

# Study on Spatial Differentiation and Accessibility of A-Level Scenic Spots in Yunnan Province

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**Abstract:** A level scenic spot in Yunnan province as the research object, using the nearest, geographical concentration and nuclear density index analyzes the spatial distribution type and characteristics of level A scenic spot, using OD cost matrix based on vector road traffic network analyzes the accessibility of different types of scenic spots, using space autocorrelation analysis to explore the level A scenic spot accessibility in county space in Yunnan province. The research results show that the A-level scenic spots in Yunnan Province: 1. It presents a state of aggregation. The aggregation nature of cultural scenic spots is higher than that of natural scenic spots, forming three high-density areas with Tengchong, Lijiang and Kunming as the core; 2. Accessibility is generally general, with obvious regional differences. The accessibility is good in the areas with convenient transportation and good economy, while the accessibility of the natural scenic spots distributed in the border areas is poor; 3. The accessibility hot spots are mainly distributed in the circle areas centered on Kunming and Yuxi, and the cold spots are in the boundary areas of Pu'er, Lincang and Diqing.

**Keywords:** A-level scenic spot, Accessibility, Spatial differences, Yunnan province.

## 1. Introduction

Yunnan province is a big tourism province with rich tourism resources. The study on the spatial differentiation and accessibility of A-class scenic spots in Yunnan Province can provide basic data support for the government, tourism enterprises and tourists, which is beneficial for the government to optimize the layout of tourism scenic spots and improve the surrounding transportation system, enterprises to carry out tourism planning services and tourists to choose suitable travel destinations and plan their itineraries. The correct understanding of the differences in spatial differentiation and accessibility of A-class scenic spots is the basic work to realize the optimal allocation of tourism resources and tourism development[1].

Currently, the spatial pattern of tourist scenic spots has become a research hotspot, and there are more analyses of the spatial distribution characteristics and influencing factors of scenic spots in existing studies, but relatively less research on the accessibility of scenic spots. Scholars at home and abroad have mostly studied the spatial distribution pattern of A-class scenic spots in Yunnan Province [1-2], Chinese tourist scenic spots[3-4], A-class scenic spots in Gansu Province[5], A-class scenic spots in Xinjiang[6], A-class scenic spots in Yunnan Central City Cluster[7], and A-class scenic spots in Ganzi Prefecture[8] by using the methods of nearest neighbor index, geographic concentration index and Gini coefficient analysis. And the existing accessibility research methods mainly include buffer zone analysis method, nearest neighbor analysis method, cumulative opportunity method, raster cost distance method[9], two-step moving search method[10], etc. Domestic scholars have used these methods to study A-class scenic spots in Shanxi province[11], Chengdu city tourist scenic spots[12], A-class tourist scenic spots in China[13], tourist scenic spots in Hubei province[14], scenic spots above 3A level in China[15], Yangtze River Delta tourist attractions[16], red tourism scenic spots in Jiangxi Province[17], and tourist scenic spots in Wuhan City[18]

were studied for accessibility. Through combing the existing studies, it is found that research on the accessibility of A-class scenic spots in Yunnan Province is relatively rare, followed by accessibility studies that mainly consider the accessibility between scenic spots and rarely consider their accessibility to transportation sites and administrative centers, and the analysis is not comprehensive enough.

In this paper, the spatial distribution of A-class scenic spots in Yunnan Province is studied by using the nearest neighbor index, geographic concentration index and nuclear density, and the accessibility between scenic spots, between scenic spots and transportation sites, and from scenic spots to administrative centers is studied by using the OD cost matrix based on vector traffic road network, aiming to optimize the spatial layout of tourist scenic spots and promote the high-quality and sustainable development of tourism in Yunnan Province.

## 2. Study Area and Methodology

### 2.1. Overview of the study area

Yunnan Province is located in the southwest of China, between 21°8'32" and 29°15'8" north latitude and 97°31'39" and 106°11'47" east longitude. The western and southern parts of Yunnan Province border several regions outside the country, and the country is adjacent to Sichuan, Guizhou, Guangxi and Tibet, covering an area of more than 394,000 square kilometers. The temperature in Yunnan Province is pleasant, and the provincial capital Kunming is known as the Spring City, with an average temperature of thirteen to twenty degrees in most parts of the province. It is also one of the regions with the largest population of ethnic minorities and the largest area of distribution in China, with more than twenty ethnic minorities in total. Yunnan has the highest number of flora and fauna in China and is known as the "Kingdom of Flora and Fauna". Due to its suitable temperature, rich composition of flora and fauna and multi-ethnic characteristics, it has formed a rich and diversified

tourism resources, consisting of natural landscapes, human resources, famous monuments and ethnic customs.

