

Spatial Distribution Characteristics and Influencing Factors of Museums in Linyi, China

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Abstract: Museums have been integrated into tourism activities as cultural carriers and have become increasingly prominent in developing the regional cultural tourism industry. How to promote the high-quality development of the museum industry across China is an important topic that needs to be considered at present. Therefore, we used 56 museums in Linyi as the research object, analyzed the spatial distribution characteristics of museums in Linyi and explored the main influencing factors. The results show that (1) the museums in Linyi tend to be cohesively distributed, mainly concentrated in the central to central-eastern part of Linyi, with few museums distributed in other areas, and the distribution of museums within Linyi shows an unevenness; (2) the museums show a tendency to be centrally distributed, and museums show a centralized distribution, forming the main agglomeration area of Lanshan – Hedong-Luozhuang, as well as the two secondary agglomerations of Junan and Yinan-Yishui; (3) Factors such as the degree of resource endowment, the level of economic development, the accessibility of transport, the degree of development of tourism, and the degree of population density all combine to influence the distribution of museums in Linyi; (4) On the whole, Linyi's museums tend to be distributed in areas that are rich in natural and cultural resources, with a higher level of economic development, a well-developed transport network and proximity to rivers and lakes, a better-developed tourism industry, and a higher population density. In the future, Linyi should pay attention to the following aspects in the construction and management of museums: digging deeper into the resources to expand the types and numbers of museums; responding to the market demand and promoting the quality of museums; accelerating the construction of museums by taking advantage of the tourism industry; and improving the infrastructure to help the development of museums.

Keywords: Spatial distribution, Influencing factors, Development of museums, Linyi, China

I. Introduction

As a temple of human civilization inheritance and emotion dissemination, museums preserve and display the witnesses of human beings and the human environment, and are an essential window for people to understand the local culture, customs and history, as well as an important classroom for cultural propaganda and historical inculcation [1-4]. Museums have been integrated into tourism activities as cultural carriers and have become increasingly prominent in developing the regional cultural tourism industry. However, there is an imbalance and insufficiency in the development of museums in different parts of China, and it is necessary to continue to promote the high-quality development of China's museum industry in the future [5-9]. Therefore, this study takes Linyi as an example to explore the spatial distribution characteristics and influencing factors of museums based on different dimensions to provide references for subsequent studies on the scientific development of museums and the enhancement of cultural competitiveness.

II. Overview of The Study Area

Linyi is in the southeastern part of Shandong Province, where the Yangtze River Delta Economic Circle meets the Bohai Sea Economic Circle. Named after the Linyi River, Linyi is the core birthplace of the Dongyi culture, with a history of more than 3,000 years of city building. The Communist Party of China (CPC) created the Yimeng Revolutionary Base in the Linyi in modern times, and established the Shandong Provincial Government in Dadian Town, Junan County, in August 1945. In December 1994, the State Council of China approved abolishing Linyi area and county-level Linyi City and establishing

prefecture-level Linyi City. Linyi has attractions such as Mount Yimeng, Daigu landform, the former residence of Wang Xizhi, Zhuquan Village, and Tangtou Hot Spring, and historical celebrities such as Zeng Zi, Xun Zi, Zhuge Liang, Wang Xizhi, Yan Zhenqing, and Xiao Daocheng. In recent years, the national policy of promoting the construction of museums and the need for regional tourism development, the construction of museums in the counties and districts under the jurisdiction of Linyi has been increasing, and museums have become important tourist attractions.

III. Data and Methodologies

A. Data and Sources

The main data of the study (Table 1) include (1) the Museum information of 2021 published on the website of the State Administration of Cultural Heritage of China, in which there are 56 museums belonging to Linyi; (2) The geographic coordinates of the museums in Linyi counties and districts obtained by using Baidu map to pick up the coordinate system; (3) Population and GDP of each county and district of Linyi are obtained from the Statistical Yearbook of Linyi of 2021; (4) Data of tourist attractions with grade 3A-level and above of each county and district of Linyi are from the official website of Linyi government; (5) The geographic information of primary administrative divisions is from the website of China Temporal sequence Administrative Map; (6) The data of roads, rivers, lakes are from the website of OpenStreetMap.

