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Article

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Spatial configuration of multidimensional tourism elements in a nature-based mountain destination: POI evidence from Zhangjiajie, China

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Abstract Tourism elements shape how destinations organize visitor services and reconcile tourism development with conservation. However, existing research has focused mainly on individual resource or attraction categories, leaving destination-level, multi-element patterns in nature-based mountain destinations underexplored. This study examines Zhangjiajie, a World Heritage mountain destination in China, by integrating point of interest (POI) data with multi-source geographic datasets. We apply kernel density estimation, standard deviational ellipses, network-based accessibility analysis, bivariate spatial autocorrelation, and the Geodetector to seven tourism elements: dining, accommodation, transportation, sightseeing, shopping, entertainment, and public services.The results show that: tourism elements form a dual-core hierarchical structure centered on the Yongding urban area and Wulingyuan; all elements except sightseeing and accommodation are oriented northeast–southwest along the road network and Lishui River corridor; accessibility declines outward from the Yongding urban core, with average travel times exceeding 155 minutes in much of Sangzhi County; dining, shopping, transportation, entertainment, and public services co-locate strongly in a host–guest shared pattern (Moran's I > 0.79), whereas sightseeing is weakly associated with all other elements (mean Moran's I ≈ 0.16), and accommodation occupies an intermediate position, showing the strongest association with sightseeing (Moran's I = 0.268); road network density (q = 0.53–0.61) and population density (q = 0.46–0.55) explain most service elements far better than sightseeing (q = 0.12 and 0.11), while topographic relief has negligible explanatory power (q ≤ 0.03). Given the removal of tourist facilities from the heritage property, this attraction–service separation is partly a designed outcome of conservation governance rather than a deficiency. The study operationalizes a seven-element framework for destination-level analysis and suggests bridging the separation through low-impact gateway services and transit links rather than expanding services within protected areas.

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The spatial configuration of tourism elements, including dining, accommodation, transportation, sightseeing, shopping, entertainment, and public services, forms the supply structure through which destinations deliver visitor experiences. It also shapes service quality and destination competitiveness[1–4]. Tourist attractions are the primary attractors, so their spatial relationship with supporting facilities is central to regional tourism planning[5]. This relationship varies across destination types. Studies of urban destinations link accommodation location to centrality and to areas where tourist activity concentrates[6-8]. In nature-based mountain destinations, attractions are tied to scenic landforms that are often peripheral and topographically constrained[9], whereas service facilities follow market access and population. Conservation regulation adds another force, because many Chinese mountain scenic areas have relocated commercial facilities outside their core zones. Attraction and service separation is therefore partly designed. Understanding its extent, form, and correlates is essential for planning that reconciles conservation with visitor services.

Point of interest (POI) data from online map platforms provide fine-grained and frequently updated records of tourism-related facilities and are now widely used in tourism spatial research[10]. Studies using kernel density estimation, nearest-neighbor indices, standard deviational ellipses, spatial autocorrelation, and the Geodetector have documented agglomerated distributions of tourist attractions across Chinese cities, provinces, and regions. These distributions are organized around urban cores or within core and peripheral and multicore configurations[11-17]. The reported drivers include natural endowment and topography[13-15], transport and socioeconomic conditions[11,12,15,18,19], and road accessibility and existing facilities[20,21]. Their relative importance varies across regions. Because the attraction inventories in these studies usually combine natural, urban, and cultural sites, it remains unclear whether the same factors apply to sightseeing and service elements in a destination dominated by natural scenery. POI data also have limitations: they represent extensive scenic areas as points and may overrepresent commercial establishments. These limitations are considered when interpreting the results.

Fewer studies have examined how different tourism elements relate spatially to one another. Recent POI studies have begun to analyze multiple tourism elements together, but these analyses remain concentrated at urban or county scales[10]. The hotel location literature cited above is similarly urban in focus. Prior work on Zhangjiajie has examined the coupling between ecotourism flows and transport accessibility, identifying a core and peripheral structure anchored by the Wulingyuan, Tianmen Mountain, and Huanglong Cave triangle[22], as well as the factors shaping online attention to Zhangjiajie National Forest Park[23]. However, the citywide configuration of tourism elements, particularly the spatial relationship between sightseeing and service elements, has not been systematically examined.

Two gaps therefore remain. First, evidence on tourism element configuration derives mainly from attraction-focused analyses at urban, provincial, or county scales, while integrated analyses of nature-dominated mountain destinations remain scarce. Second, existing work has emphasized the distribution of individual element types rather than the spatial association between sightseeing and service elements or the extent to which their explanatory factors differ. This study addresses these gaps in Zhangjiajie. The city's core scenic resource, the Wulingyuan Scenic and Historic Interest Area, was inscribed on the World Heritage List in 1992. After a 1998 World Heritage Centre and IUCN mission found the property overrun with tourist facilities, local authorities began removing buildings from the scenic area in 1999[24]. This history makes Zhangjiajie a useful case for examining attraction and service separation. Drawing on POI data and multi-source geographic datasets, we apply kernel density estimation, standard deviational ellipses, network-based accessibility analysis, bivariate spatial autocorrelation, and the Geodetector to seven tourism elements

across the city. We use "spatial mismatch" descriptively to denote weak or negative spatial association between sightseeing and service elements, rather than in its original labor-market sense[25]. Given the conservation regime, such mismatch is not presumed to indicate a deficiency.

We address three research questions: (1) How are the different tourism elements distributed across the city? (2) Do sightseeing and service-oriented elements exhibit spatial coupling or spatial mismatch? (3) Which infrastructural, socioeconomic, and topographic factors explain the spatial differentiation of each element, and do these factors differ between sightseeing and service elements? Because service facilities are market oriented and restricted from scenic cores in this destination, we hypothesize that H1: service-oriented elements are more likely to cluster in urban and road-accessible areas than in scenic resource cores. Because sightseeing elements are resource bound, whereas service elements share a market-access logic and tend to co-locate, we hypothesize that H2: sightseeing elements are more weakly coupled with service-oriented elements than service elements are with one another. Following the same logic, H3 predicts that road network density and population density exert stronger explanatory power over service elements than over sightseeing elements.

