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Study on the Spatial Pattern and Influencing Factors of Scenic Villages in Shandong Province

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Abstract: Based on the data of 859 scenic villages in Shandong Province, the spatial pattern of scenic villages in Shandong Province and various prefectural cities and the factors affecting them were quantitatively studied by using spatial analysis methods such as average nearest neighbor index method and kernel density analysis, as well as combining with geodetic detector analysis tools. The results show that: (1) the scenic villages in Shandong Province have significant aggregation distribution characteristics, but there are differences in the spatial types of scenic villages in different prefectural-level cities; (2) the scenic villages in Shandong Province show the spatial distribution characteristics of "three core dense areas and multiple sub-core dense areas", and the spatial distribution in different regions has significant differences. The spatial distribution of scenic villages in Shandong Province is characterized by The "three core intensive areas" are Taian-Jinan, Zibo-Weifang central Luzhong core agglomeration area and Rizhao-Qingdao east Luzhong core intensive area; (3) scenic villages in Shandong Province are affected by a combination of natural conditions, socio-economic conditions, tourism resource conditions, and transportation conditions, among which there is a strong dependence on river density and the number of tourists received.

Keywords: Scenic Villages; Spatial Patterns; Influencing Factors; Geographical Detector; Shandong Province.

1. Introduction

On the premise of retaining the aborigines, the scenic village refers to the unique natural landscape, folk culture, farming culture and historical relics of the village as the main attraction, and the village is built into a certain tourism infrastructure and public service area[1]. Scenic villages have become a powerful starting point and an important way to promote the strategy of rural revitalization. At the same time, a new model of rural tourism to promote rural revitalization has been formed, and the three major changes of "rural-scenic spots, farmers-tourism practitioners, and agricultural products-tourism commodities" have been realized. In 2020, Shandong Provincial Department of Culture and Tourism and other five departments jointly formulated the " Guiding Opinions on the Construction of Village Scenic Areas " in which they proposed to strive to create about 1,000 scenic villages suitable for living, industry and tourism by the end of 2022, so as to realize the transformation and upgrading of beautiful villages to scenic villages.

The scenic village is a new product of the integration and development of rural tourism and beautiful rural construction, which plays a role in promoting the regional development of rural tourism[2]. However, less attention has been paid to the spatial pattern of scenic villages. Only some scholars have conducted relevant research on scenic villages in Zhejiang Province [2-4], and related research has focused on rural tourism. Scholars have done a lot of research on the spatial distribution pattern[5], spatial evolution [6], spatial structure optimization[7], spatial distribution influencing factors[8] of rural tourism. On the spatial scale, it is mostly concentrated in representative tourist destinations such as countries [9] and provinces[10]. In terms of research methods, statistical analysis, modeling analysis, spatial analysis[11] and other methods are used to study rural tourism in the study area. Based on this, this paper takes three batches of scenic villages evaluated in Shandong Province from 2021 to 2022 as the research object, and combines the actual construction situation of scenic villages in Shandong Province, using spatial analysis method and geographical detector model to explore the spatial distribution pattern of scenic villages in Shandong Province and the influence degree of different factors on the spatial distribution pattern of scenic villages, in order to provide reference for the construction and sustainable development of scenic villages in Shandong Province.

2. Materials and Research Methods

2.1. Overview of the Study Area

Shandong Province, referred to as ' Lu ', is located in the eastern coast of China and the lower reaches of the Yellow River. It is located between latitude 34°22.9′-38°24.01′and longitude 114°47.5′-122°42.3′. The territory includes two parts: the peninsula and the inland. The Shandong Peninsula stands out in the Bohai Sea and the Yellow Sea, and faces off with the Liaodong Peninsula. The inland part is bordered by Hebei, Henan, Anhui and Jiangsu provinces from north to south. The east-west length of Shandong is 721.03 km, the north-south length is 437.28 km, and the land area of the province is 15.58 km2. Shandong Province is one of the birthplaces of the ancient culture of the Chinese nation, and it contains rich tourism resources. By 2022, there will be more than 3,500 large-scale rural tourist spots in the province; it has 33 national leisure tourism and rural tourism demonstration sites, ranking first in the country. 44 national key villages and towns of rural tourism; there are 143 demonstration units of leisure agriculture and rural tourism in Shandong Province, and 34 creation units of rural B & B agglomeration areas. Its rural tourism reception scale has accounted for half of the province 's tourism scale, highlighting the ' Qilu model ' of ' hospitable Shandong, beautiful countryside '[12].

