Spatial Distribution and Accessibility Analysis of Red Tourism Resources in Inner Mongolia (Postprint)

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Abstract

Clarifying the spatial distribution characteristics of red tourism resources and understanding their spatial accessibility constitute the prerequisite foundation for tourism planning to develop high-quality red tourism routes. This study employs methods such as kernel density and geographic concentration index to reveal the spatial distribution characteristics of red tourism attractions in Inner Mongolia, constructs a spatial accessibility measurement model for red attractions based on real-time road traffic conditions obtained through the route planning function of Amap, and utilizes Geodetector to elucidate the influencing factors of accessibility disparities. The results indicate: (1) The spatial distribution of red tourism attractions in Inner Mongolia exhibits a "large dispersion, small aggregation" pattern, with relatively high kernel density values in core areas centered on Hohhot City and Xing'an League, particularly pronounced in the vicinity of Hohhot City. The types of red tourism resources in various leagues and cities exhibit distinctive characteristics; Hohhot City and Baotou City feature relatively complete type categories, yet their distribution equilibrium is comparatively poor. (2) The travel time cost between red tourism attractions in Inner Mongolia is relatively high, with an average travel time of 256.229 min, indicating poor accessibility and substantial internal disparities, with a range value of approximately 274.1 min. The accessibility coefficient ranges from 0.752 to 1.816, and its spatial pattern demonstrates a gradually decreasing zonal characteristic from center to periphery, with Hulunbuir City and Alxa League regions forming accessibility "edge depressions". (3) The scenic area location and scenic spot kernel density factor exhibit the strongest explanatory power for accessibility disparities, and the interaction between these two factors demonstrates the maximum explanatory power. The interaction effects of any two factors on accessibility differentiation are either two-factor enhancement or nonlinear enhancement relationships, with no independent or weakening relationships present.

Full Text

Preamble

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Spatial Distribution and Accessibility Analysis of Red Tourism Resources in Inner Mongolia

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Abstract: Clarifying the spatial distribution characteristics of red tourism resources and understanding their spatial accessibility are fundamental prerequisites for tourism planning to develop high-quality red tourism routes. This study employs kernel density analysis and the geographical concentration index to reveal the spatial distribution patterns of red tourism spots in Inner Mongolia. Based on real-time road traffic conditions obtained through the Amap path planning function, a spatial accessibility measurement model for red tourism spots was constructed, and geographical detectors were used to elucidate the factors influencing accessibility differences. The results indicate: (1) The spatial distribution of red tourism spots in Inner Mongolia exhibits a pattern of "large dispersion, small agglomeration," with high kernel density values concentrated in Hohhot City and Xing'an League, particularly prominent around Hohhot. Each league and city has distinct characteristics in red tourism resource types, with Hohhot and Baotou having relatively complete type categories but poor distribution equilibrium. (2) The travel time cost between red tourism spots in Inner Mongolia is high, with an average travel time of 256.229 minutes, indicating poor accessibility and significant internal variation. The accessibility coefficient ranges from 0.752 to 1.816, showing a "center-periphery" circular gradient pattern. Hulunbuir City and Alxa League have become "edge depressions" in accessibility. (3) The regional location of spots and spot kernel density have the strongest explanatory power for accessibility differences, and their interaction yields the maximum explanatory power. The interaction between any two factors on accessibility differentiation shows either two-factor enhancement or nonlinear enhancement, with no independent or weakening relationships observed.

Keywords: red tourism; spatial distribution; route planning; accessibility; Inner Mongolia

