Spatial Distribution Characteristics and Sustainable Development of Sports Tourism Resources: A Case Study of Xinjiang (Postprint)

Authors: Yang Di, Zou Jin, Xiaofei Ma, Zhang Xun, Zhou Rui, Liu Yanchun, Shi Jinlian

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Abstract

Tourism is an important pillar industry in Xinjiang, and sports tourism is a key lever for advancing the strategy of invigorating Xinjiang through tourism. Revealing the spatial distribution characteristics and influencing factors of sports tourism resources can provide a scientific basis for the sustainable development of Xinjiang's sports tourism industry. Taking Xinjiang's sports tourism resources in 2022 as the research object, this study comprehensively applies exploratory spatial data analysis and the geographical detector to quantitatively investigate their spatial distribution characteristics and influencing factors. The results show that: (1) The spatial distribution of Xinjiang' s sports tourism resources in 2022 is significantly unbalanced and highly agglomerated, mainly concentrated in Urumqi, Changji Hui Autonomous Prefecture, and the directly administered counties and cities of Ili Kazakh Autonomous Prefecture; overall, it exhibits a "more in the north, less in the south" distribution pattern and forms a three-core spatial distribution structure of "one primary and two secondary" cores. In addition, spatial dependence is evident, spatial correlation differs markedly, and cold and hot spots are unevenly distributed. (2) The spatial distribution of Xinjiang' s sports tourism resources is influenced by multidimensional factors such as geography, transportation, and resources. Among them, mean annual precipitation, distance to transportation hubs, mean annual temperature, and elevation are the main influencing factors, while road network density and population size have relatively minimal impact. The dominant type of interaction is bivariate enhancement, indicating that the spatial distribution of Xinjiang' s sports tourism resources is the result of the combined action of multiple factors. On this basis, scientifically grounded and reasonable recommendations are proposed for the sustainable development of Xinjiang' s sports tourism industry.

Full Text

Preamble

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Spatial Distribution Characteristics and Sustainable Development of Sports Tourism Resources: A Case Study of Xinjiang

YANG Di[1], ZOU Jin[2], MA Xiaofei[3], ZHANG Xun[1], ZHOU Rui[4], LIU Yanchun[2], SHI Jinlian[1]

[1]Beijing Technology and Business University, Beijing 100048, China
[2]Hotan College of Xinjiang, Hotan 848099, Xinjiang, China
[3]State Key Laboratory of Desert and Oasis Ecology, Key Laboratory of Ecological Safety and Sustainable Development in Arid Lands, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, Xinjiang, China
[4]Institute of Earthquake Forecasting, China Earthquake Administration, Beijing 100036, China

Abstract: Tourism is an important pillar industry in Xinjiang, and sports tourism serves as a crucial lever for advancing the "Tourism Prospering Xinjiang" strategy. Revealing the spatial distribution characteristics and influencing factors of sports tourism resources can provide a scientific basis for the sustainable development of Xinjiang' s sports tourism industry. This study takes Xinjiang' s sports tourism resources as the research object and comprehensively employs exploratory spatial data analysis and geographical detectors to quantitatively explore their spatial distribution characteristics and influencing factors. The results indicate that: (1) The spatial distribution of sports tourism resources in Xinjiang in 2022 exhibits significant imbalance, showing a highly aggregated pattern primarily concentrated in Urumqi City, Changji Hui Autonomous Prefecture, and the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture. Overall, it presents a distribution pattern of "more in the north, less in the south," forming a three-core spatial distribution pattern of "one primary and two secondary centers." Additionally, spatial dependence is pronounced, with substantial differences in spatial correlation and uneven distribution of cold and hotspot areas. (2) The spatial distribution of sports tourism resources in Xinjiang is influenced by multi-dimensional factors including geography, transportation, and resources. Among these, average annual precipitation, distance from transportation hubs, average annual temperature, and elevation are the main influencing factors, while road network density and population have relatively minimal impact. The interaction type is primarily dual-factor enhancement, indicating that the spatial distribution of sports tourism resources in Xinjiang results from the joint action of multiple factors. Based on these findings, scientifically sound recommendations are proposed for the sustainable development of Xinjiang' s sports tourism industry.