2.2. Data Source

This paper selects the list data of 859 scenic villages in

three batches published by Shandong Provincial Department of Culture and Tourism (http://whhly.shandong.gov.cn) in 2021 and 2022 as the research object, and establishes the spatial database and visual expression of scenic villages with the help of Baidu map API coordinate picking and ArcGIS software (Fig.1). The administrative division data and SRTM 90 m DEM data of Shandong Province are all derived from geospatial data cloud (https://www.gscloud.cn);A level scenic spot data is derived from Shandong Provincial Department of Culture and Tourism, and social and economic data is derived from ' Shandong Statistical Yearbook '.

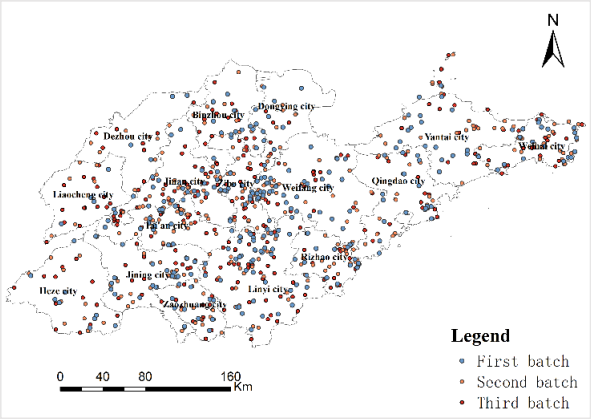

Fig 1. Spatial distribution map of scenic villages in Shandong Province

2.3. Research Methods

2.3.1. Average Nearest Neighbor Index

The average nearest neighbor index is used to characterize the degree of mutual neighbor of point elements in geospatial space. Generally, there are uniform, random and agglomeration distribution states[13] . The average nearest neighbor index is used to identify the spatial distribution pattern of scenic villages in Shandong Province. The formula is as follows:

$$\boldsymbol{R = r_1/r_E = \frac{1}{n}\sum_{i=1}^{n} R_i / \frac{1}{2}\sqrt{n/S}} \quad (1)$$

Among them: R is the nearest point index, r_1 represents the average distance between the actual scenic village point and the nearest point, r_E represents the theoretical nearest distance, n represents the number of scenic villages, R_i is the distance between the i scenic village point and its nearest point, S represents the area of the study area. When R = 1, the scenic villages are randomly distributed, and when R > 1, the scenic villages tend to be evenly distributed. When R < 1, scenic villages tend to be clustered.

2.3.2. Nuclear Density Analysis

Kernel density analysis is used to calculate the density of elements in their surrounding neighborhoods, which can clearly reflect the spatial agglomeration degree of the analysis target[14]. The formula is:

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

Among them, $f(x)$ is the estimated value of kernel density of scenic villages. The larger the value of $f(x)$ is, the more concentrated the scenic villages are. n is the number of scenic villages within the scale; h is the bandwidth; k is the weight of scenic village x; $x - x_i$ denotes the distance between the estimated point x and the observed point x_i.

2.3.3. Hotspot Analysis

The hot spot analysis is to calculate Getis-Ord G_i^* statistics for each element in the data set, calculate the z-score and p-value through the model, and use the hot spot analysis to obtain the high or low value elements of the scenic villages in Shandong Province. The location of clustering in space[15]. The formula is as follows:

$$\boldsymbol{G_i^*(d) = \sum_{j=1}^{n} W_{ij}(d) x_j / \sum_{j=1}^{n} x_j} \quad (3)$$

Among them: n is the number of scenic villages in Shandong Province; W_{ij} is the spatial weight matrix.

2.3.4. Geographical Detector

Geographical detector is commonly used to analyze spatial heterogeneity, including factor detection, interaction detection, risk area detection, and ecological detection. By comparing the q values of different influencing factors, the dominant factors affecting the spatial differentiation of scenic villages can be detected and analyzed[16]. The formula is as follows:

$$\boldsymbol{q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST}} \quad (4)$$

Among them, q is the detection index of the distribution of scenic villages by influencing factors, and its value range is [0, 1]. L is the number of classifications of certain factors, and N and σ^2 are the sample size and variance of the overall scenic villages, respectively. N_h is σ_h^2, which is the sample size and variance of the factor layer h. When the explanatory power q value of the impact factor X_i is closer to 1, the influence of X_i on the distribution characteristics of scenic villages is stronger, and vice versa.

