Postprint: Spatial Distribution Characteristics and Influencing Factors of Tourism Elements in Inner Mongolia Counties Based on POI Data Mining

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Abstract

Based on the tourism "six elements" theory, using Point of Interest (POI) data for tourism at the county level in Inner Mongolia, and through methods such as nearest neighbor index, kernel density estimation, entropy method, composite index, spatial autocorrelation, and geographical detector, this study explores the spatial distribution characteristics and influencing factors of tourism elements in Inner Mongolia counties in 2023. The results show that: (1) Tourism elements in Inner Mongolia counties exhibit significant agglomeration distribution characteristics, among which the elements of "food", "accommodation", and "shopping" show the most prominent agglomeration, followed by "entertainment" and "transportation" elements, while the "tourism" element is relatively dispersed. (2) The density distribution of tourism elements is unbalanced, with the density in areas south of the fitted line generally higher than that in the northern regions; particularly, cities such as "Hohhot-Baotou-Ordos", Chifeng, and Tongliao have formed dense areas of tourism elements. (3) Tourism elements demonstrate significant positive global autocorrelation, while local autocorrelation encompasses four agglomeration patterns: low-low, low-high, high-high, and high-low. (4) Factors influencing the spatial distribution characteristics of tourism elements in Inner Mongolia counties encompass multiple dimensions including economic, social, cultural, and natural environment, among which economic and cultural factors are the core influencing factors.

Full Text

Abstract

Based on the "six elements" theory of tourism, this study explores the spatial distribution characteristics and influencing factors of tourism elements in In-

ner Mongolia' s counties in 2023 using point of interest (POI) data. Through methods including nearest neighbor index, kernel density estimation, entropy weighting, comprehensive index analysis, spatial autocorrelation, and geographical detector, the research reveals four key findings. First, tourism elements in Inner Mongolia's counties exhibit significant clustering patterns, with "food,""accommodation," and "shopping" showing the strongest agglomeration, followed by "entertainment" and "transportation," while "tourism" (attractions) remains relatively dispersed. Second, density distribution is uneven, with areas south of the fitting line (from Alxa Left Banner to Jalaid Banner) generally showing higher densities than northern regions, particularly in the Hohhot-Baotou-Erdos cluster, Chifeng, and Tongliao, which form dense tourism element concentrations. Third, tourism elements demonstrate significant positive global autocorrelation, with local autocorrelation revealing four distinct clustering patterns. Fourth, the spatial distribution is influenced by multiple dimensions encompassing economic, social, cultural, and natural environmental factors, with economic and cultural factors identified as the core drivers.

Keywords: tourism elements; POI data; spatial distribution; Inner Mongolia

1.1 Study Area Overview

Inner Mongolia, located in northern China, spans the northeast, north, and northwest regions in an elongated shape. The autonomous region comprises 12 leagues and cities with 103 county-level administrative units, divided into eastern, central, and western zones. Renowned for its abundant tourism resources, Inner Mongolia features grasslands, deserts, forests, lakes, rivers, and other natural landscapes, alongside ethnic cultures, historical sites, and religious heritage. While tourism has developed rapidly due to these unique resources and improved public service systems, the market remains heavily reliant on natural scenery, resulting in relatively homogeneous and singular products that fail to meet the diverse demands of modern tourists. Tourist experience constitutes the core of tourism development, and the "six elements" directly shape this experience. Analyzing these elements helps understand visitor needs and preferences, enabling more personalized and diversified tourism products and services that enhance satisfaction.

1.2 Data Sources

The study employs three data categories: Inner Mongolia county-level tourism POI data, influencing factor evaluation indicators, and spatial analysis data. Tourism POI data were collected from the Amap API using web crawler technology on August 15, 2023, and manually preprocessed to remove duplicates and errors. The data were classified according to the "six elements" (food, accommodation, transportation, tourism, shopping, entertainment), totaling 23,654 records with attributes including name, type, longitude, latitude, and administrative region. The coordinate system was converted to WGS1984. Influencing

factor data were sourced from the *Inner Mongolia Statistical Yearbook (2023)*, *China County Statistical Yearbook (2023)*, and the seventh national census data, supplemented by nighttime light data from NOAA' s National Centers for Environmental Information. Spatial analysis data were obtained from the Ministry of Natural Resources Standard Map Service.