## 2.2. Data source and pre-processing

The data of A-class tourism scenic spots in Yunnan Province are obtained from the list of A-class tourism scenic spots in Yunnan Province released by Yunnan Tourism Bureau in 2021, and the longitude and latitude coordinates of the scenic spots are obtained by Baidu picking up the coordinate system. As of 2021, there are 408 A-class scenic spots in Yunnan Province, including 9 5A-class, 115 4A-class, 204 3A-class, 71 2A-class and 9 1A-class. According to the bifurcation method, they are divided into two types of scenic spots, natural and humanistic, of which 270 are humanistic and 138 are natural. The road network data are obtained through the National Basic Geographic Information Center network. This paper is mainly based on ArcGIS10.5 software operation platform to establish geodatabase, data processing and spatial analysis, extracting traffic network and topology checking, establishing network data set, taking scenic spots, traffic stations and municipal administrative centers as nodes for network analysis and calculating spatial accessibility.

## 2.3. Research Methodology

### 2.3.1. Nearest neighbor index

The nearest neighbor index is the ratio of the actual nearest neighbor distance to the theoretical nearest neighbor distance[1], which is used to analyze the type of distribution of point elements in geographic space. The formula for the nearest neighbor index is:

$$R = \frac{\bar{D}_0}{\bar{D}_E}, \bar{D}_E = \frac{1}{2\sqrt{D}}, D = \frac{n}{A} \quad (1)$$

Where R is the nearest neighbor index,  $\bar{D}_0$  is the actual nearest neighbor distance,  $\bar{D}_E$  is the theoretical nearest neighbor distance, D is the point density, n is the number of scenic spots, and A is the area of the region. When  $R < 1$ , scenic spots tend to be aggregated; when  $R = 1$ , scenic spots tend to be randomly distributed; when  $R > 1$ , scenic spots tend to be uniformly distributed.

### 2.3.2. Geographic concentration index

The Geographic Concentration Index is a measure of the degree of geographic concentration of the study population[1], calculated as

$$G = 100 \times \sqrt{\sum_{i=1}^n (T_i / T_{ai})^2} \quad (2)$$

Where G is the geographical concentration index,  $T_i$  is the number of attractions in the  $i$ th municipality, and  $T_{ai}$  is the total number of attractions. The value of G ranges from 0 to 100, the closer to 100 the more concentrated the distribution; the closer to 0 the more dispersed the distribution.  $\bar{G}$  is the geographical concentration index when each scenic spot is equally distributed in each city and state. If  $G > \bar{G}$ , the scenic spot is concentrated; if  $G < \bar{G}$ , the scenic spot is dispersed[1].

### 2.3.3. Nuclear density

Kernel density analysis is mainly used to calculate the density of spatial distribution of a certain spatial element on the Earth's surface or within a certain regional scale around it,

and the algorithm is:

$$f_n(x) = \frac{1}{nh} \sum_{u=1}^n k\left(\frac{x-x_u}{h}\right) \quad (3)$$

In the formula,  $f_n(x)$  denotes the kernel density function; h is the bandwidth and  $h > 0$ ; n denotes the number of points whose linear distance to the point  $\leq h$ ; k function denotes the distance relationship between each point and the core;  $x - x_u$  denotes the point valuation, the distance from x to  $x_u$ .

### 2.3.4. 1.3.4 Reachability measurement model

In the study of tourist attractions, accessibility is the average of the distance that can be traveled from the attraction to its surrounding area in a given time, or the average of the time it takes for the attraction to travel to other locations within a certain region, or the average travel time of a tourist attraction based on the transportation network[9]. Accessibility reflects the ease of access between an area and other areas within a specific spatial range, and there are various models for its measurement. In this paper, the average travel time between attractions in the region, between attractions and transportation stations, and between attractions and administrative centers is used to measure the accessibility of the network of the attraction, which reflects the location of the attraction and the ease of transit for tourists[12], and its calculation formula is:

$$A_i = \frac{\sum_{j=1}^n T_{ij}}{n} \quad (4)$$

Where: i and j are the attractions in Yunnan Province;  $T_{ij}$  is the shortest travel time for attraction i in Yunnan Province to reach attraction j through the transportation network; n is the total number of A-class attractions;  $A_i$  is the average travel time for attraction i. The smaller the value, the better the accessibility of the attraction.