3. The Spatial Distribution Characteristics of Scenic Villages in Shandong Province

3.1. Spatial Type Characteristics

Using ArcGIS10.8 software to analyze the average nearest neighbor index of scenic villages in Shandong Province and scenic villages in various prefecture-level cities (Table 1). The results show that the average observation distance of scenic villages in Shandong Province is 5833.306 m, the expected average distance is 8649.157 m, the nearest neighbor ratio R = 0.674 < 1, and the significance level P < 0.01, indicating that the scenic villages in Shandong Province have obvious spatial aggregation distribution characteristics. Most of the scenic villages in each prefecture-level city are clustered, and only Binzhou City, Dongying City, Heze City, Liaocheng City and Zaozhuang City are randomly distributed. According to the proportion of scenic villages in prefecture-level cities, the development of scenic villages in Shandong Province is not balanced, and the proportion of scenic villages in Shandong Province is different. Among them, the number of scenic villages in Linyi City, Weifang City and Jinan City accounts for a large proportion, while the number of scenic villages in Liaocheng City, Dongying City and Dezhou City accounts for a small proportion.

3.2. Spatial Density Characteristics

To further reveal the specific situation of the spatial structure of scenic villages in Shandong Province, the kernel density analysis tool in ArcGIS10.8 was used to analyze the kernel density of 859 scenic villages in Shandong Province, and the kernel density map of scenic villages in Shandong Province was obtained (Fig.2).

Table 1. Analysis of the proportion of scenic villages and the nearest neighbor index in prefecture-level cities in Shandong Province

Perfecture-level city	The proportion of scenic villages (%)	Average observation distance (m)	Expected average distance (m)	The nearest neighbor ratio	z-score	Dispersion pattern	p-score
Shandong province	100.00%	5833.306	8649.157	0.674	-18.254	Significant aggregation	0.000
Binzhou city	4.77%	7849.393	7684.726	1.021	0.262	Close to random	0.793
Dezhou city	2.56%	9204.934	12551.233	0.733	-2.392	aggregation	0.017
Dongying city	3.03%	7299.414	7213.684	1.012	0.116	Close to random	0.908
Heze city	4.07%	9686.105	9770.648	0.991	-0.098	Close to random	0.922
Jinan city	8.96%	5323.176	8174.058	0.651	-5.855	Significant aggregation	0.000
Jining city	7.57%	5117.141	7977.968	0.641	-5.531	Significant aggregation	0.000
Liaocheng city	3.14%	7749.058	9121.670	0.850	-1.496	Close to random	0.135
Linyi city	12.46%	5912.460	6687.129	0.884	-2.292	aggregation	0.022
Qingdao city	6.40%	5984.676	8476.117	0.706	-4.170	Significant aggregation	0.000
Rizhao city	5.70%	4093.054	5016.109	0.816	-2.464	aggregation	0.014
Tai'an city	6.75%	5546.286	6887.628	0.805	-2.837	Significant aggregation	0.005
Weihai city	7.45%	4592.511	6419.505	0.715	-4.356	Significant aggregation	0.000
Weifang city	9.55%	9204.934	12551.2331	0.733	-2.392	aggregation	0.017
Yantai city	6.40%	8455.457	9758.659	0.866	-1.895	aggregation	0.058
Zaozhuang city	4.07%	4699.038	5453.484	0.862	-1.566	Close to random	0.117
Zibo city	7.10%	4552.455	5964.359	0.763	-3.537	Significant aggregation	0.000

The results show that the scenic villages in Shandong Province show the spatial distribution characteristics of ' three core intensive areas and multiple sub-core intensive areas ', and there are significant differences in the spatial distribution of different regions. Among them, the ' three core concentration areas ' are mainly the Luzhong core concentration area formed at the junction of Tai 'an-Jinan, Zibo-Weifang and the Ludong core concentration area formed at the junction of Rizhao-Qingdao. Overall, the distribution of scenic villages in Shandong Province shows a high degree of aggregation in central Shandong.