1.3.1 Nearest Neighbor Index

The nearest neighbor index, originally proposed by Clark and Evans (1954) for analyzing spatial point patterns, identifies distribution modes. This study applies it to examine tourism element distribution patterns in Inner Mongolia' s counties. The index interpretation follows: values equal to 1 indicate random distribution; values less than 1 suggest clustering; and values greater than 1 indicate dispersion.

1.3.2 Kernel Density Estimation

Kernel density estimation measures the probability density function of random variables, effectively quantifying the intensity of element distribution within specific areas. Higher values indicate greater concentration. This method reveals spatial clustering characteristics of tourism elements in Inner Mongolia' s counties.

1.3.3 Entropy Method

The entropy method is an objective weighting technique based on information entropy principles, widely used in multi-attribute decision analysis. By allocating weights according to data dispersion, it eliminates subjective interference. This study employs the entropy method to determine indicator weights for evaluating tourism element development levels.

1.3.4 Comprehensive Index Method

The comprehensive index method integrates multiple related indicators into a single value to reflect overall characteristics of a phenomenon. This approach involves indicator selection, data standardization, weight determination, index construction, and interpretation. The study builds a comprehensive index to reveal spatial correlation features of tourism element development levels across Inner Mongolia' s counties.

1.3.5 Spatial Autocorrelation

Following Tobler' s first law of geography, which states that everything is related to everything else but near things are more related than distant things, this study employs spatial autocorrelation to examine geographic correlations

and clustering characteristics of tourism element development levels. The analysis includes both global and local spatial autocorrelation. Global Moran' s I ranges between -1 and 1, with values greater than 0 indicating spatial clustering and values less than 0 indicating dispersion. Local spatial autocorrelation, using Local Indicators of Spatial Association (LISA), identifies specific clustering locations and patterns, including high-high (positive correlation) and high-low (negative correlation) configurations.

1.3.6 Geographical Detector

The geographical detector is a spatial analysis technique with minimal assumptions that handles both numerical and categorical data. This study utilizes its factor and interaction detection functions to explore influencing factors and their interactions. The q-statistic measures the explanatory power of independent variable X on dependent variable Y, ranging from 0 to 1, where higher values indicate stronger influence. Interaction detection assesses whether combined factors enhance explanatory power or act independently.

2.1 Spatial Typology Characteristics of Tourism Elements

The nearest neighbor index for Inner Mongolia' s tourism "six elements" is 0.42, indicating a clustered distribution pattern (Table 2). Disaggregated analysis reveals that all element types show clustering, with indices ranging from 0.05 to 0.50, Z-values less than -2.58, and P-values below 0.01. The clustering intensity follows the order: "food" (0.05), "accommodation" (0.08), "shopping" (0.11), "entertainment" (0.23), "transportation" (0.31), and "tourism" (0.50). The "food," "accommodation," and "shopping" elements exhibit the strongest clustering, reflecting their concentration in accessible central areas to facilitate tourist services. "Entertainment" and "transportation" show moderate clustering, indicating relatively dispersed distribution while maintaining service accessibility. The "tourism" element displays the weakest clustering, suggesting that attractions are more widely distributed across the region.

2.2 Spatial Density Characteristics of Tourism Elements

Kernel density analysis using ArcGIS 10.8 reveals two primary characteristics: widespread distribution with multiple scattered points, and consistently higher densities south of the fitting line (from Alxa Left Banner to Jalaid Banner) compared to northern areas. South of the line, two large contiguous clusters emerge: a western cluster centered on the Hohhot-Baotou-Erdos region and an eastern cluster in Chifeng and Tongliao extending toward Hinggan League. North of the line, densities are lower, characterized by isolated points lacking connectivity. Both "tourism" and "transportation" elements show significant contiguous clustering, forming core activity zones. The "transportation" core covers Hohhot-Baotou-Erdos, Chifeng, Tongliao, and Hulunbuir, exerting strong radiating effects. The "tourism" element generates multiple primary and secondary

centers across the 12 leagues and cities, creating a rich spatial structure that provides diversified support for regional tourism development.

[Figure 1: see original paper]

2.3 Spatial Association Characteristics of Tourism Elements

Given Inner Mongolia' s vast territory and uneven population density, this study calculates per capita and per land area indicators to evaluate tourism element development levels. Using entropy weighting, the global Moran' s I for the "six elements" is 0.39 ($Z > 2.58$, $P < 0.01$), confirming significant spatial clustering. Individual element indices range from 0.33 to 0.45, all passing significance tests, indicating similar clustering intensities across element types.