Table 1. Research objects and data sources

Data	Sources	Website
Museum information	The State Administration of Cultural Heritage of China	http://nb.ncha.gov.cn/museum.html
Geographic coordinates of the museums	Baidu map picking coordinate system	https://api.map.baidu.com/lbsapi/getpoint/index.html
Data of population and GDP	Statistics Bureau of Linyi	http://tjj.linyi.gov.cn/info/1061/12062.htm
Data of tourist attractions with grade 3A-level and above	The government of each county and district of Linyi	http://www.linyi.gov.cn/
Geographic information of administrative divisions	China Temporal sequence Administrative Map	https://www.shengshixian.com/pages/d35ae5/
Data of roads, rivers, lakes	OpenStreetMap	https://www.openstreetmap.org

B. Theoretical Basis

Average Nearest Neighbor Index

Museums can be abstracted as point-like elements with three types of spatial distribution: random, uniform and cohesive, which are usually identified in research using the Average Nearest Neighbor Index (R). The Average Nearest neighbor formula is [5, 6]

$$R = \bar{r}_i / r_E \quad (1)$$

$$r_E = \frac{1}{2\sqrt{m/A}} = \frac{1}{2\sqrt{D}} \quad (2)$$

Where: \bar{r}_i represents the mean distance between each point and its nearest neighbor; r_E is the theoretical nearest neighbor distance when point elements are randomly distributed; m represents the number of point elements; A represents the study area; D represents the number of point elements per unit area. When $R=1$, point elements is considered randomly distributed; when $R>1$, point elements is considered dispersed; when $R<1$, point elements is considered clustered.

Imbalance Index

The imbalance index (S) can reflect the degree of balanced distribution of museums in Linyi, and is calculated as follows [7-12]:

$$S = \frac{\sum_{i=1}^n Y_i - 50(n+1)}{100n - 50(n+1)} \quad (3)$$

Where: n denotes the number of counties and districts in Linyi; Y_i denotes the cumulative percentage of the number of museums in each county and district as a proportion of the total number of museums in Linyi, ranked from largest to smallest after the i^{th} position. s takes values from 0 to 1: when $S=0$, the transmission of museums is evenly distributed in the counties and districts; when $S=1$, the museums are all concentrated in one county and district.

Geographical Concentration Index

The Geographical Concentration Index (G) can indicate the concentration of the distribution of the object of study and is used to explore the concentration of the distribution of museums [10-16]:

$$G = 100 \sqrt{\sum_{i=1}^n \left(\frac{X_i}{T} \right)^2} \quad (4)$$

Where: X_i represents the number of museums owned by the i^{th} county and district in Linyi; T is the total number of museums in each county and district in Linyi; n represents the number of counties and districts in Linyi; the larger the value of G , the higher the degree of concentration, assuming that museums are evenly distributed when $G=G_0$; if $G>G_0$, it means that museums are concentrated, and conversely, more dispersed.

Kernel Density

Kernel density analysis can calculate the density of point elements around each output grid, which can intuitively reflect the degree of concentration and discrete traditional villages; the formula is [5-9]:

$$f(x) = \frac{1}{nh} \sum_{i=1}^n k\left(\frac{x-x_i}{h}\right) \quad (5)$$

Where: $k()$ is the kernel density function; h is the bandwidth; n is the number of points in the threshold range; $(x-x_i)$ denotes the distance from the valuation point x to the event x_i .

C. Selected Software

Because the coordinates captured in Baidu map picking coordinate system are Baidu coordinates, it is necessary to convert them to World Geodetic System coordinates (WGS), which is carried out in QGIS 3.34. The calculation of Imbalance Index and Geographical Concentration Index are realized by using equation 3 and 4 in EXCEL. The related information of Average Nearest Neighbor Index and Kernel Density are calculated by equation 1, 2 and 5 in ArcGIS 10.8. All the Figures in this study are generated by ArcGIS 10.8 and embellished in Illustrator.

IV. Distribution Characteristics

A. Spatial Distribution

The collected data of museums in Linyi are divided into counties and districts for quantitative statistics and visualization, resulting in a map of the distribution of the number of museums in each county and district in Linyi City (Fig. 1). In Fig. 1, the red data points indicate the specific locations where the museums are located, and the shade of the bottom colour in each county reflects the number of museums in the county. Currently, the number of museums in each district and area in Linyi under its jurisdiction amounts to 56, of which 14 are in Yinan, ten are in Hedong, nine are in Lanshan, seven are in Junan, two are in Pingyi, two are in Luozhuang, Feixian, Laning, Linshu and Mengyin each, and 1 is in Tancheng. Overall, the number of museums in Linyi varies significantly from county to county, and museum construction is uneven.

