

Article

Spatial Distribution, Accessibility, and Influencing Factors of the Tourism and Leisure Industry in Qingdao, China

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Abstract: Analysing the spatial distribution patterns of the urban tourism and leisure industry is crucial for meeting the dual demands of residents and visitors for a better quality of life. Most existing studies on spatial distribution characteristics and the accessibility of leisure tourism have been carried out individually and lack the relationship between the tourism and leisure industry and accessibility. Based on Qingdao's POI data, spatial visualisation methods and Geodetector are used to explore spatial distribution, accessibility, and influencing factors. (1) It is found that the overall and various types of the tourism and leisure industry in Qingdao exhibit clustered distribution, with an imbalance between coastal and inland areas. (2) There are notable spatial disparities in overall accessibility within Qingdao, with most regions falling within the 70-min isochrone. The spatial distribution of accessibility at the county level aligns with the overall accessibility patterns. (3) Various factors influence the spatial distribution of the tourism and leisure industry. Per capita disposable income is the primary factor affecting the spatial layout of Qingdao's tourism and leisure industry. After interacting with other factors, GDP per capita and tourist trips become key influencing factors. These findings can promote the sustainable development of urban tourism in Qingdao and provide a valuable reference for other cities.

Keywords: Qingdao city; tourism and leisure industry; spatial distribution; accessibility; influencing factors; sustainable development



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1. Introduction

1.1. The Role of the Tourism and Leisure Industry in Sustainable Urban Tourism Development

The increase in people's leisure time, the growing focus on health, and the rise of leisure and vacation tourism have led to a shift in tourism consumption [1]. Traditional sightseeing tourism no longer meets the needs of modern people. Leisure and vacation tourism have become a hotspot for consumer activity [2]. The tourism and leisure industry is crucial for tourism development [3], impacting regional tourism competitiveness [4] and supporting sustainable tourism development. In this context, studying the spatial distribution pattern of Qingdao's tourism and leisure industry can aid in urban land planning and the rational layout of urban functional areas [5], thus promoting sustainable urban tourism development.

The tourism and leisure industry is a fundamental part of tourism and plays a crucial role in driving the development of the tourism economy. For example, some complex malls integrate shopping, dining, entertainment, and leisure activities into one location, catering to both residents and tourists. Residents benefit from convenient access to various amenities, while tourists enjoy a comprehensive destination that offers diverse experiences in one place. All of these can stimulate local economic growth. Therefore, its spatial layout should not only meet the residents' daily leisure needs but also consider visitors' tourism experience at the destination [6,7]. The spatial pattern of the tourism and leisure industry refers to the distribution characteristics of business organisations in terms of structure,

scale, and number, with tourism and leisure services elements as the main components [6,8]. Tourism and leisure activities are essential for improving residents' happiness index and visitors' experiences [9]. The tourism and leisure industry is a comprehensive industry integrating tourist attractions, shopping, accommodation and catering, leisure and entertainment, public transportation facilities, etc. Due to its typical economic nature, it will spontaneously generate spatial agglomeration in a specific urban area [10]. Because of its comprehensive nature, its spatial layout can significantly impact the sustainable development of urban tourism.

1.2. Research on Spatial Distribution

Leisure and tourism research has a long-standing history, initially focused on psychological and sociological fields [11]. Christaller was the first to propose that vacationers would form a diffusion range when travelling outside the city [12]. Foreign scholars concentrate on three areas of study in the tourism and leisure industry. Firstly, they explore the motivations of specific tourism subjects based on the theory of leisure constraints [13]. Additionally, they examine the layout, landscape planning, and functional strategy [14,15] of public leisure and recreational spaces (such as historical squares [15], coastal spaces [16], and city parks [17]). They propose concepts such as "recreation around the city area [18]" and "urban RBD [19]" and summarise models such as the semi-circular band, Rodoman, Crosson, and Gil-Lay [20]. The third is to focus on leisure agriculture, rural leisure tourism [21], urban leisure tourism [22], marine leisure tourism [23], and other leisure objects. They examine their spatial evolution and influencing factors [24] with fewer studies related to the spatial structure of the tourism and leisure industry.

However, research on the spatial distribution of the tourism and leisure industry is of great significance for the sustainable development of urban tourism. According to Smith, the spatial distribution of tourism resources can significantly impact the distribution of tourism productivity [25]. Early studies on the spatial structure of urban tourism and leisure industry were primarily based on location theory, with the "core-edge" theory model being the most typical application [26]. In recent years, with the advent of the big data era, there has been a significant change in data acquisition and research paradigms [27], facilitating the study of the spatial distribution of urban leisure tourism activities. Point of Interest (POI) data include basic information such as name, latitude, longitude, address, and type. Compared to traditional data, POI data is more timely, easily transmittable, and easier to store [28–30]. With the aid of big data, research has mainly focused on the spatial layout of tourism and leisure services facilities [31] and the relationship between tourism resources and tourism transportation [32]. Some scholars have adopted mathematical models [33], and some have used spatial analysis methods [34] to study the spatial distribution of tourism resources. Other scholars have studied the spatial distribution of tourism resources from the dynamic [35] and static [36] perspectives. For example, Rainer analysed the spatial distribution patterns and evolution of recreational agriculture in Argentina [37]. However, research on the spatial distribution of tourism resources is mainly from national and provincial perspectives, with fewer studies at the district and county scales. This research will take Qingdao as an example to explore what kind of characteristics the spatial distribution of the tourism and leisure industry will present in a small administrative area.

1.3. Research on Accessibility

The spatial distribution of the tourism and leisure industry is closely related to accessibility. Accessibility refers to the ability to reach a given place through public transport facilities. Hansen first introduced the concept of accessibility in 1959 [38]. The tourism transportation system is a bridge connecting tourists and destinations, and it also links various tourism and leisure activities [39]. The degree of development of the tourism transportation system directly affects the ease with which tourists reach their destinations, impacting their experience and satisfaction during travel and ultimately influencing their decision-making behaviours. Zhao believes that the time-space compression effect brought about by tourism

transportation development has greatly stimulated the demand for consumption in the tourism and leisure industry among residents and tourists [40]. Yan demonstrated through establishing the buffer that regional public transportation significantly impacts the spatial distribution of rural leisure demonstration sites [41]. Li et al. proved that the distribution of high-level scenic spots in the Yellow River Basin is closely related to the distribution of the public transportation networks [42]. It can be seen that accessibility is one of the vital evaluation indicators of public transport systems. This study combines the spatial pattern of the tourism and leisure industry with accessibility to assist travellers in planning their travel routes. Moreover, it also provides a basis for government departments to improve the public transport network to optimise the spatial layout of the tourism and leisure industry.

1.4. Research on Influencing Factors of Spatial Distribution

Through the literature review, we find that scholars have paid equal attention to the study of influencing factors. Krugman has pointed out that the primary nature (e.g., climate and geomorphology) and the secondary nature (e.g., features of the human environment and technological base generated by human activities) work together in spatial differentiation and urban development [43]. Studies on the factors influencing spatial distribution are mostly systematically analysed in multiple dimensions, such as the natural environment and human society. Masson's study found that the traffic factor also profoundly influences the distribution of leisure tourism resources [44]. Considering the existing studies, we can conclude that various factors affect the spatial distribution of the tourism and leisure industry. Since conditions vary from region to region, one of the aims of this study is to investigate whether some unique factors affect the spatial distribution of Qingdao's tourism and leisure industry.