### 2.3.5. ESDA spatial association

The Moran's I index of ESDA (Exploratory Spatial Data Analysis) was introduced to detect the resultant model of accessibility spatial relationship in order to quantitatively grasp the inner pattern of regional tourism spatial structure in a holistic way[13]. Its formula is:

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{s^2 \sum_{i=1}^n \sum_{j=1}^n W_{ij}} \quad (5)$$

At a given significance level, if Moran's I is significantly positive, it indicates that regions with higher (or lower) accessibility are spatially significantly clustered, while the opposite indicates that the accessibility of the region is spatially significantly different from that of the surrounding areas.

In the local spatial autocorrelation index, compared to the local Moran index statistic which is weaker in detecting high-value clusters than the detection of low-value clusters, there is a greater deficiency in the identification of the clustering range, the local G-coefficient (Getis-Ord) can detect the

clustering area more accurately, so this paper further uses Getis-Ord to calculate the correlation between each county unit and the accessibility of neighboring units degree for identifying high-value clusters and low-value clusters in different spatial locations[14]:

$$G_i^*(d) = \frac{\sum_{j=1}^n w_{ij}(d)x_j}{\sum_{i=1}^n x_j} \quad (6)$$

To facilitate interpretation and comparison,  $G_i^*(d)$  is normalized to  $Z(G_i^*) = [G_i^* - E(G_i^*)] / \sqrt{Var(G_i^*)}$ . Where:  $E(G_i^*)$  and  $Var(G_i^*)$  are the mathematical expectation and variance of  $G_i^*$ , respectively, and  $w_{ij}(d)$  is the spatial weight. The positive and negative values of  $Z(G_i^*)$  were used to detect the distribution of cold hotspot areas of tourism spatial accessibility.

### 3. Results and Analysis

#### 3.1. Spatial distribution pattern of A-class scenic spots

##### 3.1.1. Type of spatial distribution

Calculating the actual nearest neighbor distance and

**Table 1.** Most proximity index of different types of scenic spots

Category	All A-class scenic spots	Nature	Humanities
Actual closest distance (Km)	12.01	24.76	14.48
Theoretical nearest distance (Km)	15.54	26.72	19.10
Nearest neighbor index R	0.773	0.927	0.758
Distribution Type	Clustering type	Clustering type	Clustering type

##### 3.1.2. Spatial distribution characteristics

In order to explore the spatial distribution characteristics of each type of A-class tourism scenic spots in Yunnan Province, this paper uses ArcGIS10.5 to analyze the kernel density of all A-class tourism scenic spots, natural scenic spots and humanistic scenic spots, and the results are shown in Figure 1. The results are shown in Figure 1. The spatial distribution of nuclear density of A-class scenic spots in Yunnan Province varies significantly, showing the characteristics of "more in the northwest and central part, less in the east and southwest sides". Further analysis reveals that: firstly, tourist attractions are mainly concentrated in three high nuclear density regions, the western Yunnan region centered on Baoshan, the northwest Yunnan region with Lijiang, Dali and Diqing as the main regions, and the central Yunnan region with Kunming, Jianshui and Wenshan as the main regions, while other regions have relatively low density, especially Zhaotong,

theoretical nearest neighbor distance of A-grade scenic spots in Yunnan Province, the nearest neighbor indexes of all A-grade scenic spots, natural scenic spots and humanistic scenic spots are shown in Table 1, which are 0.773, 0.927 and 0.758 respectively, with R-values less than 1, indicating that the spatial distribution types of these types of scenic spots are all aggregation type. Through comparison, humanistic scenic spots are more aggregated than natural scenic spots, which is due to the fact that natural scenic spots have specific formation conditions and are the products of long-term development of nature, and some landscapes are formed in the process of geographic evolution, while humanistic landscapes are more influenced by human factors and have certain territoriality, so they are more aggregated.

