# MOUNTAINS OF POTENTIAL: UNVEILING THE SPATIAL DYNAMICS AND KEY INFLUENCES OF MOUNTAIN-TYPE SCENIC SPOTS IN CHINA

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**Abstract.** This study investigates the spatial distribution patterns and key influencing factors of 4A and 5A-grade mountain scenic spots across China's 31 provinces, utilizing a 2022 dataset. Firstly, a comprehensive theoretical framework was developed to quantitatively analyze the distribution patterns, concentration, equilibrium, and density of these scenic spots, employing advanced geospatial analysis techniques. Then, a geographic detector model was applied to identify dominant influencing factors, incorporating economic, social, transportation, and geographical variables. The findings reveal a highly clustered yet spatially uneven distribution of high-grade mountain scenic spots, with significant regional disparities. Key determinants include average annual precipitation, regional elevation, and transportation infrastructure development. Notably, the interaction between precipitation levels and transportation networks emerges as a critical factor, enhancing both accessibility and tourism appeal. These findings offer valuable insights for optimizing the spatial planning of mountain tourism destinations and fostering sustainable development strategies.
**Keywords:** *mountain-type scenic spots, geo-spatial analysis, influencing factors, spatial distribution patterns*

## Introduction

The development of mountain tourism resources plays a pivotal role in both the economic growth of mountainous regions and in advancing global sustainability goals, particularly the United Nations Sustainable Development Goal (SDG) on "sustainable cities and communities" (Avotra and Nawaz, 2023). China's vast and varied topography, with nearly two-thirds of its landmass comprised of mountainous regions, provides a rich foundation for mountain-based tourism. These areas, characterized by their natural beauty, biodiversity, and cultural heritage, form the largest category of tourist attractions in the country, making them critical assets in the tourism market. Their scarcity and non-renewable nature enhance their value as key resources (Yan et al., 2023). In the context of China's rapidly expanding tourism industry, the spatial distribution of mountain tourist


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attractions exhibits significant variability, influenced by a range of economic, social, and environmental factors. The uneven distribution of these attractions has led to challenges such as inadequate protection of tourism resources, ecological degradation, product homogeneity, and a lack of unique tourism offerings (Shuiwang and Kefeng, 2021). Additionally, seasonal fluctuations in visitor traffic, coupled with natural constraints and transformation challenges, have contributed to an imbalanced geographical development of mountain scenic spots across China (Li, 2024). In response to these issues, the State Council of China has proposed the establishment of the China Mountain Tourism Alliance, aimed at promoting the coordinated development and scientific planning of mountain scenic spots. This initiative seeks to address the challenges of resource conservation, tourism product diversification, and the enhancement of tourism infrastructure. It also emphasizes the need to foster balanced development across different regions, thereby supporting the upgrading of existing mountain tourism destinations (Zhang and Song, 2024). Understanding the spatial distribution patterns of China's mountain scenic spots is therefore critical for optimizing their spatial structure, promoting sustainable tourism development, and ensuring equitable growth across the country.

The importance of mountain-type scenic spots extends beyond regional economic development to contribute significantly to national tourism strategies (Liu et al., 2023). While substantial research has been conducted on the sustainable development of mountain tourism, with a particular focus on tourist preferences, fewer studies have addressed the spatial distribution patterns of these destinations. Research by De et al. (2015), for example, explored the relationships between society, land, and mountain landscapes, highlighting the ways in which people's preferences for mountain scenic spots are influenced by social and environmental factors. Rijal (2004) provided insights into the Kunbu Mountain region, proposing a sustainable tourism model that identifies the challenges and opportunities for promoting mountain tourism. Similarly, Cozma et al. (2014) and colleagues examined the rural tourism potential in Rodna Mountain National Park, Romania, offering valuable lessons for regional tourism planning and development. In a similar vein, Miliević et al. (2020) proposed strategies for sustainable tourism development in the western mountains of Serbia, advocating for the integration of nearby mountain areas to form cohesive tourism regions.

The concept of spatial distribution in tourism studies has a long history, originating in the 1990s with Wilson's (1996) statistical theory of spatial distribution models, which provided a foundation for understanding how tourist attractions are distributed across regions. In the early 2000s, Hoffer et al. (2005) further advanced these methods, exploring the spatial organization of tourist destinations and the factors influencing their development. More recently, studies like those by Rogerson et al. (2019) have applied spatial analysis to tourism geography, focusing on border regions in southern Africa to understand the dynamics of tourism in adjacent cities. Jiang et al. (2024) also contributed to the field by analyzing the geographical distribution of tourist attractions in Hubei Province, linking these patterns to terrain and regional economic factors.

In recent years, spatial analysis has become a more prominent tool in tourism studies, with a broader, interdisciplinary focus that includes not only economic factors but also social, cultural, and environmental elements. This comprehensive approach has provided valuable theoretical support for sustainable tourism practices, offering practical recommendations for managing and developing global tourism destinations (Li et al., 2023). However, despite the increasing sophistication of spatial analysis techniques, few studies have applied these methods to the mountain tourism sector in China from a macro


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perspective. Given China's diverse topography and vast tourism market, understanding the spatial distribution characteristics of mountain tourist attractions is crucial for promoting coordinated development and unlocking the full potential of mountain tourism resources (Hu et al., 2023).

This study contributes to the field in three key ways (*Fig. 1*): (1) by providing a comprehensive analysis of the spatial distribution characteristics of high-grade mountain scenic spots in China, including an exploration of the key factors that influence these patterns; (2) by examining the current distribution characteristics and proposing strategies for the creation, upgrading, and optimization of these tourism destinations; and (3) by emphasizing the need for coordinated regional development and the enhancement of underutilized mountain tourism resources.

