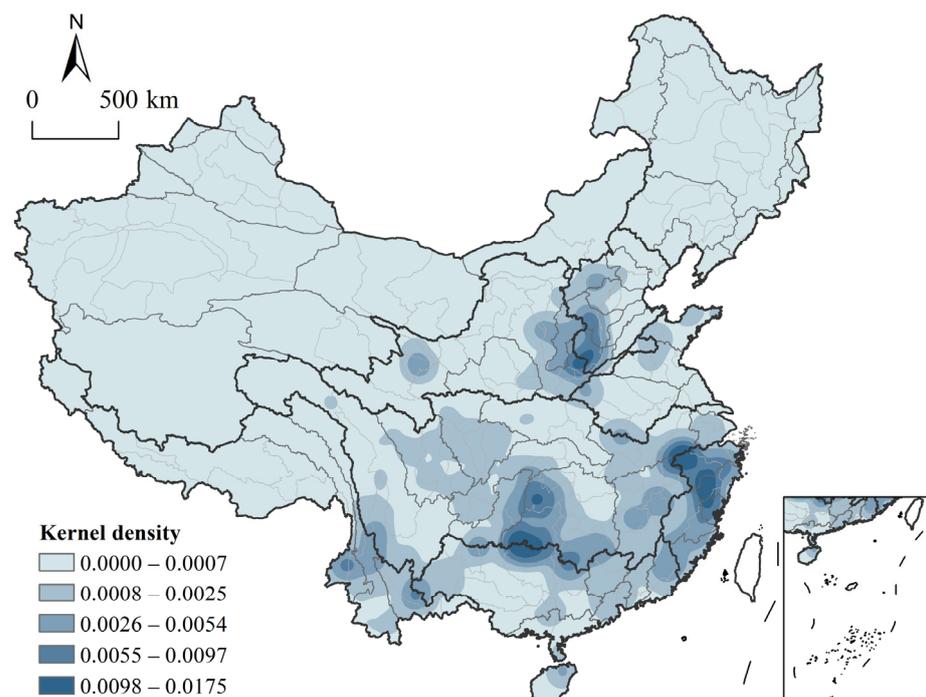
Table 3 shows the average nearest neighbor index of traditional villages in China and each first-level watershed. All  $p$  values are less than 0.01, showing that they pass the significance test at the 1% level. Each region’s average nearest neighbor index ranges from 0.46 to 0.82, which is less than 1, indicating that traditional village distribution in each region is agglomeration, albeit to varying degrees. Although traditional villages are not concentrated in the Yellow River watershed, it has the lowest average nearest neighbor index and the highest degree of agglomeration among the nine first-level watersheds. The

reason for this is that the Yellow River watershed is one of the birthplaces of Chinese civilization; as a result of the impact of traditional culture, most traditional villages are located along major rivers (e.g., the Yellow River and the Fen River). The Northwest River watershed has the highest average nearest neighbor index and the lowest degree of agglomeration. This is because, although the watershed covers the largest area, the natural environment is relatively harsh, and the population distribution is sparse, leading to few and scattered traditional villages (26, 0.38%) in the watershed. It is worth noting that the degree of traditional village aggregation in the entire country is higher than in all nine first-level watersheds. From this, it can be seen that a certain scale and relative agglomeration of traditional villages are generally formed in the whole country and each first-level watershed, implying a good development in China's traditional village protection efforts.

**Table 3.** The results of average nearest neighbor index.

Region	Index Value	Z-Score	p Value	Pattern
Northwest River watershed	0.82	−1.8034	0.0071	Agglomeration
Northeast River watershed	0.63	−6.0000	0.0000	Agglomeration
Huaihe River watershed	0.56	−12.3186	0.0000	Agglomeration
Haihe River watershed	0.51	−20.5218	0.0000	Agglomeration
Southwest River watershed	0.53	−20.5334	0.0000	Agglomeration
Yellow River watershed	0.48	−26.0896	0.0000	Agglomeration
Pearl River watershed	0.69	−18.8834	0.0000	Agglomeration
Southeast River watershed	0.72	−19.1802	0.0000	Agglomeration
Yangtze River watershed	0.65	−33.8512	0.0000	Agglomeration
Total	0.46	−84.5674	0.0000	Agglomeration

To understand the characteristics of the traditional village distribution in space more intuitively, we calculated their kernel density using ArcGIS 10.5 software and classified the results into five levels according to the natural break method (Figure 3). Traditional villages are unevenly distributed in space, with considerable regional differences; their distribution has a clear agglomeration trend, with a concentrated and contiguous pattern based on “core density area–ring-core expansion group–belt area”, as depicted in Figure 3.



**Figure 3.** Kernel density map of traditional villages in China.

The core density area includes one single-center core density area and two double-center core density areas, all of which have kernel density values of more than 98 traditional villages/10,000 km<sup>2</sup>. The single-center core density area is located at the junction of the Qindan River watershed and the Zhangwei River mountainous watershed, which radiates outward to form a ring-core extension group. In southern China, a double-center core density area, with the upper and lower Yuanjiang Pushi Town watersheds and the Liujiang River watershed as the core, radiates outward to form a ring-core expansion group. Another double-center core density area is found in the upper Oujiang Wenxi watershed and lower Fuchun River Reservoir watershed. These two double-center core density areas and their extension groups comprise China's most extensive concentrated and contiguous areas with the most traditional villages. Noted is the existence of a double-center sub-core density area in the southeastern part of the southwest watershed, which radiates outward to form a mini-ring-core extension group. Furthermore, some relatively independent single-center sub-core density areas occur in the western Yellow River watershed, the eastern Huaihe River watershed, and the southern Pearl River watershed, but their coverage area is limited. Overall, traditional villages are low-density in the vast majority of China, with a concentrated and contiguous aggregation pattern. This shows that the traditional village distribution is not random, but rather follows a particular pattern influenced by the natural environment.

#### 4.4. Influencing Factors of Traditional Village Distributions

We calculated the *q*-statistic value of each influencing factor on the traditional village distribution using the factor detector of Geodetector, respectively, and the results are shown in Table 4. The *p* values of all influencing factors in the measurement results are less than 0.01, which means that all factors passed the significance test. According to Table 4, the factors affecting the traditional village distribution in order of strength to weakness are: annual precipitation > annual average temperature > river density > population density > elevation > road density > NDVI > topography relief > GDP density.

**Table 4.** The detected results of nine influencing factors.

Influencing Factors	<i>q</i> -Statistic	<i>p</i> -Value	Influencing Factors	<i>q</i> -Statistic	<i>p</i> -Value
Annual precipitation	0.2606	0.0000	Population density	0.1880	0.0000
Annual average temperature	0.1950	0.0000	GDP density	0.1250	0.0000
Elevation	0.1787	0.0000	Road density	0.1621	0.0000
Topography relief	0.1315	0.0000	River density	0.1929	0.0000
NDVI	0.1533	0.0000			

##### 4.4.1. Climate

Precipitation and temperature have a decisive impact on human production and living activities, and they are also important natural factors in traditional village site selection and layout. Today, abundant precipitation and comfortable temperatures are still necessary for agricultural and urban development. Annual precipitation and annual average temperature have the strongest explanatory power on the traditional village distribution in China, with 26.06% and 19.50%, respectively. To eliminate the chance of a single year, we calculated the multi-year mean annual precipitation and annual average temperature, based on China's annual precipitation and annual average temperature datasets in 2006–2015; then, we overlaid traditional villages with them to obtain the climate distribution map of traditional villages in China (Figures 4 and 5).