In summary, scholars have produced a substantial body of research on the spatial distribution of objects. However, some areas require further study and improvement. First, regarding the research subjects, most existing studies on spatial distribution characteristics and the accessibility of leisure tourism have been carried out individually and lack a relationship between the tourism and leisure industry and accessibility. Second, regarding research scale, previous studies have mainly concentrated on large-scale levels, such as national and urban agglomerations, with fewer studies at the district and county levels. Finally, regarding research data, traditional tourism and leisure spatial data are obtained through interviews and observations, often lacking timeliness and accuracy. Therefore, interdisciplinary research combining big data and geospatial spatial analysis is urgently needed. What are the spatial distribution characteristics of the tourism and leisure industry within smaller administrative regions? Are there any unique factors influencing Qingdao's tourism and leisure industry spatial distribution?

Given this, this study uses POI data and takes Qingdao districts (cities) as research units. First, spatial analysis methods are used to explore the spatial distribution clustering characteristics, density characteristics, and spatial matching with various levels of the public transportation network. Next, based on raster accessibility analysis and Qingdao's four-level road networks, the study investigates the overall and district-level spatial differentiation patterns of accessibility. Finally, this study identifies the influencing factors and offers optimisation suggestions from an accessibility perspective. The spatial distribution of the tourism and leisure industry is closely related to public transportation, consumer demand, the urban environment, and even industrial policies. Therefore, studying the spatial distribution of the tourism and leisure industry and their influencing factors is of great significance for understanding the development mechanisms of the tourism and leisure industry and promoting the sustainable development of urban tourism.

2. Materials and Methods

2.1. Study Area

Qingdao, located in the southern part of the Shandong Peninsula, is an essential coastal centre, seaside resort city, and national historical and cultural city in China (as

shown in Figure 1). In 2023, Qingdao was successfully recognised as one of the top ten most beautiful coastal leisure cities in China by tourists. Qingdao administers seven districts and three cities (Shinan District, Shibei District, West Coast New Area, Laoshan District, Licang District, Chengyang District, Jimo District, Jiaozhou City, Pingdu City, and Laixi City), with a total area of 11,295 square kilometres. With the implementation of the national strategy for the Blue Economic Zone of the Shandong Peninsula, Qingdao’s urban spatial structure has undergone significant changes, leading to an uneven spatial distribution of the tourism and leisure industry across its districts. Based on the development concept of “city as tourism,” analysing the spatial differentiation of Qingdao’s tourism and leisure industry can help efficiently aggregate elements of this industry and promote the sustainable development of urban tourism. It would also provide valuable insights for other tourist cities looking to optimise their spatial structure.

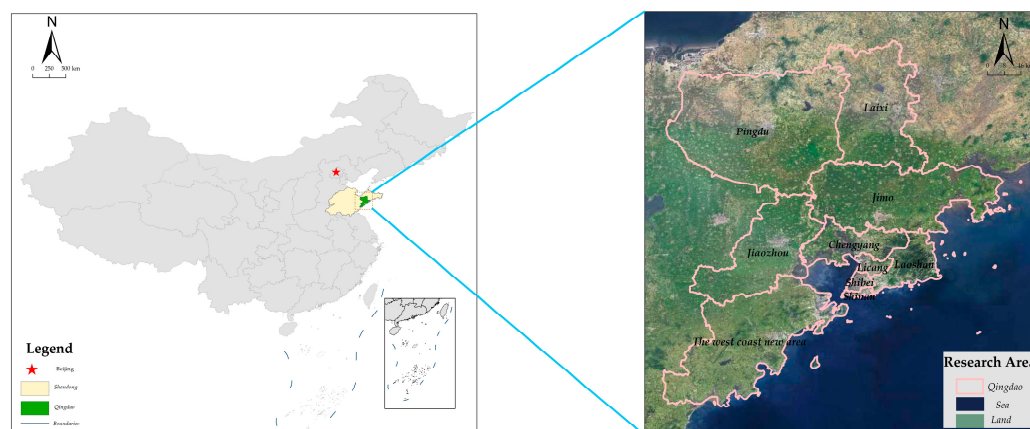


Figure 1. Geographical Location of Qingdao.

2.2. Data Collection

The study is underpinned by two primary categories of data: urban geographic base data and POI data. The urban basic statistical data are sourced from the China Statistical Yearbook (<https://www.stats.gov.cn/>) (accessed on 30 June 2023), the Qingdao public data service platform (<https://data.sd.gov.cn/>) (accessed on 30 June 2023), and the Wind economic database. The road data are obtained from the Open Street Map (<https://www.openstreetmap.org/>) (accessed on 30 June 2023), while the DEM data are acquired from the Geospatial Data Cloud (<https://www.gscloud.cn/>) (accessed on 30 June 2023).

The Point of Interest (POI) data are sourced from the Amap Open Platform. The study utilized the official API data interface platform of Amap, using Python to obtain POI data for 23 categories in Qingdao for the year 2022, including catering services, scenic spots, shopping services, educational and cultural services, life services, sports and entertainment, and accommodation services. Subsequently, Qingdao’s tourism and leisure industry was categorised into five major types (Table 1) based on the National Tourism and Related Industry Classification (2018), Industrial Classification for National Economic Activities (GB/T 4754-2017) [45], and a literature synthesis [46,47]. The data were cleaned by removing data outside the study area, duplicate data, and incorrect data, resulting in 86,115 valid data points. The data were then projected and imported into ArcGIS 10.8 for spatial analysis.

Table 1. The Classification of Tourism and Leisure Industry in Qingdao.

Type	POI Type	POI Number
Catering services	Tea houses, coffee shops, fast food restaurants, cold drink stores, foreign restaurants, Chinese restaurants, bars, etc.	49,620
Scenic spots	Beaches, scenic spots, memorials, temples and Taoist temples, zoos, aquariums, etc.	2204
Shopping services	Convenience stores, shopping centres, malls, etc.	11,391
Sports and entertainment	Museums, science and technology museums, bath and massage places, theatres, exhibition halls, sports venues, etc.	11,921
Accommodation services	Economy hotel chains, hotels and guest houses, guesthouses and hotels, star-rated hotels	10,979

2.3. Research Methodology

2.3.1. Average Nearest Neighbour Index

The average nearest neighbour index is a geographic indicator used to indicate the degree of proximity of Qingdao's tourism and leisure industry. The average nearest neighbour (ANN) is used to calculate the distance between the centre of each point and the centre of the nearest point, and the average of all these distances is determined to calculate the agglomeration degree of various leisure industries [48]. The formula is as follows:

$$ANN = \frac{\bar{D}_0}{\bar{D}_E} \quad (1)$$

$$\bar{D}_0 = \frac{\sum_{i=1}^n d_i}{n} \quad (2)$$

$$\bar{D}_E = \frac{0.5}{\sqrt{\frac{n}{A}}} \quad (3)$$

In the formula, \bar{D}_0 represents the average observed distance between a point element and its nearest neighbouring point in space. \bar{D}_E represents the expected average distance between elements in a random state. n is the number of the tourism and leisure industry; A is the area of the research; d_i is the distance from one point to its nearest point. $ANN \leq 0.5$ and $ANN \geq 1.5$ indicate that the distribution of tourism and leisure industry is aggregated and uniform, respectively; $0.5 < ANN \leq 0.8$ indicates an aggregated-random distribution; $0.8 < ANN < 1.2$ indicates a random distribution; $1.2 \leq ANN < 1.5$ indicates a random-dispersed distribution.