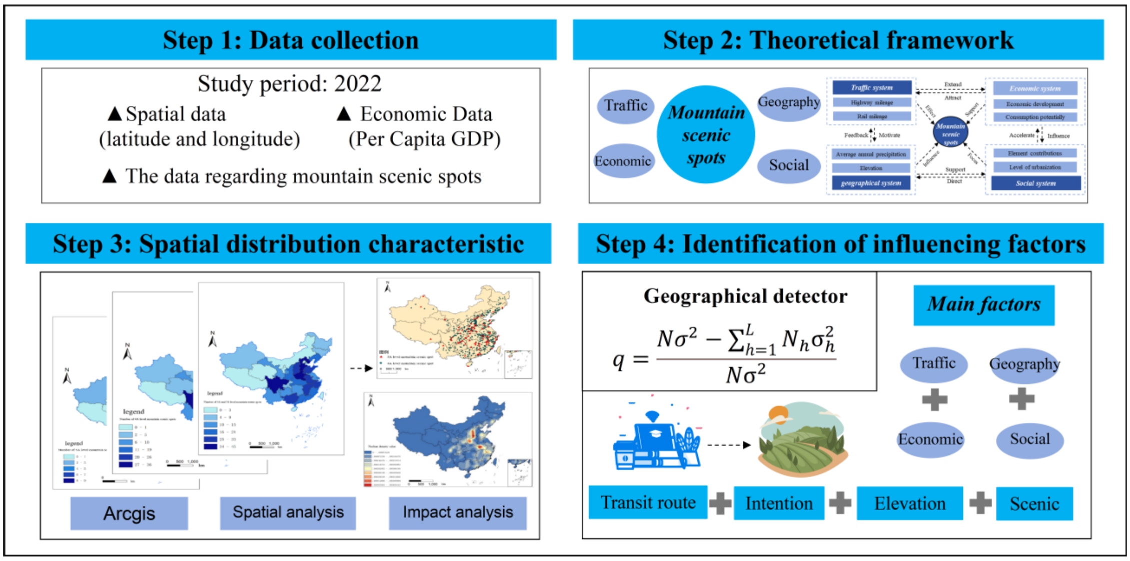


***Figure 1.*** *Graphical abstract*

## Theoretical framework

Tourism consumption patterns have evolved significantly in response to increasing national income and changing social expectations. As disposable incomes rise, tourists' demands for diverse, high-quality experiences have expanded, particularly within the realm of natural tourism resources such as mountain scenic spots. These locations, distinguished by their aesthetic beauty, cultural value, and scientific importance, have become central to high-quality tourism offerings (Nie and Palmer, 2016). Mountain tourism is not only an important driver of economic growth, but it also supports the national agenda for ecological sustainability and high-quality development (Gratzer et al., 2017). As tourism continues to transition toward more personalized and sustainable forms, the role of mountain scenic spots in fulfilling these evolving demands has become increasingly critical. In this context, understanding the spatial organization of mountain scenic spots is key to facilitating the growth of the tourism industry and ensuring its long-term sustainability.

Drawing on system theory, the mountain scenic spot can be understood as a complex open system that interacts with its external environment through various subsystems (*Fig. 2*). These subsystems—economic, social, transportation, and geographic—are interdependent and their interactions create feedback loops that shape the spatial distribution and development of mountain tourism (Yakovenko et al., 2024). This


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integrated approach helps explain the forces driving the expansion and transformation of mountain tourism and the factors influencing the location, accessibility, and development of these areas.

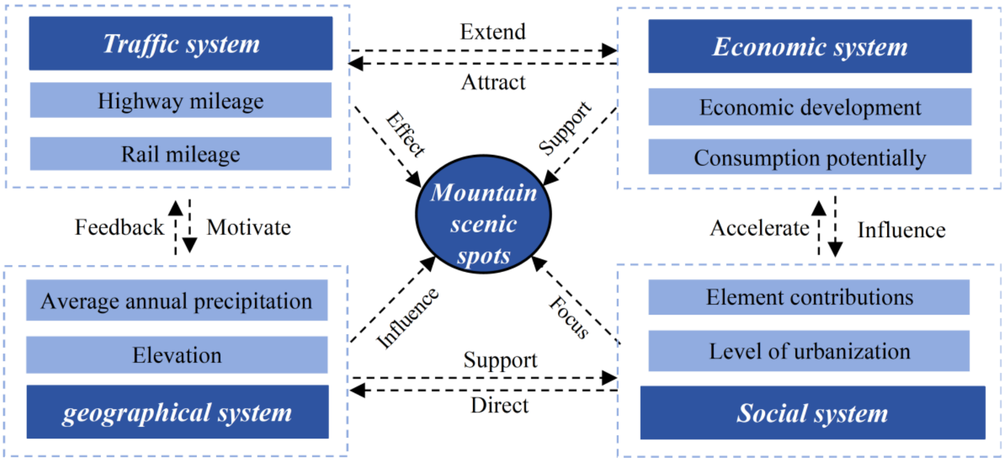


***Figure 2.*** *Theoretical framework for mountain tourism analysis*

Economic System: The economic prosperity of a region, particularly through the rise in per capita GDP, influences the tourism demand for mountain scenic spots. As incomes increase, there is a shift toward more diversified and high-quality tourism experiences. Research indicates that a higher GDP is directly linked to increased tourism demand, as people seek out destinations that offer both natural beauty and unique experiences (Nie and Palmer, 2016).

Social System: Urbanization plays a crucial role in shaping tourism demand by altering factors such as labor force participation, industrial structure, and market development. The diversification of mountain tourism offerings is closely related to these socio-economic changes. As more people migrate to urban centers, the demand for leisure activities, particularly those involving nature and escape from urban stress, increases (Mo et al., 2024).

Traffic System: The accessibility of mountain scenic spots is heavily influenced by the development of transportation infrastructure. Research has shown that investments in roads, railways, and air travel significantly increase visitor numbers by reducing travel time and enhancing comfort. High-grade highways and high-speed railways, in particular, enable tourists to reach remote mountain locations more easily, contributing to the growth of mountain tourism in these areas (Luo et al., 2023).

Geographic System: Geographic factors such as altitude, precipitation, and climate conditions play a pivotal role in determining the attractiveness and accessibility of mountain scenic spots. High-altitude areas, while offering stunning natural landscapes, can be more difficult to access, especially during adverse weather conditions. Research indicates that moderate precipitation and a mild climate enhance the overall tourist experience, while excessive rainfall can create safety concerns by making roads slippery and reducing visibility (Rosmarlinasia et al., 2024).

Therefore, this theoretical framework highlights the interdependence of economic, social, transportation, and geographic factors in shaping the spatial distribution and development of mountain scenic spots. By understanding these interconnected systems, policymakers and tourism developers can better design strategies for promoting sustainable tourism in these unique destinations.

## Research methods

### *GDP and population growth*

This study utilizes data from the 2022 provincial sections of mainland China, excluding Hong Kong, Macao, and Taiwan. It includes a list of five mountain scenic spots sourced from the official website of China's National Culture and Tourism (https://zwfw.mct.gov.cn/scenicspot) and four additional spots identified through queries to provincial culture and tourism hall websites. Data were collected via telephone and email for those provinces without publicly available levels. The number of respondents is approximately 100 people. The geographical location of each scenic spot is determined based on information from tourist service centers, with longitude and latitude data obtained using the Baidu Map API. Administrative division data are sourced from the National Center for Basic Geographic Information (http://www.ngcc.cn/ngcc/). Influencing factor data are drawn from the China Statistical Yearbook and the annual statistical bulletins of various provinces.

### *Data processing*

First, the Baidu Map API is utilized to locate scenic spots rated 4A and above. Following this, ArcGIS 10.2 software is imported after verifying the spatial data. The location information for 4A and 5A mountain scenic spots undergoes a projection conversion to the GCS WGS 1984 geographic coordinate system. The Asia Lambert Conformal Conic projection coordinate system is then applied, as it is suitable for creating maps of China, resulting in a distribution map. Finally, a spatial database of 4A and 5A mountain tourist attractions in China is constructed to serve as a foundation for future research.

#### *The nearest-neighbor index*

The nearest neighbor index is a crucial indicator utilized to assess the degree of proximity between point features in geographic spatial distribution (Liasidou et al., 2024). Consequently, this article employs the nearest neighbor index to differentiate the overall spatial distribution type of high-grade mountainous scenic spots in China. The calculation formula is as follows:

$$R = \frac{\overline{r_1}}{r_E} = 2\sqrt{D} \cdot \overline{r_1} \qquad \text{(Eq.1)}$$

In *Equation 1*, $\overline{r_1}$ represents the mean distance between the actual nearest points within the study area, while $\overline{r_E}$ denotes the mean theoretical nearest distance, and $D$ refers to the density of point-like features. When $R < 1, \overline{r_1} < \overline{r_E}$, the point-like elements exhibit a cohesive distribution; When $R = 1, \overline{r_1} = \overline{r_E}$, the point-like features tend to be randomly distributed; and When $R > 1, \overline{r_1} > \overline{r_E}$, the point-like elements are uniformly distributed. The formula is calculated as follows:

$$\overline{r_E} = \frac{1}{2\sqrt{n/A}} = \frac{1}{2\sqrt{D}} \qquad \text{(Eq.2)}$$