The relationship between the traditional village number and annual precipitation is multi-type, as shown in Figure 4. Specifically, they have an inverted U-shaped relationship for annual precipitation of 416–595, 1218–1530, and 1530–1961 mm, respectively; traditional villages are evenly distributed regarding annual precipitation of 595–1218 mm; and when the annual precipitation is less than 416 mm, the traditional village number increases

exponentially with increasing annual precipitation. The annual precipitation at the three inverted U-shaped zones' turning points is 520, 1352, and 1768 mm, respectively. The traditional village number is positively related to annual precipitation in a certain range to the left of the turning point. They are, on the other hand, negatively correlated. Compared to other ranges with the same length of annual precipitation, the annual precipitation range around the turning point has the most traditional villages, indicating that villages surrounding the turning point are more likely to be designated as official traditional villages. Moreover, the statistics reveal that most traditional villages (92.80%) are located in areas with an annual precipitation of 500–2000 mm, implying that this annual precipitation range is favorable for traditional village preservation. When the annual precipitation exceeds 2000 mm, the traditional village number decreases sharply, indicating that excessive annual precipitation may not be suitable for traditional village preservation.

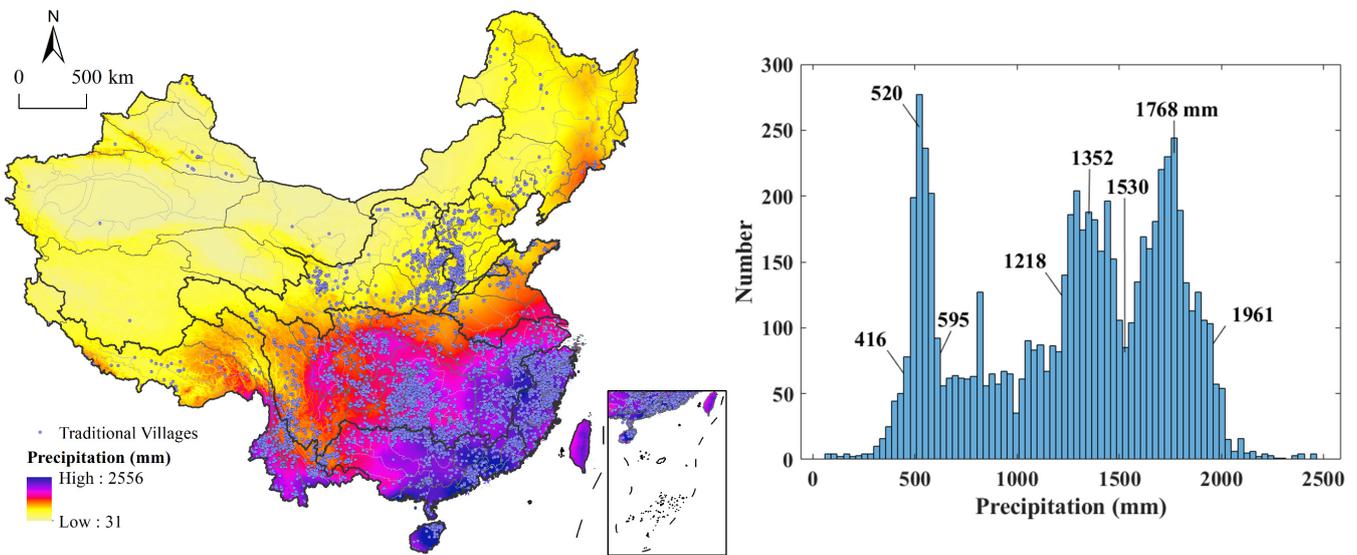


Figure 4. Relationships between traditional villages and annual precipitation in China.

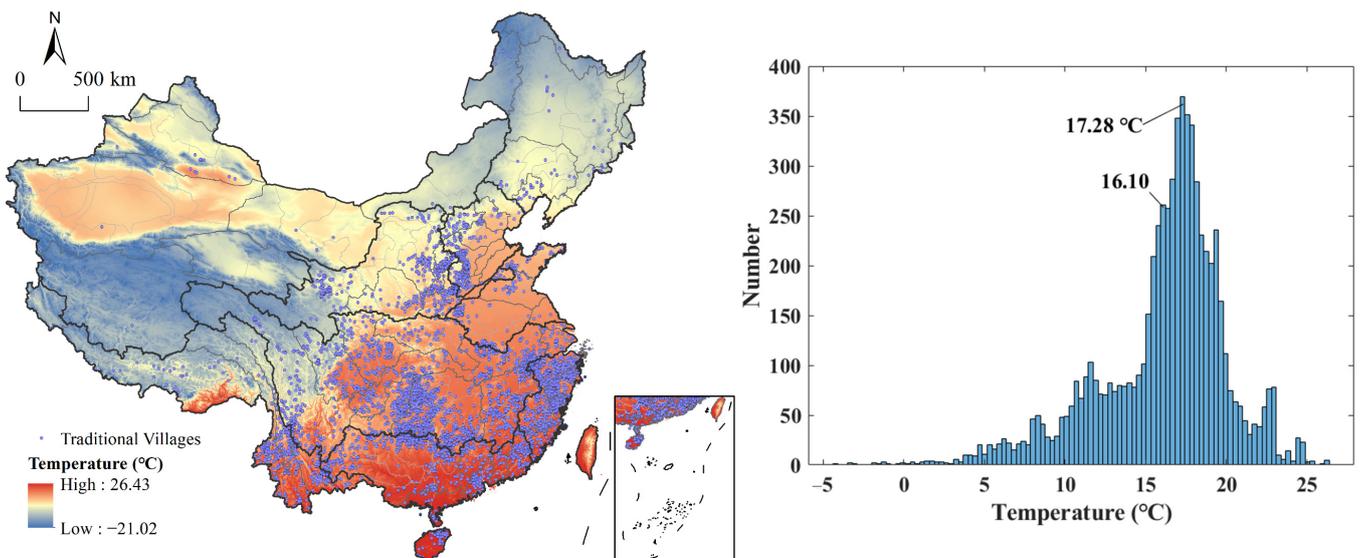


Figure 5. Relationships between traditional villages and annual average temperature in China.

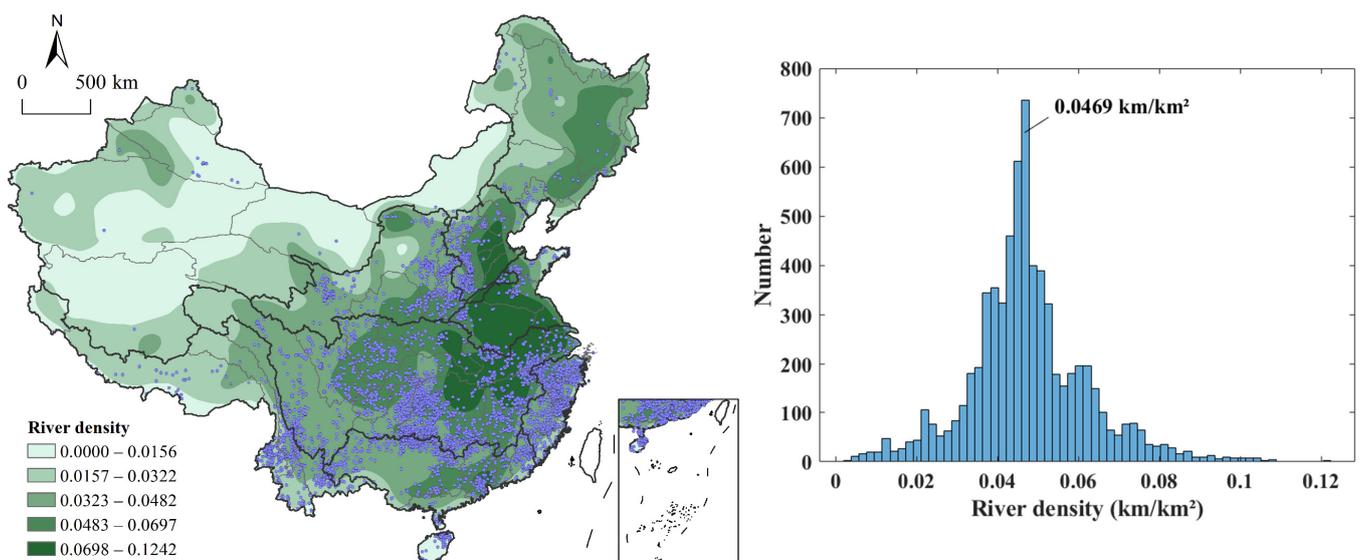
There is a clear inverted U-shaped relationship between the traditional village number and annual average temperature, as shown in Figure 5. The turning point's annual average temperature is 17.28 °C. In total, 56.40% of traditional villages are located to the left of