B. Types of Spatial Distribution

At the study level of counties and districts, each museum can be regarded as a point-like element, whose geographical location can be represented by a coordinate point. Point elements usually have three spatial distribution types: random, uniform, and cohesive. The geographic coordinates of the 56 museums in Linyi were imported into the ArcGIS10.8 software platform, and the operation (Eq. 1, 2) through the Average Nearest Neighbor tool therein yielded $R=2.831125$, i.e., $R < 1$, which determines that the type of spatial layout of the museums in each county and district of Linyi belongs to the cohesive type of distribution.

C. Degree of Equilibrium in Spatial Distribution

The imbalance index can study the balanced degree of distribution of point elements in different regions. According to equation (3), the imbalance index $S=0.47078$ is calculated in EXCEL, indicating that museums are unevenly distributed in each district and county. According to the statistical data used to generate the museum Lorenz curve (Fig. 2), the Lorenz curve is farther away from the uniform distribution line, and the curve protrudes with a larger arc, indicating that the distribution is not balanced within each region. The combined number of museums in four counties and districts, namely Yinan, Hedong, Lanshan, and Junan, accounted for 71.4% of the total number of museums, whereas the number of museums in Tancheng, Yishui, Mengyin, Linshu, Lanling, and Feixian were fewer.

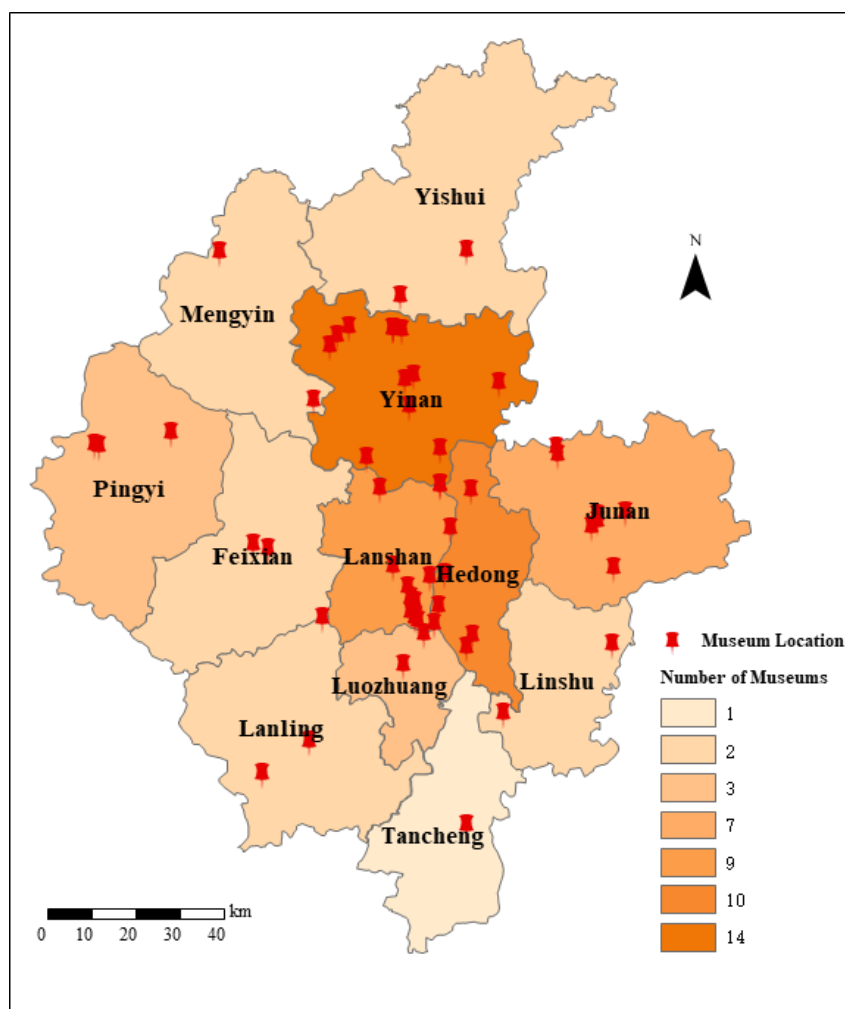


Fig.1 Distribution of museums in Linyi

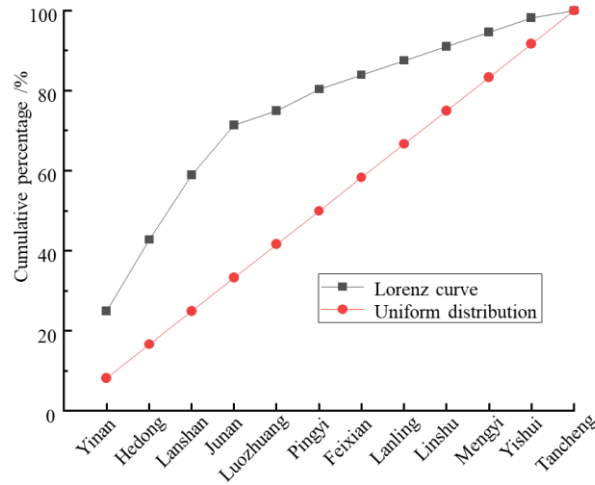


Fig. 2 Lorenz curve of distribution of museums in Linyi

D. Analysis of Spatial Distribution Aggregation Area