This study makes three contributions. First, it operationalizes a seven-element system by adding tourism-oriented public services to the conventional six elements, consistent with the ancillary-services dimension of destination frameworks[26]. Second, it provides citywide evidence on the spatial relationship between sightseeing and service elements in a nature-based mountain destination under conservation regulation, a setting that differs from the urban and regional contexts on which existing evidence rests. Third, by comparing the explanatory power of infrastructural, socioeconomic, and topographic factors across element types, it identifies where service provision is shaped by factors different from those shaping attractions. This comparison informs spatial planning that balances conservation with visitor services.

Study area

Zhangjiajie City is a prefecture-level city in northwestern Hunan Province, China. It lies in the upper and middle reaches of the Lishui River, which passes through the urban core and forms the main population corridor. The city is located in the hinterland of the Wuling Mountain Range and borders Changde to the east, Huaihua to the south, Xiangxi Tujia and Miao Autonomous Prefecture to the southwest, and Enshi Tujia and Miao Autonomous Prefecture in Hubei Province to the northwest. It covers 9,516 km² and administers two districts, Yongding and Wulingyuan, and two counties, Cili and Sangzhi (Figure 1).

Zhangjiajie has distinctive geomorphological features, including quartz sandstone pillar peaks and diverse karst landforms. Its economy is highly service oriented and has been sustained by tourism. The city contains several well-known scenic areas, including Tianmen Mountain National Forest Park, Zhangjiajie National Forest Park, and the Wulingyuan Scenic and Historic Interest Area. Before the COVID-19 pandemic, tourist arrivals peaked at 79.6 million in 2018. In 2020, the tertiary sector still accounted for 69.57% of the city's GDP. These figures demonstrate tourism's importance to Zhangjiajie's socioeconomic development and the practical value of examining its spatial distribution. Scenic resources are strongly place bound, whereas administrative, transport, and commercial services concentrate in urbanized areas such as Yongding District. This contrast makes Zhangjiajie an appropriate case for examining how fixed attractions and mobile services form a coordinated destination system.

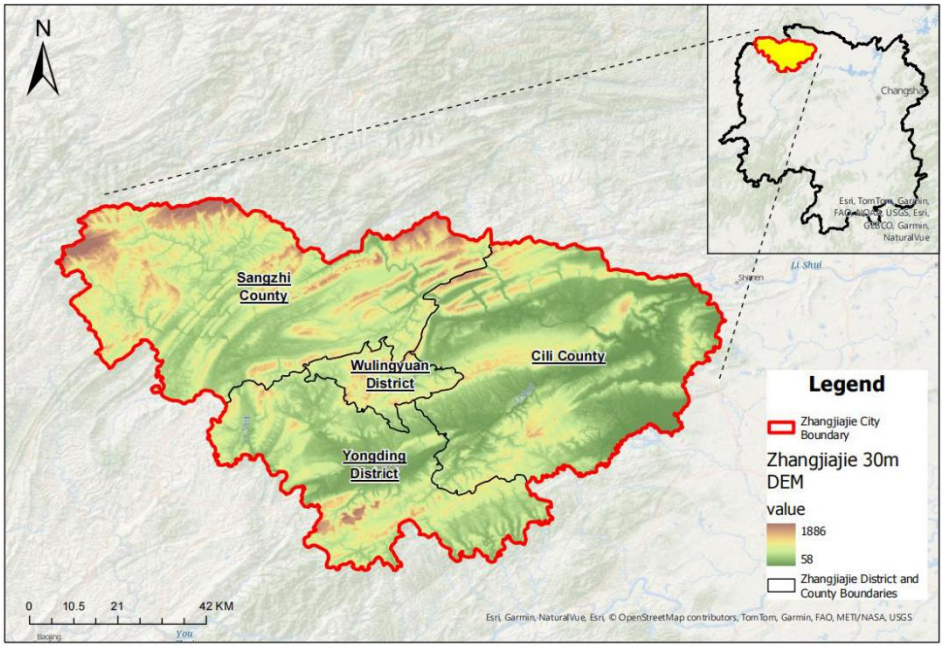


Fig. 1. Location map of Zhangjiajie City in Hunan Province, China.

Materials and methods

Data sources and processing

POI data for Zhangjiajie's tourism elements were retrieved in September 2024 through the Amap (AutoNavi) Open Platform API using Python-based web-crawling scripts. Building on the traditional six-element tourism framework of dining, accommodation, transportation, sightseeing, shopping, and entertainment, we added public services to create a seven-element classification consistent with the Statistical Classification of Tourism and Related Industries issued by China's National Bureau of Statistics in 2018. After coordinate rectification, classification, and deduplication, the final dataset contained 22,887 POI records across seven categories (Table 1). Dining and shopping accounted for 51.5% of all records, whereas sightseeing and entertainment accounted for 3.0% and 3.2%, respectively. This distribution is consistent with evidence that Zhangjiajie visitors are primarily motivated by scenic sightseeing and concentrate expenditure on dining, accommodation, transportation, and sightseeing, while shopping and entertainment together account for only 30.3% of tourist spending. Because individual retail units occupy small areas, shopping is likely to be overrepresented in the POI counts. Conversely, each sightseeing attraction covers a comparatively large area, so its lower POI count should not be interpreted as weak scenic-resource supply.

