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Distribution Characteristics and Influence Factors of Key Rural Tourism Villages: A Case Study of Beijing

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Abstract Taking 138 key rural tourism villages in Beijing for example, this paper applied GIS analysis to analyze the spatial distribution characteristics of these villages, selected the influence factors of the villages considering the classification characteristics, so as to explore the impact of different influence factors on its spatial distribution. The results showed (i) Key rural tourism villages in Beijing manifested an aggregated distribution on the whole, they were unevenly distributed and mostly located in the fringe area of northern mountainous areas and plains, such as Huairou District and Miyun District. Such a "multi-center distribution" pattern was significantly influenced by terrains and natural resources. (ii) Depending on local natural and cultural resources, tourism resources, development characteristics and functional differences, key rural tourism villages in Beijing could be devided into natural scenery type, scenic area-dependent type and agriculture experiencing type. (iii) Key factors influencing the distribution of these villages included mean temperature, annual precipitation, quantity of scenic area, road network density, agricultural land and so on, and the interaction of dual factors exerted more significant impact on single factors.

Keywords Rural tourism, Key rural tourism villages, Spatial distribution characteristics, Classification of rural areas, Influence factors

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Against the background of rural revitalization and "the thirteenth five-year plan" of tourism development, rural tourism in China has witnessed the opportunity period of rapid development, and gradually become an important engine of driving rural economic growth[1]. The selection of key villages for rural tourism launched by Ministry of Culture and Tourism in 2019 was the intersection of these two major strategies, i.e. choosing villages from all over the country with abundant tourism resources, profound cultural inheritance, mature tourist products, and demonstration effect. Beijing owns rich historical and cultural heritage, and modern metropolitan landscapes, providing outstanding conditions for rural development[2].

In recent years, rural tourism development has become a focus of the academic field. Foreign researches on rural tourism concentrated on economic influence[3], tourist perception[4], spatial distribution[5], sustainable development[6] and so on. Scaglione, A. and Mendola, D. divided the perceived value of agritourism into 5 dimensions of function, convenience, emotion, society and education[4]. Domestic researches on key rural tourism villages focused on spatial distribution[7], development influence factors[8], development model[9], network attention[10] etc.. For example, in terms of spatial distribution, the researches disclosed distribution laws and influence factors of key rural tourism villages in different regions which were closely related to regional economic development level, tourism resource endowment, traffic conditions and etc.[11].

This study comprehensively applied geographic information science methods such as geographic detector, Kernel density analysis and spatial distribution index, used the data of 138 key rural tourism villages in Beijing, systematically explored the spatial distribution characteristics of key rural tourism villages in the city and the formation mechanism. Moreover, it selected the influence factors considering the classification characteristics of the villages, and explored the impact of different influence factors on the spatial distribution.

1 Research area and data sources

1.1 Research area

Total area of Beijing City is 16,410 km^2, of which 61% is mountainous area, and 39% is plains. Terrains determine that rural tourism resources of the city are mainly located in the fringe areas between mountains and plains, these areas have not only rich natural landscapes, but also convenient transportation, providing excellent conditions for the development of rural tourism industry[12]. Beijing as a famous historic and cultural city owns profound cultural background, many of the villages depend on their historic and cultural resources such as ancient villages and remains of ancient Great Wall, forming their own tourism brands[13].

1.2 Data sources

Data sources of the key villages for rural tourism in Beijing were taken from The Ministry of Culture and Tourism and Beijing Municipal Bureau of Culture and Tourism. By 2025, The Ministry of Culture and Tourism released 4 batches of national key villages for rural tourism, among which 44 were from Beijing, and Beijing released 94 municipal key villages for rural tourism. This study took these 138 villages as the research objects (Table 1).

2 Research methods and framework

2.1 Research methods

2.1.1 Nearest neighbor index. Nearest distance is a geographic index showing the degree of mutual proximity of neighbors in geographic

Table 1 Quantity of key rural tourism villages in Beijing

Batch	Quantity	Proportion//%	Grade	Time
First	9	6.52	National	2019
Second	23	16.66	National	2020
Third	6	4.35	National	2021
Fourth	6	4.35	National	2022
Fifth	94	68.12	Municipal	2025
Total	138	100.00		

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spaces[14], the formula is as below:

$$R=\frac{\bar{r}_1}{\bar{r}_E}=2\sqrt{D}\times\bar{r}_1$$

In the formula, R indicates the nearest neighbor index, $\bar{r}_1$ is the mean of r_1 among the nearest neighbors, $\bar{r}_E$ is the theoretical nearest distance, and D is the density of neighbors.