The geographic concentration index $G=38.2993$ and $G_0=28.8675$ are calculated from equation (4), $G>G_0$, indicating that the museums are presented as concentrated distribution on the county and district scales, and the degree of concentration is high. Most of the museum studies use the kernel density analysis function of ArcGIS for kernel density mapping (Eq. 5) and then analyze the spatial concentration characteristics of museums. In kernel density estimation, bandwidth is the main factor affecting kernel density estimation. After many trials, set the bandwidth to 20km, and used ArcGIS 10.8 to generate the kernel density map of the spatial distribution of museums in Linyi counties and districts (Fig.3). The highest concentration of museums is in the central to east-central part of Linyi. The junction areas of Lanshan, Hedong and Luozhuang are the main aggregation areas with high density and some continuity; the junction areas of Yinan and Yishui, and Yishui mainly form two sub-aggregation areas, while the southern, western, and northern parts of Linyi have fewer museums distributed, and do not have a large-scale aggregation area.

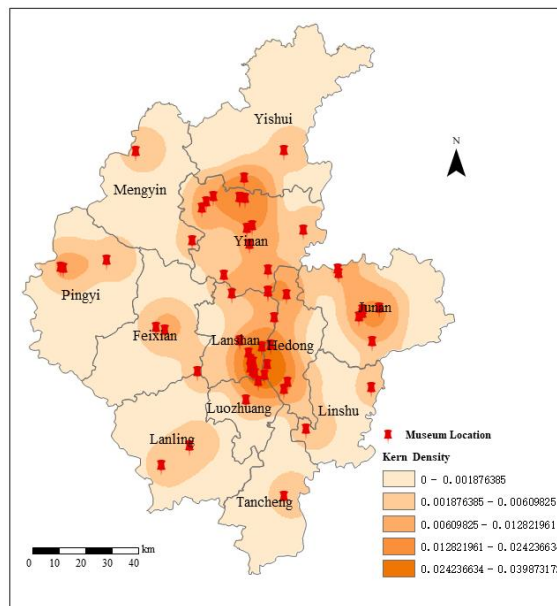


Fig.3 Kernel density map of museums in Linyi

IV. Influencing Factors of Spatial Distribution

Usually, the influencing factors of the spatial distribution of museums are mainly the natural geographic environment, history and culture, the level of socio-economic development, the level of scientific and educational development, the level of tourism development, urban planning, and government policy orientation. Linyi is in the southeastern part of Shandong Province, in the middle of the Beijing-Shanghai line, and has obvious regional characteristics as it is a national logistic hub-bearing city, an important birthplace of Dongyi culture, and an old revolutionary area. This paper analyses the interrelationship between the degree of resource endowment, the level of economic development, the accessibility of transportation, the degree of tourism development, and the degree of population density and the spatial distribution of museums in Linyi, considering the results of related research and the actual situation of the spatial distribution of museums in Linyi.