the turning point, while 43.60% are located to the right. However, traditional villages are sparsely distributed in low temperature ( $<5\text{ }^{\circ}\text{C}$ ) and high temperature ( $>20\text{ }^{\circ}\text{C}$ ) areas, accounting for 1.48% and 10.24% of the total, respectively. There are 28.67% of traditional villages with annual average temperatures of  $15\text{--}17.28\text{ }^{\circ}\text{C}$ , and the number of these traditional villages increases dramatically as the annual average temperature increases. Although the traditional village number decreases sharply in the range of  $17.28\text{--}20\text{ }^{\circ}\text{C}$  as the annual average temperature increases, this range has the most traditional villages (33.36%) compared to other ranges with the same annual average temperature length. Clearly, more than 60% of traditional villages are distributed in areas with an annual average temperature of  $15\text{--}20.28\text{ }^{\circ}\text{C}$ . Therefore, it can be concluded that the annual average temperature near the turning point ( $15\text{--}20\text{ }^{\circ}\text{C}$ ) is conducive to preserving traditional villages and meeting the entry conditions to become an official traditional village.

#### 4.4.2. River

Besides climatic factors, river density provides the strongest explanatory power (19.3%) for the traditional village distribution. Water, an important natural resource, is closely related to all aspects of human production and life [62]. River systems play a vital role in human settlements' spatial organization [63]. Historically, humans favored building villages along rivers and in areas with intertwined rivers [64,65]. On the one hand, these areas are convenient for domestic water to meet subsistence demands. On the other hand, sufficient water resources can ensure the various agricultural and livestock output, enabling self-sufficiency.

Using ArcGIS 10.5 software, we calculated the line density of China's major rivers and then divided the results into five levels according to the natural break method: low density, lower density, medium density, higher density, and high density (Figure 6). Figure 6 shows that the traditional village number has a clear inverted U-shaped relationship with river density. The river density of the turning point and the mean river density of 6819 traditional villages are  $0.0469\text{ km/km}^2$  and  $0.0475\text{ km/km}^2$ , respectively, which are comparable values and belong to the medium river density level. Statistically, there are 142, 572, and 508 traditional villages in low, lower, and high river density areas, accounting for 2.08%, 8.39%, and 7.45% of the total, respectively. Clearly, most traditional villages (5597, 82.08%) are distributed in areas with medium and higher river density.



**Figure 6.** Relationships between traditional villages and river density in China.

To further investigate the relationship between the traditional village distribution and rivers, we overlaid traditional villages with China's major rivers (Figure 7). As seen in

Figure 7, there is a significant negative relationship between the number of traditional villages and their distance from the nearest river, implying that the closer to the river, the more traditional villages there are. According to the statistics, the average distance between 6819 traditional villages and the nearest river is 8.09 km. In addition, there are 2845 (41.72%), 1735 (25.44%), 1212 (17.77%), 619 (9.08%), and 408 (5.98%) traditional villages located in areas with distances of 0–5, 5–10, 10–15, 15–20, and >20 km from the nearest river, respectively. Clearly, more than 60% of the traditional villages are located within 10 km from the river. These data reveal that most traditional villages are distributed along the river, with a clear hydrophilicity.

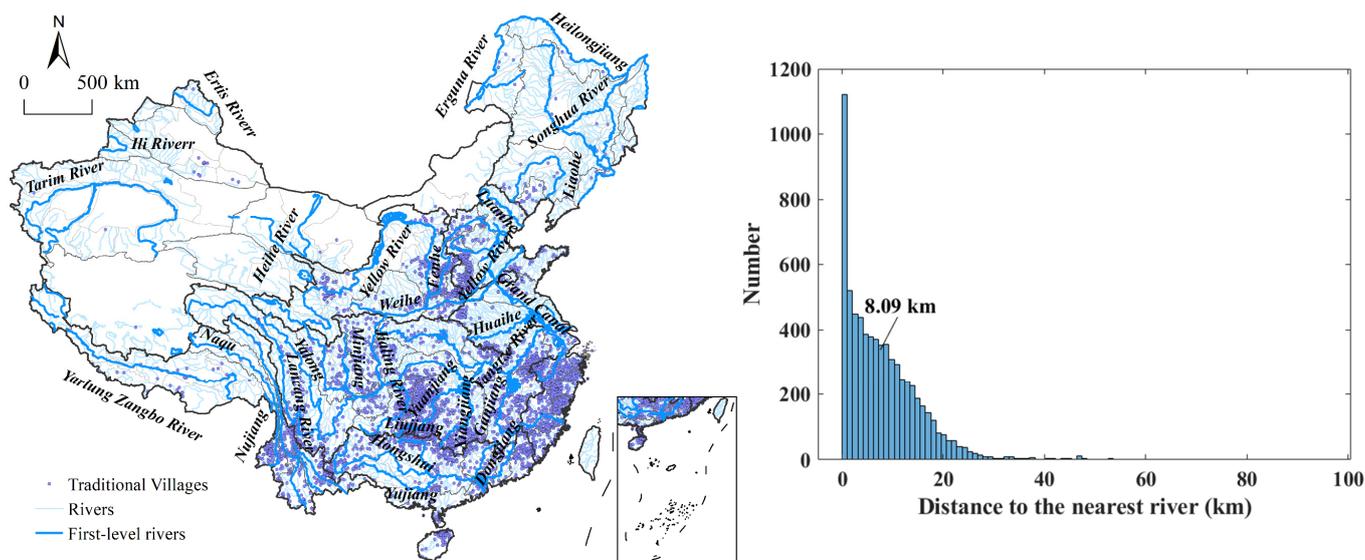


Figure 7. Relationships between traditional villages and rivers in China.