2.3.2. Standard Deviation Ellipse

The standard deviation ellipse (SDE) is primarily used to measure the directionality of point data in spatial distribution. It includes the long axis, short axis, centre point, and azimuth. The long axis reflects the distribution direction of the tourism and leisure industry, while the short axis represents the distribution range. The more significant the difference between the two, the more pronounced the directionality of the distribution of tourism and leisure industry in Qingdao; conversely, the less pronounced the directionality [49].

2.3.3. Kernel Density Estimation

Kernel Density Estimation (KDE) is a method used to measure the density of spatial points in their neighborhood [50]. It can intuitively reflect the clustering degree of the tourism and leisure industry. The kernel density calculation formula is as follows:

$$f(x) = \frac{1}{nh} \sum_{i=1}^n k\left(\frac{x - x_i}{h}\right) \quad (4)$$

In the formula, $f(x)$ represents the kernel density value at x , n represents the total number of industries, h represents the search radius, $x - x_i$ is the distance from the point x to x_i , and k is the distance weight. The larger the kernel density value, the more concentrated the spatial distribution of the tourism industry.

2.3.4. Raster Analysis Method

The raster analysis method for accessibility is a GIS-based approach used to evaluate and visualise the accessibility of various locations. This study calculates the average travel time from tourism and leisure industry points to various locations in Qingdao. Different speeds are assigned to various levels of the road network: highways at 120 km/h, national roads at 80 km/h, provincial roads at 60 km/h, and county roads at 40 km/h. The time cost required to traverse each road network grid is calculated, and the corresponding cost value is assigned. An isochrone map is created using the Spline for visualisation.

$$A_i = \sum_{j=1}^n T_{ij} / n \quad (5)$$

In the formula: A_i represents the transportation accessibility of various regions in Qingdao, T_{ij} denotes the time it takes from point i to reach point j through the public transportation network, n is the number of tourism and leisure industry points.

2.3.5. Geodetector

Geodetector can effectively detect spatial differentiation phenomena and measure the impact of various factors on the evolution patterns of Qingdao's tourism and leisure industry. It mainly includes four detectors: factor detector, interaction detector, risk area detector, and ecological detector [51]. The calculation formula is as follows:

$$q = 1 - \frac{\sum_{h=1}^L N_h \sigma_h^2}{N \sigma^2} \quad (6)$$

In the formula, q represents the influence of any factor on the spatial layout of the tourism and leisure industry in Qingdao; L is the classification or zoning, N_h and N are the number of samples in layer h and the entire area, respectively; σ_h^2 and σ^2 are the variances of the Y values for layer h and the entire area, respectively. The value q ranges from $[0, 1]$, with a larger q value indicating a more substantial influence of the factor on the spatial layout of Qingdao's tourism and leisure industry.

3. Results

3.1. Overall Spatial Distribution Characteristics

3.1.1. Spatial Clustering Characteristics

The nearest neighbour tool in the spatial statistics of ArcGIS 10.8 was used to calculate the average nearest neighbour ratios of Qingdao's tourism and leisure industry. The results are shown in Table 2. The average nearest neighbour ratios of Qingdao's tourism and leisure industry are all less than 0.5, and the Z -test values are all less than -2.58 , passing the test at the 1% significance level. The overall average nearest neighbour ratio is $0.29 < 0.5$, indicating a spatially agglomerated distribution. The nearest neighbour ratios of different types are also less than 0.5, with the smallest ratio for catering services at 0.23. Catering

services are influenced by economic level, population quality, location, and traffic, and they often cluster spatially to attract a stable customer base. The ratios for shopping services and scenic spots are 0.42 and 0.45, respectively, indicating less clustering than the other sectors. Among them, the distribution of scenic spots exhibits significant spatial coupling with the distribution of natural resources such as mountains and water, showing a spatial pattern of being along mountains and near water. However, the spatial clustering of mountains and water resources in Qingdao is not apparent. Thus, the degree of agglomeration is weaker.

Table 2. Average Nearest Neighbour Index and Spatial Distribution Type of Tourism and Leisure Industry in Qingdao.

Type	The Average Observed Distance/m	The Expected Average Distance/m	NNI	Z	P	Spatial Distribution Type
Overall	53.16	180.71	0.29	396.25	0	Agglomeration
Catering services	55.26	238.06	0.23	−327.22	0	Agglomeration
Scenic spots	513.67	1129.55	0.45	−48.97	0	Agglomeration
Shopping services	210.25	496.86	0.42	−117.78	0	Agglomeration
Sports and entertainment	184.28	485.69	0.38	−129.62	0	Agglomeration
Accommodation services	129.84	506.09	0.26	−149.02	0	Agglomeration

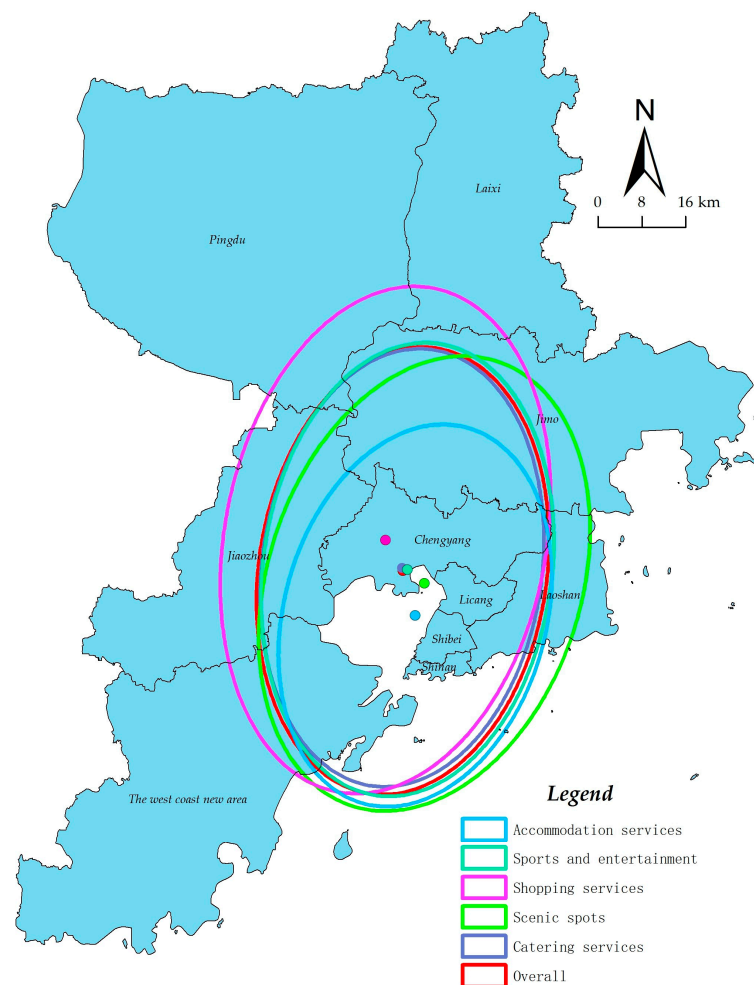
Overall, Qingdao's tourism and leisure industry show significant clustering characteristics, acting as a core link between tourists and residents and continuously promoting the integration of their relationship. During spatial evolution, leisure and entertainment areas for tourists and residents gradually overlap. Leisure and entertainment are the goals for tourists and are the primary living spaces for residents, with their spatial distances increasingly overlapping. This overlap provides safer and more convenient living and recreational spaces for regional economic development and the well-being of the people.