Tourism Element	Sub-Categories (Examples)	Count	Share (%)
Dining	Chinese restaurants, snack bars, bakeries, etc.	5,059	22.1
Accommodation	Hotels, guesthouses, hostels, etc.	2,756	12.0
Transportation	Bus stations, bus stops, railway stations, airports, etc.	2,850	12.4
Sightseeing	Parks, scenic areas, exhibition halls, etc.	701	3.0
Shopping	Shopping malls, department stores, specialty product shops, etc.	6,744	29.4
Entertainment	Karaoke venues, campsites, spa centers, etc.	742	3.2
Public Services	Public toilets, courier stations, telecom service centers, etc.	4,035	17.6

Table 1. POI classification and quantity of tourism elements in Zhangjiajie City.

The supplementary spatial datasets comprised 30m resolution digital elevation data from the Geospatial Data Cloud, road network data containing 11,949 features extracted from OpenStreetMap, 1 km resolution population-density rasters from the WorldPop project, and 130 m resolution nighttime-light imagery from the Luojia-1 satellite operated by Wuhan University. We constructed four groups of explanatory variables: road network density for infrastructural accessibility, population density for resident demand and urban agglomeration, the nighttime-light index as a proxy for economic development and nighttime consumption potential, and topographic relief derived from the digital elevation model. All datasets were projected to a common coordinate system, clipped to the Zhangjiajie administrative boundary, and resampled or aggregated to the analytical units required by each method.

Methodology

Spatial pattern analysis Kernel density estimation (KDE). KDE uses a distance-decay function to estimate point density and characterize the spatial influence of each observation[27]. The estimator is:

$$f(x) = \frac{1}{\mathrm{nh}} \sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right) \quad (1)$$

where f(x) is the kernel density value at location x; n is the total number of POIs; h is the bandwidth; K(·) is the spatial kernel weighting function; and x_i is the location of the i-th POI within a circle of radius h centered on x. Higher f(x) values indicate stronger spatial concentration.

Standard deviational ellipse (SDE). SDE characterizes the directional tendency and dispersion of a spatial point distribution[28]. Implemented with the ArcGIS Spatial Statistics toolbox, it yields a mean center, semi-axis lengths that capture spread along the principal directions, and an azimuth angle for the major axis. A small eccentricity indicates weak directionality, whereas a large eccentricity indicates stronger directional alignment.

Accessibility Analysis Transportation accessibility is operationalized as the average travel time required to traverse the road network, which measures the ease of overcoming spatial friction[29,30]. The model is expressed as:

$$A_{\mathrm{i}} = \frac{1}{\mathrm{J}} \sum_{\mathrm{j} \in J} \mathrm{t_{ij}} \quad (2)$$

where A_i is the accessibility of node i; t_{ij} is the travel time from node i to node j; and J is the total number of nodes. Lower A_i values indicate better accessibility. We reconstructed the road network as a three-tier hierarchy, w ith speeds of 110 km/h for expressways, 60 km/h for arterial roads, and 40 km/h for secondary roads. We then built an origin–destination cost matrix in the ArcGIS Network Analyst extension to generate a citywide accessibility surface.

Bivariate spatial autocorrelation Bivariate spatial autocorrelation measures the spatial association between two distinct variables according to their locations and attribute values[31,32]. The statistic is computed as:

$$\mathrm{Moran's}\ I^{a}_{zy} = \frac{X^{a}_{y} - \overline{X}_{y}}{d_{y}} \times \sum_{c=1}^{n} W_{ac} \times \frac{X^{c}_{z} - \overline{X}_{z}}{d_{z}}, (a \neq c) \quad (3)$$

where Ixy is the bivariate Moran's I between element types x and y; xi and yj are the standardized attributes of the two elements in spatial units i and j, respectively; wij is the spatial weight matrix defined by the Rook contiguity criterion; n is the number of spatial units; and S0 is the sum of all spatial weights. Moran's I ranges from -1 to 1, with higher positive values indicating stronger

spatial co-occurrence. We implemented the analysis in GeoDa using a 1,650 m × 1,650 m fishnet grid and assessed significance at the 0.05 level.

Geodetector The Geodetector is a statistical method for detecting spatial stratified heterogeneity and identifying potential drivers[33,34]. We imposed a 1 km × 1 km grid across the study area. Kernel density values for each tourism element served as the dependent variable (Y), and four variables served as independent factors (X): the nighttime-light index, road network density, population density, and topographic relief. We reclassified each variable into six strata using the natural-breaks (Jenks) method. The factor detector model is:

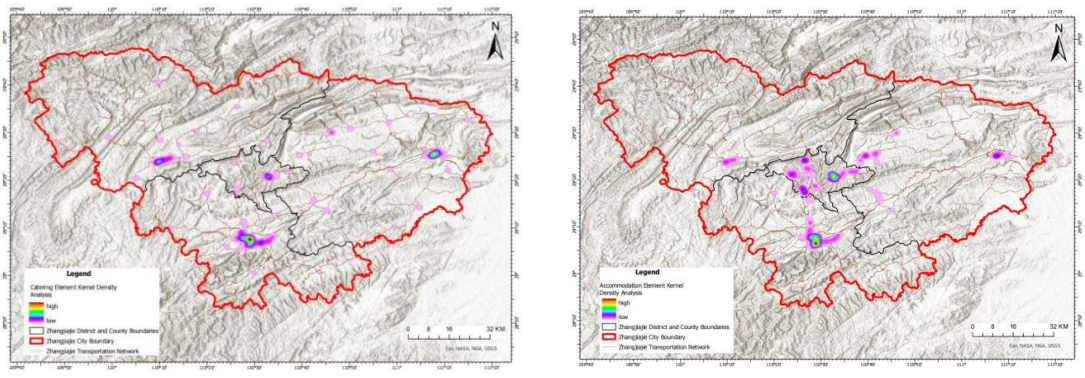
$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N \sigma^2} \quad (4)$$

where $q \in [0, 1]$ represents the proportion of spatial variance in Y explained by factor X; N_h and N are the numbers of units in stratum h and in the full study area, respectively; and σ^2_h and σ^2 are the variance of Y within stratum h and across the study area, respectively. A q value approaching 1 indicates strong explanatory power, whereas a value approaching 0 indicates negligible influence. All results were tested at the 0.05 significance level.