2.1.2 Imbalance index. Imbalance index indicates the equilibrium degree of geographic factors' spatial distribution[15], the formula is as below:

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

In the formula, S indicates the imbalance index, n is the quantity of key rural tourism villages in urban districts of Beijing, and Y_i is the cumulative percentage of the i^{th} quantity of key rural tourism villages in each county and district.

2.1.3 Geographical concentration index. Geographical concentration index indicates the concentration degree of the geographic factors' spatial distribution[16], the formula is as below:

$$G=100\times\sqrt{\sum_{m=1}^{k}\left(\frac{x_m}{T}\right)^2}$$

In the formula, G is the geographical concentration index of traditional villages, x_m indicates the quantity of key rural tourism villages in the m^{th} district of Beijing; T indicates the total quantity of key rural tourism villages in the city, k indicates the quantity of total districts in the city[17].

2.1.4 Kernel density analysis. Kernel density analysis is a statistical approach of estimating the distribution density of points or lines in a space[14], the formula is as below:

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

In the formula, $P(x)$ indicates value of kernel density, $k\left(\frac{x-x_i}{h}\right)$ is the kernel density function, n is the quantity of key villages for rural tourism, $h(h>0)$ is the bandwidth, $(x-x_i)$ is the estimated value of the distance from point x to key village x_i.

2.1.5 Standard deviation ellipse. Standard deviation ellipse is a spatial analysis method of analyzing the directional characteristics of spatial point data[18], the formula is as below.

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

In the formula, x_i and y_i is the coordinate value of the i^{th} factor, x_i and y_i is the coordinate deviation from the space coordinates of the study objects to the mean center, n is the sum of all factors.

2.1.6 Geographic detector. Geographic detector is a tool of analyzing the spatial differentiation characteristics and spatial correlation of geographical phenomena. It can be used to detect the single factor' force of explaining the dependant variable, and judge the interaction among multiple factors[19], the formula is as below:

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

In the formula, q value measures the independent variable's force of explaining the dependant variable, $q\in[0,1]$, as it is close to 1, the index can better explain the spatial distribution characteristics of key rural tourism villages, and vise versa.

2.2 Research framework

Taking 138 key rural tourism villages in Beijing for example, this study explored the spatial distribution characteristics of the villages, tried to improve quality and profits of rural tourism, upgrade the tourism industry, and promote the rural revitalization strategies. Through acquiring the position of each village using the coordinate system, ArcGIS was used to correct the position, then the geospatial information database of key rural tourism villages in Beijing could be sorted out.

First, characteristics of key rural tourism villages must be summarized, both spatial distribution characteristics and classification characteristics of the villages could be concluded from 3 perspectives of type analysis, equilibrium analysis and morphological analysis. Then relevant factors could be selected from 3 major dimensions of natural environment, social economy, and resource endowment, to construct the influence factor and index system. Relative mean of influence factors were chosen from 3 dimensions, 14 influence factors included 5 natural environment factors, 3 social economy factors, and 6 resource endowment factors. Finally, geographical detector was taken to detect the spatial factors and the interaction of these 14 factors. Through the above analysis, the location dominance of these key rural tourism villages could be obtained, development conditions of the villages identified, providing guidance for the planning of rural tourism (Fig.1).

3 Characteristics analysis of key rural tourism villages in Beijing

3.1 Distribution characteristics

3.1.1 Spatial distribution type analysis. There are 16 districts under the jurisdiction of Beijing City, and Fig.2 shows that spatial distribution of key rural tourism villages in Beijing concentrates on the 6 districts in northern part of the city, of which Miyun District accounts for the largest ratio (26.81%), then Huairou District the second (18.84). There are fewer key villages for rural tourism in the west and south part of the city, and there is none in the 6 urban districts.

The nearest neighbor index was used to calculate the nearest neighbor index of the city (0.753), indicating the aggregated spatial distribution of key rural tourism villages in Beijing. According to the data of key rural tourism villages in different districts, mean nearest neighbor indexes were analyzed to get the nearest neighbor indexes as Table 2. Nearest neighbor index of Mentougou District, Fangshan District, Daxing District, Pinggu District, Shunyi District, Tongzhou District, and Changping District was all above 1, belonging to the even type. Nearest neighbor index of Huairou District and Miyun District was below 1, belonging to the aggregated type. Nearest neighbor index of Yanqing District is close to 1, belongning to the random type.