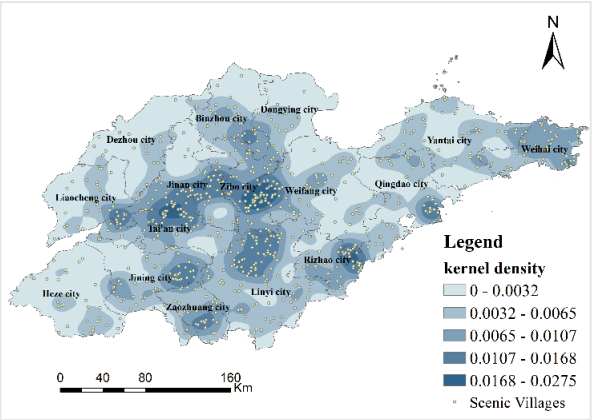

Fig 2. The nuclear density of scenic villages in Shandong Province

3.3. Regional Cold and Hot Spot Analysis

In order to deeply analyze the spatial aggregation characteristics of scenic villages in Shandong Province, the local correlation index Getis-Ord G_i^* of scenic villages in various prefecture-level cities in Shandong Province was calculated by using the hot spot analysis tool in ArcGIS10.8, and the cold and hot spot analysis results were divided into four categories : cold spot area, sub-cold spot area, sub-hot spot area and hot spot area according to the natural discontinuity method (Fig. 3). The spatial distribution of scenic villages in Shandong Province as a whole shows significant regional differences. The hot spots are mainly distributed in Zibo City, Tai'an City, Linyi City and Rizhao City. The sub-hot spots are mainly distributed in Jining City, Zaozhuang City, Weifang City, Qingdao City and Yantai City. The secondary cold spot areas are mainly distributed in Dongying City, Weihai City and Heze City; the cold spot areas are mainly distributed in Liaocheng City, Dezhou City, Binzhou City and Jinan City. The formation and distribution of scenic villages are affected by factors such as resource endowments and socio-economic development of prefecture-level cities.

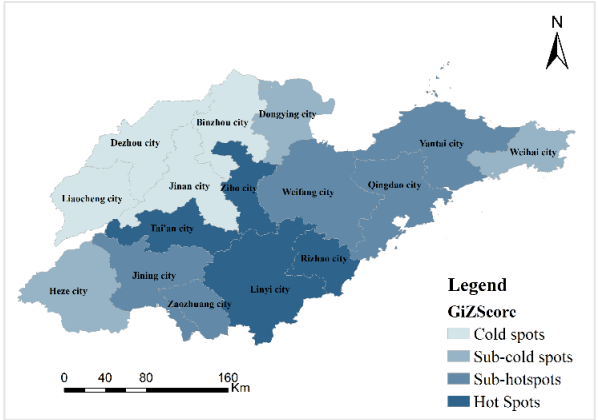

Fig 3. Cold and Hot Spot Analysis of Scenic Villages in Shandong Province

4. The Influencing Factors of the Spatial Distribution of Scenic Villages in Shandong Province

4.1. Indicator Selection

4.1.1. Natural Condition

(1) Terrain

Topography is the natural basic condition for the cultivation and construction of scenic villages, and at the same time promotes the formation and evolution of scenic

village resources. The terrain of Shandong Province is complex and diverse, including mountains, hills and plains. Combined with the actual terrain of Shandong Province, the scenic villages in Shandong Province and the DEM of Shandong Province are superimposed and analyzed, and the elevation values of scenic villages are extracted for statistical classification (Fig.4). It is concluded that the number of scenic villages within 100 m is 469, accounting for 54.6 % of the total. The number of scenic villages within 100 ~ 300 m is 279, accounting for 32.48 % of the total; the number of scenic villages above 300m has been greatly reduced, accounting for only 12.92 % of the total. It shows that the scenic villages in Shandong Province are mainly distributed in the plain area (500m) with a small number of distributions. The plain area is flat and the altitude is low. The construction of scenic villages is less difficult and the transportation is more convenient. It is more conducive to the expansion of the tourist market and the development of scenic villages.