A. Degree of Resource Endowment

Natural and cultural resources are the material foundation of museum construction. Linyi has a long history and is one of the important birthplaces of Chinese civilization; it was also one of the famous revolutionary bases during the War of Resistance Against Japanese Aggression and the War of Liberation and was known as the Holy Land of the two wars. This has created conditions for the construction of revolutionary and historical museums. For example, Yinan, Hedong and Lanshan have historically served as the seat of the city of Linyi, so the historical museums here are distributed densely, and many relics of the Yimeng Revolutionary Bases have been preserved intact in places such as Mengyin, Yinan, Junan and Hedong, so the revolutionary museums here are more widely distributed. Yinan, Junan, Lanshan, and Hedong are important areas of the Dongyi culture, with well-preserved historical and cultural resources, so many art museums exist in these areas (Fig. 4).

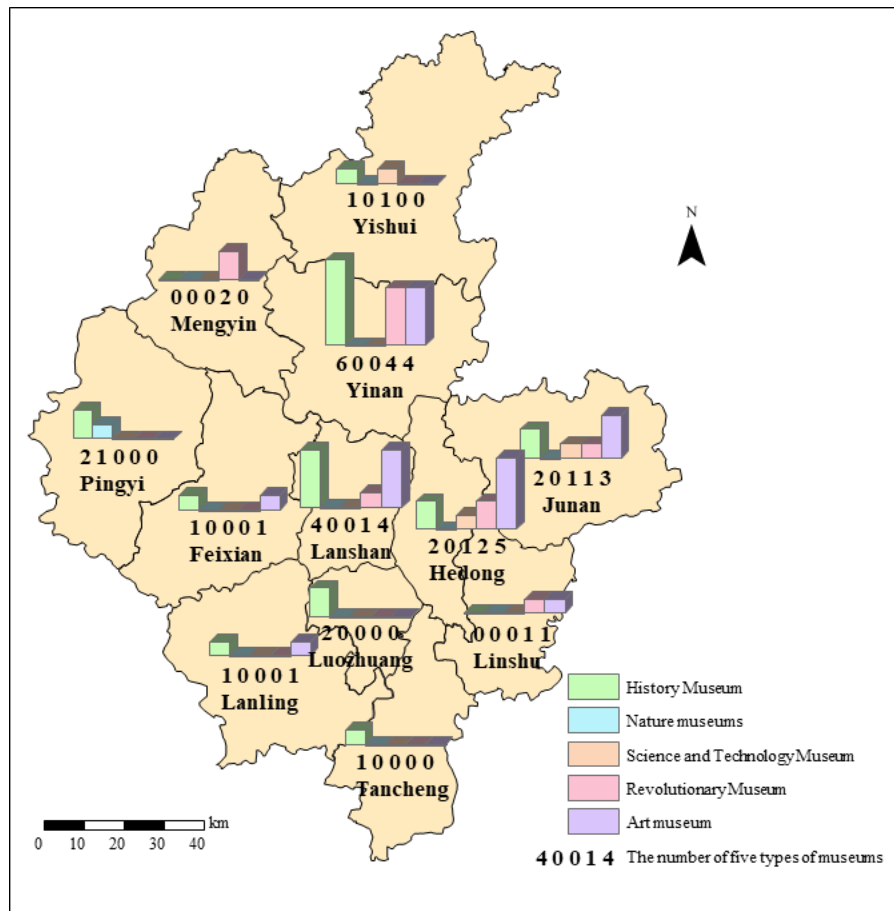


Fig.4 Distribution of five types of museums in Linyi

B. Economic Development Level

The results of using ArcGIS10.8 software to overlay the GDP of Linyi counties and districts with the distribution of museums are shown in Fig. 5. Lanshan, Hedong, Junan and other counties and districts have relatively high levels of economic development, and the number of museums in these areas is also relatively high. Overall, counties and districts with a high density of museums generally have relatively high GDP levels; however, counties and districts with high GDP levels do not necessarily have a high density of museums. Among them, Yinan has the most extraordinary performance among the counties and districts in Linyi. Although Yinan's economic development level is relatively low among the counties and districts in Linyi, it has the most significant museums. Yinan has given full play to its resource advantages in recent years, adopting market-oriented operation, integrating funds, land, and sectoral policies tilted towards cultural tourism, activating the kinetic energy of development, and emerging several non-state-owned museums.