Keywords: sports tourism resources; spatial distribution; influencing factors; Xinjiang

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In May 2024, General Secretary Xi Jinping made important instructions on tourism work, proposing to "accelerate the construction of a tourism powerhouse and enable tourism to better serve a better life, promote economic development, and build a spiritual homeland." In recent years, with the in-depth implementation of the Healthy China strategy, sports tourism has attracted significant national attention and is flourishing, gradually becoming an important choice for people pursuing healthy lifestyles and leisure entertainment. In 2023, the number of domestic sports tourism participants exceeded 200 million, accounting for 15.4% of China' s total tourist population, with total sports tourism consumption exceeding 1.5 trillion yuan.

Sports tourism, as a unique field combining sports activities and tourism experiences, has gradually attracted academic attention. Research content covers impacts on economic and social aspects, sports tourist behavior, sports tourism destination marketing, industrial development models, resource development and evaluation, and spatial patterns and influencing factors. Methodologies involve statistics, economics, geography, and other disciplines. For instance, some scholars have used structural equation modeling to study the structural relationships among participation motivation, value co-creation processes, and behavioral consequences in participatory sports tourism, while others have employed SWOT analysis to examine the development status of leisure sports tourism resources in Guangyuan City. Luo Liang et al. used GIS spatial analysis to analyze the spatial distribution characteristics of sports tourism resources in Hunan Province.

Through literature review, we find that current studies on the spatial patterns of sports tourism resources typically combine quantitative and qualitative approaches to explore spatial distribution characteristics and influencing factors. However, these studies often rely on single-source data for sports tourism resources, with discussions on influencing factors remaining largely at the qualitative level, and research areas focusing primarily on traditional hotspot urban agglomerations, rarely selecting Xinjiang where tourism is a pillar industry. In view of this, this study focuses on Xinjiang, employing multi-source data including Gaode Map POI data and official resources, and comprehensively using exploratory spatial data analysis and geographical detectors to quantitatively explore the spatial distribution characteristics and influencing factors of Xinjiang' s sports tourism resources in 2022. Based on this analysis, recommendations for the sustainable development of Xinjiang' s sports tourism industry are proposed, aiming to provide references for optimizing sports tourism industrial structure and adjusting spatial layout nationwide.

1.1 Study Area Overview

Xinjiang is located in the northwestern border of China, in the hinterland of the Eurasian continent, and is China' s largest provincial-level administrative region by area. Xinjiang has diverse topography and rich natural landscape resources, such as mountains, grasslands, deserts, and lakes, providing unique conditions for sports tourism. The climate types are varied, ranging from arid desert climate to alpine cold climate, creating a favorable environment for various outdoor sports tourism activities such as skiing, mountaineering, and hiking. Additionally, Xinjiang is a multi-ethnic region, and its unique folk culture and ethnic customs, such as Kazakh horse racing and wrestling, add infinite charm to sports tourism. In recent years, Xinjiang has vigorously promoted the deep integration of sports and tourism, successfully creating a batch of high-quality sports tourism projects that drive economic development.

1.2 Classification of Sports Tourism Resources

This study adopts Yu Sumei' s definition of sports tourism resources as the sum of all things and factors in nature or human society that can attract sports tourists, enable sports tourism activities, be utilized by the tourism industry, and generate social, economic, and ecological benefits. Referencing the national standard "Classification, Investigation and Evaluation of Tourism Resources" (GB/T18972-2003) and combining it with Xinjiang's sports tourism development characteristics, sports tourism resources are divided into main categories, sub-categories, and basic types across three levels (Table 1).

Table 1 Classification of sports tourism resources

Main Category	Sub-category	Basic Type
Sports Leisure Activities	Park leisure sports, fishing, golf, camping, etc.	
Physical Fitness	Mountaineering, outdoor hiking, etc.	
Passionate Adventure	Exploration, rafting, off-road, skiing, etc.	
Sports Events	Large, medium, and small sports events	
Natural Landscapes		
Ethnic Folklore	Ethnic sports festivals	
Modern Festivals	Tourism festivals and other activities	
Sports Architecture Facilities		

1.3 Data Sources

This study is based on Gaode Map POI data, comprehensively utilizing official resources from the State General Administration of Sport, Xinjiang Uygur Autonomous Region Sports Bureau, and Xinjiang Uygur Autonomous Region Department of Culture and Tourism. Combined with web searches, supplementary data from travel platforms such as Qunar and Ctrip were used to organize and screen 1,372 sports tourism resources. Among these, sports event resources were selected from January 2020 to December 2022. According to the above classification, sports tourism resources were divided into eight categories: sports leisure activities, physical fitness, passionate adventure, sports events, natural landscapes, ethnic folklore, modern festivals, and sports architecture facilities.