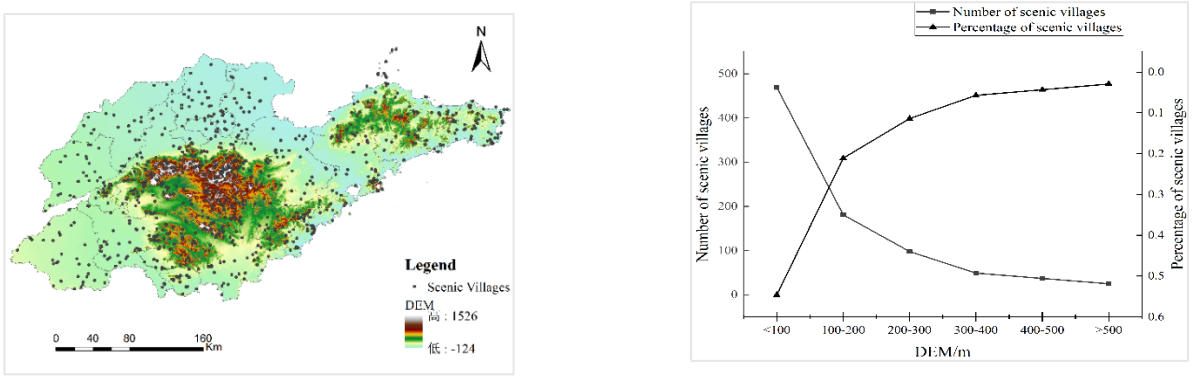

Fig 4. Spatial distribution and elevation quantity change of scenic villages in Shandong Province

(2) Rivers

The river system is one of the important factors affecting the spatial distribution of scenic villages. Good ecological environment and rich resources provide the basis for scenic villages[17].Combined with the distribution characteristics of river systems in Shandong Province, a multi-ring buffer zone of 2km to 10km is established, and the number of scenic villages in Shandong Province in each buffer zone is counted (Fig.5). It can be seen from the figure that the number of scenic villages within 2km of the buffer zone is the largest, reaching 444, accounting for 51.68 %. With the increase of the distance from the river waters, the number of scenic villages in Shandong Province decreased step by step. In the range of 2 ~ 4km, the number of scenic villages decreased significantly with the increase of distance, and the number of scenic villages changed little after 4km. It shows that the scenic villages have significant correlation with the spatial distribution of hydrological resources such as rivers and water systems within 4km.

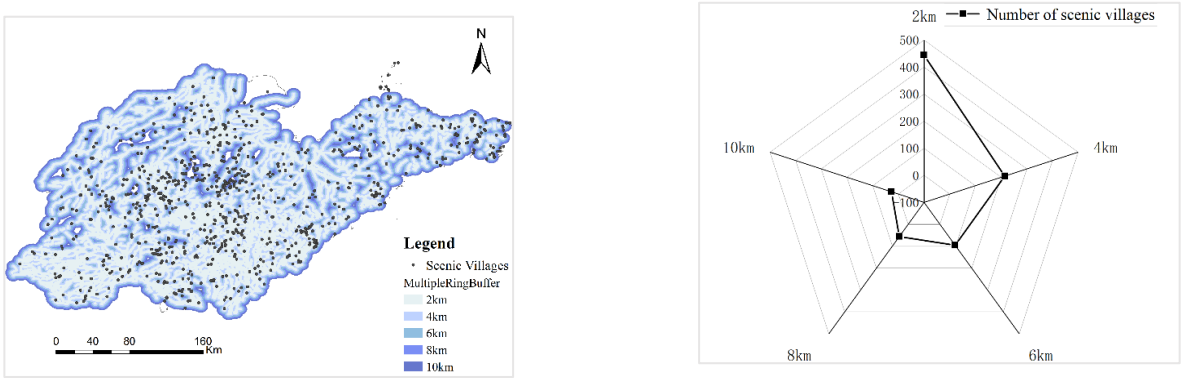

Fig 5. Spatial distribution and quantity change of scenic villages and river multi-ring buffer zones in Shandong Province

4.1.2. Economic Level

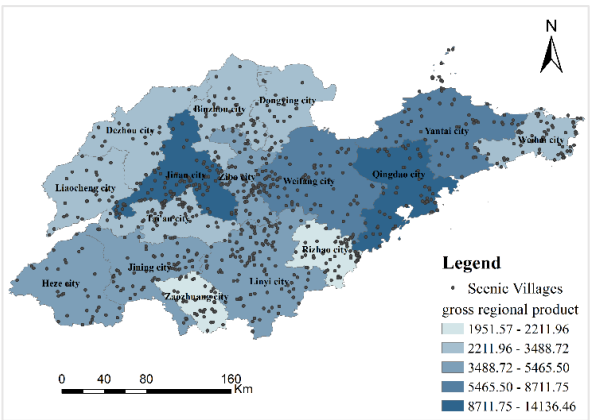

Fig 6. The superposition of regional GDP and scenic villages in Shandong Province

The level of social economy is an important factor to promote and stimulate the development of scenic villages, which affects the development level and spatial distribution of scenic villages. The gross regional product reflects the level of economic development of a region to a certain extent, and the superposition analysis of the gross regional product of scenic villages and cities in Shandong Province (Fig. 6). On the whole, the GDP of Jiaodong Peninsula (Qingdao, Yantai and Weihai) is significantly higher than that of northwest Shandong (Dezhou, Binzhou, Liaocheng and Dongying), which is consistent with the fact that the number of scenic villages in Jiaodong Peninsula is more than that in northwest Shandong. In areas with better economic development, the level of residents ' consumption is relatively high, thus driving the tourism consumption market. In addition, scenic villages in areas with better economic development have relatively perfect infrastructure, which is

conducive to the development of scenic villages. Therefore, the level of regional economic development has a certain impact on the spatial distribution of scenic villages in Shandong Province.