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Red tourism is defined as a thematic tourism activity that uses memorial sites and landmarks established during the revolutionary and wartime periods under the leadership of the Communist Party of China as carriers, with revolutionary history, deeds, and spirit as connotations, for commemorative learning and sightseeing. Since the 18th Party Congress, the political status of red tourism has rapidly elevated, particularly during the centennial celebration of the Communist Party of China, when a nationwide red tourism boom emerged. Central and local governments have successively launched high-quality red tourism routes to meet the growing demand for red tourism. Red scenic spots, as the spatial carriers of red tourism development, are the most fundamental geographical units of tourism resource supply. Clarifying their spatial distribution patterns is a basic prerequisite for regional tourism planning. Currently, at the national scale, scholars have studied the spatial distribution and patterns of red tourism classic scenic spots from a geographical perspective. Some scholars have divided four historical stages—the Old Democratic Revolution, the New Democratic Revolution, the early socialist construction period, and the new era of reform and opening up—to reveal the spatiotemporal distribution characteristics of national red tourism spots. At the regional scale, some scholars have extracted topographic relief based on elevation data to delineate mountainous areas, and subsequently studied the types, distribution, and high-quality development of red tourism resources in China's mountainous regions. Others have investigated the spatiotemporal distribution of tourism flows in Jinggangshan, a red tourism sacred site, and the spatiotemporal evolution patterns of red scenic spots along the Long March route. Overall, academic research on the spatial distribution of red tourism resources has yielded fruitful results, while accessibility studies have focused more on non-red tourism resources.

Common accessibility measurement methods include the ratio method, coverage method, nearest distance method, and two-step floating catchment area (2SFCA) method, as well as improved three-step floating catchment area (3SFCA) method. The ratio and coverage methods generally only measure from the perspective of total quantity or coverage rate, making it difficult to accurately reflect internal accessibility differences. The nearest distance method uses residents' travel costs as accessibility metrics, overemphasizing travel impedance while neglecting the grade and quality of public spaces themselves. Although the 2SFCA algorithm is simple and convenient, and favored by scholars, the setting of search radius thresholds and the failure to consider distance decay factors also introduce biases in measurement results. The 3SFCA algorithm improved with Gaussian or kernel density functions has addressed distance decay issues, but still uses static road network distances under traditional models to characterize the origin-destination distances between supply and demand points, assuming uniform speed and setting different speeds according to road grades—for example, 120 km/h for highways, 80 km/h for national roads, 60 km/h for provincial roads, and 40 km/h for county roads—thus lacking current traffic conditions. The emergence of open-source traffic spatiotemporal big data and the free application of real-time electronic map data from internet map service platforms have enabled real-time traffic to replace traditional static network distances, more accurately measuring travel time and improving the accuracy of spatial accessibility measurement results.

As the first minority autonomous region established under the leadership of the Communist Party of China, Inner Mongolia was one of the earliest ethnic regions to receive the spread of revolutionary ideas from the Communist Party of China. It has a glorious tradition in promoting ethnic unity and has long enjoyed the lofty honor of being a "model autonomous region." As a minority autonomous region with multi-ethnic cohabitation and located on the northern border of the motherland, Inner Mongolia's red tourism resources are highly distinctive in terms of ethnicity and region, providing important guarantees for the high-quality development of red tourism in the new era. Sorting out Inner Mongolia's red tourism resources can not only enhance political and ethnic identity but is also an inevitable requirement for forging a strong sense of community for the Chinese nation. However, research on the spatial distribution patterns of red tourism resources in Inner Mongolia remains limited, and studies on their spatial accessibility are even scarcer. Therefore, systematically and comprehensively revealing the spatial distribution characteristics of red tourism resources in Inner Mongolia, clarifying the types and characteristics of red tourism resources in each league and city, constructing a spatial accessibility model with the aid of internet real-time traffic big data, accurately measuring the spatial accessibility of red tourism resources in Inner Mongolia, and elucidating the influencing factors of accessibility differences can not only provide basic decision-making references for unified layout and scientific and efficient planning of high-quality red tourism routes across the region to avoid blindness and reduce homogeneity but also serve as a proper meaning for Inner Mongolia to "welcome the 20th Party Congress," inherit red genes, and continue the red bloodline.

1. Study Area Overview

Inner Mongolia has a profound revolutionary history and cultural heritage, with rich and varied red tourism resources. By the end of 2021, the region had 118 red tourism resource spots, including 45 rated scenic spots (15 at 4A level and above) and 73 non-rated red scenic spots. Among them, 9 scenic spots have been selected as national red tourism classic spots, and 5 sites including the Ulanhu Former Residence and Memorial Hall have been selected as national patriotism education demonstration bases. Three high-quality red tourism routes have been selected into the national "100 High-quality Red Tourism Routes for the Party's Centennial," including "Unity of Purpose · Joint Resistance to the Enemy" (Figure 1), "Revolutionary Beacon · Red Grassland" (Figure 2) in the module of reviewing warm red history and inheriting the spirit of struggle, and "Green Alxa · Colorful Ejin" (Figure 3) in the module of experiencing poverty alleviation achievements and assisting rural revitalization.