In *Equation 2*, $n$ denotes the number of point-like features identified in the research object, $A$ represents the area of the research site, and $D$ indicates the density of these


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point-like features. Based on this calculation formula, the nearest distance for the spatial distribution of high-grade mountainous scenic spots in China is:

$$\overline{r_E} = \frac{1}{2\sqrt{n/A}} = \frac{1}{\sqrt{505/9600000}} \approx 68.938\ km \quad \text{(Eq.3)}$$

*Geographical concentration index*

The geographic concentration index is a key indicator in spatial geography that assesses how concentrated a specific geographical element distribution is. This article employs the geographic concentration index to evaluate the concentration of high-grade mountainous scenic spots in China. The calculation formula is as follows:

$$G = 100 \times \sqrt{\sum_{i=1}^{n} \left(\frac{x_i}{T}\right)^2} \quad \text{(Eq.4)}$$

In *Equation 4*, $G$ denotes the geographic concentration index, indicating the number of 4A and 5A level mountain scenic spots in the i-th provincial administrative region. Here, n represents the total number of provincial administrative regions being studied, while $T$ signifies the overall number of 4A level and above mountain scenic spots in China. The values for G range from 0 to 100. A higher G value indicates a greater concentration of 4A level and above mountain scenic spots, whereas a lower G value reflects a more dispersed distribution.

*Gini coefficient*

The Gini coefficient is a crucial tool in geography for analyzing the spatial distribution of discrete regions and examining the variations in distribution across different areas (Wright, 2024). This article applies the Gini coefficient to measure the spatial distribution of mountain scenic spots in major geographical regions of China. The calculation formula is as follows:

$$G_{ini} = \frac{-\sum_{i=1}^{N} P_i \ln P_i}{\ln N} \quad \text{(Eq.5)}$$

$$C = 1 - G_{ini} \quad \text{(Eq.6)}$$

In *Equations 5* and *6*, the term represents the proportion of mountain scenic spots rated 4A and above in the i-th region compared to the total number of mountain scenic spots rated 4A and above in the country. Here, $N$ denotes the number of regions, $G_{ini}$ signifies the inequality of the distribution, and C indicates the balance of this distribution. The value of $G_{ini}$ ranges from 0 to 1: a value closer to 1 indicates a higher degree of imbalance, while a value closer to 0 suggests a tendency toward equilibrium.

*Unbalance index*

To further clarify the distribution balance of 4A-level and above mountain scenic spots across various provinces of China, this article introduces the imbalance index to measure the degree of balance in the distribution of mountain scenic spots in different regions. The calculation formula is as follows:


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$$S = \frac{\sum_{i=1}^{n} Y_i - 50(n+1)}{100n - 50(n+1)} \quad \text{(Eq.7)}$$

In *Equation 7*, $n$ denotes the number of provincial-level administrative regions, $Y_i$ represents the cumulative percentage of 4A and above mountain scenic spots within each region compared to the national total, ranked from highest to lowest. The imbalance index $S$ is from 0 to 1. A value of $S = 1$ indicates an even distribution of scenic spots across provinces, whereas $S = 1$ signifies that all scenic spots are concentrated in a single province.

*The density analysis of the spatial distribution*

To visually represent the spatial density distribution of mountainous scenic spots rated 4A and above across various provincial-level administrative regions in China, this article employs a density estimation method. A search radius is established, within which the number of point-like elements is counted. Different weights are assigned based on proximity to the center—those closer receive greater weights—to calculate the density value of the target network point. The calculation formula is as follows:

$$f_h(x) = \frac{1}{n \cdot h} \sum_{i=1}^{n} k\left(\frac{x - X_i}{h}\right) \quad \text{(Eq.8)}$$

In *Equation 8*, $k(x)$ is the kernel function, $h > 0$ is the distribution bandwidth, $x - X_i$ refers to the distance between the estimated points in the grid and each sample point $X_i$. The larger the value of $f(x)$, the denser the distribution of point-like geographic features, and vice versa, the more dispersed they are.

*Geo-detector*

The geographic detector is a crucial method for examining the factors that influence research subjects. This article applies this method to investigate the factors affecting the spatiotemporal patterns of 4A level and above mountain scenic spots (Zhao et al., 2024). First, the natural breakpoint method classifies the indicators for each element, allowing for the assessment of the influence of each factor. The formula for value calculation is as follows:

$$q = \frac{N\sigma^2 - \sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} \quad \text{(Eq.9)}$$

In *Equation 9*, $N_h$ represents the number of samples in the next level region; $N$ denotes the sample size of the entire study area; $L$ signifies the number of research areas at the next level; $\sigma^2$ represents the square difference in the number of 4A level and above mountain scenic spots in the entire research area; and $\sigma_h^2$ denotes the variance of the number of 4A level and above mountainous scenic spots in the next level research area.

## Results

***Overview of the spatial distribution of mountain-type scenic spots***

By the end of 2022, there were a total of 505 4A and 5A mountain scenic spots across 31 provincial administrative regions in China, including 78 5A spots and 427 4A spots.


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In this paper, we classify the collected 4A and 5A scenic spots in China according to their administrative divisions and visualize their provincial spatial distribution using the Jenks natural break point method. *Figure 3a* represents the number of 4A and 5A level scenic spots in the southern region, *Figure 3b* represents the number of 4A and 5A level scenic spots in the western and northern regions. *Figure 3c, d* represent the interprovincial distribution of 4A and 5A level scenic spots in China.