3.1.2. Centre of Gravity for Spatial Distribution

Using ArcGIS 10.8 software, the barycentric coordinates, rotation, area, and flattening of Qingdao's tourism and leisure industry can be obtained. The results are shown in Table 3 and Figure 2. Overall, Qingdao's barycentric coordinates of the tourism and leisure industry are mainly located near Shaogezhuang Village and South Huazhong Road in Hongdao Street, Chengyang district. The agglomeration area shows a "northwest-southeast" distribution, covering Chengyang, Licang, Shibe, and Shinan, with a clear directionality. Specifically, the barycentric coordinates of each type are within an 18 km buffer zone centred on the geometric centre of Qingdao. Shopping services are the closest to the geometric centre of Qingdao, at only 5.77 km. Secondly, the elliptical area can characterise the spatial distribution range of each type of tourism and leisure industry to some extent. Among them, shopping services have the largest distribution range of 4346.41 km², which aligns with the fact that they have the nature of host-guest sharing. Its wide spatial distribution range can satisfy the daily needs of tourists and residents to the greatest extent. On the other hand, the accommodation services have the smallest distribution range of 2692.88 km², indicating a more centralised and efficient land utilisation. Overall, Qingdao's tourism and leisure industry demonstrates the characteristics of clustered distribution around the geometric centre.

Table 3. Barycentric Coordinates and Flattening of Tourism and Leisure Industry in Qingdao.

Type	Barycentric Coordinates	Long-Axis /km	Short-Axis/km	Rotation /°	Area/km ²	Flattening
Overall	120°16′26.39″ E, 36°13′18.70″ N	41.25	26.37	8.53	3417.44	0.36
Catering services	120°16′20.05″ E, 36°13′36.82″ N	40.35	25.63	7.75	3249.21	0.36
Scenic spots	120°19′7.40″ E, 36°12′6.81″ N	42.84	28.69	18.18	3860.43	0.33
Shopping services	120°14′12.59″ E, 36°16′19.24″ N	46.97	29.46	10.86	4346.41	0.37
Sports and entertainment	120°16′59.26″ E, 36°13′26.87″ N	41.76	26.45	7.74	3470.12	0.37
Accommodation services	120°18′5.88″ E, 36°8′54.87″ N	35.71	24.00	15.49	2692.88	0.33

**Figure 2.** Spatial Distribution Direction of Qingdao's Tourism and Leisure Industry.

3.1.3. Spatial Density Characteristics

To gain a more comprehensive understanding of Qingdao's spatial distribution of the tourism and leisure industry, we used ArcGIS's density analysis tool to conduct a kernel density analysis (Figure 3). This process allowed us to create a map that vividly illustrates the distribution pattern of the industry in the region. The map shows that the minimum value of Qingdao's tourism and leisure industry is 0, the maximum value is 451.38, the average value is 7.45, and the standard deviation is 27.03. The result highlights the imbalance between the coastal and inland areas. As can be seen from Figure 3, the level of tourism and leisure industry agglomeration in coastal and inland areas varies greatly, showing significant spatial differentiation characteristics. High-density agglomeration

is primarily found in Chengyang, Licang, Shibei, Shinan, and the West Coast New Area. They form a belt-like layout along the coast in an inverted “7” shape. The degree of agglomeration decreases from Shinan and Shibei towards both sides, spreading in a belt-like shape. The sub-density agglomeration area is mainly found in Pingdu, Laixi, Jiaozhou, and Jimo, distributed spatially in a “square” with relatively decentralised distribution. It aligns with the strategic layout of the Bay development space in the 14th Five-Year Tourism Development Plan of Qingdao. It focuses on the new development positioning of Jiaozhou Bay, laying out leisure tourism along the coastline, developing high-quality theme lines, and starting the “Jiaozhou Night Bay” brand.

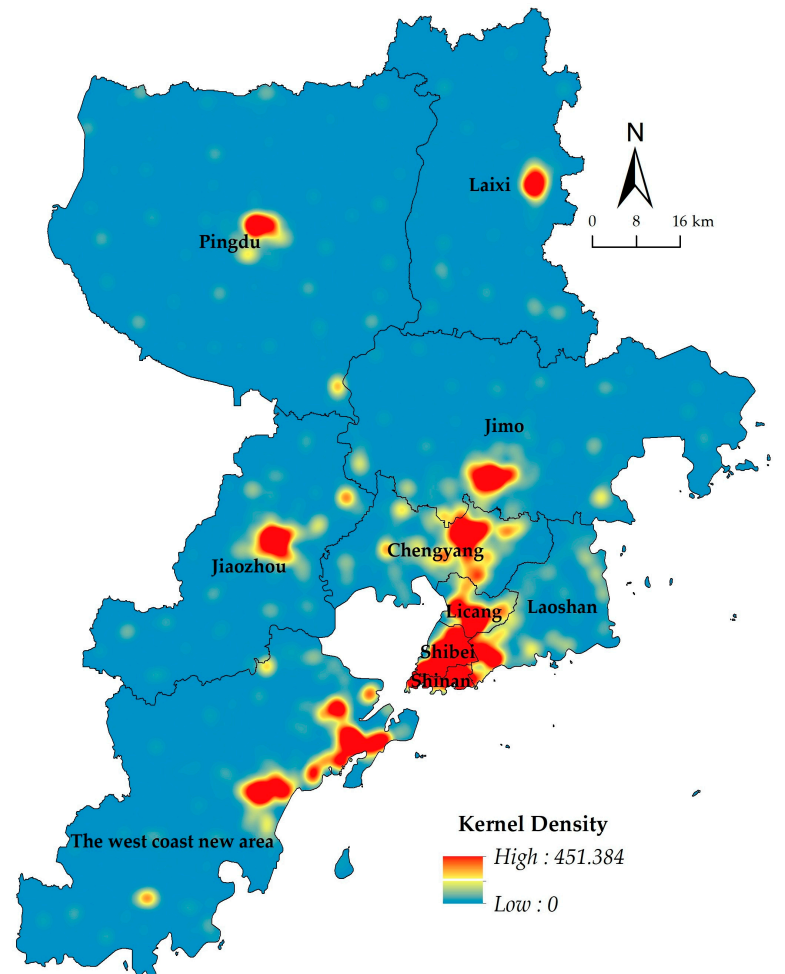


Figure 3. Kernel Density Analysis of Qingdao’s Spatial Distribution of Tourism and Leisure Industry.

The density value would decrease with distance, making it a relative value. A cluster analysis is carried out further to analyse its spatial agglomeration characteristics (Figure 4). The results are divided into three grades based on the size of the kernel density: 149–451 as the high-density area (grade i), 40–149 as the medium-density area (grade ii), and 0–40 as the low-density area (grade iii). In terms of area proportion, the high-density, medium-density, and low-density zones account for 0.85%, 3.60%, and 95.55% of the total area, respectively. Regarding spatial distribution, high-density zones are mainly located on the northern coast of the new area. Medium-density zones are primarily found in Shibei, Shinan, Laoshan, the West Coast New Area, Jimo, Chengyang, and other coastal areas. Low-density zones include Pingdu, Laixi, Jiaozhou, the West Coast New Area, and most of Jimo.