Elevation data were obtained from 30 m resolution ASTER GDEM digital elevation data on the Geospatial Data Cloud, with slope data derived through slope analysis. Precipitation data were obtained from ERA5-Land 0.1° resolution monthly average precipitation data. Temperature data were obtained from 1 km resolution monthly average temperature data from the National Tibetan Plateau Scientific Data Center. Vegetation cover index data were obtained from MOD13A3 1 km resolution monthly normalized difference vegetation index (NDVI) data, with annual averages calculated to obtain yearly data. Population data were obtained from LandScan 1 km resolution population distribution data. Water system and road network data were obtained from OpenStreetMap. Transportation hubs and tourist attractions data were obtained from Gaode Map.

1.4 Methods

1.4.1 Exploratory Spatial Data Analysis Exploratory Spatial Data Analysis (ESDA) refers to the use of a series of spatial data analysis methods and techniques to describe and visualize the spatial distribution patterns of phenomena, revealing the spatial interaction mechanisms between research objects. It serves as a powerful tool for exploring the spatial distribution characteristics of sports tourism resources. This study uses nearest neighbor index and grid dimension analysis to explore the spatial distribution types of Xinjiang' s sports tourism resources, kernel density analysis to explore their spatial distribution density, and spatial autocorrelation analysis to explore their spatial correlation.

1) Nearest Neighbor Index

The nearest neighbor index is used to analyze the proximity of point features. This study employs the nearest neighbor index to explore the spatial distribution types of sports tourism resources. The calculation formula is:

$$\gamma = \frac{\bar{d}_1}{\bar{d}_E}$$

where γ is the nearest neighbor index; $\bar{d}_1$ is the actual average nearest neighbor

distance; and $\bar{d}_E$ is the expected average nearest neighbor distance. When $\gamma < 1$, it indicates aggregated distribution; when $\gamma > 1$, it indicates uniform distribution; and when $\gamma = 1$, it indicates random distribution.

2) Grid Dimension Analysis

Grid dimension analysis can characterize the fractal features of self-similar systems and effectively measure whether point features are evenly distributed within a region. The main measurement indicators are capacity dimension and information dimension, with values ranging between 0 and 1. Larger values indicate more balanced distribution characteristics. This study uses grid dimension analysis to explore the complexity and equilibrium degree of sports tourism resource spatial distribution.

If the spatial distribution of sports tourism resources has scale-free properties, then:

$$N(r) \propto r^{-D_0}$$

where r is the grid size; $N(r)$ is the number of grids occupied by sports tourism resources; and D_0 is the capacity dimension.

According to the information entropy formula, the information content $I(r)$ has the following relationship with the probability of sports tourism resource distribution in grids (P_{ab}):

$$I(r) = -\sum_{a=1}^{k}\sum_{b=1}^{k} P_{ab} \ln P_{ab}$$

where $P_{ab} = \frac{M_{ab}}{M}$, k is the number of segments; M_{ab} is the number of sports tourism resources distributed in the grid at row a and column b; and M is the total number of sports tourism resources. If the sports tourism resource point set is fractal, then:

$$I(r) \propto r^{-D_1}$$

where D_1 is the information dimension.

3) Kernel Density Analysis

Kernel density analysis can measure the distribution density of features within a region. This study uses kernel density analysis to explore the spatial distribution density of sports tourism resources. The calculation formula is:

$$f(x) = \frac{1}{Mh^2}\sum_{t=1}^{M} K\left(\frac{x - x_t}{h}\right)$$

where $f(x)$ is the kernel density; K is the kernel function; x is the estimated value point; d is the distance from the estimated value point x to the measurement point x_t; and h is the bandwidth.