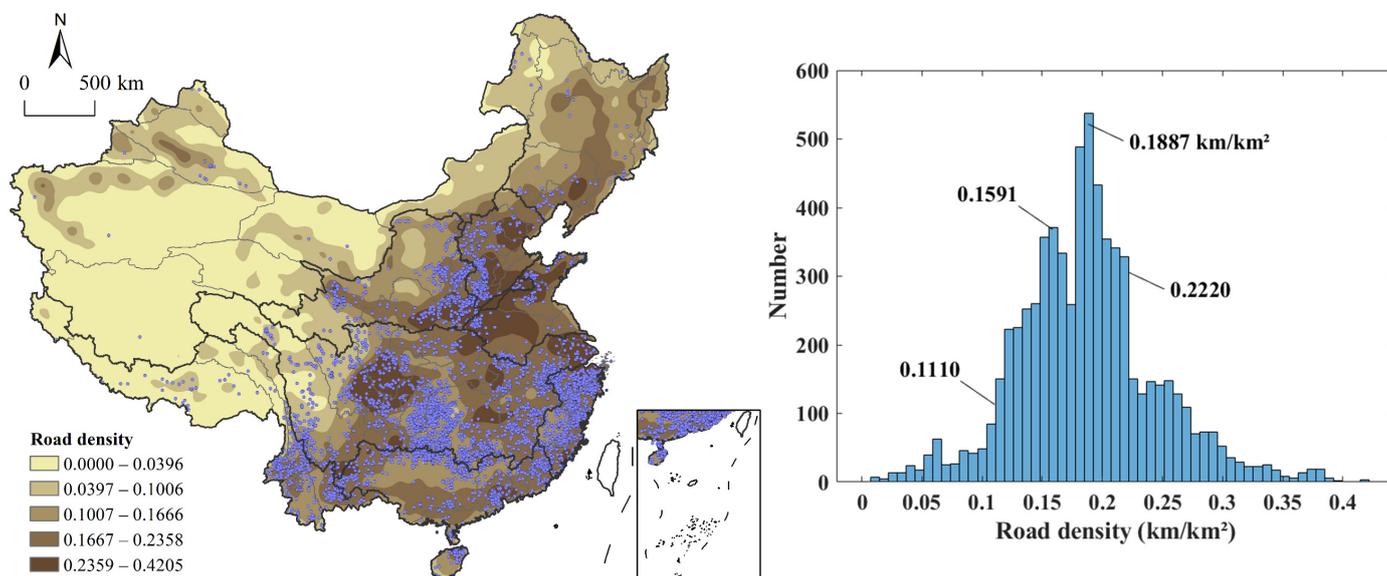
In summary, the traditional village distribution is closely related to rivers, and traditional villages are frequently found in areas with medium and higher river density. The traditional village number and river density show an exponential increase and decrease in the areas to the left and right of the turning point. In other words, low or high river density areas may have a negative impact on traditional villages. At the same time, although traditional villages are usually located near rivers and have clear hydrophilicity, they keep a certain distance from rivers.

#### 4.4.3. Transportation

The road is not only an important carrier for material transportation and human travel, but it is also a unique medium for transmitting human civilization and culture. Modern transportation has an important influence on the traditional village development and its traditional culture transmission [8,14]. The explanatory power of modern road density on the traditional village distribution is 16.2%.

Using ArcGIS 10.5 software and the natural break method, we calculated the line density of modern roads and divided the results into five categories: low density, lower density, medium density, higher density, and high density (Figure 8). Despite the two turning points, the overall relationship between the traditional village number and road density is an inverted U-shaped, as seen in Figure 8. The road density of the left turning point is 0.1591 km/km<sup>2</sup>, which is a medium road density level. The road density (0.1887 km/km<sup>2</sup>) of the right turning point is slightly higher than the mean road density (0.1870 km/km<sup>2</sup>) of the 6819 traditional villages, both of which belong to the higher road density level. We found that the traditional village number increases exponentially with the increasing road density on the left side of the left turning point. The opposite is true on the right inflection point's right side. The lower or higher the road density, the smaller the distribution of

traditional villages. Traditional villages are rarely found in low and high road density areas, with 44 (0.65%) and 1191 (17.47%), respectively. Most traditional villages (78.92%) are located in areas with medium and higher road density. This indicates that areas with medium and higher road density are suitable for preserving traditional villages.



**Figure 8.** Relationships between traditional villages and road density in China.

#### 4.4.4. Topography

Topography directly influences the local climate, soil, and other living conditions. The flat plains have more arable land, while the rugged topography limits farming activities and population agglomeration [66]. Elevation and topography relief have a 17.9% and 13.15% explanatory power, respectively, on the traditional village distribution.

Figures 9 and 10 show the overlay of traditional villages with elevation and topography relief, respectively, concluding that the traditional village distribution is closely related to them. The higher the elevation or topography relief, the less traditional villages are distributed, indicating that the traditional village distribution is negatively correlated with them. The 6819 traditional villages have a mean elevation and topography relief value of 707 and 80 m, respectively. There are 3419 (50.14%), 1937 (28.41%), 1013 (14.86%), and 450 (6.59%) traditional villages located in the elevations of <500, 500–1000, 1000–2000, and >2000 m, with the mean topography relief of 59, 105, 87, and 116 m, respectively. That is, more than 90% of traditional villages are located in areas with elevations below 2000 m, whereas the mean elevation and topography relief of these traditional villages are 403 and 78 m, respectively; among them, approximately 80% of traditional villages are located in low elevation areas below 1000 m. In comparison, traditional villages with high elevations (above 1000 m) are mainly located on the Yunnan-Guizhou and Qinghai-Tibet Plateaus, and their number is relatively small. It is worth noting that the mean topography relief of traditional villages in the elevation of 500–1000 m is relatively high. In fact, there are 689 traditional villages located in areas with elevations of 500–1000 m and topography relief of >150 m. These traditional villages are mostly found in southeast coastal China's hills and low mountains (Figures 9 and 10). Overall, traditional villages have an obvious “low elevation and small topography relief” distribution pattern.

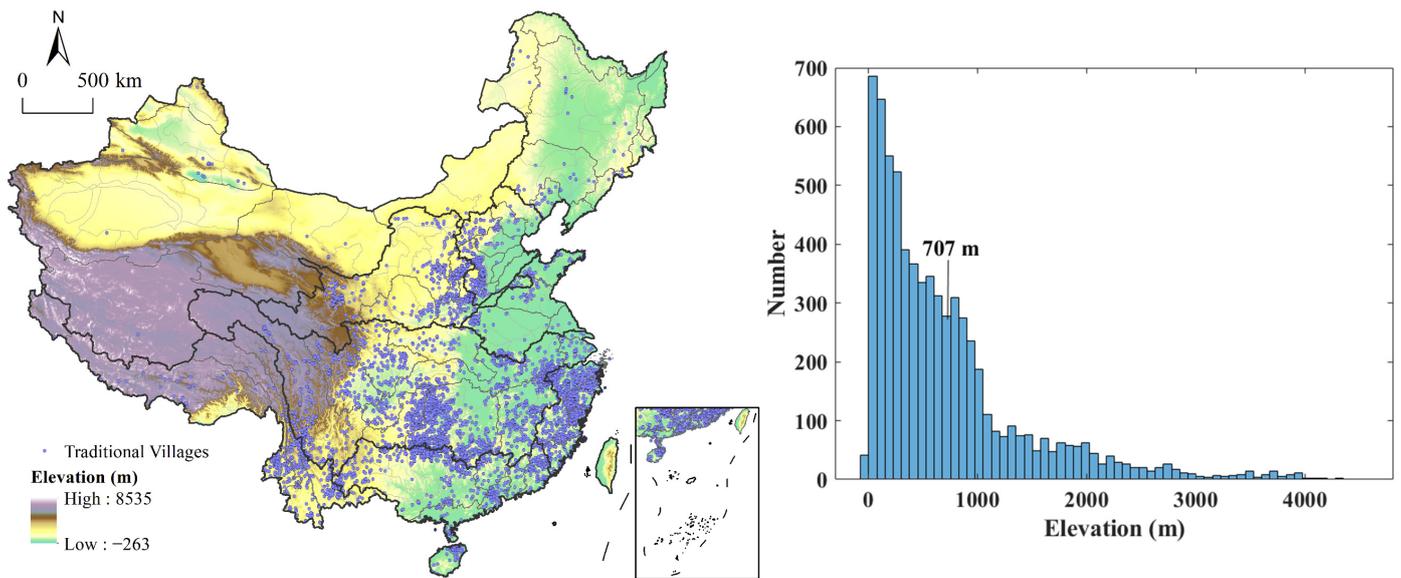


Figure 9. Relationships between traditional villages and elevation in China.