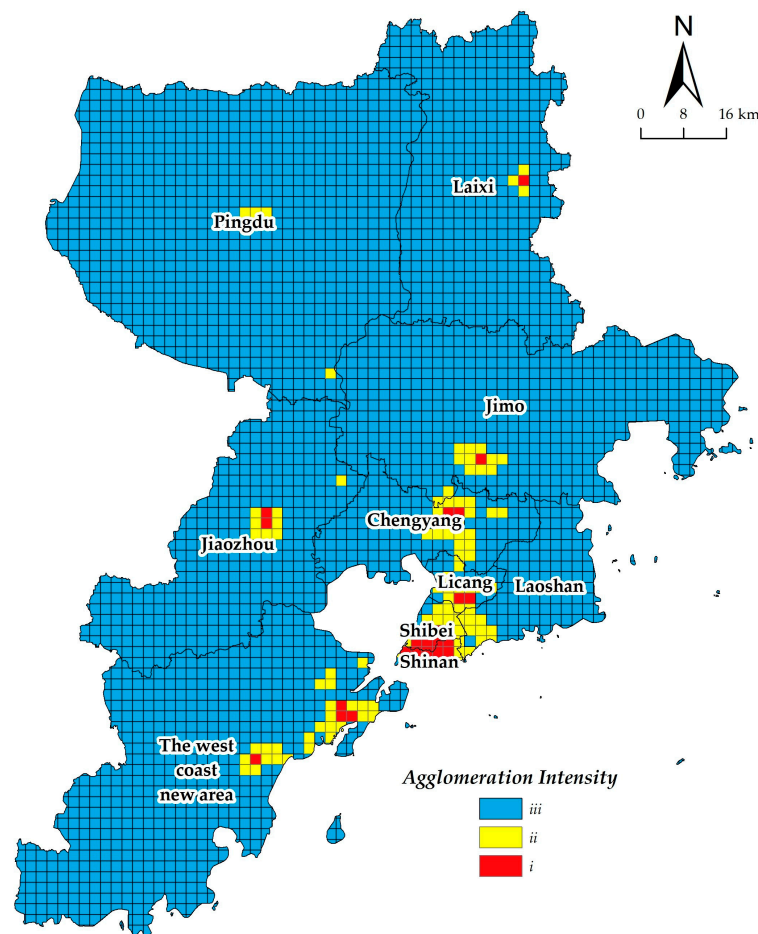


Figure 4. Density Grades of Tourism and Leisure Industry in Qingdao.

Overall, the layout of Qingdao's tourism and leisure industry demonstrates spatial distribution imbalance characteristics, showing strong spatial autocorrelation. The industry distribution density is highly correlated with the layout of public transportation stations and the level of economic development.

3.1.4. Spatial Matching Characteristics

Travel agencies, tourist hotels, and transportation departments are the three main sectors of the modern tourism industry [42]. Among them, the transportation department is crucial in connecting tourist destinations and sources. Generally, the higher the transportation accessibility in an area, the greater the possibility of various industry clusterings. Using the ArcGIS 10.8 multi-ring buffer tool, a four-level buffer zone (Figure 5) was established with roads at all levels (highways, national roads, provincial roads, and county roads) as the axes. The buffer zones were classified as 0–0.5 km, 0.5–1 km, 1–1.5 km, and 1.5–2 km to explore further the spatial distribution status of Qingdao's tourism and leisure industry. The results reveal a decreasing number of the tourism and leisure industry with increasing distance, consistent with Tobler's first law.

Within a 2 km range of highways, there are 26,398 tourism and leisure industry (30.65%). Within a 2 km range of national roads, there are 45,633 tourism and leisure industry (52.99%). And within a 2 km range of provincial roads, there are 80,490 tourism and leisure industry (93.47%). Additionally, there are 79,635 tourism and leisure industry within a 2 km range of county roads (92.48%). Overall, there is a high degree of connectivity between the tourism and leisure industry and provincial and county roads. In the 0–1 km range, the number of tourism and leisure roads along county roads is greater than along

provincial roads, national roads, and highways. Therefore, compared with other types of roads, county roads have the optimal combination with the tourism and leisure industry.

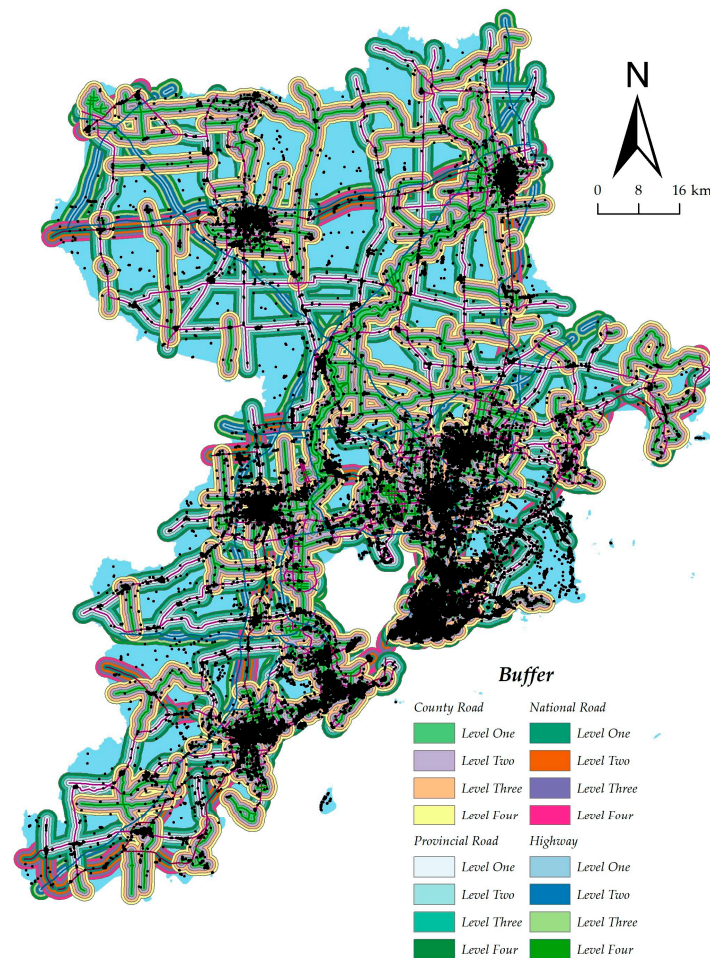


Figure 5. The Overlay of Spatial Relationship between the Tourism and Leisure Industry and the Public Transportation Road Network in Qingdao.

3.2. Overall Spatial Accessibility Distribution Pattern

Based on ArcGIS 10.8, accessibility analysis was carried out, as illustrated in Figure 6. It shows a significant difference in the spatial distribution of transportation accessibility in Qingdao. Using the natural breaks method, we divided it into eight time periods. Most areas (81.91%) are within the 70-min traffic isochronous circle, while only a tiny proportion (18.09%) are above 70 min. Accessibility decreases from the centre to the surrounding areas, aligning with the distribution trend of the tourism and leisure industry. It confirms that Qingdao's public transportation network significantly impacts the distribution of the tourism and leisure industry. The 8 time periods can be further divided into high, medium, and low accessibility zones: 30–46 min is the high accessibility zone, 46–70 min is the medium accessibility zone, and over 70 min is the low accessibility zone. They account for 41.28%, 51.72%, and 7.00%, respectively. It was found that nearly half of the areas in Qingdao have a high level of accessibility, which can effectively meet the needs of tourists and citizens for tourism and leisure.