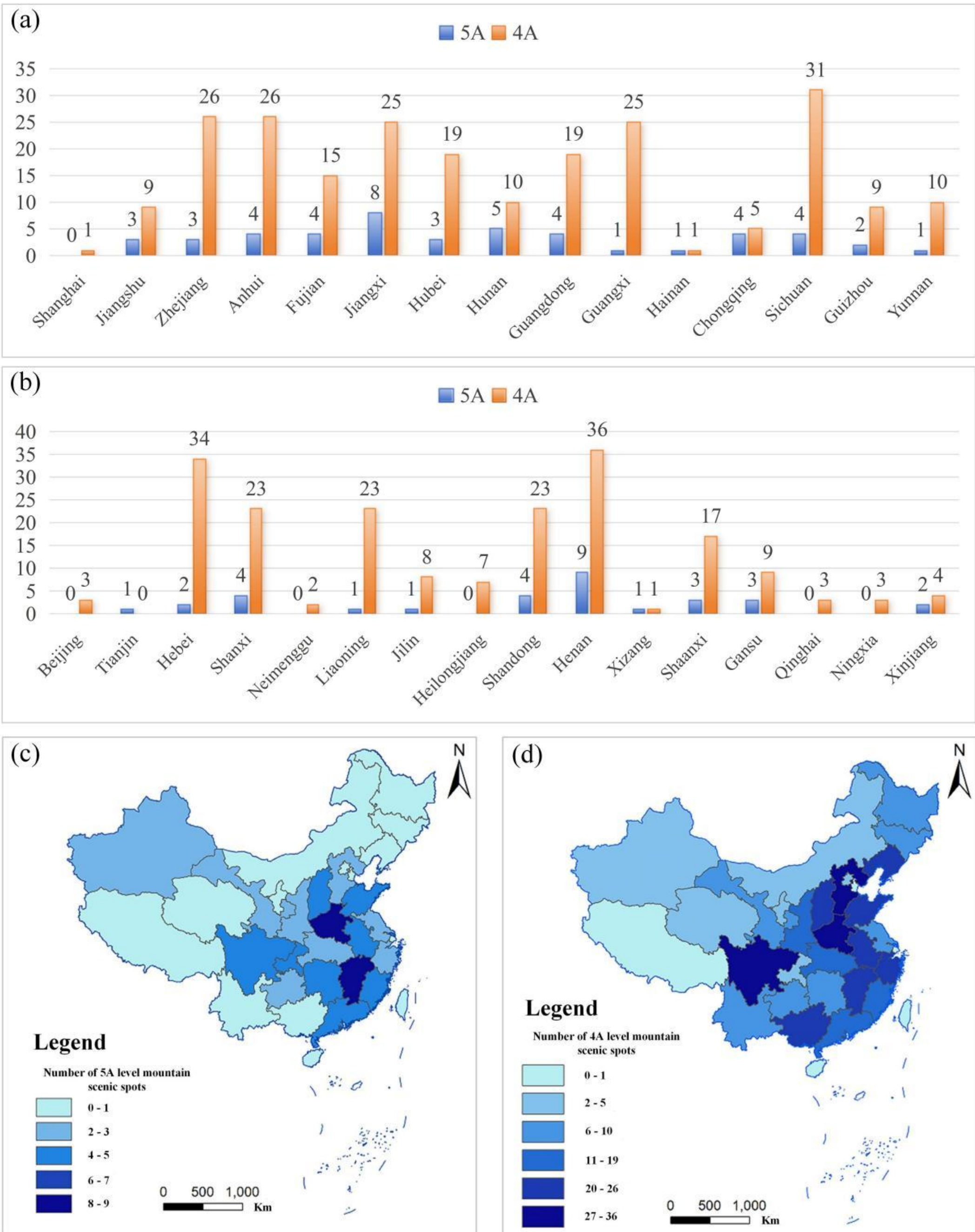


***Figure 3.** Inter-provincial distribution map of 4A and 5A mountainous scenic spots*

As shown in *Figure 3*, Henan and Jiangxi provinces in China lead with 9 and 8 5A mountain tourist attractions, respectively. Meanwhile, Tianjin, Liaoning, Jilin, Guangxi,


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Hainan, Yunnan, Xizang, and several other provinces each have only one 5A mountain tourist attraction. Beijing, Inner Mongolia, Heilongjiang, Shanghai, Qinghai, Ningxia, and Xinjiang currently have no 5A level mountain tourist attractions.

When examining the number and distribution of 4A mountain tourist attractions, Henan province ranks first in the country with 36 attractions, followed by Hebei Province with 34. Sichuan and Zhejiang provinces are third and fourth, with 31 and 26 attractions, respectively. Anhui and Jiangxi also performed well, placing in the top 10 with 26 and 25 attractions, respectively. The Guangxi Zhuang Autonomous Region and Shandong Province each have 25 and 23 4A mountain tourist attractions. Shanxi ties with Liaoning for 10th place, with 23 attractions. In contrast, Tianjin, Xizang, Hainan, Shanghai, and Inner Mongolia have a relatively low number of 4A mountain scenic spots, with only 0, 1, 1, 1, and 2, respectively, ranking them as the bottom five.

Overall, China's 5A mountain tourist attractions demonstrate a clear pattern of density in the southeast and sparsity in the northwest, as illustrated in *Figure 4*. Specifically, North China, the lower reaches of the Yangtze River, and the Sichuan and Chongqing regions are areas of dense distribution for 5A mountain tourist attractions, while northwest China and the Qinghai-Tibet region are relatively sparse. In general, Henan, Hebei, Sichuan, and Jiangxi have the highest number of high-grade mountain scenic spots, while Shanghai, Tianjin, Tibet, Inner Mongolia, Hainan, Qinghai, and Ningxia have fewer. This distribution pattern highlights the variations in tourism resources and development across different regions of China.

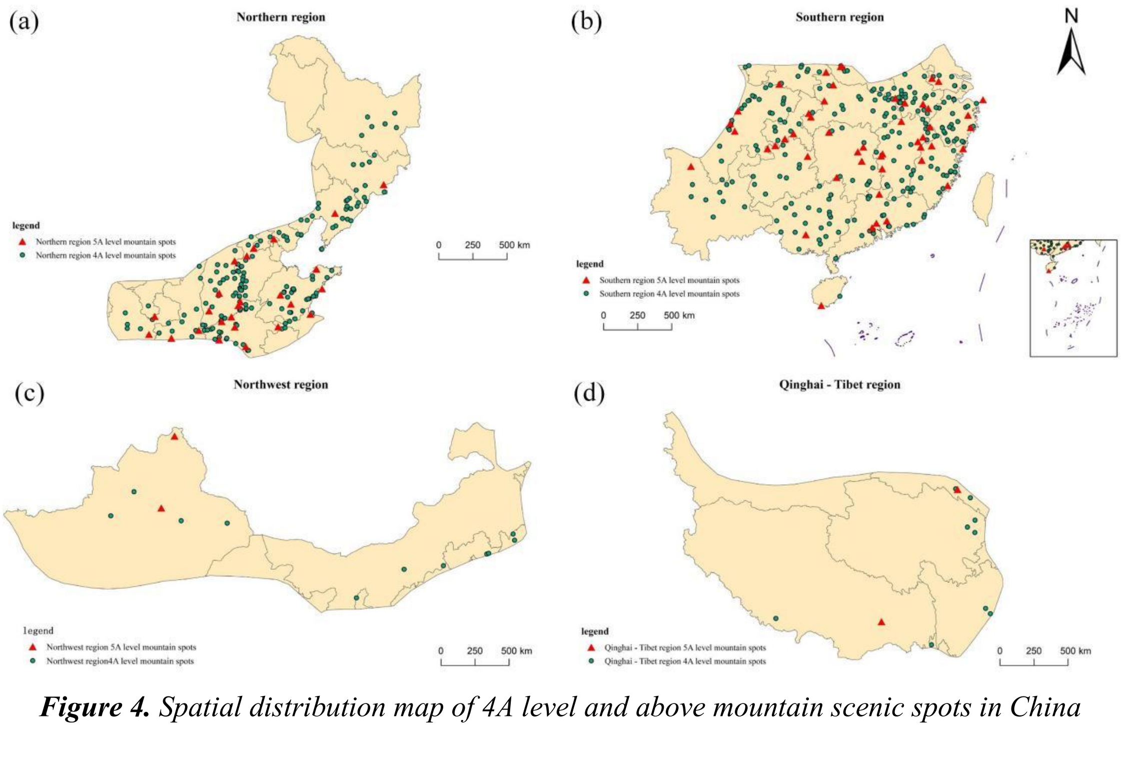


***Figure 4.*** *Spatial distribution map of 4A level and above mountain scenic spots in China*

In this study, the collected latitude and longitude data were represented as point elements to create a spatial distribution map of high-grade mountain scenic spots in China. As illustrated in *Figure 4*, this map reveals a clear heterogeneity in the spatial distribution of these scenic spots. Notably, the distribution among different provinces is uneven, with significant disparities between the eastern and western regions.


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### *Spatial distribution type*

The spatial distribution of 4A and 5A mountain scenic spots in China can be represented as a pattern of dotted geographical elements. This distribution is characterized as condensed, random, and uniform. This study employs the nearest neighbor index for evaluation as shown in *Table 1*.