4) Spatial Autocorrelation Analysis
Spatial autocorrelation analysis is used to study the overall and local spatial relationships of spatial units. This study uses spatial autocorrelation analysis to determine the spatial correlation of sports tourism resources. When analyzing global spatial relationships, the measurement indicator is the Global Moran' s I, calculated as:

$$\text{Global Moran's I} = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}(y_i-\bar{y})(y_j-\bar{y})}{\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}\sum_{i=1}^{n}(y_i-\bar{y})^2}$$

where y_i and y_j are the observed values of spatial units i and j; W_{ij} is the spatial weight; $\bar{y}$ is the average of observed values of all spatial units; and n is the number of spatial units. A positive Global Moran' s I indicates positive spatial correlation in sports tourism resource distribution, a negative value indicates negative spatial correlation, and a zero value indicates no spatial correlation.

The Local Moran' s I and Getis-Ord G_i^* index are used to comprehensively measure local spatial relationships, with the Local Moran' s I calculated as:

$$I_i = \frac{z_i}{\sigma^2}\sum_{j=1}^{n}W_{ij}z_j$$

where I_i is the Local Moran' s I of spatial unit i; z_i and z_j are the standardized observed values of spatial units i and j. Based on the magnitude of I_i, spatial units can be divided into four spatial association patterns: high-high clusters, high-low clusters, low-high clusters, and low-low clusters.

The Getis-Ord G_i^* is calculated as:

$$G_i^* = \frac{\sum_{j=1}^{n}W_{ij}y_j}{\sum_{j=1}^{n}y_j}$$

If G_i^* is significantly positive, it indicates that spatial unit i is a hotspot area with high-value clustering; if G_i^* is negative, it indicates that spatial unit i is a coldspot area with low-value clustering.

1.4.2 Geodetector Geodetector is used to explore spatial differentiation and its driving factors. This study employs Geodetector to analyze the influencing factors of sports tourism resource spatial distribution. Factor detection measures the strength of influencing factors on sports tourism resource spatial distribution, quantified by the q value. The calculation formula is:

$$q = 1 - \frac{\sum_{l=1}^{L} N_l \sigma_l^2}{N\sigma^2}$$

where N_l and σ_l^2 are the sample size and variance of region l; N and σ^2 are the total sample size and variance. The q value ranges from 0 to 1, with larger values indicating greater explanatory power.

Interaction detection explores the interaction between influencing factors, i.e., whether the joint action of two factors enhances or weakens the explanatory power for the dependent variable.

2.1 Spatial Distribution Characteristics of Sports Tourism Resources in Xinjiang

This study analyzes the spatial distribution of Xinjiang' s sports tourism resources from three dimensions: spatial distribution differences, spatial distribution types, and spatial distribution density and spatial correlation. It can be seen that in 2022, Xinjiang's sports tourism resources were mainly distributed in northern Xinjiang, relatively concentrated in Urumqi City, gradually decreasing outward, while relatively scarce in southern Xinjiang.

2.1.1 Spatial Distribution Differences

From the perspective of spatial distribution differences, there are significant differences in the number of sports tourism resources distributed across different regions of Xinjiang, with Urumqi City having the largest number and Beitun City, Kokdala City, and Tumxuk City having extremely small numbers. Overall, sports tourism resources in Xinjiang are unevenly distributed in space, showing strong regional differences. The proportion of different types of sports tourism resources in Xinjiang in 2022 is shown in Figure 3. Overall, there are significant differences in the number of different types, mainly dominated by sports leisure activities, natural landscapes, and sports architecture facilities, while ethnic folklore and modern festivals account for extremely small proportions. The spatial distribution of different types of sports tourism resources also varies (Figure 4). Sports leisure activity resources are mainly concentrated in northern Xinjiang, where the climate is suitable, natural landscapes are abundant, and infrastructure such as transportation, accommodation, and catering is relatively complete, providing convenience for sports leisure activities. Sports architecture facility resources are mainly concentrated in Urumqi City. As the provincial capital, Urumqi has dense population, high demand for sports facilities, and higher economic development levels that provide financial support for sports facility construction, with complete infrastructure supporting facility operation. Overall, geographical environment, resource endowment, transportation, and other factors influence the development potential and attractiveness of different types of sports tourism resources in specific regions.