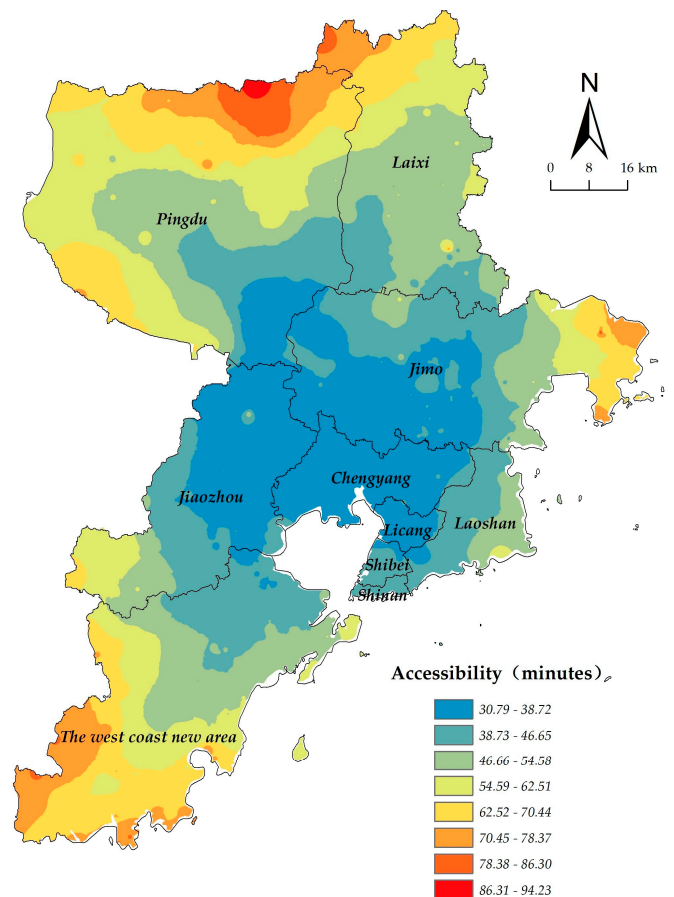


Figure 6. Qingdao Traffic-isochronous Circle.

3.3. Spatial Differentiation of Accessibility at Unit Level

To investigate the accessibility level from the perspective of Qingdao's administrative divisions, Qingdao's districts are used as the research units. The accessibility levels of various areas are calculated and classified into five categories according to the natural breaks (Figure 7). The results indicate that the accessibility of each administrative region decreases from the centre area to the periphery. Most districts have relatively high accessibility, consistent with the overall distribution of accessibility. Specifically, Chengyang and Licang belong to the high accessibility zone; Shibe and Jiaozhou belong to the second highest accessibility zone; Shinan, Jimo, and Laoshan belong to the medium accessibility zone; Laixi belongs to the second lowest accessibility zone; and Pingdu and West Coast New Area belong to the low accessibility zone. Combining the previous kernel density analysis results, it can be seen that the vast majority of the tourism and leisure industry is distributed around Jiaozhou Bay. These POI points are all located within areas of high accessibility, where the level of accessibility is highest, and the degree of POI aggregation is also highest. A few points are distributed in the second and lowest accessibility zones, such as Pingdu, Laixi, and the West Coast New Area. This study argues that the tourism and leisure industry in Pingdu and Laixi is centrally exhibited, meaning that tourism and leisure are distributed around the administrative centres. The closer they are to the administrative centre, the more complete the infrastructure, thus the higher the degree of POI aggregation. The aggregation of hotspots in the West Coast New Area is closely related to the endowment of tourism resources. The West Coast New Area has many tourism resources, such as Golden Beach, Silver Beach, Qingdao Shell Museum, and Urban Balcony Scenic Area. These tourism resources have the characteristics of natural immobility and high tourist heat, so they attract a considerable aggregation of tourism and leisure, forming prominent hotspot aggregation areas with relatively low impact from transportation accessibility.

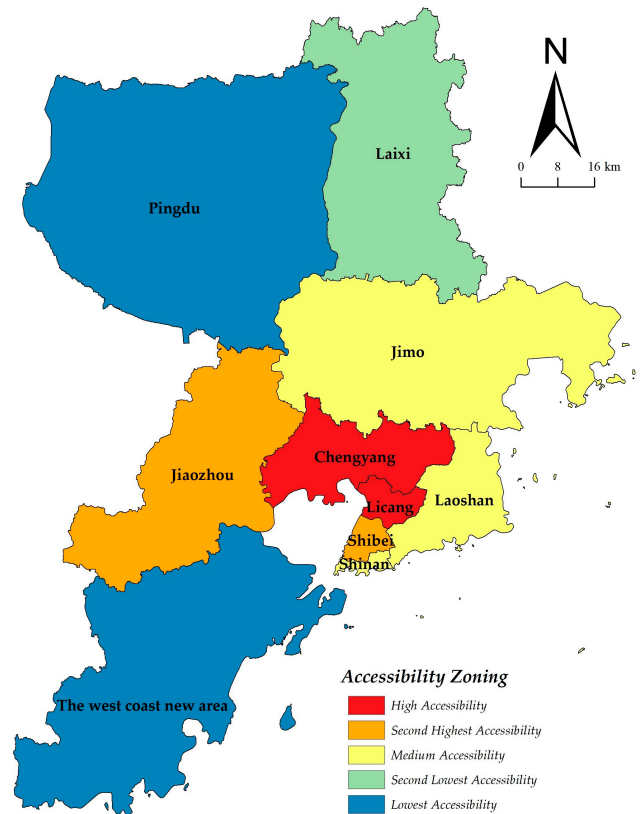


Figure 7. Accessibility Distribution Map of Each District in Qingdao.

3.4. Factors Influencing the Spatial Distribution of Tourism and Leisure Industry in Qingdao

3.4.1. Selection of Influencing Factors

Exploration of the influencing factors can provide a basis for the sustainable development of urban leisure tourism. Based on the geographical specificity of Qingdao and existing research results [52–56], this study constructs an indicator system of factors impacting the spatial distribution of Qingdao’s tourism and leisure industry. It mainly focusses on the socioeconomic dimensions, public transportation facilities, natural geography, and tourism development to explore the influence of each factor on the spatial distribution of tourism and leisure in Qingdao (Table 4).

Table 4. Indicator System of Influencing Factors for Spatial Distribution of the Tourism and Leisure Industry in Qingdao City.

Dimensions	Indicators	Evaluation Indicators
Socioeconomy	Level of economic development	GDP per capita Per capita disposable income Number of newly registered market entities Night light intensity
	Social factors	Urbanisation rate Population density Transaction area of commercial housing
Public transportation facilities	Transport condition	Density of bus and subway stations
	Accessibility	Distance to the prefecture-level city
Natural geography	Elevation	/
Tourism development	Tourist trips	/
	Tourism resource endowment	Ocean park, marine particular protected area, nature reserve, etc., area proportion

3.4.2. Detection of Influencing Factors

Through factor detection using the Geodetector, we can obtain the factor detection results for the evaluation indicators (Table 5).

Table 5. Factor Detection Results.

Dimensions	Factors	q
Socioeconomy	GDP per capita	0.04 *
	Per capita disposable income	0.72 ***
	Number of newly registered market entities	0.69 ***
	Night light intensity	0.25 ***
	Urbanisation rate	0.15 ***
	Population density	0.66 ***
	Transaction area of commercial housing	0.71 ***
Public transportation facilities	Density of bus and subway stations	0.53 ***
	Distance to the prefecture-level city	0.65 ***
Natural geography	Elevation	0.04 *
Tourism development	Tourist trips	0.05 **
	Tourism resource endowment	0.22 ***

Note: *, **, and *** are significant at the significance level of 10%, 5%, and 1%, respectively.