3.1.2 Equilibrium analysis of the spatial distribution. The calculation showed that quantity of

Table 2 Nearest neighbor indexes and distribution types of key rural tourism villages in all districts of Beijing

District	Quantity of villages	Nearest neighbor index	Type	Z value
Mentou District	12	1.270 189	Uniform type	1.790 558
Huairou District	26	0.951 228	Aggregated type	−0.475 761
Fangshan District	11	1.723 372	Uniform type	4.589 749
Daxing District	4	3.077 832	Uniform type	7.950 078
Miyun District	20	0.904 514	Aggregated type	−0.816 930
Pinggu District	9	1.810 933	Uniform type	4.654 114
Shunyi District	5	2.738 677	Uniform type	7.437 635
Tongzhou District	2	272.719 587	Uniform type	735.134 538
Yanqing District	37	1.005 572	Random type	0.064 845
Changping District	12	1.414 156	Uniform type	2.744 642

districts in Beijing n was 15, the imbalance index S=0.667 632 85. As for the imbalance index, S was closer to 1, indicating the uneven distribution of key rural tourism villages in the city, and spatial distribution of key rural tourism villages in Beijing showed imbalanced aggregate trend. The research further drew the Lorenz Curve for description (Fig.3). In the figure there is a reference straight line showing even distribution, and the other is the cumulative percentage curve, showing the obvious up-growing trend, clearly manifesting the imbalanced distribution of key rural tourism villages.

Imbalance index itself failed to express the equilibrium degree of key rural tourism villages comprehensively, this study applied geographical concentration index for the verification. The formula showed that the geographical concentration index of key rural tourism villages in Beijing G=39.558. Supposing the 138 key villages were evenly distributed in all districts, the mean geographical concentration index G_0=25. $G>G_0$, showing the relative concentrated distribution of key rural tourism villages in Beijing, keeping in consistency with the imbalance index analysis.

3.1.3 Morphological analysis of the spatial distribution. ArcGIS was used for the kernel density analysis (Fig.4). The figure showed that key rural tourism villages were mainly distributed in Yanqing Distirct, center and south of Huairou District, and north of Changping District, the overall distribution morphology showed the "multi-center distribution" layout, and the zonal distribution along the Yanshan Mountains.

Through calculating the standard deviation ellipse of key rural tourism villages in the city, coordinates of the ellipse center could be obtained (116.414 487, 40.324 603), by north of the city. Length of the major semi axis was 72.63 km, and the minor semi axis was 36.61 km, the oblateness was 0.495 9, and the rotation angle 66.87°. There was a significant difference between the major and minor semi axis, the overall ellipse was obviously demonstrated along the southwest-northwest, keeping consistent with the Yanshan Mountains.

3.2 Classification characteristics

There is no uniform standard for classifying key rural tourism villages in China, this paper used the standards of selecting key rural tourism villages issued by The Ministry of Culture and