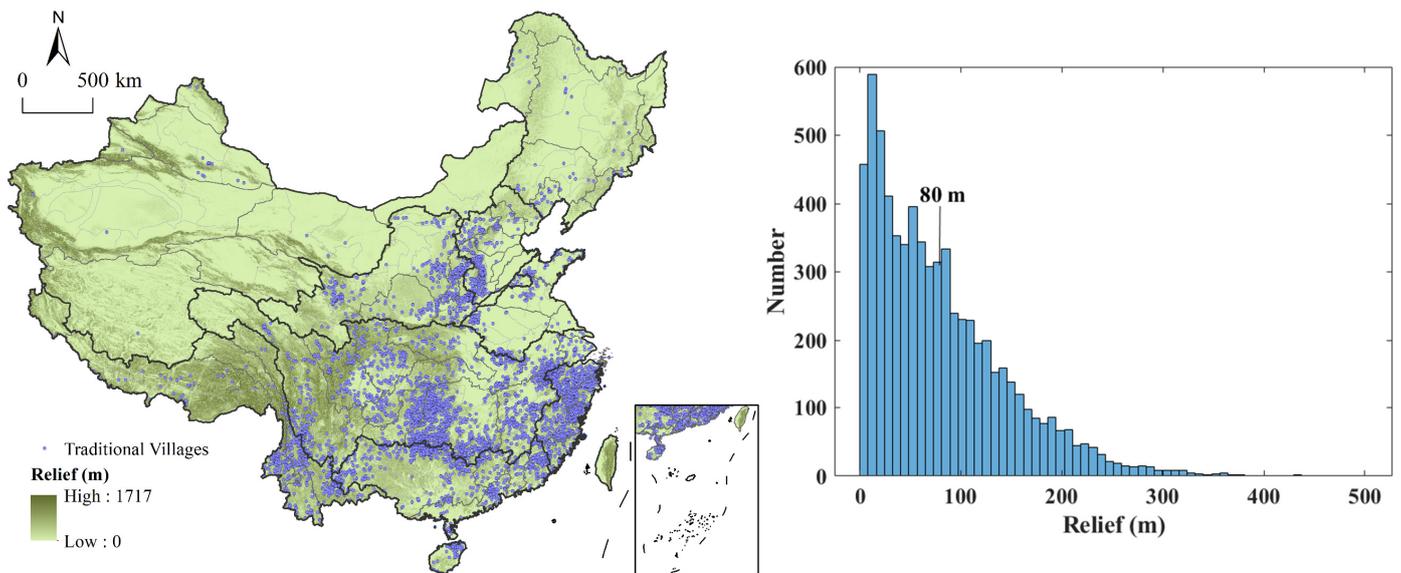


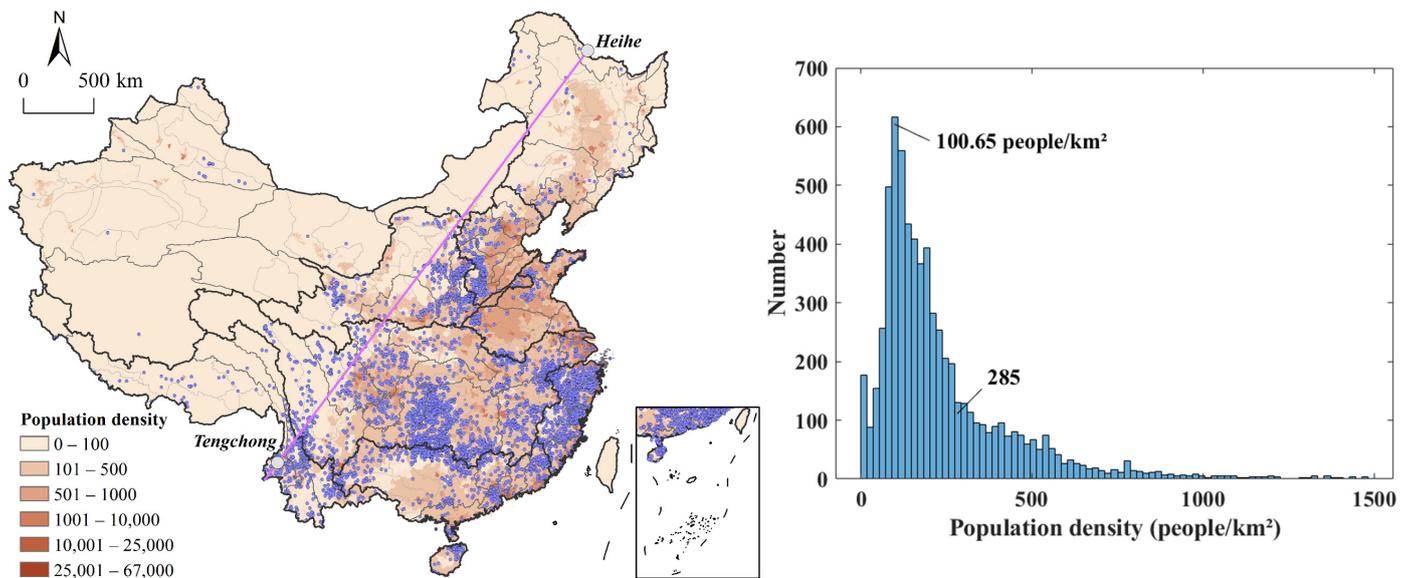
Figure 10. Relationships between traditional villages and topography relief in China.

#### 4.4.5. Population and Economy

With an explanatory power of 18.80%, the influence of population density on the traditional village distribution is rated fourth. The relationship between traditional villages and population density is seen in Figure 11. It should be noted that the traditional villages' highest population density is 16,668 people/km<sup>2</sup>. To visually understand population density's impact on the traditional village distribution, we selected traditional villages (6708, 98.37%) with a population density of fewer than 1500 people/km<sup>2</sup> to draw the histogram.

As shown in Figure 11, the traditional village number first increases and then decreases as the population density increases. The population density of the turning point and the mean population density of 6819 traditional villages are 100.65 and 285 people/km<sup>2</sup>, respectively. On the left side of the turning point, the traditional village number gradually increases with the increasing population density. Conversely, the traditional village number decreases exponentially; the higher the population density, the less traditional villages are distributed. Actually, there are 1501 (22.01%), 3455 (50.67%), 1060 (15.54%), and 803 (11.78%) traditional villages distributed in areas with population densities of 0–100.65, 100.65–285,

285–500, and >500 people/km<sup>2</sup>, respectively. This information indicates that traditional villages are concentrated in low population density areas. Such a finding is in line with the general law that the formation of villages is mainly the result of population aggregation in small areas. Furthermore, the traditional village distribution roughly coincides with the Heihe–Tengchong line [67] of population distribution in China, with traditional villages (6.91%) in the west of the line being more scattered and traditional villages (93.09%) in the east being more concentrated.