At the same time, the geographical concentration index is used to analyze the geographical concentration of A-class tourist attractions in Yunnan Province, and its geographical concentration index is 28.84, while the average geographical concentration index of prefectures is 25.5. From the perspective of prefectures and cities, A-class tourist attractions in Yunnan Province are concentrated and distributed with unevenness.

Nujiang and Pu'er, where the number of scenic spots is relatively small in general. Secondly, the A-class tourist attractions in Yunnan Province show the characteristics of distribution around administrative sites and cities with better economy, such as the city cluster in central Yunnan centered on the provincial capital Kunming, with dense distribution of attractions, while in some marginal urban areas, the distribution of attractions is sparse. The highest density of humanistic scenic spots is in Baoshan City, followed by Kunming, Yuxi, Honghe and Dali, which form several density zones with a more aggregated distribution, while natural scenic spots are relatively more scattered in distribution. In general, the natural scenic spots in Yunnan Province are distributed along the topography and water system, mostly concentrated in the areas with rich natural landscape, while the humanistic scenic spots are mainly distributed around the central cities in clusters.

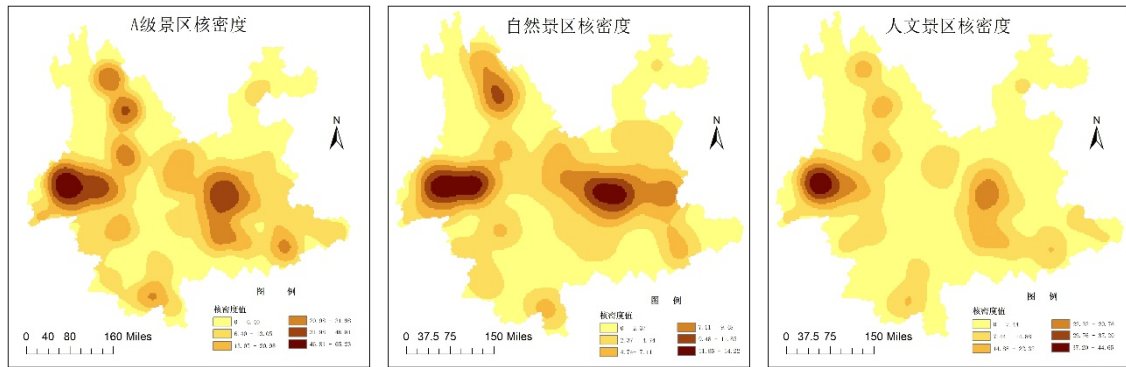


Figure 1. Distribution of nuclear density in different types of scenic spots

### 3.2. Reachability Measure and Evaluation

#### 3.2.1. Accessibility spatial distribution pattern

This study uses attractions, traffic sites and administrative centers as nodes and is based on the highway traffic structure of Yunnan Province, so the travel speed of different levels of

highways needs to be considered. According to the provisions of the "Technical Standards for Highway Engineering of the People's Republic of China (JTGB-2003)" and combined with the actual situation of Yunnan Province, the travel speed of highways at all levels is determined as shown in Table 2.

Table 2. Yunnan Province road traffic network composition and speed

Road grade	High-speed rail	Expressway	national highway	Provincial roads	County roads
Travel speed (km/h)	300	100	80	60	40

In general, the level of socio-economic development and the proximity to airports and high-speed railway stations affect the travel ability and willingness of tourists, so the accessibility of A-class tourist attractions is not only related to the transportation road network, but also has a close relationship with the level of socio-economic development and the relative location of transportation sites, so this paper adds the accessibility of scenic transportation sites and the accessibility of scenic municipal administrative centers to further measure the accessibility of A-class tourist attractions in Yunnan Province. The accessibility of tourist scenic spots in Yunnan Province.

In this paper, the accessibility of all A-class scenic spots, humanistic scenic spots and natural scenic spots, respectively, is measured between scenic spots, scenic spots transportation stations and scenic spots municipal administrative centers. Using each type of scenic spot as the starting point, the average travel time of each scenic spot to reach other scenic spots, the nearest transportation station and the nearest

municipal administrative center is calculated based on the road networks of different grades with certain time intervals, and the accessibility cost is plotted. The results are shown in Figures 2, 3 and 4.