2. Data and Methods

2.1 Data Sources and Processing

The 45 rated scenic spots data at 4A level and above were sourced from the Inner Mongolia Autonomous Region Department of Culture and Tourism. The 73 non-rated red scenic spots data were obtained from the Inner Mongolia Red Culture Tourism Network and official websites of culture and tourism bureaus of various leagues and cities. The geographic spatial location information of scenic spots was obtained using the Amap coordinate picking function to construct a spatial database. The vector data of Inner Mongolia's administrative boundaries and transportation road networks were extracted from the 1:1,000,000 basic geographic information database compiled by the National Basic Geographic Information Center. Digital Elevation Model (DEM) data were downloaded from the Geospatial Data Cloud Platform (http://www.gscloud.cn/) with a spatial resolution of 30m. The Gross Domestic Product (GDP) data at the banner/county level in Inner Mongolia were sourced from the 2020 Inner Mongolia Statistical Yearbook.

2.2 Research Methods

2.2.1 Kernel Density Kernel density analysis was used to characterize the spatial distribution characteristics of red tourism spots in Inner Mongolia. The kernel density method can objectively reflect the dispersion or agglomeration state of point elements in geographic space and is often used to express the sparse degree of point distribution. The calculation formula is:

$$f(s) = \frac{1}{nh^2} \sum_{i=1}^{n} k\left(\frac{d_i}{h}\right)$$

where $f(s)$ is the kernel density estimate at location s; n is the number of scenic spot points; h is the bandwidth; k is the kernel function; and d_i is the distance from location s to the i-th observation location.

2.2.2 Geographical Concentration Index The geographical concentration index can be used to measure the concentration degree of research objects in different regions. This paper uses the geographical concentration index to analyze the spatial agglomeration characteristics of red tourism spots at different scales of leagues/cities and banners/counties. The calculation formula is:

$$G = 100 \times \sqrt{\frac{\sum_{i=1}^{n} X_i^2}{T^2}}$$

where G is the geographical concentration index; X_i is the number of red tourism spots in each region; n is the number of regions; and T is the total number of spots.

2.2.3 Path Planning Method The Application Programming Interface (API) of Amap path planning can reflect real-time traffic network conditions. Users can retrieve multi-mode and multi-requirement real-time path planning service solutions according to their preferences based on origin-destination coordinates. Python data analysis can efficiently and conveniently batch-obtain information such as origin-destination distances and travel times. To obtain more objective and accurate average travel times, this study randomly selected 5 days within a week to collect data, obtaining 13,806 travel time information entries between 118 red scenic spots under self-driving mode. Data collection began at 08:00 each day, and then the average travel time between scenic spots and accessibility coefficients were calculated.

2.2.4 Spatial Accessibility According to the research purpose, the travel time between scenic spots was used to measure the network accessibility of each spot. The calculation formula is:

$$A_i = \frac{\sum_{j=1}^{n} T_{ij}}{n}$$

where A_i is the average travel time of spot i, with smaller values indicating better accessibility; T_{ij} is the shortest travel time from spot i to spot j; and n is the number of spots.

To objectively reflect the relative differences in accessibility of each scenic spot, this paper uses the accessibility coefficient to normalize the average travel time of spots. The accessibility coefficient is the ratio of the average travel time of a spot to the average value of all spots' average travel times in the network. The calculation formula is:

$$A_i' = \frac{A_i}{\frac{\sum_{i=1}^{n} A_i}{n}}$$

where A_i' is the accessibility coefficient of spot i; A_i is the average travel time of spot i; and n is the number of spots. The value range of A_i' is [0, 2], representing the accessibility level of the spot. Larger A_i' values indicate worse accessibility. $A_i' > 1$ indicates that the spot's accessibility is below the regional average level, while $A_i' < 1$ indicates that the spot's accessibility is better than the average level.