In summary, the spatial distribution of Xinjiang' s sports tourism resources in 2022 shows significant regional differentiation at the spatial scale and prominent differences in dominant types across regions.

2.1.2 Spatial Distribution Type

According to the nearest neighbor index calculation results (Table 2), the nearest neighbor index of sports tourism resources in 2022 is 0.53, indicating a highly aggregated spatial distribution. The nearest neighbor indices of different resource types are all less than 1, showing significant aggregation characteristics.

Table 2 Nearest neighbor index of sports tourism resources in Xinjiang

Resource Type	Nearest Neighbor Index
Sports Leisure Activities	0.52
Physical Fitness	0.64
Passionate Adventure	0.61
Sports Events	0.59
Natural Landscapes	0.58
Ethnic Folklore	0.71
Modern Festivals	0.68
Sports Architecture Facilities	0.49
Overall	0.53

The number of grids occupied by sports tourism resources $N(r)$ and information content $I(r)$ were calculated, and after fitting regression, the capacity dimension and information dimension were determined. The scatter plots of $N(r)$ and $I(r)$ (Figure 5) show that the capacity dimension value is 0.73 and the information dimension value is 0.69, indicating that the distribution of Xinjiang' s sports tourism resources has a certain aggregation trend, but this aggregation is not uniform. The information dimension value of 0.69 indicates uneven spatial distribution with significant differences.

In summary, the spatial distribution of Xinjiang' s sports tourism resources in 2022 shows significant imbalance, with highly aggregated distribution mainly concentrated in Urumqi City, Changji Hui Autonomous Prefecture, and the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture.

2.1.3 Spatial Distribution Density

Using ArcGIS software for kernel density analysis, the kernel density distribution map of sports tourism resources was drawn (Figure 6). Overall, the spatial distribution density of Xinjiang' s sports tourism resources in 2022 shows significant differences, presenting a pattern of "more in the north, less in the south"and forming a three-core spatial distribution pattern of "one primary and two secondary centers." Among them, the primary core is the most densely distributed

area of Urumqi City and its surrounding areas, while the secondary cores consist of the western region dominated by the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture and Bortala Mongol Autonomous Prefecture, and the southwestern region centered on Aksu Prefecture.

2.1.4 Spatial Correlation

Using the Global Moran' s I tool in ArcGIS for global spatial autocorrelation analysis, the results show that the Global Moran' s I index is 0.12, the Z-score is 7.32, and the P-value is less than 0.01, indicating significant positive spatial correlation in Xinjiang' s sports tourism resource distribution in 2022 with obvious spatial dependence characteristics. The Getis-Ord General G tool was then used to determine high-low clustering, with a Z-score of 8.21, indicating significant high-value clustering.

Further local spatial autocorrelation analysis was conducted using the Anselin Local Moran I tool to generate a LISA cluster map of sports tourism resource density in Xinjiang (Figure 7). The results show that high-high clusters are mainly concentrated in Urumqi City and its surrounding areas; high-low clusters are scattered across various regions; low-high clusters are mainly concentrated in the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture, Tacheng Prefecture, and Kashgar Prefecture, sporadically scattered in other areas; and low-low clusters are minimal, distributed in the southern border of Hotan Prefecture. Overall, the spatial correlation of Xinjiang's sports tourism resources in 2022 shows obvious differences, generally presenting characteristics of "high-high" and "low-low" clustering and "high-low" scattering.

The Getis-Ord G_i^* tool was further used to explore hotspot and coldspot areas of sports tourism resources (Figure 8). The results show that Xinjiang' s sports tourism resources have only hotspot areas in 2022, mainly concentrated in Urumqi City and its surrounding areas, which is largely closely related to these regions' unique natural resources, convenient transportation networks, and government policy support. Overall, the distribution of cold and hotspot areas of Xinjiang' s sports tourism resources in 2022 is extremely unbalanced.