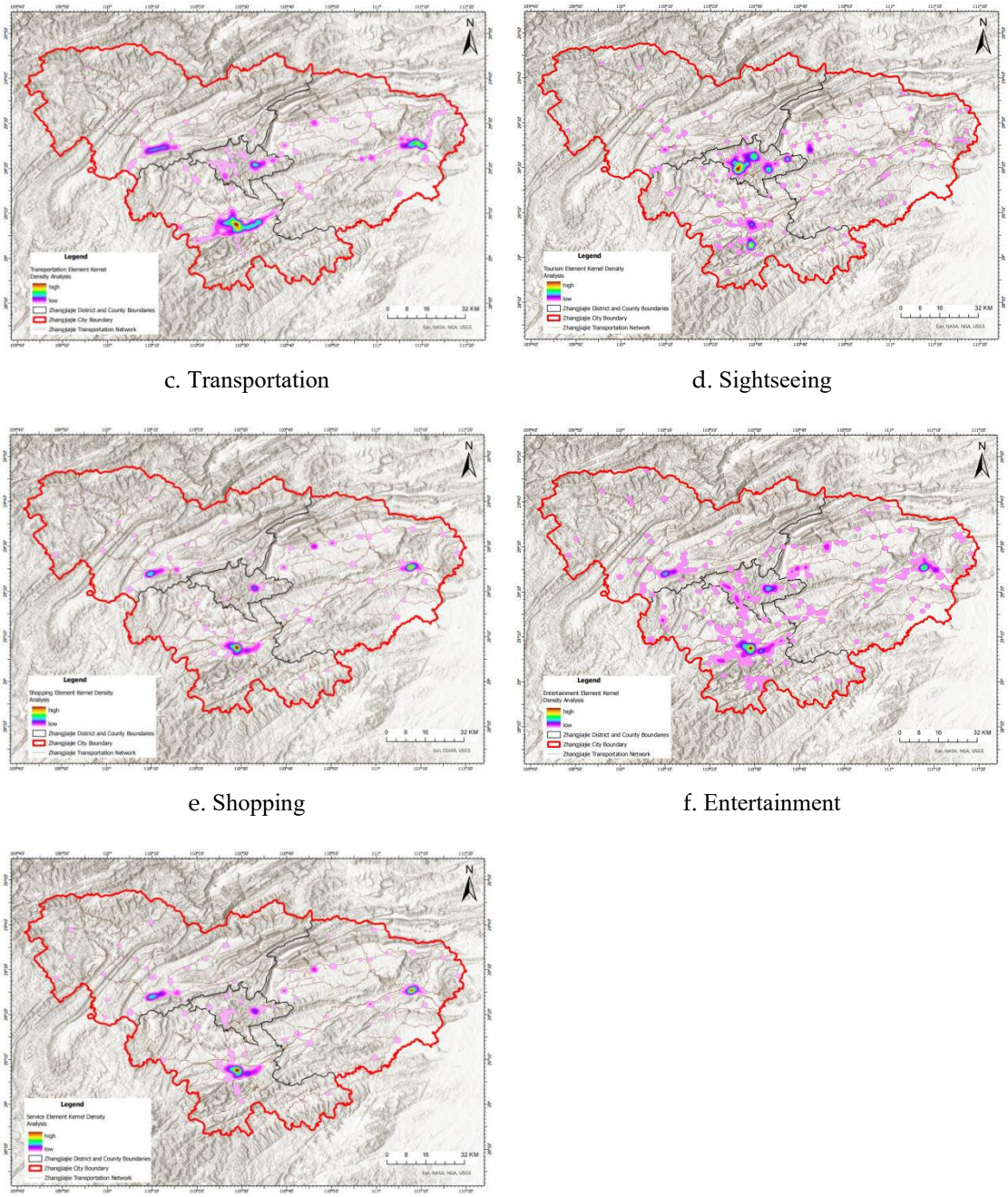
Study results and analysis

Spatial density patterns

Kernel density analysis reveals pronounced spatial agglomeration of tourism elements in Zhangjiajie (Figure 2), concentrated mainly in the urban cores of the two districts and the two county seats. The highest KDE values occur in central Yongding District, and density decreases outward in a concentric pattern. Beyond the district and county centers, tourism elements appear sporadically without clear clustering. Overall, the distribution conforms to a major-center and minor-center hierarchy. Yongding and Wulingyuan districts form the two major centers, while Cili and Sangzhi county seats function as minor centers. This configuration reflects the locational advantages of core scenic areas and the broader level of urban socioeconomic development, supporting H1.



a. Dining b. Accommodation



c. Transportation

d. Sightseeing

e. Shopping

f. Entertainment

g. Public services

Fig. 2. Kernel density analysis of tourism element POIs in Zhangjiajie City

Dining, entertainment, shopping, and public services show similar KDE distributions in the urban core, indicating a strong host and guest shared spatial pattern. These elements are closely associated with transport infrastructure, diffuse along road corridors, and show an elongated northeast to southwest orientation in central Yongding District. Sightseeing elements, by contrast, are anchored in scenic landscapes and are less aligned with the orientation of the road network. Zhangjiajie's core attractions are tied to quartz sandstone pillar peaks, and the distribution of these natural resources is largely predetermined[14]. Their spatial distribution is therefore relatively fixed by scenic resources. At the district scale, Wulingyuan has higher overall KDE values than Yongding because it contains the internationally renowned Wulingyuan Scenic Area, including Zhangjiajie National Forest Park, Tianzi Mountain, Suoxiyu, and Yangjiajie. Yongding is anchored by Tianmen Mountain National Forest Park. Cili and Sangzhi counties contain fewer tourism resources than the core

scenic areas. Overall, tourism elements form a dual-core structure anchored by Wulingyuan Scenic Area and Tianmen Mountain National Forest Park, consistent with the core and peripheral ecotourism flow structure reported by Liu et al.[22]