***Table 1.*** *Nearest neighbor index values for 4A and 5A mountain scenic spots*

| Scenic spot grade | Actual nearest neighbor distance/km | Theoretical nearest neighbor distance/km | Nearest neighbor index | Space division fabric type |
|---|---|---|---|---|
| 4 A | 47.487 | 74.971 | 0.633 | Condensed type |
| 5 A | 142.698 | 175.412 | 0.834 | Condensed type |
| 4A and 5 A | 43.799 | 68.938 | 0.635 | Condensed type |

Using the average nearest neighbor tool within the spatial statistical tool ArcGIS 10.2 to calculate distances in kilometers, we find that the nearest neighbor index, R, is 0.635, which is less than 1. The Z-score is -15.677, and the p-value is less than 0.01. These results provide strong evidence that the actual nearest neighbor distance is less than the theoretical nearest neighbor distance. Consequently, China's 4A and 5A mountainous scenic spots demonstrate a cohesive spatial distribution (*Fig. 5*).

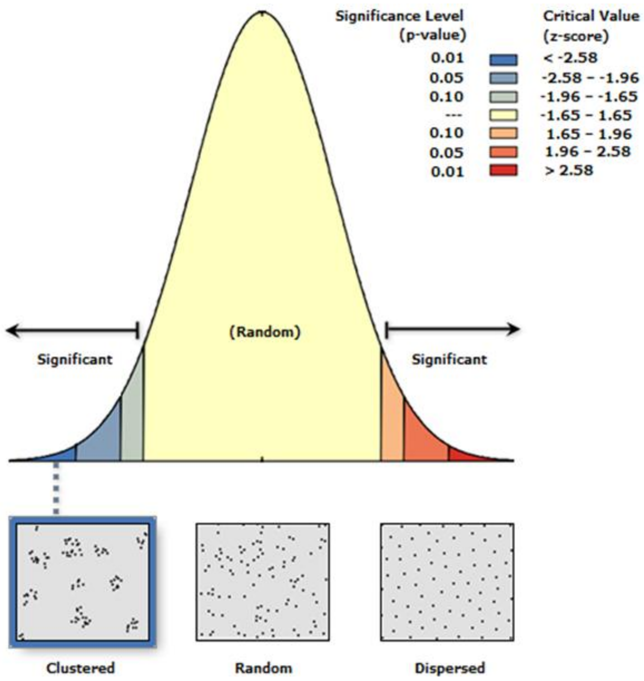


***Figure 5.*** *Significance test of average nearest neighbor for high-level mountain scenic*

Specifically, the actual nearest distance for 4A level mountainous scenic spots in China is 47.487 km, compared to a theoretical nearest distance of 74.971 km, resulting in a nearest neighbor index of 0.633. For 5A level mountain scenic spots, the actual nearest distance is 142.698 km, with a theoretical nearest distance of 175.412 km, yielding a nearest neighbor index of 0.834. In summary, both 4A and 5A level mountainous scenic


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spots in China exhibit a cohesive distribution pattern, although the degree of cohesion appears to decrease as the level of the scenic spot increases.

### *Spatial distribution characteristics of mountain-type scenic spots*

#### *Spatial distribution and concentration degree*

According to the geographical concentration index method, the G value for 4A and above mountains in China is 22.49. Building on this, the study assumes that the 505 4A and above mountain tourist attractions in China are evenly distributed across provincial administrative regions. This means that the number of 4A and 5A mountain tourist attractions in each province would be approximately 16.29, calculated by dividing 505 by 31. Based on this assumption, the G value for the geographic concentration index is 17.96. A comparison reveals that 22.49 is greater than 17.96, indicating that the distribution of 4A and above mountain tourist attractions is relatively concentrated and deviates from an ideal uniform distribution. These findings align with the conclusion that the distribution of scenic spots is indeed concentrated.

#### *Equilibrium degree of spatial distribution*

The nearest neighbor index and the geographical concentration index illustrate the spatial distribution trends and concentration levels of 4A-level mountain scenic spots in China. However, they do not adequately describe the degree of dispersion within each province, which hinders a comprehensive assessment of distribution equilibrium. To analyze the spatial distribution of these scenic spots more effectively, this paper employs the Gini coefficient and the imbalance index as evaluation criteria. Given China's vast size and diverse geographical environments, these factors significantly influence the distribution of mountain scenic spots. By conducting subregional studies, we can gain a deeper understanding of spatial distribution and facilitate regional comparisons. This paper categorizes China into seven geographical areas: North China, Northeast China, East China, Central China, South China, Northwest China, and Southwest China. The distribution of 4A mountain scenic spots across these regions is presented in *Table 2*.

***Table 2.*** *Distribution of 4A level and above mountain scenic spots in seven major zones*

| Partition | Number of scenic spots | Proportion (%) | Cumulative proportion (%) |
|---|---|---|---|
| North China region | 69 | 13.67 | 13.67 |
| Northeast region | 40 | 7.92 | 21.59 |
| East China | 151 | 29.9 | 51.49 |
| Central China | 82 | 16.24 | 67.73 |
| South China | 51 | 10.10 | 77.83 |
| Northwest region | 44 | 8.71 | 86.54 |
| Southwest region | 68 | 13.47 | 100.00 |
| Total | 505 | 100.00 | |

The calculation reveals a significant imbalance in the distribution of 4A level and above mountainous tourist attractions across seven major geographical regions in China, with a relatively high degree of disparity. An examination of the statistical table detailing the distribution and quantity of these attractions in various provinces *Table 3* indicates


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that Henan, Hebei, Sichuan, Jiangxi, Anhui, Zhejiang, Shanxi, and Shandong provinces collectively account for 51.88% of the total number of 4A level and above mountain tourist attractions in the country. This data further underscores the uneven spatial distribution of these attractions in China.

***Table 3.*** *Statistical table of spatial distribution of high level mountain scenic spots*

| Partition | Number | Percentage occupied % | Cumulative percentage % | Partition | Number | Percentage occupied % | Cumulative percentage % |
|---|---|---|---|---|---|---|---|
| Henan | 45 | 8.91 | 8.91 | Gansu | 12 | 2.38 | 86.14 |
| Hebei | 36 | 7.13 | 16.04 | Guizhou | 11 | 2.18 | 88.32 |
| Sichuan | 35 | 6.93 | 22.97 | Yunan | 11 | 2.18 | 90.50 |
| Jiangxi | 33 | 6.53 | 29.50 | Jiling | 9 | 1.78 | 92.28 |
| Anhui | 30 | 5.94 | 35.44 | Chongqing | 9 | 1.78 | 94.06 |
| Zhejiang | 29 | 5.74 | 41.18 | Heilongjiang | 7 | 1.39 | 95.45 |
| Shanxi | 27 | 5.35 | 46.53 | Xinjiang | 6 | 1.19 | 96.64 |
| Shandong | 27 | 5.35 | 51.88 | Beijing | 3 | 0.59 | 97.23 |
| Guangxi | 26 | 5.15 | 57.03 | Qinghai | 3 | 0.59 | 97.82 |
| Liaoning | 24 | 4.75 | 61.78 | Ningxia | 3 | 0.59 | 98.41 |
| Guangdong | 23 | 4.55 | 66.33 | Neimenggu | 2 | 0.40 | 98.81 |
| Hubei | 22 | 4.36 | 70.69 | Hainan | 2 | 0.40 | 99.21 |
| Shanxi | 20 | 3.96 | 74.65 | Xizang | 2 | 0.40 | 99.61 |
| Fujian | 19 | 3.76 | 78.41 | Tianjin | 1 | 0.20 | 99.81 |
| Hunan | 15 | 2.97 | 81.38 | Shanghai | 1 | 0.20 | 100.00 |
| Jiangsu | 12 | 2.38 | 83.76 | Total | 505 | 100.00 | 100.00 |

The spatial distribution of 505 4A and 5A mountain attractions in China was analyzed using the nuclear density estimation method. *Figure 6a–d* represent the distribution of nuclear density in the northwest region, Qinghai Tibet region, northern region, and southern region, respectively. *Figure 6e* represents the distribution of nuclear density throughout China. *Figure 6f* presents the statistical results of the maximum, minimum, and average values of nuclear density for each region.