2.2 Influencing Factors of Spatial Distribution of Sports Tourism Resources in Xinjiang

Based on existing research and combined with the development status of tertiary industries in various regions, following the principles of data availability and scientificity, eight influencing factors were selected from three dimensions: geography, transportation, and resources. These include: geography dimension (elevation, slope, average annual precipitation, average annual temperature, population, water system density, vegetation cover index), transportation dimension (distance from transportation hubs, road network density), and resource dimension (density of tourist attractions). Geodetector was used to detect the explanatory power of each influencing factor on the spatial distribution of Xin-

jiang' s sports tourism resources, including single-factor analysis and dual-factor driving analysis.

2.2.1 Single-Factor Analysis

Geodetector was used for factor detection of single influencing factors (Table 3). The results show significant differences in the impact of various influencing factors on the spatial distribution of Xinjiang' s sports tourism resources, with the influence ranking as: average annual precipitation > distance from transportation hubs > average annual temperature > elevation > water system density > vegetation cover index > density of tourist attractions > road network density > population. Among them, average annual precipitation, distance from transportation hubs, average annual temperature, and elevation passed significance tests at the 0.01 level, indicating these factors have greater influence on sports tourism resource spatial distribution, while road network density and population have relatively minimal impact.

Table 3 Single-factor detection results

Influencing Factor	q Value	Influence Ranking
Average Annual Precipitation	0.42	1
Distance from Transportation Hubs	0.38	2
Average Annual Temperature	0.35	3
Elevation	0.31	4
Water System Density	0.28	5
Vegetation Cover Index	0.25	6
Density of Tourist Attractions	0.22	7
Road Network Density	0.18	8
Population	0.15	9

Specifically: (1) As the most important influencing factor, precipitation directly affects regional ecological environments and natural landscapes, thereby influencing the feasibility and attractiveness of sports tourism activities. Northern and central Xinjiang have relatively abundant precipitation, good ecological environments, and rich natural landscapes, which are conducive to outdoor activities such as mountaineering and hiking, while southern Xinjiang has less precipitation and more fragile ecological environments, which are not conducive to these activities. (2) Due to Xinjiang' s vast territory, transportation infrastructure is crucial for the accessibility of sports tourism resources. Areas near transportation hubs, such as Urumqi, have better-developed and utilized sports tourism resources, becoming the main concentration areas, while remote areas have limited resource development due to poor accessibility. (3) Temperature affects the suitability of sports tourism activities. Northern and central Xinjiang have suitable temperatures for various sports tourism activities, while southern Xinjiang has hot summers and cold winters that limit outdoor activities. (4)

Elevation affects topography and climate conditions, which in turn affect the types and distribution of sports tourism activities. Higher elevations in northern and western Xinjiang provide good conditions for mountaineering and skiing activities, while lower elevations in southern Xinjiang are not suitable for these activities. (5) River systems provide abundant water activity resources such as rafting, but their relatively low influence may be due to the limited distribution of rivers in Xinjiang. (6) Although road network density has some impact on destination accessibility, its influence is relatively low in Xinjiang, a region with vast land and sparse population dominated by natural landscapes. (7) Xinjiang' s natural landscapes and unique culture have strong appeal to tourists, but the distribution of these resources is not directly related to population, resulting in the relatively small impact of population factors.

2.2.2 Dual-Factor Driving Analysis

Geodetector was further used for interaction detection (Figure 9). The results show that the interactions between density of tourist attractions and average annual precipitation, average annual temperature, and distance from transportation hubs are non-linear enhancement, while interactions between other influencing factors are dual-factor enhancement, indicating that the spatial distribution of Xinjiang's sports tourism resources is the result of multiple factors working together. Among them, the interactions between average annual precipitation and slope (0.51), average annual precipitation and elevation (0.48), average annual precipitation and water system density (0.46), and average annual precipitation and vegetation cover index (0.45) are more significant, indicating that areas with sufficient precipitation, moderate slope, suitable elevation, larger water system density, and higher vegetation cover are more conducive to the formation and development of sports tourism resources.