C. Water System and Transport Network

Using ArcGIS10.8 software, the major roads, rivers and lakes in Linyi are overlaid with the distribution of museums, and the results are shown in Fig. 6. As can be seen from the figure, most museums in each county and district in Linyi are distributed along rivers and lakes and are in areas with well-developed transport networks, with only a few in a fragmented and remote distribution. As museums are necessary public cultural settings, the government and other museum owners generally pay more attention to siting them to make them easily accessible to citizens and tourists. In order to develop tourism, most of the new non-state-owned museums built in recent years have also chosen to build their museums closer to rivers and lakes, where the natural landscape is beautiful, and the traffic is usually more convenient. In recent years, the expansion of the road network in the area under the jurisdiction of Linyi City and the construction of the Lunan High-Speed Railway has led to a significant increase in transport accessibility. The positive effect of transport accessibility on the distribution of museums in Linyi may become more and more apparent.

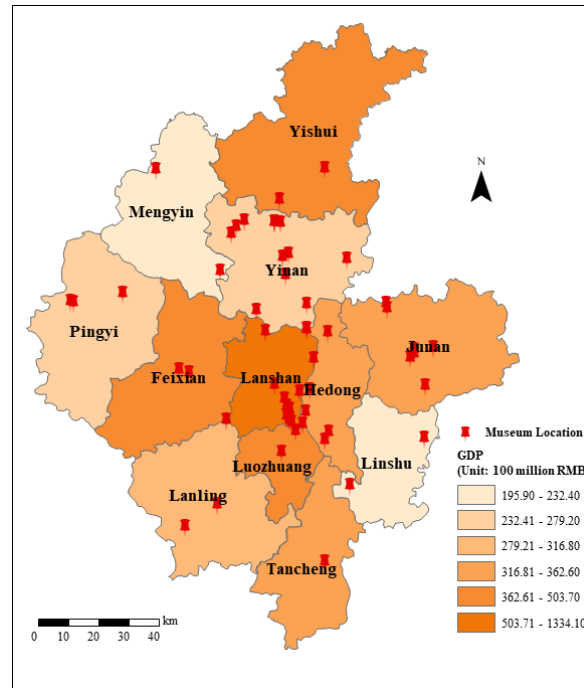


Fig.5 Superposition analysis of GDP and museum distribution in Linyi

D. Tourism Development Level

Linyi has a concentration of tourist destinations, with two 5A-level scenic spots, 27 4A-level scenic spots, and 63 3A-level scenic spots in Yimeng Mountain Tourist Area and Yishui Underground Grand Canyon. As can be seen from the distribution of 3A-level and above scenic spots in each county and district (Table 2), there are more 3A-level and above scenic spots in Junan, Lanshan,

Yinan, and Hedong, and there are a total of 40 museums in these four counties and districts, accounting for 71.4% of the total number of museums in Linyi. Generally speaking, 3A-level and above scenic spots have high tourism attraction and good quality of customer source, which is the centre of gravity of tourism development, and can provide market guarantee for museums to attract flow and increase income, and have certain positive effect on the construction of museums. However, there are exceptions, Yishui 3A-level and above scenic spots in the city's first number, but the number of museums is very small, the future in the construction of museums also has great potential for development.

E. Population Density

The population density of counties and districts in Linyi is overlaid with the distribution of museums using ArcGIS10.8 software, and the results are shown in Figure 7. The population density of Linyi counties and districts shows an apparent regular distribution, with the three central urban areas of Lanshan, Hedong and Luozhuang having the highest population density, and other counties and districts showing a gradual decrease in population density from south to north. The spatial distribution of museums is positively correlated with population density. The more concentrated the population is, the higher the urbanisation level is, the better the infrastructure is, and the more museums there are. However, there are a few counties and districts that do not conform to this pattern; for example, Luozhuang, Lanling, Tancheng and Linshu are four counties and districts with higher population densities but lower numbers of museums; Yinan has a lower population density but the highest number of museums.