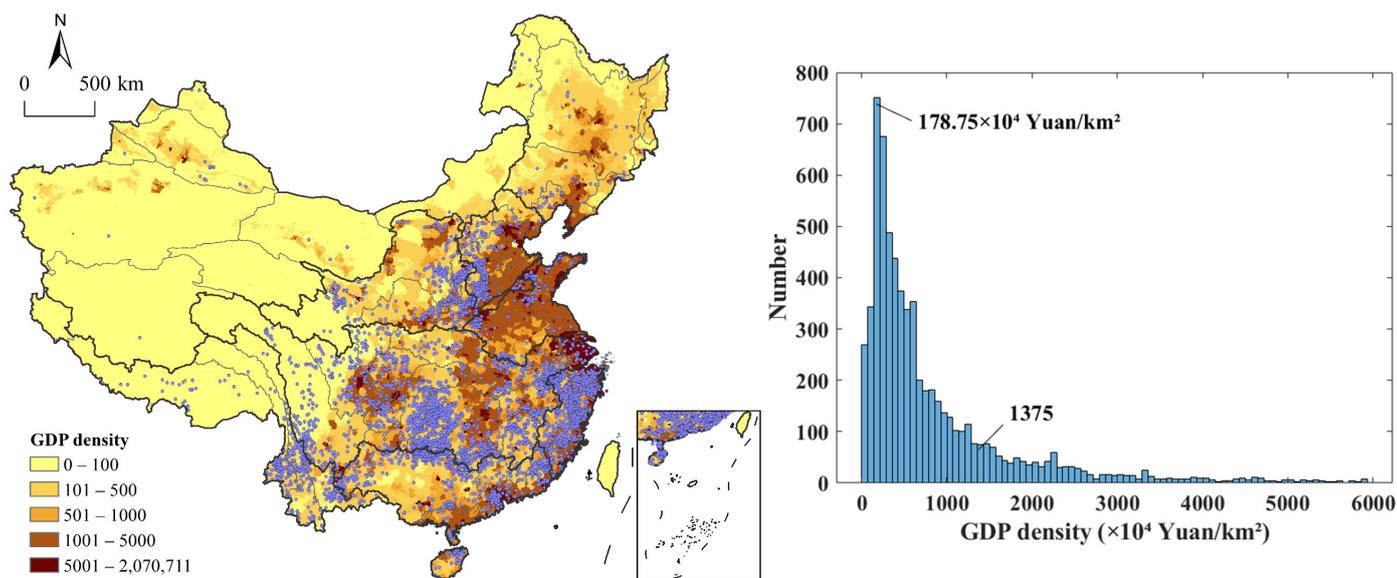
**Figure 11.** Relationships between traditional villages and population density in China.

Among the influencing factors, GDP density has the weakest explanatory power on the traditional village distribution, with an explanatory power of 12.5%. The regional economic development level is essential for traditional village protection and inheritance. The development of traditional villages, the inheritance of distinctive cultures, and the revitalization of distinctive industries depend on the regional economy's strong drive. Figure 12 shows the relationship between traditional villages and GDP density. The maximum GDP density of traditional villages is  $172,727 \times 10^4$  Yuan/km<sup>2</sup>. To better visualize the influence of GDP density on the traditional village distribution, we selected traditional villages (6582, 96.52%) with a GDP density below  $6000 \times 10^4$  Yuan/km<sup>2</sup> to plot the histogram.

As seen in Figure 12, traditional villages are concentrated in economically developed areas, such as the middle and lower reaches of the Yangtze River watershed, the Southeastern River watershed, and the junction of the Haihe and Yellow River watersheds. These areas can provide sufficient financial support for traditional villagers' protection and development, with the most traditional villages in China. Despite its undeveloped economy, the southwestern part of China still has many traditional villages. The region, which is the route of China's old Silk Road, has a long history, a large territory, and rich historical and ethnic cultural resources. Therefore, under this unique natural ecological environment and historical and cultural background, some traditional villages with unique characteristics of the southwest China region have gradually formed.

Figure 12 also shows that the traditional village number first increases and then decreases as GDP density increases. The GDP density of the turning point is  $178.75 \times 10^4$  Yuan/km<sup>2</sup>. On the right side of the turning point, the traditional village number decreases exponentially with the increasing GDP density. Using the mean GDP density ( $1375 \times 10^4$  Yuan/km<sup>2</sup>) of the 6819 traditional villages and the turning point as a standard, we found that there are 1022 (14.99%), 2117 (31.05%), 1022 (14.99%), 1269 (18.61%), and 1389 (20.61%) traditional villages distributed in areas with the GDP densities of <178.75, 178.75–458.33,

458.33–687.5, 687.5–1375, and  $>1375 \times 10^4$  Yuan/km<sup>2</sup>, respectively. Clearly, most traditional villages are distributed in areas with a GDP density of  $<687.5 \times 10^4$  Yuan/km<sup>2</sup>, including 4161 traditional villages, more than 2/3 of the total. As the GDP density can reflect the local economic level [68], we can conclude that areas with a poor local economy cause less destruction to their traditional villages, making them more likely to be retained and selected as official traditional villages.

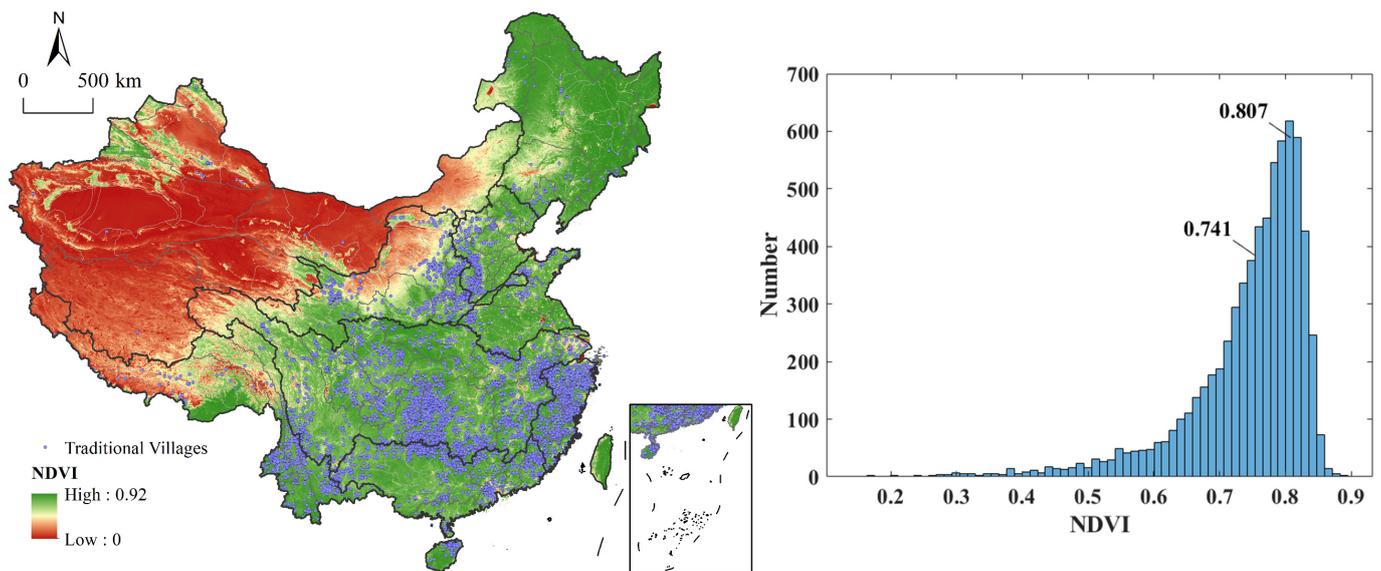


**Figure 12.** Relationships between traditional villages and GDP density in China.

#### 4.4.6. Vegetation Coverage (NDVI)

Traditional villages' site selection and layout are closely related to the ecological environment [8], which is the foundation of human survival and development [69]. NDVI is not only the best indicator for measuring vegetation coverage and growth state [70], but it is also an effective indicator for monitoring the ecological environment [71,72]. In this study, we used NDVI to provide information about the ecological environment and vegetation cover of traditional villages. To eliminate the chance of a single year, we calculated the multi-year mean annual NDVI (Figure 13), based on China's annual NDVI dataset in 2006–2015. The results of Geodetector show that the explanatory power of NDVI on the traditional village distribution is 15.33%.