3 Discussion

Unlike previous studies with single-source data on sports tourism resources, this study employs multi-source data including POI data and official resources, using exploratory spatial data analysis to quantitatively explore the spatial distribution characteristics of Xinjiang' s sports tourism resources in 2022. The study finds that Xinjiang' s sports tourism resources form a three-core spatial distribution pattern of "one primary and two secondary centers," which is more significantly spatially aggregated compared with Luo Liang et al.' s study on Hunan Province, likely related to Xinjiang' s unique geographical environment and resource endowment. Additionally, this study analyzes multi-factor interactions through Geodetector, finding significant dual-factor enhancement effects between average annual precipitation and slope, elevation, water system density, and vegetation cover index, indicating that the natural environment plays an important role in the formation and development of sports tourism resources. This finding supplements previous research deficiencies on the spatial distribution of tourism resources in Xinjiang and provides a scientific basis for the sustainable

development of sports tourism industries in Xinjiang and nationwide.

Although this study integrates multi-disciplinary and multi-methodological approaches to investigate the spatial differentiation and driving mechanisms of Xinjiang' s sports tourism resources, the indicator selection still fails to consider factors such as software and hardware facilities and per capita income. Future research should improve the influencing factor database for sports tourism resource spatial patterns from geographical, sociological, and economic perspectives to further explore key influencing factors.

4 Conclusions and Recommendations

4.1 Conclusions

This study, based on POI data, official resources, and other multi-source data, uses exploratory spatial data analysis to quantitatively explore the spatial distribution characteristics of Xinjiang' s sports tourism resources in 2022. The main conclusions are:

(1) The spatial distribution of Xinjiang' s sports tourism resources in 2022 shows significant imbalance, with highly aggregated distribution mainly concentrated in Urumqi City, Changji Hui Autonomous Prefecture, and the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture. Different types of sports tourism resources, such as sports leisure activities and sports architecture facilities, show geographical distribution differences. Overall, Xinjiang' s sports tourism resources present a distribution pattern of "more in the north, less in the south," forming a three-core spatial distribution pattern of "one primary and two secondary centers," with Urumqi City and its surrounding areas as the primary core, the western region dominated by the directly-administered counties and cities of Ili Kazakh Autonomous Prefecture and Bortala Mongol Autonomous Prefecture, and the southwestern region centered on Aksu Prefecture as the secondary cores. Additionally, the spatial dependence of sports tourism resource distribution is obvious, with large differences in spatial correlation and uneven distribution of cold and hotspot areas.

(2) The spatial distribution of Xinjiang' s sports tourism resources is affected by multi-dimensional factors including geography, transportation, and resources, with significant differences in the influence of each factor. Among them, average annual precipitation, distance from transportation hubs, average annual temperature, and elevation have greater influence, passing significance tests, while road network density and population have relatively minimal impact. The interaction type is primarily dual-factor enhancement, indicating that the spatial distribution of Xinjiang' s sports tourism resources is the result of multiple factors working together. In particular, the interactions between average annual precipitation and slope, elevation, water system density, and vegetation cover index are more significant, indicating that areas with sufficient precipitation, moderate slope,

suitable elevation, larger water system density, and higher vegetation cover are more conducive to the formation and development of sports tourism resources.

4.2 Recommendations

Based on the analysis of spatial distribution characteristics and influencing factors of Xinjiang' s sports tourism resources, the following recommendations are proposed to promote the sustainable development of Xinjiang' s sports tourism industry:

(1) **Strengthen resource integration and development in core regions.** In response to the three-core spatial distribution pattern of "one primary and two secondary centers," efforts should be made to strengthen the integration and development of sports tourism resources in core regions such as Urumqi, utilizing the resource aggregation advantages of these areas to create high-quality sports tourism projects and demonstration zones.

(2) **Enhance infrastructure construction and improve service quality.** In areas rich in sports tourism resources, especially secondary core regions, infrastructure construction such as transportation, accommodation, and catering should be strengthened to improve tourism service quality and reception capacity.

(3) **Develop differentially and distinctively.** According to the characteristics of different regions, develop regional-featured sports tourism activities with Xinjiang characteristics, such as combining Xinjiang' s rich ethnic cultures and natural landscapes to develop ethnic sports events and outdoor adventure festivals, thereby enhancing sports tourism attractiveness.

(4) **Strengthen environmental protection and promote sustainable development.** Considering the importance of natural factors such as elevation, precipitation, and temperature, environmental protection should be strengthened, sports tourism activities should be reasonably planned, and low-carbon, environmentally friendly sports tourism equipment and technologies should be promoted to reduce negative environmental impacts.

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