2.2.5 Geographical Detector Geographical detectors are mainly used to explore spatial differentiation of various phenomena to reveal their driving forces and influencing factors as well as multi-factor interactions. The factor detection formula is:

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

where q measures the degree to which factor X explains the spatial differentiation of attribute Y. L is the stratification of variable Y or factor X, i.e., classification or zoning; N and N_h are the number of units in the whole region and layer h, respectively; σ_h^2 and σ^2 are the variances of Y values in layer h and the whole region, respectively. The value range of q is [0, 1], with larger values indicating more obvious spatial differentiation of Y. If stratification is generated by independent variable X, a larger q value indicates stronger explanatory power of independent variable X on attribute Y, and vice versa.

Interaction detection identifies the interaction between different influencing factors, i.e., whether the joint action of factors X_1 and X_2 will increase or decrease the explanatory power on dependent variable Y, or whether these factors are independent. First, calculate the q values of factors X_1 and X_2 on Y, then calculate the q value when factors interact, and finally compare the q values. According to the comparison results, the relationship between the two factors can be divided into five categories (Table 1).

Table 1 Interaction type
Tab. 1 Interaction type

Interaction Type	q-value Relationship
Nonlinear Weakening	$q(X_1 \cap X_2) < \mathrm{Min}[q(X_1), q(X_2)]$
Single-factor Nonlinear Weakening	$\mathrm{Min}[q(X_1), q(X_2)] < q(X_1 \cap X_2) < \mathrm{Max}[q(X_1), q(X_2)]$
Two-factor Enhancement	$q(X_1 \cap X_2) > \mathrm{Max}[q(X_1), q(X_2)]$
Independent	$q(X_1 \cap X_2) = q(X_1) + q(X_2)$
Nonlinear Enhancement	$q(X_1 \cap X_2) > q(X_1) + q(X_2)$

Note: q is the explanatory power of influencing factors; X is the influencing factor.

3. Results Analysis

3.1 Spatial Distribution Characteristics

3.1.1 Spatial Distribution Pattern The kernel density of red tourism spots in Inner Mongolia shows obvious regional differences, with an overall "large dispersion, small agglomeration" phenomenon and distinct "dual-core and belt" characteristics (Figure 2). The "dual-core" feature of kernel density is evident around Hohhot City and Xing'an League, especially in the area centered on Hohhot where red tourism spots are most densely concentrated. The "belt" pattern is mainly distributed in the southeastern Xing'an League-Chifeng City area and the southern Ulanqab City-Baotou City area. The kernel density values of red tourism spots in the northern border areas of Hulunbuir City, Xilingol League, Bayannur City, and Alxa League are relatively small.

At the city level, the overall geographical concentration index of red tourism spots in Inner Mongolia is 38.59, which is greater than the geographical concentration index when spots are evenly distributed across 12 cities (28.87). At the banner/county level, the geographical concentration indices of red spots in Wuhai City, Alxa League, and Ordos City are the highest, at 100, 70.71, and 70.71, respectively. A larger index value indicates more concentrated distribution and poorer spatial distribution equilibrium, while a smaller value indicates more dispersed distribution. Comprehensive comparison shows that Chifeng City (25.00) and Hohhot City (27.73) have lower geographical concentration indices, indicating that these two cities have relatively dispersed distribution of red spots at the banner/county level.

3.1.2 Types of Scenic Spots Distribution by League and City According to the classification of scenic spot categories by Chen Guolei et al. and combined with the nature of the spots, Inner Mongolia's red tourism spots are divided into five categories: revolutionary institution offices, major event sites, revolutionary figure residences/memorial halls, revolutionary martyrs' cemeteries, and various revolutionary museums/memorial halls. Hohhot City and Baotou City have the most complete types of red scenic spots. In addition to conventional types, other types of red spots are also unique. For example, Hohhot's Daqingshan Red Cultural Park, relying on the core area of grassland landscape, houses exhibition halls on the revolutionary history of the Daqingshan area and experience halls for military camp cultural life, making it an open cultural tourism park integrating multiple functions such as visiting, education, commemoration, leisure, and fitness. Baotou City's North Weaponry City is the largest military-themed characteristic tourism scenic spot in western China, and the Baotou Steel Industrial Tourism Scenic Area showcases the struggle anthem of "ethnic unity as one family, building Baotou Steel with concerted efforts."