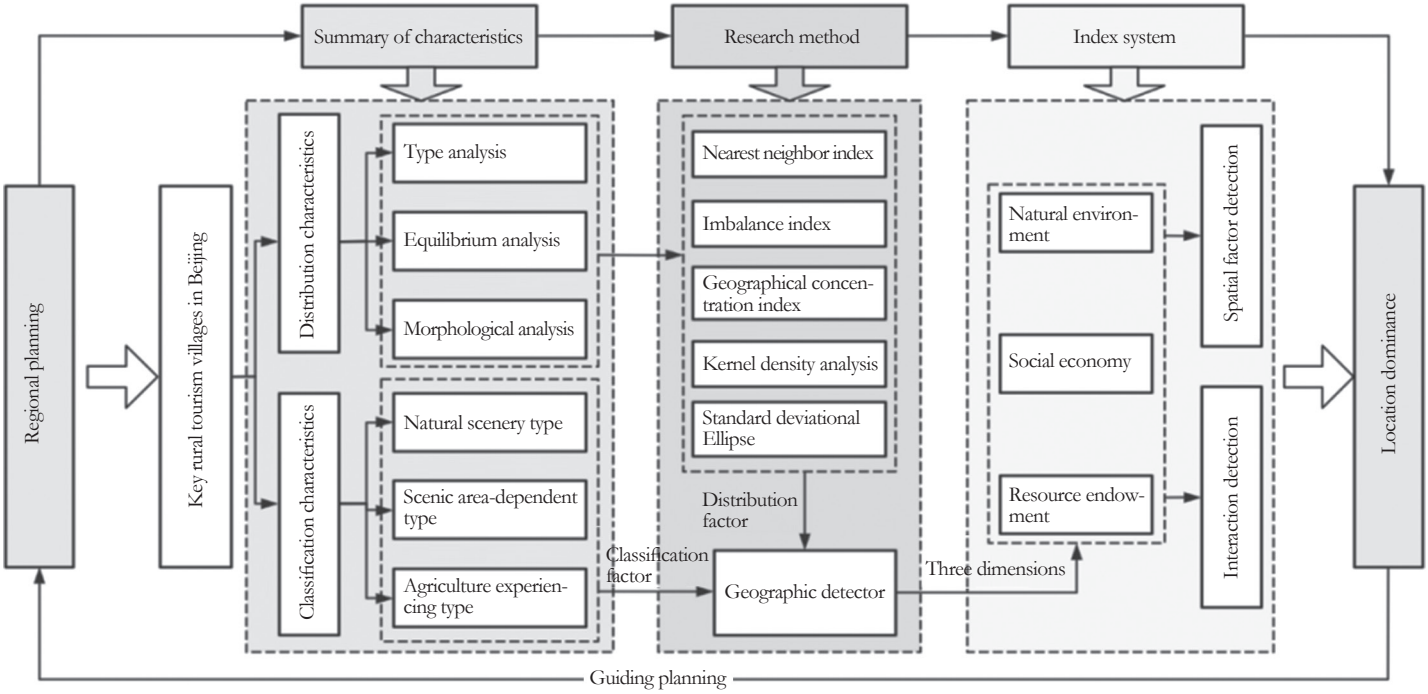

Fig.1 Research framework

Table 3 Influence indexes for the spatial distribution of key rural tourism villages in Beijing

Category	Factor selection	Index	Unit	Data source
Natural environment	Geographical conditions	Elevation (X_1)	m	GS Cloud
		Slope (X_2)	°	GS Cloud
		Aspect (X_3)	°	GS Cloud
	Climate conditions	Annual precipitation (X_4)	mm	Data Center for Resources and Environmental Sciences
		Annual mean temperature (X_5)	°C	Data Center for Resources and Environmental Sciences
Social economy	Population density	Population density (X_6)	people/km^2	Beijing Regional Statistical Yearbook
	Economic development	Regional GDP (X_7)	10^8 CNY	Beijing Regional Statistical Yearbook
	Disposable income	Per capital income (X_8)	CNY	Beijing Regional Statistical Yearbook
Resource endowment	Basic resources	Road network density (X_9)	km/km^2	OpenStreetMap
		Catering (X_{10})		Meituan APP
		Accommodation (X_{11})		Meituan APP
	Natural scenery type	Forest coverage (X_{12})	%	Science Data Bank
	Scenic area dependent type	Quantity of scenic area (X_{13})		www.visitbeijing.com.cn
	Agriculture experiencing type	Agricultural land use (X_{14})	km^2	Data Center for Resources and Environmental Sciences

Tourism, and *Classification, Investigation and Evaluation of Tourism Resources*[20], to classify 138 key rural tourism villages in Beijing. Depending on local natural and cultural resources, tourism resources, development characteristics and functional differences, those key rural tourism villages could be classified into 3 types, i.e. natural scenery type, scenic area-dependent type and agriculture experiencing type[20].

Natural scenery type depends on natural ecological landscapes (including physiographic landscape, humanistic landscape, water landscape, climatic landscape and biological landscape). Villages build recreational facilities on the basis of natural advantages, to satisfy visitors' demands on enjoying the nature and maintaining health. By integrating village culture and natural scenery, these villages provide visitors travelling experience with cultural connotations and wild fun. For example, Cuandixia Village in Mentougou District was an ancient village built along the mountain foot, its unique architectural style was perfectly integrated with neighboring natural scenery[21].

Scenic area-dependent type depends on the attraction of scenic areas (including special terrains, famous historic ruins, revolutionary culture and so on). These villages used the location advantage, the reputation and infrastructure of scenic areas to develop rural tourism, took visitors in the scenic areas as the main target consumers. For example, Beigou Village in Yanqing District was located by the foot of the Mutianyu Great Wall, took the Great Wall as the featured background, built boutique homestay and ecological activities, and became a model of the scenic area-dependent rural tourism type.

Agriculture experiencing type depends on ecological agricultural resources (including farmland, plantations, and breeding farms etc.). These villages had no outstanding natural ecological resources, or famous scenic areas, but could develop agricultural farming and breeding by using their broad idyllic scenery. For example, Caijiawa Village in Miyun District realized the in-depth integration of agriculture and tourism through inventing the characteristic village collective economic model of "building farmlands to plantations, building plantations to scenic areas, integrating agriculture and tourism".