V. Discussion and Conclusion

Overall, the distribution type of museums in Linyi is cohesive distribution; museums are unevenly distributed throughout the city, with most museums distributed in the central to east-central part of Linyi, where the combined number of museums in the four counties and districts of Yinan, Hedong, Lanshan, and Junan accounted for 71.4% of the total number of museums. At the county level, museums are concentrated and to a high degree, densely distributed in Yinan, Lanshan, Hedong, and Junan, forming the Lanshan-Hedong-Luozhuang main gathering area, as well as two sub-aggregation areas in Junan and Yinan-Yishui.

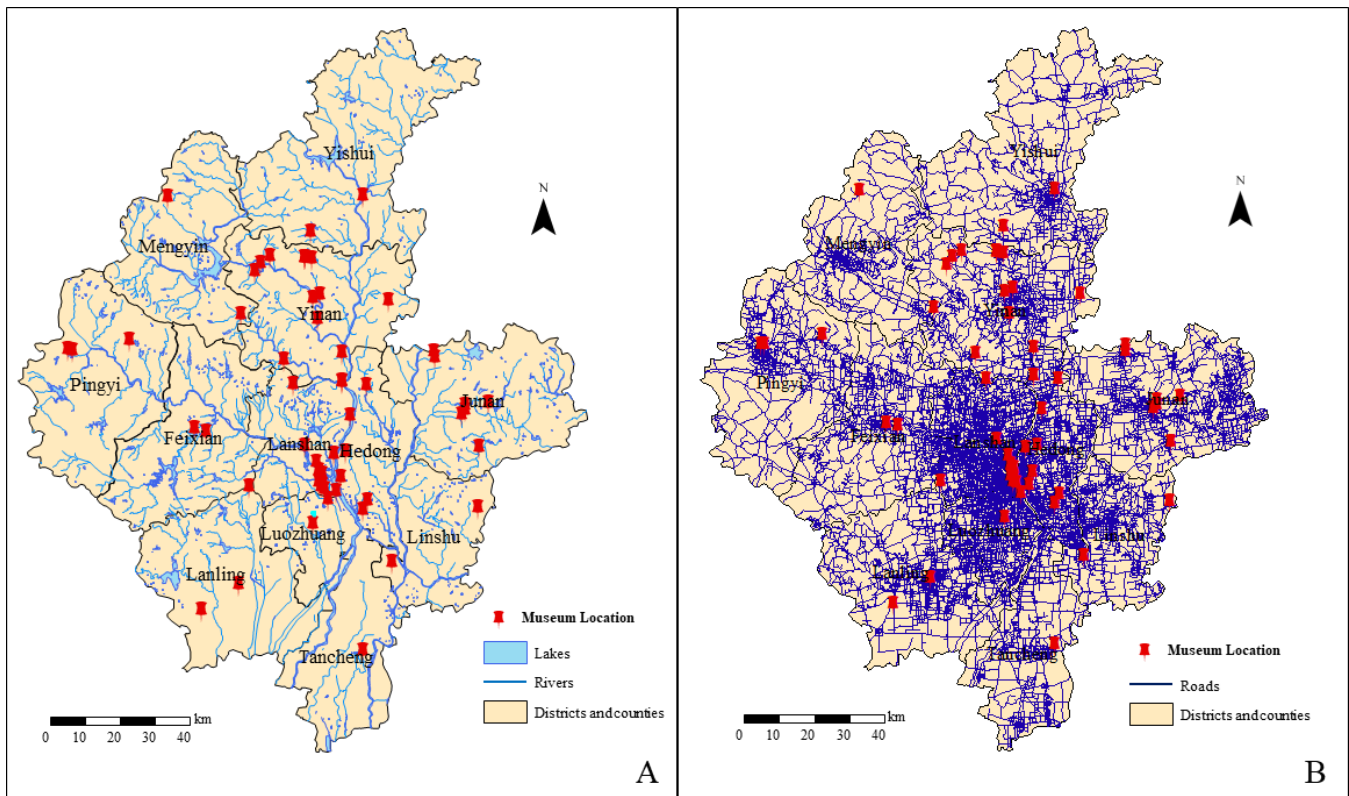


Fig.6 Superposition analysis of river system (A), road (B) and museum distribution in Linyi.