Overall, the analysis reveals that areas with high concentrations of high-grade mountain attractions are primarily located in the border regions of Hebei, Shanxi, Hubei, Anhui, Henan, and Shaanxi, forming the first tier of density distribution. The second tier includes Zhejiang, Jiangxi, Shandong, Sichuan, and Liaodong. The third tier comprises southwest Chongqing, the Pearl River Delta, eastern Fujian, and northeastern Hebei. In contrast, large provinces such as Inner Mongolia, Xinjiang, Qinghai, and Tibet have relatively low densities of scenic spots. Overall, the spatial distribution of high-grade mountain tourist attractions in China reveals a “herringbone” pattern characterized by a concentration in the southeast and sparse distribution in the northwest, delineated by the Heihe-Tengchong line.

Regionally, the peak nuclear density in Northeast China is the highest (6.42), significantly higher than the national level (5.01), indicating the existence of a highly significant cluster of scenic spots in the region; The southern region ranks second (5.35), still higher than the national average; The peak values in the northwest (0.06) and Qinghai Tibet region (0.35) are less than 7% of the national level, revealing a typical characteristic of sparse distribution. From the perspective of spatial agglomeration intensity, the southern


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region has the highest concentration of scenic spots with an average kernel density value of 1.15, which is 135% higher than the national average (0.49). This is closely related to the region's superior natural geographical conditions and mature tourism development system. The average values in the northwest and Qinghai Tibet regions are only 0.03, which is less than 3% of the southern region, highlighting the restrictive effect of arid climate and high-altitude environment on scenic area development.

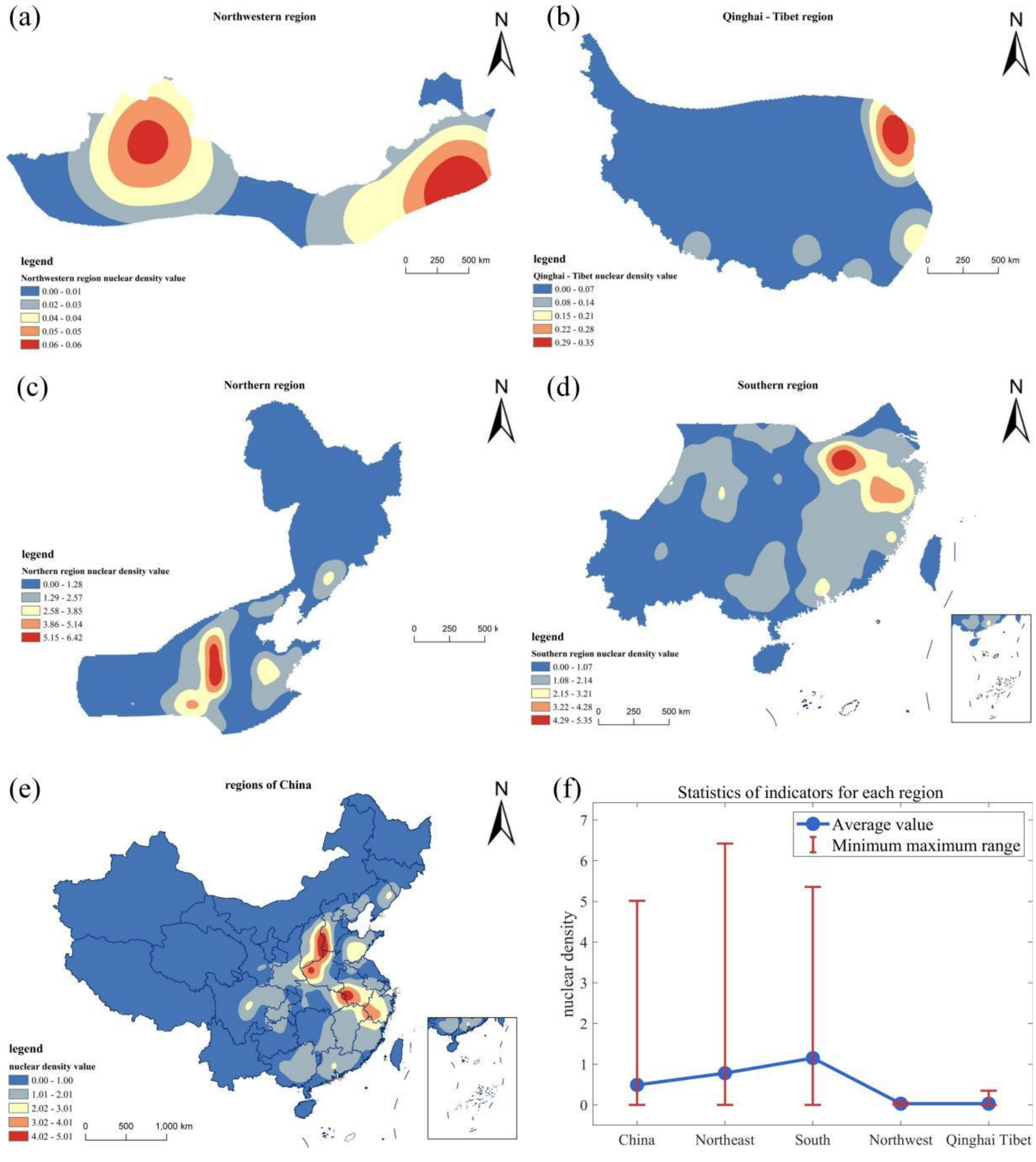


***Figure 6.*** *Distribution of nuclear density in 4A and above mountain scenic spots*

## ***Influencing factors of the spatial distribution of mountain-type scenic spots***

### *Spatial distribution and concentration degree*

To explore the causes of the differences in the spatial distribution of high-grade mountain scenic spots in China, geographical detectors were employed to analyze the


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factors of economy, society, transportation, and geography. This analysis aims to reveal their influence on the distribution of these scenic spots, as shown in *Table 4*.

***Table 4.*** *Detection results of spatial distribution of high-grade mountain scenic spots in China*

| | x1 | x2 | x3 | x4 | x5 | x6 |
|---|---|---|---|---|---|---|
| Q value | 0.100 | 0.220 | 0.073 | 0.381 | 0.180 | 0.354 |
| P value | 0.691 | 0.220 | 0.826 | 0.258 | 0.758 | 0.095 |

(1) From an economic perspective, the q-value of per capita GDP (x1) is 0.100, indicating a general impact. This suggests that the distribution of high-grade mountain scenic spots is influenced by various factors, including natural resources, climatic conditions, and geographical location. As a result, regions with high per capita GDP may not necessarily attract the establishment of high-grade mountain scenic spots. Conversely, some areas with lower per capita GDP may boast rich natural landscapes and unique ecological environments, making them more likely candidates for such scenic spots.