4 Influence factors of the spatial distribution

4.1 Building index system

The key difference between researches on the distribution of rural tourism villages and

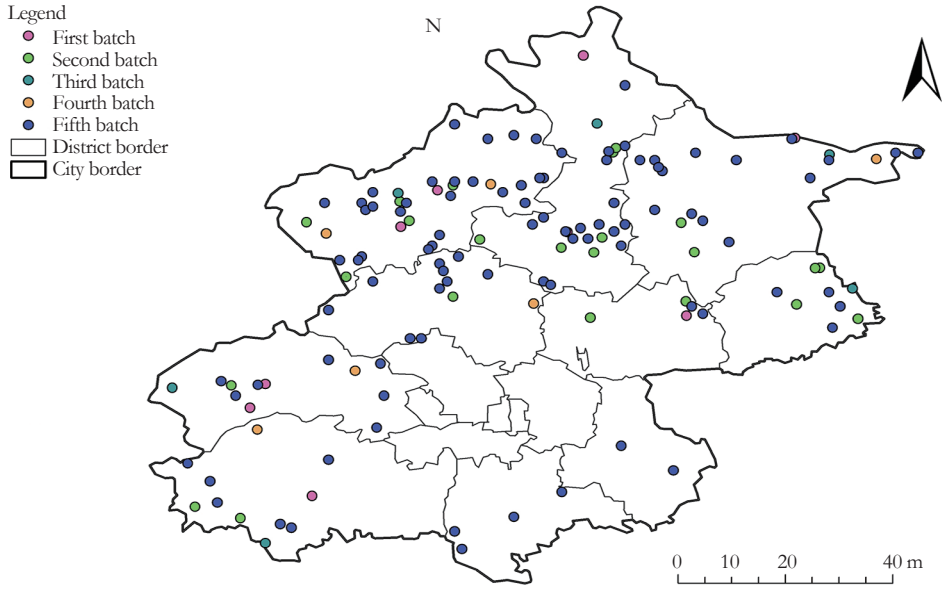

Fig.2 Distribution of key rural tourism villages in Beijing

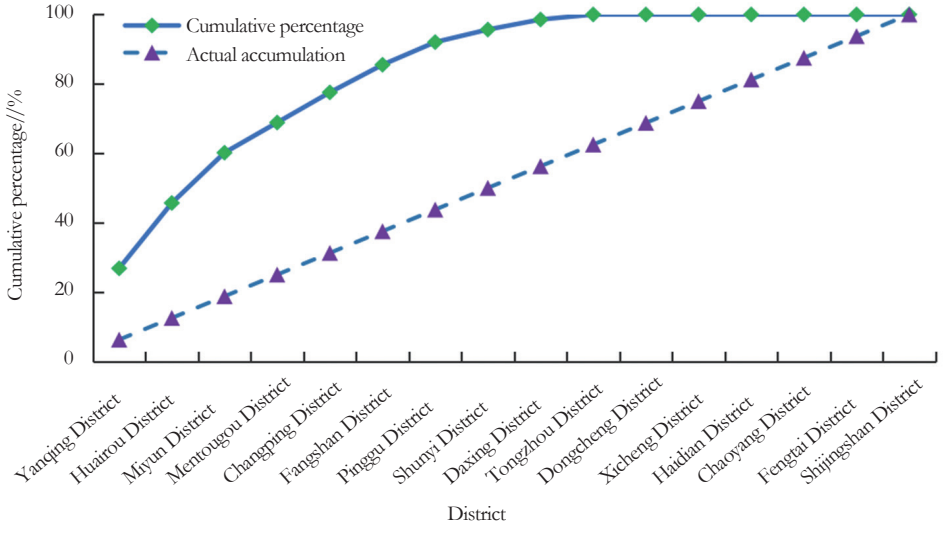

Fig.3 Results of imbalance index analysis

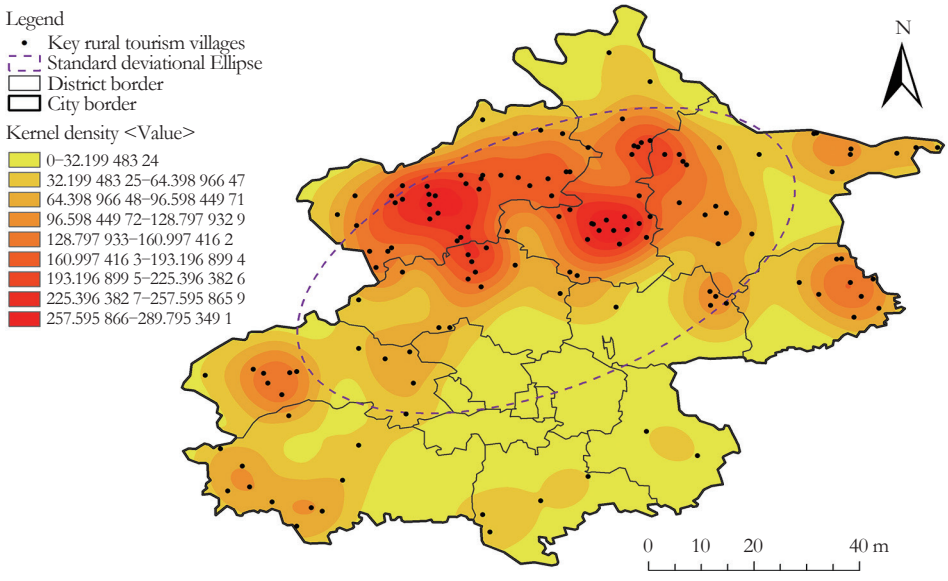

Fig.4 Spatial distribution characteristics of key rural tourism villages in Beijing