As can be seen from Figure 2, for all A-class scenic spots, the average travel time ranges from 2.86h-15.20h, with an average value of 4.83h; the average travel time for humanistic scenic spots ranges from 2.79h-9.59h, with an average value of 4.68h; the average travel time for natural scenic spots ranges from 2h-15.25h, with an average value of 5.13h. The accessibility between humanistic scenic spots is significantly better than that of natural scenic spots; secondly, the accessibility of all types of scenic spots shows a trend of gradually spreading outward from the central area and gradually decreasing accessibility, with the worst accessibility between attractions in Zhaotong and Diqing, the worse accessibility of natural scenic spots in Diqing, and the worse accessibility of humanistic scenic spots in Zhaotong.

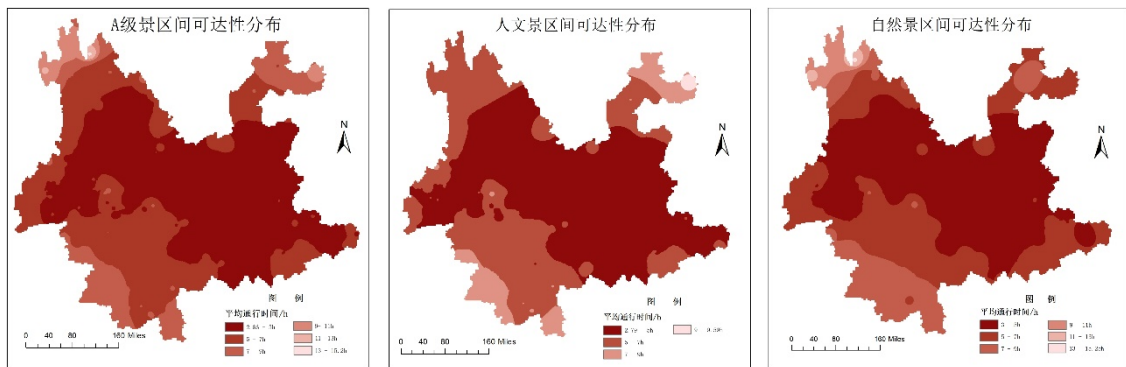


Figure 2. Accessibility costs between different types of scenic spots

From Figure 3, the travel time from A-class scenic spots to the nearest traffic station is between 0.08h-11.44h, with an average value of 1.23h. The areas with high accessibility are mainly the central areas of Kunming, Dali and Lijiang, while

the accessibility of Diqing area is the worst; the travel time from humanistic scenic spots to the nearest station is between 0.13h-4.38h, with an average travel time of 1.1h. The areas with high accessibility are similar to the A-class scenic spots,

and the worst accessibility is located in the fringe areas of Nujiang, Lincang and Lijiang; the travel time from natural scenic spots to the nearest transportation sites ranges from 0.08h-11.48h, with an average travel time of 1.47h, and the areas with high accessibility are in the area from Kunming

and Yuxi to Honghe, while the poor accessibility is in the border of Diqing and some areas of Honghe Prefecture. All three types of scenic spots show a trend of gradually decreasing accessibility outward, centered on high-speed railway lines and airports.

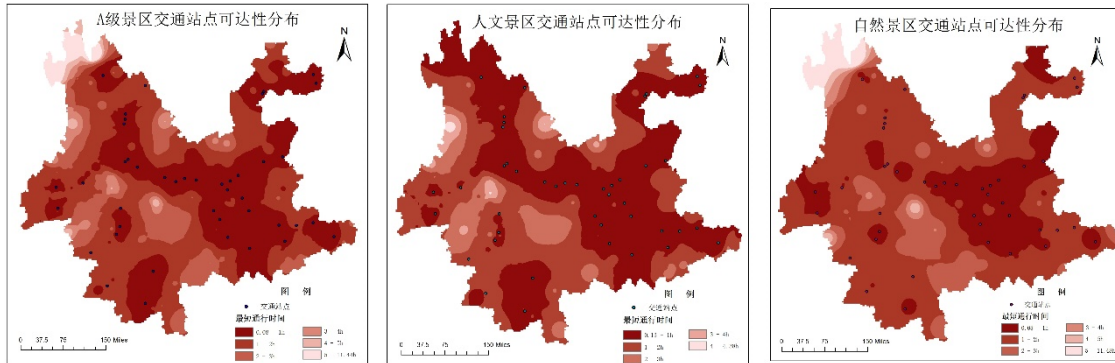


Figure 3. Accessibility cost of transportation stations in different types of scenic spots