Table 2. Distribution of scenic spots and ownership of museums in Linyi

County or district	The number of 5A-level Scenic Spots	The number of 4A-level Scenic Spots	The number of 3A-level Scenic Spots	The number of state-owned museums	The number of non-state-owned museum	Total number of museums
Feixian	0	2	5	1	1	2
Junan	0	2	6	2	5	7
Lanling	0	2	4	1	1	2
Lanshan	0	1	7	4	5	9
Linshu	0	2	3	0	2	2
Luozhuang	0	0	2	0	2	2
Mengyin	0	2	6	2	0	2
Pingyi	1	2	1	2	1	3
Tancheng	0	1	1	1	0	1
Yinan	0	6	6	6	8	14
Yishui	1	5	16	1	1	2
Hedong	0	2	6	2	8	10

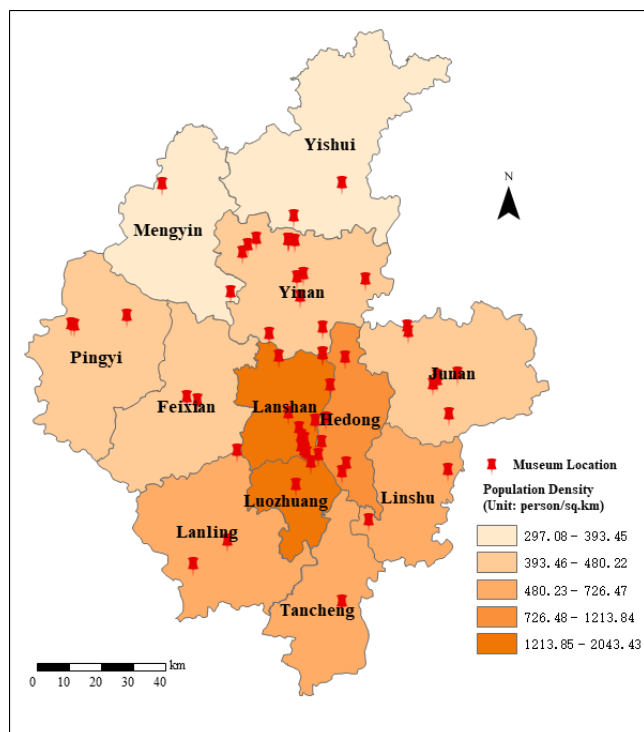


Fig.7 Superposition analysis of population density and Museum Distribution in Linyi

Multiple factors, such as the degree of resource endowment, the level of economic development, the accessibility of transport, the degree of tourism development, and the density of population, influence the distribution of museums in Linyi's counties and

districts. Museums tend to be distributed in areas rich in natural and cultural resources, have a high level of economic development, have a well-developed transport network, are close to rivers and lakes, have a better-developed tourism industry, and have a higher population density. However, there are exceptions; for example, Yinan has the highest number of museums despite its relatively low level of economic development among all districts and counties in Linyi; Yishui has a high level of tourism development, with the highest number of scenic spots of 3A grade and above, but the number of museums is almost at the bottom; and four counties, Luozhuang, Lanling, Tancheng and Linshu, have a high population density but a relatively small number of museums. Therefore, Linyi City can consider the following aspects in constructing museums in the future.

Digging deeper into resources and expanding the types and number of museums. Linyi City has superior natural geographical conditions, with the Yimeng Mountain World Natural Heritage, and rich human resources, with several revolutionary relics, famous historical and cultural cities and towns, and traditional villages. All counties and districts should continue to dig deeper and rationally develop the region's natural, scientific, historical, and cultural resources in an all-round and multi-means manner, to expand the types and numbers of museums.

Respond to market demand and promote the quality of museums. Linyi should follow the national development strategy, actively use the policy advantages at all levels, respond to the market demand, focus on building the brand of state-owned museums, vigorously improve the quality of the construction of museums without rank, and promote the upgrading of museums, and play the role of private forces to build high-quality museums, and promote the rapid development of non-state-owned museums.

Accelerate the construction of museums by taking advantage of the tourism industry. As the tourism industry has a strong driving capacity, Linyi should continue to take advantage of the tourism industry to accelerate the construction of museums around the core scenic spots and famous scenic spots, and use the brand and market advantages of the tourist attractions to promote the construction of museums and high-quality joint development of the tourism industry.

Improve the infrastructure to help the development of museums. Each region should accelerate the construction of transport and other infrastructure while seizing the opportunity to develop the new infrastructure era, focusing on improving the information infrastructure, and providing museums with the hardware foundation and software environment for the construction and development.

Acknowledgments

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