4.1.3. Traffic Condition

In the era of global tourism, self-driving travel has become one of the most important modes of travel. Transportation is the basic condition for the development of tourism, and convenient transportation provides important support for rural leisure tourism[18] . Convenient transportation in the weekend micro-leisure market can not only improve the tourist source and tourist satisfaction, but also help to improve the economic benefits of scenic villages. Taking 2km, 4km, 6km, 8km and 10km as buffer zones, the multi-ring buffer zone analysis of the main roads in Shandong Province was carried out, and the number of scenic villages in each buffer zone was counted (Fig.7). The results show that the number of scenic villages accounts for the largest proportion in the 2km buffer zone, and the number of scenic villages gradually decreases with the increase of the distance from the road buffer zone, indicating that traffic accessibility is conducive to the development of scenic villages. Through buffer analysis, the distribution of scenic villages is closely related to the location of the main traffic roads. The number of scenic villages far away from the main roads is significantly reduced, indicating that scenic villages have obvious dependence on traffic roads.

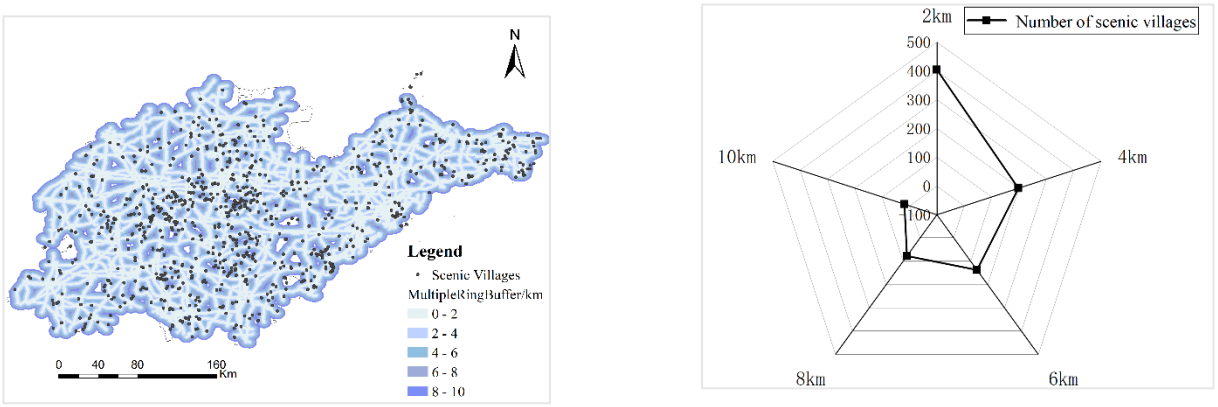

Fig 7. Spatial distribution and quantity change of multi-ring buffer zones of scenic villages and roads in Shandong Province

4.1.4. Social Factors

(1) Demographic factors

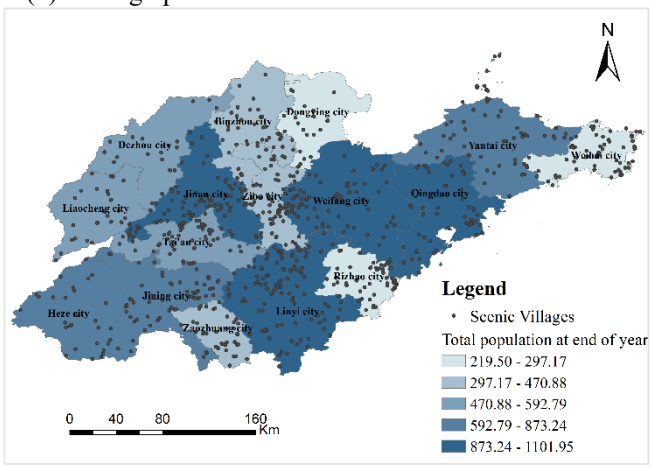

Fig 8. The superposition of the total population at the end of the year and the scenic villages in the cities of Shandong Province