As seen in Figure 13, the traditional village number first increases and then decreases as the NDVI increases. The NDVI values of 6819 traditional villages range from 0.16 to 0.89, with a mean value of 0.741. The NDVI of the turning point is 0.807. On the left side of the turning point, the traditional village number shows a strong exponential increase with the increasing NDVI. Conversely, the traditional village number shows a significant negative correlation with NDVI. The statistical results show that there are 841 (12.33%), 4339 (63.63%) and 1639 (24.04%) traditional villages distributed in the NDVIs of 0.160–0.650, 0.650–0.807, and 0.807–0.890, respectively. Clearly, most traditional villages are distributed in areas with a high level of vegetation cover (NDVI), which can be viewed as the area around the turning point in this study. Overall, NDVI is an important factor influencing the traditional village distribution. The designation of official traditional villages in China has fully considered the local vegetation cover.



**Figure 13.** Relationships between traditional villages and NDVI in China.

## 5. Discussion

### 5.1. Characteristics of Traditional Village Distributions in China

China has a vast landmass with significant diversity in natural conditions, historical cultures, and economic development throughout its various regions [35,73]; this diversity causes the traditional village distribution to show obvious regional differences. Due to zonal characteristics for the change in each element in China [74], the traditional village distribution is also characterized by a high degree of stability and continuity in local areas. Overall, traditional villages are unevenly distributed in the watershed units and are concentrated in some particular watersheds, such as the Dongting Lake watershed, Qiantang and Xijiang River watersheds. At the third-level watershed scale, however, the impact of “neighboring reliance” has formed, which is beneficial to the traditional village development in the whole region. The average nearest neighbor index result reveals that traditional villages exhibit strong aggregation in local areas, indicating that the traditional village protection in China has good development. The findings on the kernel density of traditional villages further prove the existence of this aggregation. Despite significant regional differences in the traditional village distribution in space, a trend of local aggregation has emerged. Traditional villages form a concentrated and contiguous agglomeration distribution pattern in space based on “core density area–ring-core expansion group–belt area”. This aggregation characteristic in space is conducive to resolving the issue of dispersed protection and development of traditional villages, as well as exploring a new model of traditional villages’ agglomeration protection and development focusing on a geographical unit.

### 5.2. Relationship between Traditional Villages and Influencing Factors

The aggregation pattern of the traditional village distribution in China is not random; a variety of factors cause it.

According to the results of the Geodetector and overlay analyses, annual precipitation and annual average temperature have the most significant impact on the traditional village distribution. Our study shows that traditional villages are concentrated in areas with moderate precipitation and suitable temperature, which is compatible with natural law. Human life and agricultural production require a certain amount of precipitation. Low precipitation and frequent droughts are detrimental to agricultural production and settlement formation; areas with these climatic characteristics, such as the northwest part of China, usually have fewer traditional villages. Excessive precipitation increases the likelihood of natural disasters, such as flooding and geology, which is detrimental to the long-term preservation of traditional villages. In areas with low annual average temperatures, the freezing period

is longer and the crop growing period is shorter, which is not conducive to agricultural production and human life. The areas with high annual average temperatures (above 20 °C) are mainly located in southern China. In these areas, where human activity and economic growth are more prevalent, only 10.24% of traditional villages have been preserved.

Generally, traditional villages are concentrated in low-elevation areas with small topography relief. On the one hand, areas with flat topography provide favorable conditions for human settlement and aggregation due to their superior land production capacity, developed transportation systems, and convenient lifestyle. On the other hand, the relatively low elevation makes it easier for humid marine air currents from eastern China to reach inland and bring abundant precipitation, which is conducive to agricultural development [44]. However, due to historical factors, some traditional villages failed to occupy favorable topography and were distributed in remote mountainous areas, such as the Yunnan-Guizhou plateau, the Wuyishan hilly area, and the ancient Huizhou area [36] (the current junction of Anhui and Jiangxi). These areas are typically characterized by high elevation and large topography relief. This independent natural geographical environment, however, provides residents with a relatively enclosed and secure space, making them less susceptible to external influences and the effects of current rapid urbanization. The majority of these traditional villages were established by war-avoidant ancient northern residents [33,36,54]. For example, in the early Yuan dynasty, the siege by Yuan dynasty troops forced the masses and former dynasty troops to migrate deeper into the Wuyishan hilly region [54].

Modern transportation conditions have a significant impact on the sustainable development of traditional villages. As carriers of China's traditional cultural heritage, traditional villages are fragile and nonrenewable; they are vulnerable to the influence of other cultures, particularly in the current context of rapid urbanization. In areas with convenient transportation, there are frequent external exchanges and strong modern cultural effects, which may gradually cause traditional villages to lose their original characteristics. Although poor transportation conditions impede communication between villages and the external society and limit the transmission of cultural heritage values of traditional villages, they prevent, to a certain extent, the integration of some cultures and maximize the preservation of residents' traditional lifestyles, thus avoiding the disappearance of many traditional villages. Nevertheless, this condition is not conducive to the traditional villages' sustainable development due to the limited distance of their cultural heritage values' transmission. In general, a medium road density not only ensures traditional village access, but also prevents the adverse effects of excessive interregional communication on traditional villages.

Rivers play a key role in determining the traditional village distribution. Consistent with previous studies [8,16,45], traditional villages have a clear hydrophilicity. The high availability of water sources promotes human aggregation, thus forming various unique rural settlements and cultural customs [44]. As a model for cultural heritage transmission and rural settlement revitalization in China, traditional villages rely heavily on rivers. Our study shows that most traditional villages are distributed along rivers but keep a certain distance apart. This is because, while rivers give sustenance to human survival, they also bring some disasters to the development of villages [75]. For example, the Yangtze River watershed suffered severe floods in 1931, affecting an area of up to  $15 \times 10^4$  km<sup>2</sup>. During the Qing dynasty, the Yellow River captured the Huai River several times, flooding large areas of the Haihe and Huaihe River watersheds. It should be emphasized that sufficient river resources may typically be converted into tourism resources, hence driving local tourism development and enhancing rural economic prosperity.

The sufficient population is the foundation for the formation of early villages and the key to ensuring the long-term development of traditional villages today. The traditional cultural inheritance of traditional villages is reflected in the process of the villagers' production and life; thus, the traditional village's sustainable development depends on the villagers. Our study shows that traditional villages are concentrated in areas with low population density. In other words, traditional villages are rarely found in densely populated areas.

Currently, most developing countries are experiencing rapid urbanization, with more and more rural residents migrating to urban areas. From 1978 to 2019, China's rural population decreased from 80.61% to 39.40% [76]. Although the decline in rural population density has reduced the pressure on rural resources and the destruction of traditional villages, it has an adverse influence on traditional villages' protection and development. At present, the hollowing phenomenon in China's rural areas is intensifying, which occurs not only in remote and less developed areas, but also in developed areas [20]. In this context, similar to ordinary villages, traditional villages are facing a decline in their numbers.