Spatial directional distribution

Standard deviational ellipse analysis reveals the directional characteristics of tourism element distributions in Zhangjiajie (Figure 3). The sightseeing and accommodation ellipses have low eccentricities and are close to circular, indicating weak directional tendencies. The other five categories, namely dining, transportation, shopping, entertainment, and public services, are oriented northeast to southwest. This orientation closely follows Zhangjiajie's road network and the Lishui River corridor, consistent with a guiding role for transport infrastructure in the distribution of tourism services. The sightseeing and accommodation ellipses are more concentrated and directionally neutral, with centers near Tianmen Mountain National Forest Park and the Wulingyuan Scenic Area.

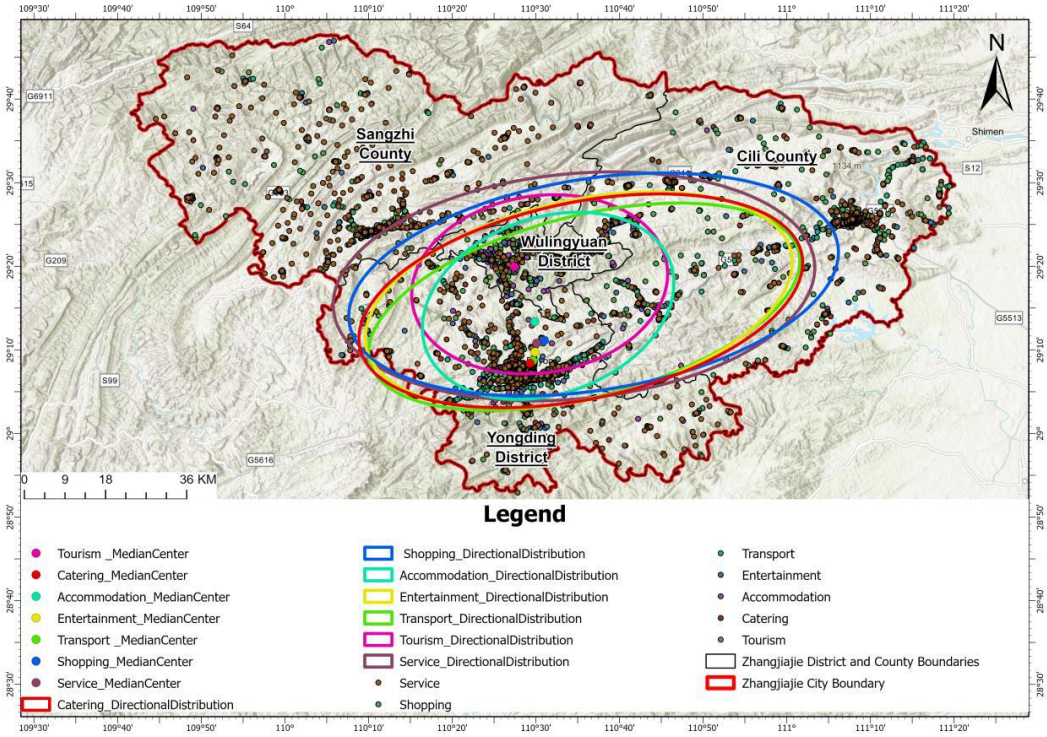


Fig.3. POI standard deviational ellipses and median centers of various tourism elements in Zhangjiajie City.

The mean centers of the six non-sightseeing elements form a linear pattern within Yongding District and extend northward. This pattern confirms that Yongding, the administrative and transport hub of Zhangjiajie, is the principal node for tourism consumption and service activities outside sightseeing. The district contains the airport, high-speed rail station, intercity railway station, and bus terminals. By contrast, the sightseeing mean center lies in Wulingyuan District, reinforcing its role as the spatial locus of the main tourism attractors. This duality, with scenic resources in Wulingyuan and services in Yongding, reflects a structural separation between attractions and service infrastructure. If services remain concentrated in Yongding while visitors travel to Wulingyuan and Tianmen Mountain, gaps may arise among sightseeing, dining, shopping, entertainment, and public services. Planning should therefore assess complementary services at attraction gateways to improve destination service quality and visitor experience.

Transportation accessibility

Network-based accessibility analysis reveals a centrifugal decline in accessibility, with the shortest travel times concentrated in central Yongding District (Figure 4). Blue zones (50-85 min) cover the Yongding urban core; green zones (85-110 min) extend to the urban periphery and the Wulingyuan district center; yellow-green to yellow zones (110-155 min) encompass the area around Cili County seat; and orange to red zones (155-205 min) occur mainly in Sangzhi County and along the city boundary.