With the development of social economy, rural tourism has a broad market prospect, and population density is one of the important factors affecting the spatial distribution of scenic villages. In the era of slow life, suburban rural tourism destinations have become one of the choices for weekend leisure travel for surrounding urban residents. Experiencing rural life and appreciating rural natural landscapes have become a new trend. Generally speaking, the tourist market of scenic villages is mainly composed of surrounding urban residents within a 2-hour traffic radius, and the tourism market demand of scenic villages in densely populated areas is also large. Therefore, population density is the basic guarantee for the development of scenic village tourism. The nuclear density map of scenic villages in Shandong Province and the total population of cities in Shandong Province at the end of the year are superimposed (Fig. 8). Jinan City, Linyi City, Weifang City and Qingdao City have a large population, and they are positively correlated with the number of scenic villages. It shows that the scenic villages have a high degree of dependence on the densely populated tourist market, and the development of scenic villages needs the support of a stable tourist market.

(2) Tourism resources

According to the guidance on the cultivation and construction of scenic villages in Shandong Province, scenic villages need to meet the core standards of 3A-level tourist attractions in important aspects such as tourism public service facilities. High-level scenic spots have perfect infrastructure and rich tourist market, and their radiation effect can drive the rapid development of surrounding scenic villages[19]. Therefore, combined with the spatial distribution of 4A and 5A scenic spots in Shandong Province, the multi-ring buffer zone analysis of high-level scenic spots is established, and the number of scenic villages in each buffer zone is counted (Fig.9). The results show that the number of scenic villages in the buffer zone of high-level scenic spots in the range of 5km-15km gradually increases, with a total of 526, accounting for 61.23 %. The number of scenic villages in the buffer zone of 15km ~ 50km gradually decreased. It can be seen that within 15 km from the high-level scenic spot, the radiation effect is strong. The scenic villages affected by the radiation effect of high-level scenic spots can not only reduce the investment in tourism infrastructure and tourism project products, but also achieve a mutually beneficial and win-win distribution pattern with high-level scenic spots to a certain extent.

4.2. Impact Factor Detection

The spatial distribution of scenic villages in Shandong Province is the result of many factors. Based on the existing research and the actual situation of Shandong Province, this paper selects 9 indicators from four aspects: natural conditions, social and economic conditions, tourism

resources conditions and traffic conditions to identify and analyze the influencing factors of the spatial distribution characteristics of scenic villages in Shandong Province.

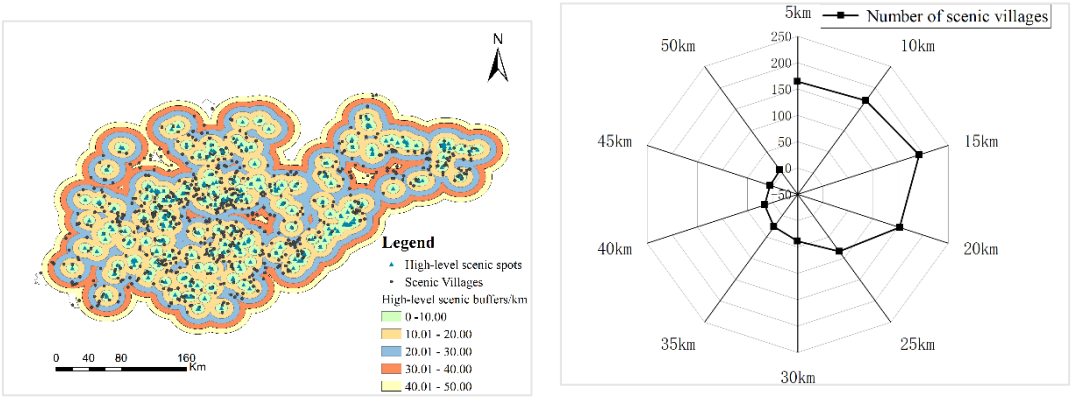

Fig 9. Buffer distribution and quantity change of high-level scenic spots in scenic villages of Shandong Province

The natural conditions are represented by elevation (X1) and river density (X2). The socio-economic conditions are characterized by the gross regional product (X3), the proportion of the tertiary industry (X4), and the total population at the end of the year (X5). The conditions of tourism resources are characterized by the number of tourists (X6), tourism income (X7) and high-level scenic spots (X8). Traffic conditions are characterized by road network density (X9). Based on buffer analysis and superposition analysis, it can only show that the scenic villages in Shandong Province are affected by some influencing factors, and cannot effectively quantify the explanatory degree of the influencing factors of the scenic villages in Shandong Province. Therefore, the geographical detector is used to discretize the selected influencing factors to detect the explanatory degree of each influencing factor on the spatial distribution of scenic villages in Shandong Province and the interaction between factors.