Among the influencing factors, GDP density has the weakest explanatory power on the traditional village distribution. According to our findings, most traditional villages are located in low GDP density areas, and their distribution is characterized by a clear economic marginalization. This can also be interpreted as traditional villages benefiting from a degree of economic backwardness. However, there is a strong two-level effect between the sustainable development of traditional villages and economic development. In general, in developed areas, traditional villages are developed intensively, destroying many traditional villages in the construction of new rural and urbanized areas. In these regions, however, the idea of protecting traditional villages and transmitting their unique traditional culture is more widely accepted, and sufficient funds are available for their sustainable development. This also supports another characteristic of the traditional village distribution from the economic perspective, i.e., most traditional villages are distributed in relatively developed areas. In contrast, the mobility of capital, material, and information between urban and rural areas is generally slow in underdeveloped areas, making traditional villages less susceptible to external interference and influence. Despite this, utilizing rural land and cultural resources, expanding industries and markets, and transmitting unique traditional culture are all challenging problems in these areas. Therefore, the traditional villages' sustainable development must be organically integrated with local economic development and villagers' poverty alleviation.

The surrounding environmental condition of a village is crucial, as it not only impacts the health and safety of the villagers but also determines the village's direction and the related economy [77]. Most traditional villages have high NDVI values, according to our study. The result is expected, as high vegetation cover is the basis for livability [8]. This occurrence is easily explained. First, traditional villages have a clear hydrophilicity. Rivers nourish the fertile soil, and the areas they flow through are typically rich in species and densely vegetated, providing a solid basis for agriculture. Second, remote mountainous areas and hills typically have a dense forest cover, contributing to water conservation, climate regulation, and improving local ecological and habitat quality. These areas provide natural havens for traditional villages and have a certain number of traditional villages. Northwest China, in contrast, has a harsh natural environment, limited natural resources, and low NDVI values, making it unsuitable for human settlement and limiting the development of local agriculture and economy, with only a few traditional villages. Therefore, the vegetation cover factor must be thoroughly considered in the process of protecting and developing existing traditional villages, as well as in the designation of new official traditional villages.

### 5.3. Watershed Management Model

Based on the study findings, we propose a watershed management model to enhance traditional villages' protection and sustainable development.

Generally, traditional villages in a certain agglomeration area have a similar geographical environment, cultural customs, and development requirements [33], such as the ancient Huizhou traditional village cluster, the Jinshang traditional village cluster, and some ethnic traditional village clusters. Traditional villages have a long-term material and cultural exchange history in these areas and maintain close economic, historical, and cultural ties today. Therefore, traditional villagers' protection and development should not be limited to individual villages or villages within a given administrative unit; instead, they should be

conducted within a certain geographical unit. Our study confirms that traditional villages are distributed unevenly across watershed units, with aggregation in certain watersheds; meanwhile, the traditional village number in the watershed units forms a “neighbor dependency” effect. In addition, the traditional village distribution has obvious concentrated and contiguous aggregation characteristics in space. This information provides important references for resolving the issue of traditional villages’ dispersed protection and development and developing a new model of traditional villages’ agglomeration protection and development in space.

In recent years, the role of the watershed unit in the studies of the regional economy, aquatic ecosystems, and sustainable development has been widely recognized [47,50,51]. Given the high aggregation and hydrophilicity of traditional villages, it is vital to include them in watershed units to overcome the limitations of administrative units and to guarantee that their geographical environment and cultural customs are similar. Specifically, it can be considered to manage traditional villages within existing watershed units. Second, the aggregation, hydrophilicity, and ethnicity of traditional villages [33] as well as socio-political factors are considered when dividing smaller-scale watershed control units to realize a smaller-scale watershed management model. This management model can not only promote traditional villages’ protection and sustainable development in high-density agglomerations, but also prevent vicious competition caused by homogenization.

#### 5.4. Advantages and Limitations

Unlike previous studies, we investigated the distribution characteristics of the 6819 existing traditional villages in China by adopting spatial analysis and quantitative statistical methods, with the watershed functioning as the research unit. Not only does our study overcome the limitations of administrative research units in previous studies, but it also assures that the geographical environment and cultural customs of traditional villages within a specific area are similar. Using the watershed as the research unit not only provides scientific and reasonable study findings, but also contributes to enhancing the protection of regional characteristics and cultural customs. Using Geodetector and quantitative analysis, we also assessed the influence of climate, river, transportation, topography, socio-economic, and vegetation factors on the traditional village distribution in a qualitative and quantitative way. Overall, this study effectively investigates the characteristics and influencing factors of traditional village distribution, which not only contributes to protecting and developing existing traditional villages, but also provides a reference for the designation of new official traditional villages. It provides a new perspective for the study on traditional villages. In addition, it can serve as an important reference for studies on villages and cultural heritage sites in other countries or regions; as discussed in Section 1, their formation is highly similar to China’s traditional villages, i.e., they are closely related to rivers.

Although our study offers important findings about traditional villages in China, it has some limitations. First, this study homogenized traditional villages; in the future, we will identify certain types of traditional villages (e.g., ethnic villages, folklore villages, and ancient architectural villages) for more in-depth research to propose more targeted protection responses and development suggestions. Second, the traditional village distribution is influenced by various factors, with ethnic minorities, cultural areas, and cultural inheritance potentially having a more considerable impact in some areas [78]. Therefore, it is necessary to further study the impact of these factors on the traditional village distribution.

## 6. Conclusions

Using series spatial analysis methods, mathematical statistics, and Geodetector, we analyzed the characteristics of the existing traditional village distribution in China and its relationships with relevant influencing factors in a quantitative and qualitative way. The following are the main conclusions:

The number of traditional villages differs significantly across China’s various third-, second-, and first-level watersheds. Traditional villages are mostly distributed in the Dongt-

ing Lake watershed, Qiantang and Xi River watersheds. There is a “pyramid” distribution in the number of third-level watersheds with different traditional village number scales. In addition, the traditional village distribution has a significant positive spatial correlation, i.e., the third-level watersheds with a higher or lower number of traditional villages are characterized by agglomeration in space. The results of the LISA analysis show that the impact of “neighboring reliance” has formed. The HH-type distribution with a concentrated characteristic is often found at the boundaries of first-level watersheds. The LH-type distribution is usually adjacent to the HH-type distribution clusters. The LH-type distribution occurs only in the Huaihe River watershed. Most third-level watersheds belong to the LH-type distribution.

The traditional village distribution in China and each first-level watershed is agglomeration, albeit to varying degrees. The Yellow River watershed has the highest agglomeration, whereas the Northwest River watershed has the lowest. The results of kernel density analysis further prove the existence of this aggregation characteristic. Despite significant regional differences in the traditional village distribution in space, a trend of local aggregation has emerged. Traditional villages form a concentrated and contiguous agglomeration distribution pattern in space based on “core density area–ring-core expansion group–belt area”. The core density area includes one single-center core density area and two double-center core density areas, which are mainly located in areas near the junction of first-level watersheds. The sub-core density area shows a sporadic distribution and has a limited coverage area.

The factors affecting the traditional village distribution are complex and diverse. Most traditional villages are distributed in areas with moderate annual precipitation, suitable annual average temperature, low elevation, and small topography relief. Annual precipitation, annual average temperature, and river density are the foundations of traditional village formation and have the strongest explanatory power on the traditional village distribution. There is a clear inverted U-shaped relationship between the traditional village number and annual average temperature, river density, and road density; most traditional villages are located near the turning point. The explanatory power of population density and GDP density on the traditional village distribution is ranked fourth and last, respectively. On the right side of the turning point, the traditional village number decreases exponentially as GDP and population density increase. NDVI offers more explanation than topography relief and GDP density. On the left side of the turning point, the traditional village number increases exponentially with increasing NDVI, indicating that a good ecological environment is essential for traditional villages.

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