the traditional villages lied in the selection of factors[23], in addition to natural environment and social economy, the former had to choose resource endowment for rural tourism as an essential factor. Based on the existing researches[9,16,22,24]. This study selected 14 indexes as the independent variables X_i from 3 dimensions of natural environment, social economy and resource endowment, and took the kernel density value of the key rural tourism villages as the dependent variable Y, to establish the index system (Table 3).

Natural environment included 2 major categories, i.e. geographical conditions (including elevation X_1, slope X_2, aspect X_3, Fig.5) and climatic conditions (including annual precipitation X_4, annual mean temperature X_5), they were all essential factors influencing the site selection of villages. Geographical conditions determined the village layout and traffic accessibility. Climatic conditions influenced ecological resources that influenced the distribution of key rural tourism villages, warm and humid climate was favorable for the growth of grain crops and formation of natural landscapes. Social economy factors included population density (X_6), regional GDP (X_7), per capita income (X_8), which directly or indirectly influenced tourism development potential or attraction of the villages. Resource endowment could be classified into basic resources and "type" resources. Basic resources included road network density (X_9), catering (X_{10}), and accommodation (X_{11}), while "type" resources were selected according to the classification of key rural tourism villages in Beijing mentioned in the above context, one influence factor was selected from each key village type.

4.2 Geographic detector analysis

4.2.1 Spatial factor detection. Factor detection from the geographic detector was applied to obtain results as Table 4. It was found that annual mean temperature (X_5), annual precipitation (X_4), quantity of scenic area (X_{13}), road network density (X_9), and agricultural land (X_{14}) were dominant influence factors in the distribution of key rural tourism villages in Beijing, with a q value range of [0.183 3, 0.307 5]. Population density (X_6), regional GDP (X_7), elevation (X_1), catering (X_{10}), per capita income (X_8) were moderate factors with a q value range of [0.058 8, 0.167 7]. Forest coverage (X_{12}), slope (X_2), aspect (X_3) and accommodation (X_{11}) were weak influence factors with a q value range of [0.019 7, 0.031 4].

Among the natural resource factors, 2 indexes of the climatic conditions had the highest q value, they were dominant influence factors, air temperature and precipitation influenced village construction, river and vegetation. Among the geographical conditions, elevation had greater influence than slope and aspect did (Fig.5a), building villages in moderate-altitude regions facilitated the village development and economic growth. In terms of social economy factors, population density, regional GDP and per capita income were moderate influence factors, excluding the impact of urban downtown, population and regional economy had positive role in promoting rural tourism development, and key rural tourism villages were concentrated in the junction of mountainous areas and plains. Among the resource endowment factors, quantity of scenic area, road network density, and agricultural land were dominant influence factors, the q value of scenic area quantity and road network density was above 2.0, indicating that attraction of scenic area and convenient transportation had greater impact on tourists' selection.

4.2.2 Detection of interaction. Geographic detector was used for the interaction detection, and it was found that the interaction of dual influence factors had the synergetic enhancement effect, the effect could be demonstrated in 2 ways: non-linear enhancement and dual-factor enhancement (Fig.6). The figure showed that there were 11 of them had a q value above 0.45 after interaction, the highest 3 was road network density ∩ quantity of scenic areas, q=0.242;

Table 4 Detection results of influence factors for the distribution of key rural tourism villages in Beijing

Index	q value	p value	Index	q value	p value	Index	q value	p value
X_1	0.127 2	0.003 4	X_6	0.167 7	0.000 0	X_{11}	0.019 7	0.947 0
X_2	0.024 1	0.588 8	X_7	0.146 3	0.000 0	X_{12}	0.031 4	0.500 9
X_3	0.020 1	0.485 7	X_8	0.058 8	0.019 5	X_{13}	0.264 3	0.000 0
X_4	0.296 6	0.000 0	X_9	0. 210 2	0.566 1	X_{14}	0.183 3	0.000 0
X_5	0.307 8	0.000 0	X_{10}	0.082 2	0.443 9			