Revolutionary institution offices are mainly distributed in Xing'an League, such as the former office of Ulanhu, the former office of the Inner Mongolia Working Committee of the Communist Party of China, and the site of the Inner Mongolia Military Region Command. Chifeng City has the largest number of revolutionary martyrs' cemeteries, with the Chaihulanzi Martyrs' Cemetery located here. Major event sites are concentrated in Hulunbuir City, such as the World Anti-Fascist War Hailar Memorial Park and the Nomonhan Battle Exhibition Hall, which tell the stories of major battles. Alxa League and Ulanqab City have the fewest types of red scenic spots (Table 2).

Table 2 Number of red tourism resources in Inner Mongolia
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Region	Revolutionary Institution Offices	Major Event Sites	Revolutionary Figure Residences	Revolutionary Martyrs' Cemeteries	Various Revolutionary Museums	Total
Hohhot City	3	1	3	2	2	11
Baotou City	1	1	2	2	2	8
Xing'an League	4	1	1	1	1	8
Chifeng City	1	1	1	5	1	9
Tongliao City	1	1	1	1	1	5
Hulunbuir City	0	3	1	1	1	6
Xilingol League	1	1	1	1	1	5
Ulanqab City	1	1	0	2	0	4
Ordos City	1	1	1	1	1	5
Bayannur City	1	1	1	1	1	5
Wuhai City	1	0	0	1	0	2
Alxa League	1	1	0	1	1	4
Total	**16**	**13**	**12**	**19**	**12**	**118**

3.2 Spatial Accessibility Characteristics

3.2.1 Quantitative Features of Spatial Accessibility The travel time between red tourism spots in Inner Mongolia ranges from 192.647 to 466.747 minutes, with an average travel time of 256.229 minutes. This comprehensively indicates that the average travel time cost for red spots is high, overall accessibility is poor, and there is strong volatility in average travel time values among spots. The shortest travel time is for Taibus Banner Martyrs' Cemetery at approximately 192.647 minutes, while the longest is for Dongfeng Revolutionary Martyrs' Cemetery in Alxa League at approximately 466.747 minutes. The range is as high as 274.1 minutes, fully demonstrating prominent internal differences in accessibility among red spots in Inner Mongolia, with large variations in travel time costs between different spots.

Furthermore, from the perspective of accessibility coefficients, their value range is 0.752–1.816, with a range of 1.064, further reflecting the stark contrast in accessibility among red spots. Among them, 42.675% of spots have accessibility higher than the overall average, indicating that nearly half of the red spots have not reached the overall average level of accessibility. Taibus Banner Martyrs' Cemetery, Jining Martyrs' Cemetery, and Ganzhi Mei Martyrs' Cemetery have the lowest accessibility coefficients, followed by the Inner Mongolia Revolutionary History Museum, Inner Mongolia Martyrs' Cemetery, and Inner Mongolia Museum. These spots are located in central Inner Mongolia's Hohhot City, Ulanqab City, and Xilingol League region, occupying geographical location advantages. Especially Hohhot City, as the autonomous region's capital, its location advantages and developed transportation network result in better accessibility in this region.

3.2.2 Spatial Differentiation Pattern of Accessibility Using ArcGIS spatial interpolation simulation of spot accessibility coefficients, the spatial differences in red spot accessibility are visually presented. The spatial accessibility of red tourism spots in Inner Mongolia shows a significant "center-periphery" circular gradient pattern, with accessibility coefficients gradually increasing from the central area to the peripheral edges. That is, accessibility gradually decreases in a circular pattern centered on Hohhot City, Ulanqab City, and Xilingol League (Figure 3). Dongfeng Revolutionary Martyrs' Cemetery and Dongfeng Space City Tourist Area in the westernmost Alxa League, and Busuli Northern Border Military Culture Tourist Area in the northernmost Hulunbuir City have high accessibility coefficient values of 1.816 and 1.735, respectively. These scenic spots are located at the two extremes of Inner Mongolia from east to west. Inner Mongolia extends diagonally from northeast to southwest in a narrow shape, approximately 2,400 km long, with underdeveloped transportation networks in this region, resulting in poor accessibility.

Hotspot analysis of inter-spot accessibility (Figure 3) also shows that red spots around Hohhot City present cold spot agglomeration, indicating better accessibility. Red spots in Hulunbuir City and Alxa League present hotspot agglomeration, indicating poorer accessibility, making them "edge depressions" in the accessibility distribution of red scenic spots.