(2) In terms of social factors, the q-value of the urbanization rate (x2) is 0.220, demonstrating a significant impact on the spatial distribution of scenic spots. As urbanization progresses, areas with higher urbanization rates tend to experience increased tourism demand, making them more attractive for high-grade mountain scenic spots. Additionally, a larger urban population reflects greater market potential and consumer spending power, which are crucial for the sustainable development and competitiveness of tourism. In contrast, the q-value of population density (x3) is only 0.073, indicating a relatively minor influence. This suggests that while population density is an important social and economic indicator, it is less significant than the urbanization rate in determining the spatial distribution of high-grade mountain scenic spots. This may be attributed to the fact that such scenic spots are typically located in areas with beautiful natural scenery and good ecological conditions, where population density may not be high.

(3) Regarding transportation, the total mileage of the transportation network (x4) exerts the greatest influence on the spatial distribution of high-grade mountain scenic spots in China, with a q-value of 0.381. The extensive coverage of the transportation network is crucial for infrastructure development, directly impacting the attractiveness and competitive strength of scenic spots. A well-developed transportation network not only enhances accessibility and the overall travel experience for tourists but also mitigates the effects of natural disasters on the operation of scenic spots, ensuring the sustainability and safety of tourism services. As a result, this enhances the overall competitiveness of these attractions.

(4) Regarding the geographical dimension, regional elevation (x5) significantly influences the spatial distribution of high-grade mountain scenic spots in China, evidenced by a q-value of 0.180. This indicates that the altitude of a region partly determines the locations of these scenic spots. High-altitude areas often feature unique natural landscapes and climatic conditions that attract tourists, leading to a concentration of high-grade mountain scenic spots in those regions. Additionally, average annual precipitation (x6) plays a crucial role, with a q-value of 0.354. This reflects that adequate precipitation significantly impacts vegetation growth, water conservation, and landscape


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diversity in mountain scenic spots. Consequently, areas with higher average annual precipitation are more likely to support the formation and maintenance of attractive natural landscapes, making them important distribution zones for high-grade mountain scenic spots.

*Dual-factor interaction*

The results of the double-factor interaction detection (*Fig. 7a*) indicate that the q values for various interaction types are greater than 0.5. *Figure 7b* represents the degree of interaction between significant influencing factors. Among these, the spatial distribution of mountain-type scenic areas shows the strongest interaction with annual precipitation (x6) and total mileage of the traffic network (x4), with a q value of 0.772. This suggests that sufficient precipitation and well-developed transportation infrastructure significantly influence the scenic appeal and accessibility of mountain areas. Tourists may prefer to visit mountain locations that offer adequate water resources for various activities and are easily accessible via convenient transport.

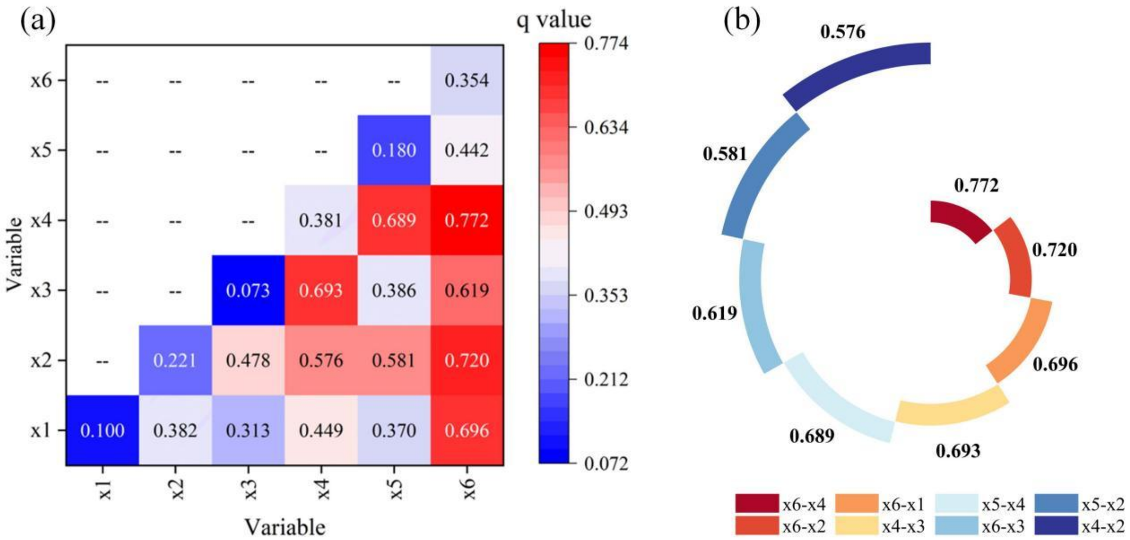


***Figure 7.** Dual factor interaction analysis of spatial distribution of mountain-type scenic spots*

Additionally, the interactions between average annual precipitation (x6), urbanization rate (x2), and population density (x3) with total transportation network mileage (x4) are also strong, with q values of 0.772 and 0.693, respectively. The urbanization rate reflects economic development and population concentration; higher urbanization often correlates with improved infrastructure and services. When combined with sufficient precipitation, this can enhance the natural landscapes and water resources of mountain scenic areas, making them more attractive to tourists.

Furthermore, high population density may indicate a larger potential tourist market, while total road and railway mileage signifies transportation convenience. Together, these factors can facilitate easier access to scenic spots, and areas with high population density may offer more tourism resources. The interplay of these elements likely significantly impacts the accessibility and tourist flow to mountain scenic areas, positively affecting tourism revenue.


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## Discussion

### *Research comparison*

This study identifies the key factors influencing the distribution of mountain scenic spots in China using the geographic detector model. The results provide a scientific foundation for tourism planning and resource management while suggesting potential avenues for future research. The analysis highlights that the proportion of the urban population and the average annual precipitation are the most significant factors affecting the distribution of mountain scenic spots in China. The proportion of the urban population indicates the level of urbanization in a region, which directly influences the development of tourism infrastructure, the availability of tourism services, and the overall size of the tourism market. Higher urbanization rates typically result in a larger pool of potential tourists. For instance, Zhejiang Province, with its high urbanization, is home to mountain attractions like Tianmu Mountain and Yandang Mountain, which draw many visitors due to their well-developed transportation infrastructure and tourism facilities. Additionally, average annual precipitation plays a crucial role in shaping the natural landscape and ecosystem of scenic spots. Ample rainfall supports water resources and biodiversity, enhancing the attractiveness of locations such as the Lushan Mountain scenic area in Jiangxi Province, which features numerous waterfalls and streams due to its abundant rainfall, thereby attracting many tourists.

This study goes beyond examining the influence of individual factors by investigating the interactions between them, offering a more comprehensive understanding of scenic spot distribution. It reveals that the significant positive interaction between the urban population proportion and urban population density, as well as the synergistic effect of the total mileage and elevation of transportation infrastructure, significantly affects the distribution of scenic spots. These findings underscore the necessity of considering multi-factor interactions in tourism planning and management and provide a scientific basis for relevant policy formulation.

Furthermore, this study thoroughly investigates the spatial distribution characteristics and influencing factors of mountain scenic spots in China (*Table 5*). Regarding research focus, Xie et al. (2021) examine the spatial structure of the tourism economy in 28 EU member states; Wang et al. (2022) analyze the temporal and spatial evolution of UNESCO global geoparks; Tang and Chun (2021) explore the spatial distribution of classic Chinese red tourism sites; and Zhang et al. (2023) provide a comprehensive study of the spatial distribution characteristics and driving factors of tourism resources in China. These studies, conducted between 2021 and 2023, reflect a growing academic interest in the spatial distribution characteristics of tourism. Each study offers unique contributions, such as insights into the spatial dependence of regional tourism economies, which are crucial for the protection and promotion of global geoparks, or enhancements to the educational and cultural value of red tourism. Collectively, they provide a comprehensive perspective for tourism planning and management.