Table 5 Location dominance

District	Quantity of Key villages	Natural factors					Social economy			Resource endowment					
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
Mentou District	12	5	5	4	2	1	1	1	3	2	2	3	4	3	2
Huairou District	26	4	4	4	1	1	1	1	2	1	5	4	5	4	3
Fangshan District	11	3	4	3	4	2	2	2	2	3	3	3	3	5	5
Daxing District	4	1	1	3	5	5	3	2	3	3	3	4	3	1	5
Miyun District	20	3	4	5	1	2	1	1	1	1	4	5	5	5	4
Pinggu District	9	2	4	5	3	2	2	1	1	1	3	3	3	2	4
Shunyi District	5	1	2	4	3	3	3	3	2	2	3	1	3	1	5
Tongzhou District	2	1	1	3	5	4	3	2	2	3	4	4	3	4	5
Yanqing District	37	5	4	5	1	1	1	1	1	1	3	3	5	3	5
Changping District	12	3	4	2	2	2	3	2	3	3	4	2	4	3	4
Dongcheng District	0	1	2	3	5	5	5	4	5	5	1	1	1	3	1
Xicheng District	0	1	1	4	5	5	5	4	5	5	1	1	1	4	1
Chaoyang District	0	1	1	3	4	5	4	5	5	4	1	1	2	4	2
Fengtai District	0	1	1	2	5	5	4	3	4	4	1	1	2	3	2
Shijingshan District	0	2	3	5	4	4	4	2	5	4	1	1	1	1	1
Haidian District	0	2	3	1	3	4	4	5	5	4	1	1	2	4	2

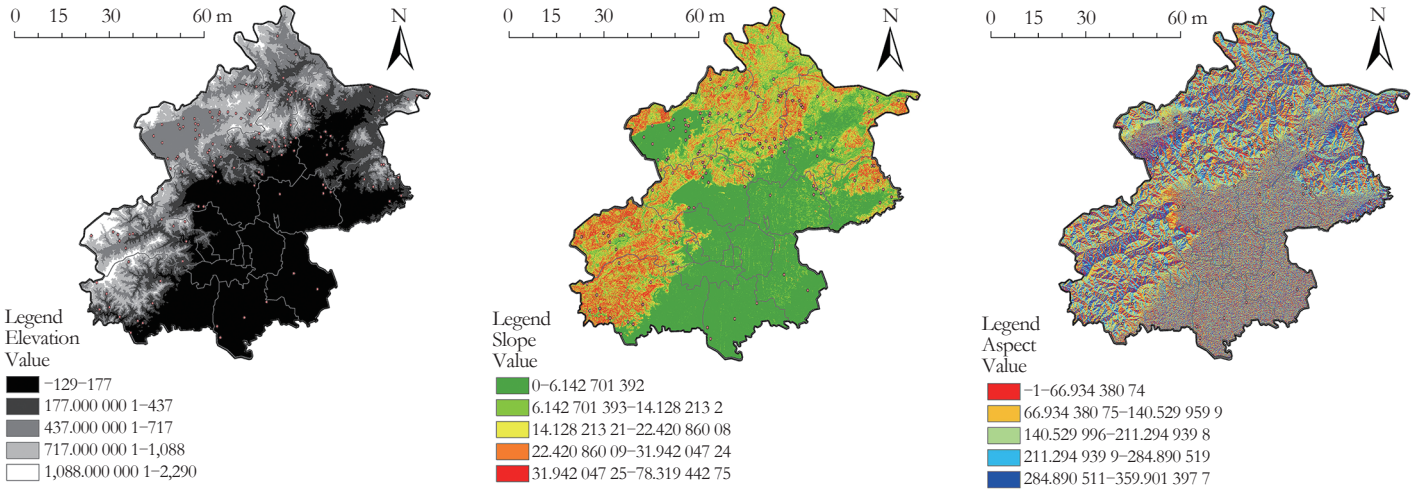

Fig.5 Distribution of natural environment

annual mean temperature ∩ per capita income, q=0.462 11; annual precipitation ∩ agricultural land, q=0.462 11. The first indicated the more accessible areas with convenient transportation, abundant scenic area resources provided visitors more options, indicating that regions with convenient transportation and more scenic areas were likely to form the key rural tourism villages. The second indicated that in regions with pleasant climate and higher resident income, residents travelled in higher frequency and spent more on travelling. The third indicated in regions with moderate precipitation and abundant agricultural land, it was easier to develop rural tourism projects with agricultural characteristics, and attract visitors to participate in agricultural experiencing activities.