LISA cluster maps (Figure 2) reveal four patterns: (1) low-low clusters where lagging development may result from scarce resources, inadequate infrastructure, or poor market development (e.g., "shopping" and "food" in Ejin Banner and Alxa Right Banner); (2) low-high clusters where counties with limited development can leverage neighboring advantages (e.g., "transportation" and "entertainment" in Siziwang Banner and Qahar Right Wing Middle Banner); (3) high-high clusters with well-developed services (e.g., "food" and "tourism" in Xincheng, Huimin, Saihan, and Yuquan districts); and (4) high-low clusters that may create isolation effects (e.g., "entertainment" in Huolinguole, "accommodation" in Bayan Obo Mining District, and all elements in Horqin District), requiring enhanced regional cooperation.

[Figure 2: see original paper]

2.4.1 Evaluation Index System Construction

Tourism element spatial patterns result from complex interactions among economic, social, cultural, and natural factors. Drawing on existing research and data availability, this study selects 15 key indicators across four dimensions to analyze 103 county-level units (Table 3). The dependent variable (Y) is county tourism development level, measured by per capita and per land area availability of each tourism element type.

2.4.2 Influencing Factor Detection

Factor detection using natural breaks classification and geographical detector analysis reveals that all indicators except year-end household registration population and average precipitation are significant (Table 5). The factors are categorized into three strength levels: strongest, stronger, and general drivers.

Nighttime light data and cultural/entertainment employment represent the strongest drivers, reflecting economic activity, population density, urbanization, and reception capacity. Stronger drivers include highway mileage (transportation accessibility), average education years (service quality), theater numbers

(cultural vitality), per capita disposable income (consumption capacity), urbanization rate (service infrastructure), GDP (economic strength), and public budget revenue (investment capacity). General drivers include tertiary industry GDP proportion, school numbers, PM2.5 concentration, administrative area, green coverage, and sewage treatment rate.

From the analytical framework, three characteristics emerge: (1) economic factors are primary drivers, with cultural factors also playing crucial roles; (2) social factors significantly impact tourism development, though population scale has limited effect; and (3) natural factors vary in influence, with environmental quality being particularly important for tourism attraction.

2.4.3 Interaction Detection of Influencing Factors

Interaction analysis reveals that all factor pairs exhibit nonlinear enhancement or dual-factor synergy, where combined explanatory power exceeds the sum of individual effects. Even factors insignificant in single-factor tests, such as year-end household registration population and average precipitation, show significant enhancement when interacting with other variables. This demonstrates that tourism element spatial distribution results from complex, dynamic interactions rather than simple linear superposition, highlighting the importance of a multi-factor synergistic perspective.

3 Discussion

This study examines tourism "six elements" using POI data to reveal spatial distribution patterns and driving factors in Inner Mongolia's counties. The findings align with previous research while offering broader data coverage and a more multidimensional perspective. Unlike studies focusing on economically developed or resource-unique areas, this research provides new insights for borderland tourism public services and industry development. The analytical framework emphasizes cultural environment' s importance in enriching tourism products and enhancing overall value.

Based on these findings, three recommendations emerge. First, optimize tourism element layout by prioritizing core "food," "accommodation," and "shopping" elements while improving service quality and experiences; enhancing "entertainment" and "transportation" accessibility and appeal through better networks and diversified activities; and balancing "tourism" element distribution through specialized product development and route construction. Second, strengthen regional tourism synergy by leveraging central city radiating effects, improving infrastructure, promoting peripheral area development, and creating distinctive tourism brands through resource sharing. Third, pay special attention to northern border areas by developing specialized tourism products to stimulate regional economic growth.

4 Conclusions

This study yields four main conclusions. (1) Tourism elements in Inner Mongolia' s counties show significant clustering, with "food," "accommodation," and "shopping" being most concentrated, "entertainment" and "transportation" moderately clustered, and "tourism" relatively dispersed. This pattern facilitates hotspot formation while balancing resource development and conservation. (2) Density distribution is uneven, with southern regions showing higher densities than northern areas, particularly in the Hohhot-Baotou-Erdos cluster, Chifeng, and Tongliao. Northern border areas hold substantial development potential requiring enhanced connectivity and regional synergy. (3) Positive global spatial autocorrelation indicates clustering trends, while local autocorrelation reveals four patterns demonstrating interdependence and development potential across counties. (4) Spatial distribution is shaped by integrated economic, social, cultural, and natural factors, with economic and cultural factors as core drivers, social factors having significant influence, and natural factors playing important interactive roles despite limited individual significance.

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