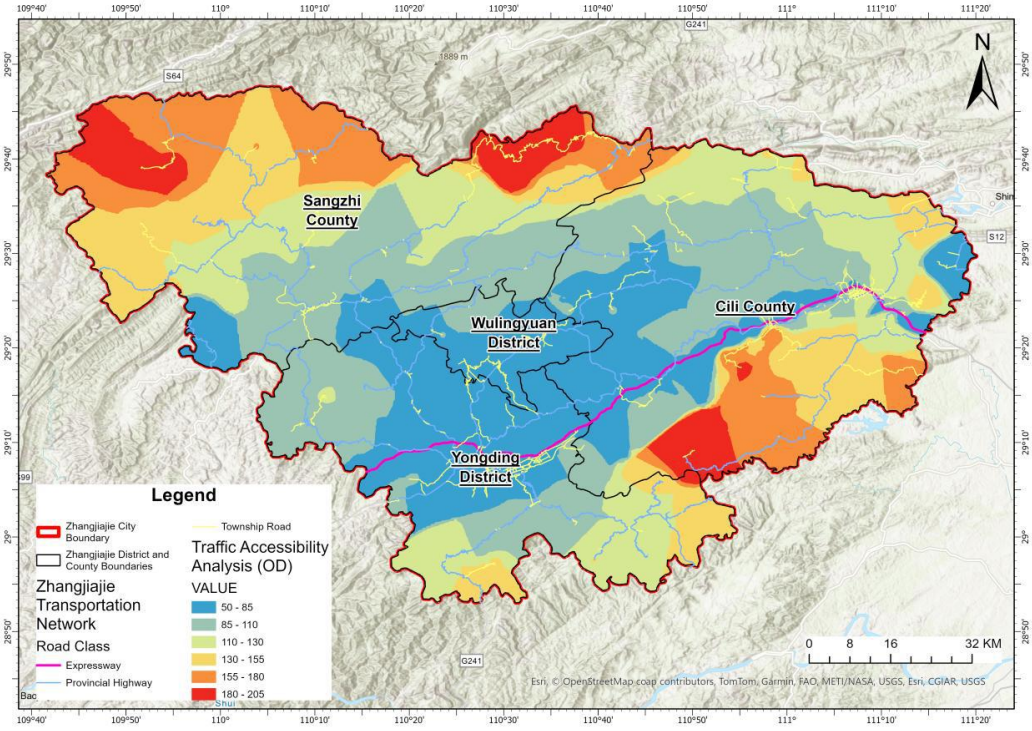


Fig.4. Analysis of transportation accessibility (travel time) in Zhangjiajie City.

Average travel time within the central urban area is 50–85 minutes, and the one-hour accessibility isochrone extends approximately 90 km east to west and 50 km north to south. Northwestern areas of Sangzhi County and southeastern boundary zones have poor accessibility, with large areas requiring more than 155 minutes of travel. This pattern constrains the development and use of peripheral tourism resources because they are weakly connected to major visitor flows and service nodes. During peak seasons and public holidays, congestion will further increase travel times. Improving accessibility to peripheral counties, especially Sangzhi, is therefore a priority for spatially balanced tourism development in Zhangjiajie.

Bivariate spatial autocorrelation among tourism elements

Bivariate spatial autocorrelation analysis identifies two contrasting patterns of association among Zhangjiajie's tourism elements (Table 2). The first is strong spatial co-occurrence. Dining, shopping, transportation, entertainment, and public services have positive associations with one another, with all bivariate Moran's I values above 0.79. This pattern indicates high co-location and mutually reinforcing development among these five elements. The highest Moran's I occurs between dining and public services (0.829), which may reflect their shared role in serving residents and visitors and their common dependence on population concentration and urban functional zoning. Moran's

I values between shopping, transportation, entertainment, and public services all exceed 0.8. Accommodation has a lower association with public services (0.664), but the overall pattern indicates a host and guest shared spatial structure among service elements.

Element	Dining	Pub. Ser.	Shopping	Transp.	Sightseeing	Entertain.	Accommod.
Dining	—						
Public Services	0.829**	—					
Shopping	0.822**	0.827**	—				
Transportation	0.824**	0.813**	0.793**	—			
Sightseeing	0.127*	0.140*	0.115*	0.150*	—		
Entertainment	0.827**	0.810**	0.803**	0.819**	0.172*	—	
Accommodation	0.805**	0.664**	0.658**	0.710**	0.268*	0.745**	—

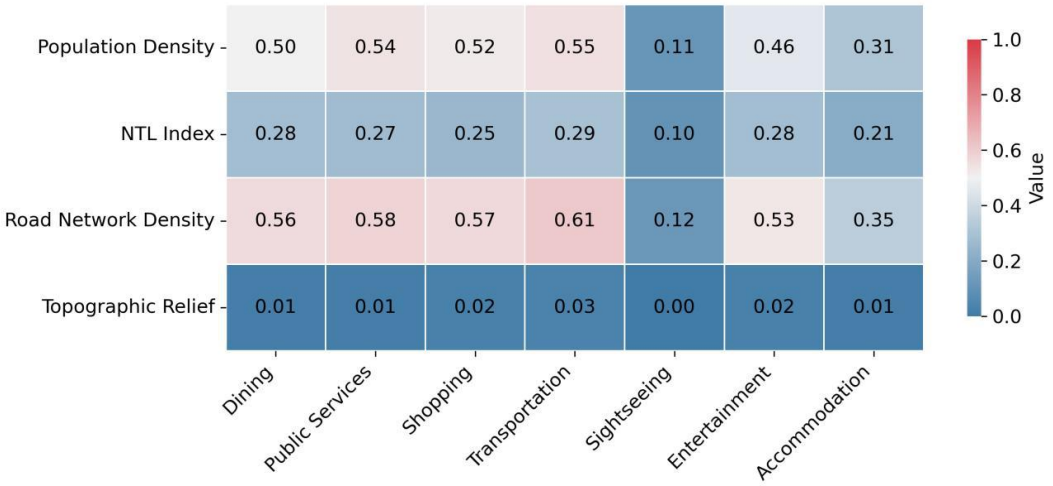
Table 2. Bivariate spatial autocorrelation results (Moran's I) between tourism element POIs in Zhangjiajie City.

Note: Pub. Ser. = public services; Transp. = transportation; Entertain. = entertainment; Accommod. = accommodation. ** indicates high spatial correlation ($p < 0.01$); * indicates low spatial correlation ($p < 0.05$).