Future research should aim to integrate these methodologies and perspectives for a more holistic analysis of tourism spatial distribution. Additionally, there is a need to strengthen cross-regional comparative studies, particularly regarding the distribution of tourism resources across varying cultural and geographical contexts. Incorporating more socioeconomic factors into research models could also lead to more accurate predictions and explanations of the dynamic changes in tourism spatial distribution. Through this comparative analysis, we can clearly delineate differences in methodology, focus, and


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regional emphasis across studies, enriching our understanding of the spatial distribution of tourism and offering valuable reference points and potential directions for future research.

***Table 5.*** *Horizontal comparison of research status*

| Thesis title | Author | Study area | Main methods | Year |
|---|---|---|---|---|
| Research on the Spatial Structure of the European Union's Tourism Economy and Its Effects | Xie et al. | The 28 EU member states | Spatial structure; Social network | 2021 |
| Analysis on Temporal and Spatial Evolution of UNESCO Global Geoparks and Impact Factors | Wang et al. | UNESCO Global Geoparks | Nearest Neighbor Index; Gini Coefficient | 2022 |
| Spatio-temporal evolution and influencing factors of Chinese red tourism classic scenic spots network attention | Tang et al. | Red tourism classic scenic spots | Network attention; Spatio-temporal evolution | 2021 |
| Spatial Distribution Characteristics and Driving Factors of Tourism Resources in China | Zhang et al. | China | Macro-pattern; influencing factors | 2023 |
| Spatial Distribution and Accessibility of High Level Scenic Spots in Inner Mongolia | Wu et al. | Inner Mongolia | Nearest Neighbor Index; Kernel Density Analysis | 2022 |

### *Policy recommendations*

Based on the analysis above, we propose policy suggestions across four key areas: transportation, economy, geography, and society, to promote the sustainable development of China's mountain scenic spots. In the study of China's mountain scenic spots, optimizing the transportation system is essential for enhancing accessibility and attractiveness. We recommend strengthening the transportation network in mountainous areas by increasing special tourist lines, improving road quality, and expanding railway coverage. Additionally, promoting eco-friendly vehicles, such as electric buses and bike lanes, will mitigate the negative environmental impacts of tourism, fostering a balance between tourism development and ecological protection.

Regarding the geographical system, safeguarding natural resources is fundamental to achieving sustainable development in mountain scenic spots. Our research underscores the necessity of implementing strict environmental protection regulations and sustainable development strategies during tourism development. It is crucial to plan the layout of scenic spots according to geographical characteristics and resource distribution to prevent overdevelopment and resource waste, thereby ensuring rational utilization and long-term protection of these resources. In the economic system, the development of mountain scenic spots significantly contributes to local economies. Policymakers should encourage investment from both the private and public sectors by offering incentives such as tax breaks and financial subsidies to stimulate local economic growth. Moreover, it is vital to develop a diverse range of tourism products—including ecological, cultural, and adventure tourism—to cater to various tourist groups and increase tourism revenue, ultimately driving the growth of related industries. In the social system, enhancing local community participation in tourism planning and management is crucial. Involving local communities in the decision-making process ensures that tourism development aligns with cultural and social needs while creating employment opportunities and strengthening


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community ties. Additionally, providing education and training to improve the skills of local residents in tourism service and management is essential for enhancing the quality of the tourism experience and promoting sustainable tourism development.

In conclusion, comprehensive policy recommendations across the transportation, economic, geographical, and social systems can effectively promote the sustainable development of China's mountain scenic areas. These strategies not only aim to protect unique natural and cultural resources but also seek to improve the quality of life for local residents and offer tourists a high-quality experience. Our recommendations are grounded in data analysis and take into account various social, economic, environmental, and cultural factors to achieve the comprehensive benefits of tourism development.

## Conclusion

This study examines 505 high-grade mountain scenic spots in China, including 78 classified as 5A-level and 427 as 4A-level, with a focus on understanding the spatial distribution patterns and influencing factors of these key tourism resources. Using tools such as ArcGIS 10.2 and drawing upon methodologies from tourism studies, geography, statistics, and economics, the research investigates the distribution characteristics of these scenic spots, with a particular emphasis on overall distribution, types, density, equilibrium, and concentration. Additionally, the study explores the economic, social, transportation, and geographical factors that influence the spatial patterns of these mountain tourism sites.

The key findings of this study showed that the spatial distribution of high-grade mountain scenic spots across China reveals considerable disparities. Provinces like Henan and Jiangxi are prominent in the number of 5A scenic spots, while other provinces show a much lower presence. Overall, these sites exhibit a clustered pattern, with 5A scenic spots showing lower spatial cohesion compared to 4A spots. The degree of spatial cohesion tends to decrease as the grade of the scenic spots increases, indicating that higher-tier sites are more spread out and less concentrated. Although the high-grade mountain scenic spots are relatively concentrated, they deviate significantly from an ideal uniform distribution, indicating a spatial imbalance. The Gini coefficient of 0.947 and an imbalance index of 0.053 point to a high concentration of these spots in certain areas, especially in border regions such as Hebei, Shanxi, Hubei, Anhui, Henan, and Shaanxi. This creates a pattern where areas in the southeast are denser with tourist attractions, while regions in the northwest, including Inner Mongolia, Xinjiang, Qinghai, and Tibet, have a notably low density of scenic spots. Moreover, the spatial distribution of high-grade mountain scenic spots is shaped by several factors, including geographical features, economic conditions, social dynamics, and transportation infrastructure. Among these, average annual precipitation, regional elevation, and the total length of transportation networks are found to have significant influences. The interaction between annual precipitation and the combined mileage of highways and railways has the strongest explanatory power for spatial distribution patterns ($q = 0.772$). This suggests that favorable climate conditions and robust transportation infrastructure are essential for enhancing the accessibility and attractiveness of mountain scenic spots.

This study offers several important insights that can contribute to tourism development in China and beyond. First, the findings regarding spatial distribution patterns and the factors influencing the concentration and accessibility of high-grade mountain scenic spots can inform tourism planning and management in other mountainous regions


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worldwide. Many countries with diverse topographies and rich natural landscapes, such as Nepal, India, Brazil, and countries in the Alps, can benefit from the study's findings on how geographical, economic, and infrastructural factors shape tourism attraction. Furthermore, the analysis of spatial cohesion and the relationship between different grades of mountain scenic spots provides valuable lessons for countries seeking to optimize their tourism offerings. By understanding how to enhance the cohesion of high-grade sites and balance the spatial distribution of tourism resources, policymakers and developers in other mountainous regions can address issues of overcrowding in popular destinations while promoting lesser-known areas with high tourism potential.

The study's findings also highlighted the importance of transportation and climate factors in enhancing the accessibility and attractiveness of mountain tourism sites. These insights can be applied to improve tourism infrastructure in other mountainous areas, ensuring that both remote and popular destinations are adequately connected and attractive to a global tourist market. Moreover, the interplay of transportation development and climatic conditions could serve as a model for other countries working to build resilient and sustainable tourism infrastructure in challenging natural environments. This study provides a comprehensive framework for understanding the spatial dynamics of mountain tourism, which has practical implications not only for China but also for countries with mountainous tourism destinations. By focusing on the critical factors that shape the success of mountain tourism development, such as infrastructure, climate, and spatial distribution. This research offers strategies for promoting sustainable, balanced, and high-quality tourism growth on a global scale.

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