From Figure 4, we can see that the accessibility of each type of scenic spots to the municipal administrative center, Kunming, Yuxi, Wenshan, Dali, Lijiang, Baoshan, Xishuangbanna as the center of the circle area is the best, more than fifty percent of the scenic spots the shortest travel time is within 2h, A-class scenic spots to the municipal administrative center of the shortest travel time between 0.12h-11.36h, the average travel time is 1.43h, Diqing border

of The shortest travel time from humanistic scenic spots to the municipal administrative center is between 0.08h-4.08h, with an average travel time of 1.3h; the shortest travel time from natural scenic spots to the municipal administrative center is between 0.22h-11.4h, with an average travel time of 1.68h, with the worst accessibility in the Diqing border, and natural scenic spots are obviously lower than humanistic ones.

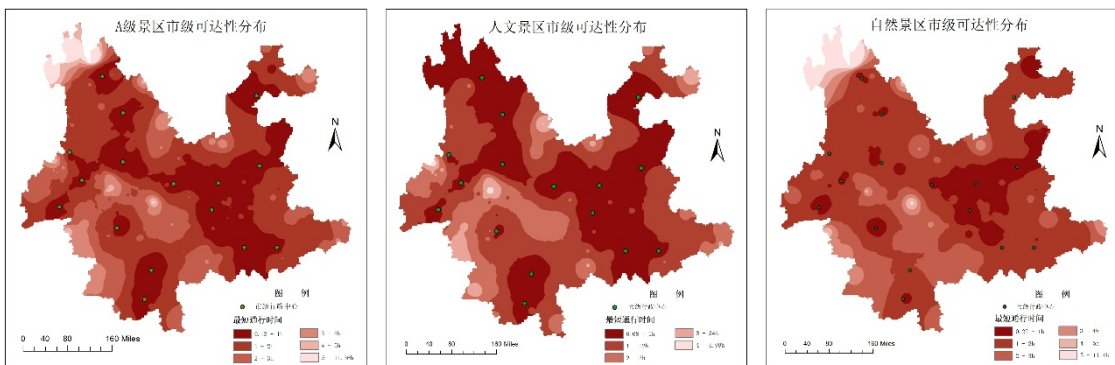


Figure 4. Accessibility costs of municipal administrative centers in different types of scenic areas

In general, the three types of scenic spots with good accessibility are located in areas with developed transportation and economy, while the accessibility of scenic spots in marginal areas is poor; meanwhile, the accessibility of humanistic scenic spots is generally better than that of natural scenic spots, which is due to the fact that humanistic scenic spots are more clustered than natural scenic spots, mainly located in towns with long history and dense road networks, while natural scenic spots are mainly located in places with more natural resources, and These places often have complex landscapes and inconvenient transportation.

### 3.2.2. Spatial correlation characteristics of the reachability distribution

This paper uses spatial autocorrelation analysis and hotspot

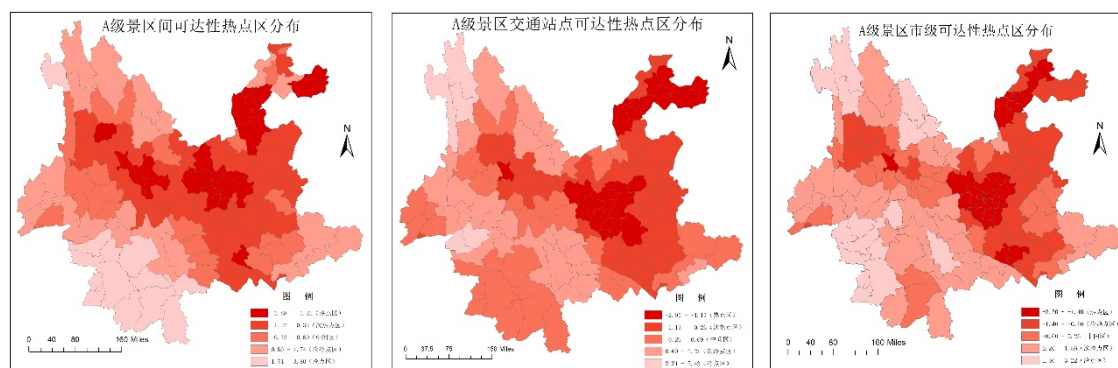
analysis to study the spatial correlation characteristics of inter-view accessibility, transportation site accessibility and municipal accessibility of various types of scenic spots in Yunnan Province on county-level regions. The results are shown in Table 3. The Moran's I of all types is positive, indicating that the accessibility of each type of scenic spots has some spatial autocorrelation on county-level regions, and there is a strong spatial autocorrelation between the accessibility of transportation sites and the accessibility of municipal administrative centers of A-class scenic spots in Yunnan Province.