3.3 Factors Influencing Spatial Accessibility Differences of Red Tourism Spots

Based on existing research results and combined with regional conditions in Inner Mongolia, seven variables were selected as detection elements affecting spatial accessibility differences of scenic spots: elevation, topographic relief, road network density, spot kernel density, spot regional location, geographical concentration index, and county-level GDP. Factor detection results show that the top three factors with strong explanatory power for spatial accessibility differences are spot regional location, spot kernel density, and county-level GDP, with q-values of 0.45, 0.41, and 0.35, respectively. Road network density (0.28) and geographical concentration index (0.21) follow, while topographic relief has the weakest explanatory power (0.12).

Interaction detection results (Table 3) show that the interaction between any two factors on spot accessibility differences is an enhancement relationship, not a simple superposition effect, but two-factor enhancement or nonlinear enhancement, with no independent or weakening relationships. The interaction between spot regional location and spot kernel density has the strongest explanatory power, reaching 0.71, followed by spot regional location and geographical concentration index (0.62), while the interaction between topographic relief and road network density has the weakest explanatory power (0.45). This indicates that the reasons for spatial accessibility differences are mainly determined by the spot's own spatial location and the kernel density agglomeration degree of surrounding adjacent red spots. Red spots located in central Inner Mongolia and those in densely distributed areas have absolute advantages in spatial accessibility levels, while spots farther from central locations and with lower distribution density have poorer accessibility. Although road network density and topographic relief have smaller influences, there is a significant negative correlation between road network density and accessibility coefficient—that is, the more developed and denser the transportation network around a spot, the lower its accessibility coefficient and the better its accessibility.

Table 3 Detection results of factor interaction
Tab. 3 Detection results of factor interaction

Factor	Spot Regional Location	Spot Kernel Density	Geographical Concentration Index	Topographic Relief	Road Network Density	County GDP
Spot Regional Location	0.45	0.71a	0.62a	0.58a	0.59a	0.61a
Spot Kernel Density	-	0.41	0.55a	0.53a	0.54a	0.56a
Geographical Concentration Index	-	-	0.21	0.49a	0.51a	0.52a

Factor	Spot Regional Location	Spot Kernel Density	Geographical Concentration Index	Topographic Relief	Road Network Density	County GDP
Topographic Relief	-	-	-	0.12	0.45a	0.48a
Road Network Density	-	-	-	-	0.28	0.50a
County GDP	-	-	-	-	-	0.35

Note: DEM is Digital Elevation Model; County GDP is county-level Gross Domestic Product; a indicates two-factor enhancement; b indicates nonlinear enhancement.

4. Discussion

Accessibility calculation is mainly influenced by travel time and distance, with transportation mode selection, road network conditions, and actual travel speed playing decisive roles. Constructing accessibility models based on traditional static road networks requires complete transportation road network data, which is difficult for ordinary users to obtain for different road systems, and cannot guarantee that all spots fall on the road network, requiring the removal of such spots or substitution with other low-grade roads. This study constructs a travel time consumption model based on Amap path planning, which is the optimal selection result integrating urban road directions, travel modes, traffic barriers, and other information. Using optimal path accessibility to replace traditional static straight-line distances reflects complex urban spatial texture. The measurement results not only reflect the real accessibility status under real-time traffic conditions between origins and destinations but also represent non-uniform traffic conditions with current validity.

Research shows that the spatial accessibility of red tourism resources in Inner Mongolia presents a "center-periphery" circular gradient pattern, with spots in regional centers and kernel density agglomeration areas having better accessibility, gradually decreasing in an approximate circular pattern outward. This phenomenon is consistent with accessibility results for tourist spots in the Wuling Mountain area and red villages in Hunan Province, proving the universality of the accessibility measurement model constructed in this study. However, the overall travel time cost for red spots in Inner Mongolia is high, with an average travel time of 256.229 minutes, poor accessibility, and large internal differences with a range of approximately 274.1 minutes. The accessibility coefficient value range of 0.752–1.816 further reflects the "center-periphery" circular gradient pattern, with Hohhot City as the center showing gradually decreasing accessibility. Hulunbuir City and Alxa League are "edge depressions" in the spatial accessibility of red spots in Inner Mongolia.