The second pattern is spatial divergence. Sightseeing elements have substantially weaker associations with all other tourism elements, with six bivariate Moran's I values ranging from 0.115 to 0.268 (mean ≈ 0.16). These values are well below the associations among the other five categories. The lowest value occurs between sightseeing and shopping (0.115), indicating that shopping is the service element least co-located with scenic areas. This divergence is consistent with the resource-bound location of Zhangjiajie's core attractions and restrictions on commercial development within World Natural Heritage sites and national protected areas. These results support H2.

Influencing factors: geodetector analysis

The Geodetector results (Figure 5) show systematic differences in the explanatory power of the four factors across tourism element categories. Population density, road network density, and the nighttime-light index have their strongest associations with transportation elements ($q = 0.55$, 0.61, and 0.29, respectively) and their weakest associations with sightseeing elements ($q = 0.11$, 0.12, and 0.10). Across categories, road network density consistently has the highest q value, making it the strongest measured explanatory factor for tourism element differentiation in Zhangjiajie ($q = 0.56$ for dining, 0.58 for public services, 0.57 for shopping, 0.61 for transportation, and 0.53 for entertainment).



Figu.5. Geodetector q values for the influencing factors of tourism element POIs in Zhangjiajie City.

Population density has relatively strong associations with transportation, public services, dining, shopping, and entertainment (q = 0.46-0.55), indicating that population agglomeration generates demand for service facilities and contributes to their spatial clustering. Its q value is lower for sightseeing (0.11) and accommodation (0.31). Core attractions are located within World Natural Heritage sites, national forest parks, and nature reserves, where permanent populations are limited. Accommodation follows a different logic because lodging facilities cluster around scenic areas and serve visitors rather than local residents.

The nighttime-light index, used as a proxy for regional economic development, is also associated differently with the tourism elements. High-brightness zones are concentrated in central Yongding and extend along roads toward Wulingyuan and the county seats of Sangzhi and Cili. The highest q value occurs for transportation elements (0.29), consistent with the concentration of transport facilities in economically active areas. The q value for sightseeing is only 0.10, consistent with the location of scenic areas away from brightly lit urban and commercial zones.

Road network density has the strongest explanatory power across the tourism elements. The road network radiates from urban centers and connects the district and county nodes, so its density distribution resembles the spatial agglomeration of tourism elements. The highest q value occurs for transportation elements (0.61), although this association is partly definitional because many transportation POIs are located on roads. The q value for sightseeing is only 0.12, indicating weak spatial coupling with the urban road network. Scenic areas rely partly on internal road systems that operate independently of the urban network. This pattern highlights a distinction between nature-based and urban cultural destinations: natural landscape attractions are tied to scenic resources and show relative independence from urban road density[12].

Topographic relief has negligible explanatory power for all tourism element categories, including sightseeing (q = 0.00-0.03). This result may seem unexpected in a city known for its sandstone geomorphology, but it should be interpreted at the adopted analytical scale. At a 1 km × 1 km resolution, raster reclassification smooths local terrain variation and reduces statistical association between relief and KDE values. Relief may also influence the broad location of scenic areas without differentiating locations at the grid scale used here. Because only one grid size was tested, this scale-based explanation remains tentative. Overall, the results support H3: road network density and population density explain service elements better than sightseeing, while relief has negligible explanatory power at this scale.

Discussion

Two spatial logics and the gradient between them

The results indicate that Zhangjiajie's tourism elements follow two spatial logics. Five service-oriented elements, namely dining, shopping, transportation, entertainment, and public services, co-locate strongly (bivariate Moran's I > 0.79) and concentrate in central Yongding and along the northeast to southwest corridor formed by the road network and the Lishui River. Sightseeing elements have weak associations with all other elements (Moran's I = 0.115-0.268), and their mean center lies in Wulingyuan District. This pattern is consistent with Christaller's observation that tourism places often occupy peripheral landscapes that are unsuitable for other uses, whereas services follow centrality and market access. It also extends to tourism supply the core and peripheral structure that Liu et al.[22] identified for ecotourism flows in Zhangjiajie.

Accommodation occupies an intermediate position. It has the strongest association with sightseeing (Moran's I = 0.268), while its associations with shopping and public services (0.658 and 0.664) are weaker than those among the other service elements. Its standard deviational ellipse is nearly circular and is centered near Tianmen Mountain and Wulingyuan. Population density explains accommodation less well (q = 0.31) than it explains the other service elements (q = 0.46–0.55). Lodging therefore follows visitor activity more closely than resident demand, consistent with urban hotel location research[8]. The attraction and service divide is better understood as a gradient than a binary split. Accommodation connects scenic areas with the urban service system, whereas dining, shopping, and public services remain embedded in resident-oriented urban space.

These findings should be interpreted in light of the conservation regime. Tourist facilities have been removed from the Wulingyuan heritage property since 1999[24], and commercial development within World Natural Heritage sites and national forest parks is restricted. The weak coupling between sightseeing and service elements is therefore partly a designed outcome of protected-area governance rather than evidence of a service deficiency. The planning question is whether this separation is effectively bridged at gateways and along access corridors. The global statistics used here identify the issue but cannot locate specific service gaps.

Explanatory factors in comparative perspective

The Geodetector results show that the four measured factors explain service elements more strongly than sightseeing elements. Road network density and population density yield q values of 0.46-0.61 for most service elements but only 0.12 and 0.11 for sightseeing. Two qualifications are important. First, the highest value, road network density for transportation elements (q = 0.61), is partly definitional because bus stops and stations are located on roads. Second, the weak explanatory power of the measured factors for sightseeing does not demonstrate that sightseeing is governed by resource endowment. No resource variable was included, and topographic relief explained little variance for any element (q = 0.00–0.03). The resource-bound interpretation is therefore consistent with, but not directly measured by, the results. The low q value for relief may reflect the 1 km grid, which smooths local terrain variation, and the role of relief as a stable background condition. Because only one grid size was tested, this remains an interpretation rather than a finding.