**Table 3.** Moran's I estimates of accessibility of different types of scenic spots in Yunnan Province

Type	A-class scenic spot	A-class humanistic scenic spot	A-class natural scenic spot
Inter-view accessibility Moran's I	0.13	0.06	0.09
Scenic transportation site accessibility Moran's I	0.28	0.11	0.08
Scenic municipal accessibility Moran's I	0.25	0.06	0.11

At the same time, by calculating the local spatial correlation index of various accessibility of county units in Yunnan Province, they are divided into 5 categories from high to low: hot spot area, sub-hot spot area, middle area, sub-cold spot area and cold spot area, and make a hot spot map of accessibility distribution of A-class scenic spots in Yunnan

Province, as shown in Figure 5. The accessibility hot spots and cold spots are consistent among different types of scenic spots, mainly distributed around Kunming and Yuxi cities, Zhaotong city, Dali Prefecture and Huize County; the cold spots are mainly distributed around Pu'er, Lincang border and Diqing border.

**Figure 5.** Distribution of accessibility hotspot areas in Yunnan Province by type of scenic spots

#### 4. Conclusion and Discussion

In this paper, qualitative and quantitative methods such as the nearest neighbor index, geographic concentration index, kernel density, accessibility measurement model and spatial correlation analysis are integrated to study the spatial differentiation characteristics and accessibility of various types of A-class scenic spots in Yunnan Province, and the following conclusions are drawn:

Firstly, the spatial distribution of A-class scenic spots in Yunnan Province is generally of aggregation type, mainly humanistic scenic spots, which are more aggregated than natural scenic spots. The A-class scenic spots in Yunnan Province are mainly distributed in the three major tourism hotspots, with Kunming, Tengchong and Lijiang as the core areas.

Secondly, the overall accessibility of humanistic scenic spots in Yunnan Province is better than that of natural scenic spots. Airports and high-speed railways have greatly improved the accessibility of scenic spots, shortened the travel time of scenic spots along the routes, and promoted local tourism development. The overall accessibility is poor in the less convenient Zhaotong, Diqing, Nujiang, Lincang, northern Lijiang, and Honghe localities.

Thirdly, the accessibility of each type of scenic spots in Yunnan Province has strong spatial autocorrelation in the county space; the hot spots of A-class scenic spots in Yunnan Province are mainly concentrated in the surrounding area centered on Kunming City, Dali and the area around Huize County, and the cold spots are along the border of Pu'er and Lincang and along the border of Diqing.

Suggestions: Zhaotong, Diqing, Nujiang, Lincang, northern Lijiang, Honghe local, the overall accessibility is poor, mainly affected by traffic conditions, should increase

investment in transportation construction, especially the overall accessibility of natural landscape to be improved.

This paper uses OD cost matrix, based on vector road network, to measure the accessibility of scenic spots by calculating the average travel time and the shortest travel time of scenic spots. It not only studies the accessibility of scenic spots, but also further studies the accessibility of scenic spots to transportation stations and the accessibility of scenic spots to municipal administrative centers, and measures the accessibility of A-class tourist scenic spots in Yunnan Province more deeply, which improves the reliability of data and is more convincing. However, this paper does not consider the influence of specific road conditions, traffic congestion and terrain height on the accessibility of scenic spots, so there may be some differences between the research results and the accessibility level of actual scenic spots, which needs further in-depth study.

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