4.2.3 Location dominance. Dominance of influence factors in each district was shown in Table 5. Digit 1−5 indicated the sequence of value from low to high. Natural breakpoint method was used to redivide them into 5 grades. Taking the elevation for example, larger digits indicated higher elevation. There were the most key rural tourism villages in Yanqing District, the elevation 5 and slope 4 indicated that geographical environment was its dominance; 2 indexes of climate conditions, 3 indexes of social economy and road network density were all 1, showing the lack of dominance; catering, accommodation and scenic areas got 3, showing the insignificant dominance.

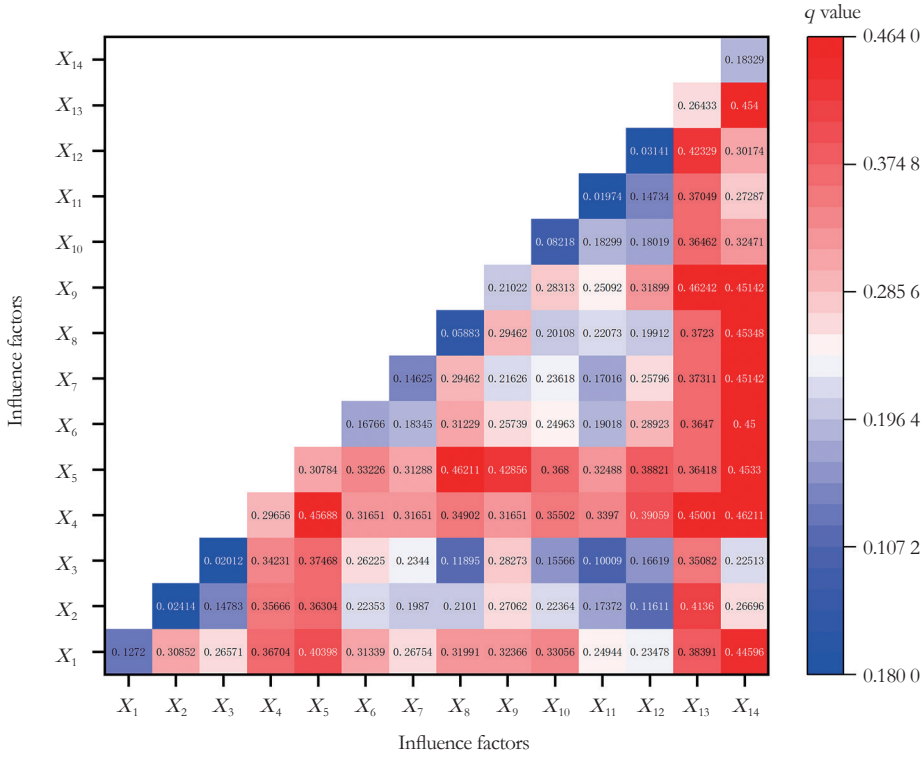

Fig.6 Interactive detection results of the influence factors the spatial distribution of key rural tourism villages in Beijing

5 Conclusions

This study applied ArcGIS and analysis methods such as nearest neighbor index and kernel density analysis to get the following conclusions:

(1) The overall spatial distribution type of key rural tourism villages in Beijing belonged to the aggregated type, and most of them in each district belonged to the even type, only that of Miyun District, Yanqing District and Huairou District belonged to the aggregated type. The reason was that there was no key village for rural tourism in the downtown area, and the above 3 districts were connected and quantity of key rural tourism villages in these 3 districts accounted for above 60%, quantity of key rural tourism villages in other regions was limited and relatively even.

(2) Distribution of key rural tourism villages in Beijing showed significant imbalance. The imbalance index was close to 1, indicating the significant difference of the villages in terms of spatial distribution, the geographical concentration index was above the mean, which further verified the conclusion, showing that key rural tourism villages were likely to concentrate in certain regions, but not evenly distributed in the whole city.

(3) Distribution of key rural tourism villages in Beijing demonstrated the obvious "multi-center concentration" pattern. Standard deviation

ellipse analysis further disclosed the obvious directional distribution of these key villages, the higher dispersion degree, the same trend with the Yanshan Mountains, which indicated the significant impact of terrains and natural resources on the distribution of key rural tourism villages.

(4) Through classifying key rural tourism villages into natural scenery type, scenic area-dependent type and agriculture experiencing type, showing clearly the diversified classification of key rural tourism villages in Beijing. Each type had its specific resource endowment and development pattern, the diversification not only enriched the connotations of rural tourism, but also satisfied the demands of different visitors.

Geographic detector results showed that key factors influenced the distribution of key rural tourism villages included mean temperature, annual precipitation, quantity of scenic areas, road network density and agricultural land. The factor interaction detection showed that the interaction of dual factors exerted greater impact on the distribution of key rural tourism villages than the single factors. Location dominance helped know the impact of influence factors in different regions, and corresponding suggestions were given.

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