Comparison with previous studies clarifies the distinctive features of this case. Studies of attraction distribution at provincial and regional scales report that natural endowment and topography matter alongside transport and socioeconomic conditions[13-15]. High-quality attractions in Shandong also depend strongly on resource endowment and topographic-landscape conditions[14]. Studies of tourism activity on the Qinghai and Tibet Plateau, by contrast, find that transport accessibility and

service facilities outweigh natural resource endowment[20,35]. These findings are not contradictory. The present analysis describes where tourism supply is located, whereas the Qinghai and Tibet studies model where visitors are active. Attraction locations are anchored by fixed scenic resources, while the use of those resources depends on the surrounding transport and service system.

Contributions

This study makes three contributions. First, it operationalizes a seven-element framework that adds public services to the conventional six elements. The public-service POIs examined here, including public toilets, courier stations, and telecommunications service centers, serve residents as well as visitors. Their strong co-location with dining, shopping, and transportation (Moran's I = 0.81-0.83) is therefore best interpreted as host and guest shared space rather than tourism-specific provision. The framework makes this shared infrastructure visible in destination analysis. Second, it provides citywide evidence that attraction and service separation in a regulated nature-based mountain destination is structural, while accommodation occupies an intermediate position between the two spatial logics. Third, by distinguishing the location of tourism supply from the use of attractions, it helps reconcile the resource-centered and accessibility-centered explanations reported in previous studies. The procedure can be transferred to other mountain and heritage destinations, provided that analysts account for overlap between some elements and explanatory variables and for the point representation of extensive scenic areas.

Practical implications

First, the functional division between the Wulingyuan scenic core and the Yongding service center should be treated as a planning premise rather than a problem to eliminate. Tianmen Mountain adjoins the central city and can draw directly on urban services, whereas Wulingyuan depends on its gateway area and transit links to Yongding. Second, where additional provision is needed, it should take the form of compact, low-impact service clusters at scenic gateways outside strictly protected zones. These clusters could provide visitor information, public toilets, emergency services, small-scale retail, and transit connections. Identifying specific gaps requires gateway-scale analysis, which the citywide statistics used here cannot provide. Third, average travel times across much of Sangzhi County exceed 155 minutes. Better connectivity to peripheral counties could broaden the distribution of tourism benefits, but total road mileage is a long-term constraint on ecological security in the Zhangjiajie Scenic Area[36]. Shuttle services and multimodal transfer nodes are therefore preferable to road expansion near protected areas.

Limitations and future research

Several limitations should be acknowledged. First, conservation zoning for the World Heritage property and other protected areas was not included among the explanatory factors. Because construction and settlement are restricted within these zones, the explanatory power of road network density and population density may partly capture regulatory effects rather than market processes alone. Second, the transportation element consists largely of facilities located along roads, so its association with road network density is partly definitional. Third, POI data represent extensive scenic areas as points and overrepresent commercial establishments. This may understate the spatial extent of sightseeing elements and contribute to their weak association with services. The sightseeing category also includes urban parks and exhibition halls and is not purely nature based. Fourth, the POI data were collected in September 2024 and may include temporarily closed establishments. Nighttime-light and population data were acquired in earlier years, and OpenStreetMap may underrepresent minor rural roads in mountainous areas. Fifth, the analysis relies on global bivariate

statistics and a single grid size. It cannot locate specific gateway service gaps or test the sensitivity of the results, including the low explanatory power of relief, to spatial scale. Finally, the single-case, cross-sectional design limits generalization. Future research could incorporate protected-area zoning, local indicators of spatial association, multiscale analysis, and multitemporal POI data, and compare mountain, heritage, and urban cultural destinations.

Conclusions

This study examined the spatial configuration of seven tourism elements in Zhangjiajie using POI data and kernel density estimation, standard deviational ellipses, network-based accessibility analysis, bivariate spatial autocorrelation, and the Geodetector. The main conclusions are as follows.

Tourism elements form a dual-core hierarchy centered on Yongding and Wulingyuan and aligned with the road network and the Lishui River corridor. Service-oriented elements concentrate in urban and road-accessible areas, whereas the mean center of sightseeing elements lies in Wulingyuan, supporting H1.

Sightseeing elements have weak associations with all other elements (Moran's $I = 0.115–0.268$), whereas dining, shopping, transportation, entertainment, and public services co-locate strongly in a host and guest shared pattern (Moran's $I > 0.79$), supporting H2. Accommodation occupies an intermediate position and follows scenic areas more closely than the other service elements. Because tourist facilities have been removed from the heritage property, this separation is partly a designed outcome of conservation governance rather than a deficiency in itself.

Road network density and population density explain service elements more strongly than sightseeing elements, supporting H3. The association between road density and transportation elements is partly definitional. Topographic relief has negligible explanatory power at the 1 km grid scale.

Zhangjiajie would benefit from coordinated service provision around scenic gateways, improved peripheral accessibility, and low-impact visitor activities that reduce spatial and temporal gaps in the tourism system. The framework and diagnostic procedure can be applied to other nature-based mountain destinations to assess spatial mismatch, identify service gaps, and support balanced and sustainable destination governance.

Data availability

The POI data were obtained from the Amap Open Platform, and the auxiliary spatial datasets were obtained from publicly available sources. Processed data are available from the corresponding author upon reasonable request.

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Author Contributions

Conceptualization, X.S., S.Y. and F.H.; methodology, X.S. and H.X.; software, X.S., and H.X.; validation, X.S., S.Y. and F.H. ; formal analysis, X.S.; investigation, X.S.; resources, F.H.; data curation, X.S.; writing—

original draft preparation, X.S.; writing—review and editing, S.Y., F.H. and H.X.; visualization, X.S.; supervision, S.Y. and F.H.; funding acquisition, F.H. All authors have read and agreed to the published version of the manuscript.

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Declarations

Conflicts of Interest

The authors declare no conflict of interest.