Based on the q value, the factors influencing the spatial distribution of Qingdao's tourism and leisure industry can be divided into three types: main influencing factors, medium influencing factors, and secondary influencing factors. The main influencing factors include per capita disposable income, the number of newly registered market entities, population density, the transaction area of commercial housing, the density of bus and subway stations, and distance to the prefecture-level city, all of which have q-values above 0.5. The medium influencing factors are night light intensity (0.25), urbanisation rate (0.15), and tourism resource endowment (0.22). The influencing factors of GDP per capita, elevation, and tourist trips are all lower than 0.1, which are secondary influencing factors.

1. Main Influencing Factors

The main influencing factor is per capita disposable income, which has the largest value of 0.72. Per capita disposable income is a crucial indicator of regional consumption capacity. Regions with higher per capita disposable incomes tend to have more robust potential consumption capacities. Tourism and leisure activities cater to the needs of high-level spiritual activities, which require a particular economic foundation for support. The pursuit of high-level tourism and leisure activities by high-income groups aligns with the business philosophy of the tourism and leisure industry, contributing to the clustering distribution of the tourism and leisure industry. Additionally, higher per capita disposable incomes make it more likely for individuals to invest their excess funds in the operation of the tourism and leisure industry, leading to their clustering distribution.

Population density is closely related to the transaction area of commercial housing. Generally, the larger the transaction area of commercial housing in a region, the greater the region's population density and the larger the customer market. Any economic activity, whether production- or service-oriented, needs a particular market potential to cover its basic operating costs. A higher population density increases demand for tourism and leisure activities, attracting more businesses to enter the market. As a result, regions with higher population density tend to have a higher tourism and leisure industry agglomeration.

The number of newly registered market entities reflects a region's economic vitality and business environment. A well-organised market and a stable economic environment would benefit market development and economic growth, and they could support the entry of new enterprises and industrial development. The presence of different types of market players helps diversify and specialise economic development, leading to knowledge sharing

and reduced transaction costs. They are ultimately promoting the growth of enterprises and attracting more industrial agglomerations.

2. Medium Influencing Factors

Among the medium-influence factors, the level of a region's tourism resource endowment is the fundamental factor influencing regional tourism development. The richer the tourism resources, the more conducive they are to developing tourism and leisure activities, promoting the agglomeration of the tourism and leisure industry. The night light intensity and urbanisation rate reflect a region's economic development level, serving as essential indicators of the vitality of the region's socioeconomic development. The higher level of economic development leads to better optimisation of the industrial structure of tourism services and promotes the agglomeration of the tourism and leisure industry.

3. Secondary Influencing Factors

Among the secondary influencing factors, the q -value of elevation and GDP per capita is only 0.04. Elevation negatively affects the distribution of tourism and leisure industry. Qingdao is a hilly coastal city, and the elevation has a slight undulation. These weakly influence the layout of the tourism and leisure industry. Additionally, it is generally believed that the higher the GDP per capita, the higher the demand for tourism. However, due to COVID-19, residents are expected to allocate more of their income to survival expenditures, reducing expenditure on leisure and tourism. As a result, the explanatory power of GDP per capita for the spatial distribution of the tourism and leisure industry is weak.

3.4.3. Interaction Detection of Influencing Factors

The results of factor interaction detection (Figure 8) indicate that the influence of any two-factor combination on the spatial layout of the tourism and leisure industry exhibits characteristics of nonlinear enhancement or dual-factor enhancement. It means that the interaction of any two factors on the spatial distribution of the tourism and leisure industry is stronger than that of any single factor. Specifically, the interaction between GDP per capita and other factors is the strongest, followed by tourist trips. It suggests that the interaction of GDP per capita and tourist trips with other factors is the dominant factor influencing the distribution of tourism and leisure industry in Qingdao. Therefore, although GDP per capita has relatively low explanatory power as an individual influencing factor, its role as a fundamental factor could directly affect tourists' willingness to travel. Additionally, tourist trips indirectly influence the market size, thereby significantly impacting the layout of the tourism and leisure industry.

Overall, the individual impact strength of GDP per capita and tourist trips is relatively low, but after interacting with other factors, they rank highest among all factors. Previous studies argue that sudden public health events have intensified tourists' perception of risks, with lower-level physiological and safety needs pushing tourists to consume survival materials. This leads to a tendency to avoid tourism activities. However, tourism activities could allow tourists to leave their familiar environments and experience physical and mental pleasure. The epidemic has led to psychological and distance compression, and tourists crave diverse tourism experiences. As a result, tourists also tend to engage in retaliatory tourism consumption. Thus, GDP per capita and tourist trips generate strong interaction effects with other factors and are important factors influencing the layout of the tourism and leisure industry.

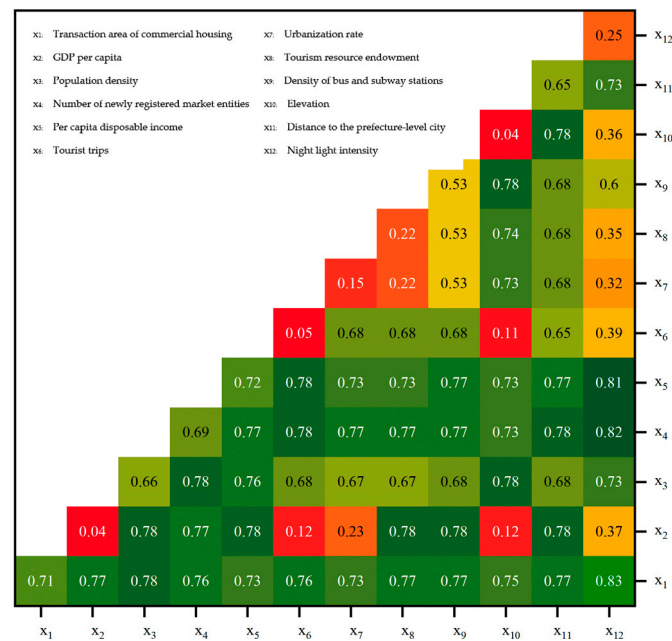


Figure 8. Interaction Detection Results.

4. Discussion

Previous studies on POI data have primarily focused on describing spatial change trends, predominantly at the provincial level [57,58]. Research at the municipal level is relatively lacking. There are also fewer studies on the relationship between the tourism and leisure industry and accessibility. Therefore, this study analyses the spatial layout, accessibility, and the factors that influence Qingdao’s tourism and leisure industry. Additionally, it addresses the interdisciplinary integration of big data with tourism, leisure, and urban planning disciplines, thereby deepening the understanding of urban leisure tourism spaces.