The results of factor detection (Table 2) show that the nine index factors of the four dimensions all pass the significance test, indicating that the nine factors have a significant impact on the spatial distribution of scenic villages. The degree of interpretation of the spatial distribution detection factors of scenic villages is: X2 > X6 > X7 > X3 > X4 > X8 > X5 > X9 > X1. The factors that affect the spatial distribution pattern of scenic villages in Shandong Province are river density and the number of tourists received, and the degree of influence is 0.802 and 0.801 respectively. In the site selection, cultivation and construction of scenic villages, areas with good natural environment and attachment to rivers are usually selected, which is in line with the development characteristics of tourism resources in coastal cities of Shandong Province.

Table 2. Detection results of influencing factors of scenic villages in Shandong Province

Index	**DEM**	**river density**	**regional GDP**	**economy structure**	**total population at the year-end**	**Number of tourists received**	**tourist income**	**high-level tourist attractions**	**road network density**
q-value	**0.209**	**0.802**	**0.787**	**0.755**	**0.713**	**0.801**	**0.797**	**0.747**	**0.363**

4.3. Interactive Detection of Impact Factors

Table 3. Interactive detection results of influencing factors of scenic villages in Shandong Province

Index	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1	0.209								
X2	0.818	0.802							
X3	0.867	0.999	0.787						
X4	0.852	0.982	0.934	0.755					
X5	0.863	0.982	0.941	0.958	0.713				
X6	0.856	0.999	0.990	0.933	0.964	0.801			
X7	0.855	0.999	0.988	0.931	0.966	0.802	0.797		
X8	0.784	0.999	0.990	0.954	0.971	0.962	0.962	0.747	
X9	0.860	0.949	0.988	0.999	0.999	0.996	0.996	0.992	0.363

The results of multi-factor interaction detection are shown in table 3. The q value under the influence of multi-factor interaction is higher than the q value under the influence of single factor, indicating that the spatial pattern of scenic villages in Shandong Province is formed by the joint influence of multiple factors. Among them, the elevation (X1) ∩road network density (X9) is a nonlinear enhancement, and the remaining factor interaction detection results are two-factor enhancement. From the perspective of the influence of each group of two-factor interactive detection on the spatial distribution pattern of scenic villages in Shandong Province, river density and regional GDP (X2∩X3), river density and number of tourists received (X2∩X6), river density and tourism income (X2∩X7), river density and high-level scenic

spots (X2∩X8), proportion of tertiary industry and road network density (X4∩X9), total population and road network density at the end of the year (X5∩X9), q value is 0.999. In a word, only by relying on good eco-tourism resources and perfect tourism infrastructure can the high-quality development of scenic villages in Shandong Province be realized.

5. Discussions and Conclusion

Based on the average nearest neighbor index, kernel density and local correlation index of ArcGIS software, the spatial pattern of scenic villages in Shandong Province was analyzed, and the characteristic factors affecting the spatial pattern were detected by using the geographic detector analysis tool. The conclusions and discussions are as follows:

(1) In terms of spatial pattern, the scenic villages in Shandong Province generally have significant aggregation distribution characteristics, but the scenic villages in different prefecture-level cities show different distribution types.

(2) In terms of spatial distribution density, the distribution of scenic villages in Shandong Province is uneven, showing a spatial distribution pattern of ' three core-intensive areas and multiple sub-core-intensive areas ', and there are significant differences in the spatial distribution of different regions. Among them, the 'three core concentration areas' are mainly the Luzhong core concentration area formed at the junction of Tai 'an-Jinan, Zibo-Weifang and the Ludong core concentration area formed at the junction of Rizhao-Qingdao.

(3) In terms of influencing factors, the influence of multi-factor interaction is greater than that of single factor, indicating that the scenic villages in Shandong Province are formed under the comprehensive influence of multiple factors, and the influence degree of each influencing factor is different. The order of influence is tourism resource conditions, social and economic conditions, natural conditions, and traffic conditions.

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