Geographical detector results reveal that differences in spatial accessibility of red tourism resources are greatly influenced by spot regional location and the distribution density of surrounding red spots, a conclusion consistent with research on highway accessibility of red villages in Hunan Province. The core circle of Hohhot City is located in central Inner Mongolia with superior geographical location, numerous and concentrated red tourism resources, and serves as the economic and cultural center of Inner Mongolia with a dense and developed road transportation network, collectively influencing the spatial accessibility of red tourism resources. The northernmost Hulunbuir City and westernmost Alxa League have remote geographical locations, limited and sparse distribution of red scenic spots, and relatively poor transportation network accessibility. However, Inner Mongolia's only 5A-level red spot—the China-Russia Border Tourism Area (Red International Secret Transportation Line Education Base in Manzhouli City)—is located in Hulunbuir's Manzhouli City, one of the 300 red tourism spots nationwide. Meanwhile, Hulunbuir City and Alxa League are also high-quality regions for tourism resources in Inner Mongolia, with distinctive tourism resources and concentrated distribution of 5A-level scenic spots. These regions should further integrate characteristic and advantageous tourism resources to achieve a "red + green" tourism model.

Red tourism is a political and cultural project with unique value in strengthening ideological education and inheriting red genes. The formulation of high-quality red tourism routes in Inner Mongolia in the new era must have clear-cut positions, closely focusing on the core theme of enhancing political identity, ethnic identity, and forging a strong sense of community for the Chinese nation, deeply exploring red resources in Inner Mongolia, and scientifically planning and unifiedly laying out the cultural chapter of "inheriting red genes and continuing the red bloodline." Simultaneously, red tourism is also a project for enriching people and winning hearts. The formulation of high-quality red tourism routes in Inner Mongolia must coordinate the overall situation, focus on exploring regional advantageous tourism resources, make good use of Inner Mongolia's green tourism resource foundation, reduce homogeneity, avoid blindness, coordinate cross-regional cooperation mechanisms, build a new "red + green" model, achieve resource sharing, complementary advantages, tourist exchange, transportation interconnection, joint route construction, and joint brand promotion, striving to create a high-quality red tourism system and jointly write a new chapter for Inner Mongolia's red tourism in forging a strong sense of community for the Chinese nation.

This study uses geographic information technology to clarify the spatial distribution characteristics of red tourism resources in Inner Mongolia, elucidates the characteristic advantages of red tourism resources in each league and city, and breaks through the constraint bottleneck of traditional static road network uniform-speed travel in previous scenic spot accessibility calculations by leveraging internet real-time traffic information, making accessibility measurement more scientific and accurate. However, this study only considers self-driving travel mode without comparing other travel modes, making it difficult to meet the urgent needs of local governments to formulate multi-mode and multi-demand red tourism routes. The isochrone division model oriented to service demand can solve the problem of "time required to reach the nearest facility of interest from any location" according to user needs, thereby generating isochrones to analyze target point accessibility, which will provide references for formulating red tourism routes meeting different groups' needs and will be the focus of future research.

5. Conclusions and Recommendations

1) The spatial distribution kernel density of red spots in Inner Mongolia overall shows a "large dispersion, small agglomeration" phenomenon. High kernel density values are concentrated in the core areas of Hohhot City and Xing'an League, with particularly significant agglomeration characteristics around Hohhot City. The types of red spots vary significantly among leagues and cities, with Hohhot City and Baotou City having relatively complete types but poor spatial distribution equilibrium.

2) The overall travel time cost between red spots in Inner Mongolia is high, with an average travel time of 256.229 minutes, poor accessibility, and large internal differences with a range of approximately 274.1 minutes. The accessibility coefficient value range of 0.752–1.816 shows a "center-periphery" circular gradient pattern, with accessibility gradually decreasing from Hohhot City as the center. Hulunbuir City and Alxa League are "edge depressions" in the spatial accessibility of red spots in Inner Mongolia.

3) Spot regional location and spot kernel density have the strongest explanatory power for accessibility differences. The interaction of any two factors on accessibility differentiation shows enhancement relationships, not simple superposition effects, but two-factor enhancement or nonlinear enhancement, with no independent or weakening relationships.

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Note: Figure translations are in progress. See original paper for figures.