4.1. Spatial Distribution of the Tourism and Leisure Industry

According to the results of the average nearest neighbour index and kernel density analysis, the spatial distribution pattern of the tourism and leisure industry in Qingdao is agglomerated. Significant differences exist in the agglomeration levels between coastal and inland areas, with a high-density agglomeration area represented by Jiao Zhou Bay. Based on the distribution along the border and the coast, relatively independent single-core agglomeration areas are formed. This finding corroborates the conclusions of some scholars that urban tourism and leisure industry exhibit a distinct core-periphery distribution [59–61]. Additionally, the buffer analysis reveals that most of the tourism and leisure industry is within 1 km along public transportation lines, exhibiting a “distance decay” law. It is consistent with Tobler’s first law [62]. This finding also supports the study’s conclusions by Liang et al. [63]. The accessibility strongly matches the spatial distribution of the tourism and leisure industry. Areas with higher accessibility usually have a higher industry agglomeration [64]. From a demand perspective, convenient tourism transportation enables tourists to reach their destinations quickly, enhancing tourism attractiveness. For example, many attractions are often located near tourism transportation stations and attract many domestic and foreign tourists [65]. From a supply perspective, areas with convenient public transportation are more likely to attract investment [66], forming comprehensive tourism facilities and influencing the spatial distribution of the tourism and leisure industry. For instance, cities along the Shinkansen line, such as Tokyo, Kyoto, and Osaka, have developed dense tourism and leisure industry [67].

4.2. Analysis of Influencing Factors

Regarding influencing factors, the spatial distribution of the tourism and leisure industry is influenced by various factors [63,68]. Socioeconomics, public transportation infrastructure, natural geography, and tourism development are important driving factors affecting the spatial distribution of the tourism and leisure industry. Among these, the natural geographical factors exhibit minimal variation and are considered static influencing factors, while socioeconomic and other factors exhibit significant variation and are considered dynamic influencing factors. According to the results of the Geodetector, per capita disposable income, the number of newly registered market entities, population density, transaction area of commercial housing, the density of bus and subway stations, and the distance to the prefecture-level city are the main factors influencing the spatial differentiation of the tourism and leisure industry. GDP per capita and tourist trips become essential factors in the layout of the tourism and leisure industry after interacting with other factors. This conclusion is consistent with the push-pull theory of tourism activities [69].

However, research also indicates that certain factors can indirectly influence the spatial distribution of the tourism and leisure industry. For instance, research indicates that the quality and accessibility of healthcare services at a tourist destination can influence travellers' choice of destination, though factors like price play a more significant role. Consequently, access to health care can indirectly impact the spatial layout of the tourism and leisure industry by affecting travellers' willingness to visit [70]. Second, the level of education is related to tourism consumption activities. Studies have shown that higher education levels are associated with increased travel frequency and intention. This, in turn, can indirectly affect the spatial distribution of the tourism and leisure industry [71]. Moreover, regional safety conditions significantly impact the spatial distribution of the tourism and leisure industry. Research shows that safety is one of the key factors in tourists' choice of destination [72]. Areas with good safety records typically attract more tourists. Thus, factors like access to healthcare, level of education, and safety indirectly influence the spatial distribution of the tourism and leisure industry by affecting tourists' choices.

4.3. Implications

From a theoretical perspective, given the diverse combination and broad involvement of Qingdao's tourism and leisure industry, the formation of its spatial pattern is inevitably driven by various factors. From the perspective of human-land sustainable interaction, the formation of urban tourism and leisure industry patterns is related to the interaction between urban land space as a geographical element [73], guided by structural transformation, and urban tourism and leisure industry as human elements, through mediation of economic, social, geographical, and public transportation factors. That is, urban land space as a geographical element, under the development orientations of old city revitalisation [74,75] and structural upgrading [76], continuously exerts varying degrees of influence on urban tourism and leisure industry as human elements through the economic, social, geographical, and public transportation factors. This enables the tourism and leisure industry to quickly adapt to the urban spatial environment while more efficiently exerting the industry's spillover effect [77]. As a result, it can promote the intensification of land use and the sustainability of tourism development. Hence, the formation of urban tourism and leisure industry patterns can be regarded as a typical manifestation of the mutual adaptation of human and land elements within the sustainable tourism human-land relationship system.

From a practical perspective, the conclusions of this study have significant implications for optimising the spatial pattern of the tourism and leisure industry in tourism cities. Under the complex situation of multiple influencing factors, city managers must assess specific urban areas' economic, social, and public transportation conditions, whether conducting macro-level planning or micro-level configuration. They should also specifically strengthen regional comparative advantages and rationally guide the tourism and leisure industry layout. For urban core areas with significant agglomeration benefits, market competition should be encouraged to stimulate the development vitality of the leisure industry [78].

For urban peripheral areas, the government should increase efforts in guiding leisure consumption, capital investment, new area development, and public transportation optimisation while balancing service equity and efficiency to achieve balanced and optimised agglomeration benefits of the urban tourism and leisure industry [79].

4.4. Limitations

Since tourism is inherently a comprehensive industry with a broad scope and vague boundaries, and there are currently no clear standards for defining leisure tourism, this study has several limitations. The limitations of this research are as follows: First, the study uses POI “point” data as the data source, which does not reflect the size of the area or scale of the volume. As a result, the analysis of a larger volume of leisure and tourism resources is lacking, which affects the data quality. Secondly, due to the lack of historical data, this study fails to analyse the evolution of the spatial pattern of the tourism and leisure industry in Qingdao from the perspective of spatial and temporal evolution. Given the above shortcomings, future research could consider using multi-source data and combining field research and interview data to explore the evolution of the distribution pattern of the urban tourism and leisure industry in spatial and temporal dimensions.

5. Conclusions

Tourism and leisure activities have become important guarantees for enhancing residents’ happiness and visitors’ experiences. Reasonable allocation of different elements of the tourism and leisure industry helps optimise the urban land use structure, promoting sustainable development in tourism. Based on the POI data, this study classifies the tourism and leisure industry into five types: catering services, scenic spots, shopping services, sports and entertainment, and accommodation services. Firstly, based on average nearest neighbour index analysis and standard deviation ellipse, this research studied the spatial clustering characteristics. Second, it was supplemented by kernel density analysis and spatial correlation analysis to explore its spatial density characteristics.

Furthermore, it uses buffer and raster analysis methods to study the spatial matching relationship between the tourism and leisure industry layout and public transportation networks, and accessibility. Finally, Geodetector is used to explore the factors that influence the spatial differentiation of Qingdao’s tourism and leisure industry. The main conclusions of the paper are as follows:

(1) The spatial distribution pattern of Qingdao’s tourism and leisure industry shows a clustered form, with the centre located on Hongdao Street, Chengyang District, and oriented in a northwest-southeast direction. There is a significant difference in clustering levels between coastal and inland areas, forming high-density clusters, as represented by Jiaozhou Bay. Moreover, relatively independent single-core clusters are formed based on their distribution along the edge and around the sea.

(2) The overall accessibility in Qingdao shows significant spatial differences. It can be divided into eight-time intervals, with most areas falling within the 70-min isochrone. The accessibility distribution exhibits a decreasing radiation pattern from the centre to the periphery, indirectly verifying the intrinsic connection between the public transportation network and the spatial distribution of the tourism and leisure industry. The accessibility of Qingdao at the unit level can be divided into five categories. The accessibility of each county-level administrative region decreases from the central area to the periphery, with most districts (cities) having high accessibility, consistent with the overall accessibility.

(3) This pattern formation results from the comprehensive interaction of socio-economic factors, natural environmental factors, public transportation networks, and tourism development. Although the “spillover effect” and “trickle-down effect” brought about by the development of tourism may weaken the development disparity between coastal and inland areas, there still exists a trend for the tourism and leisure industry to concentrate on urban centres with obvious comparative advantages, resulting in an imbalance between coastal and inland areas in the layout of urban tourism and leisure industry.

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