

Mathematical Statistics and Spatial Aggregation Characteristics Analysis of Culture, Sports, and Tourism Resources in the Yellow River Basin Based on POI Data

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Abstract

As a priority of China's regional development strategy in recent years, promoting the ecological protection and high-quality development of the Yellow River Basin is one of the important tasks to boost the country's economy and also the key to the development strategy in the central region at this stage. High-quality development of the Yellow River Basin based on the perspective of culture, sports, and tourism integration is significant for the regional ecological protection and economic revitalization. In order to measure the development of culture, sports, and tourism resources in the basin, the study applied the CRITIC model in Mathematical Statistics, the fuzzy comprehensive evaluation model, and the entropy weight TOPSIS analysis model. The results indicated that the development of the three resources in the basin varies from region to region, among which Shaanxi, Shandong, and Henan provinces have developed outstandingly while western provinces in China haven't. In addition, this study identified the spatial geographic extent and analyzed the POI (points of interest) of culture, sports, tourism, and mixed resource based on the data analysis to explore the spatial distribution characteristics and trend of changes in the Yellow River Basin. The study also made suggestions for the development of culture, sports, and tourism resources in the basin from different perspectives based on the developed theoretical model, aiming to promote high-quality development of the area.

Keywords

Integration of Sports and Tourism, Sports Tourism, High-Quality Development of the Yellow River Basin

1. Introduction

The Yellow River is known as the mother river of the Chinese nation and the birthplace of Chinese culture [1]. It plays an important role in the long history of Chinese culture. With beautiful scenery, the river is abundant not only in rich natural and human resources but also in distinctive and brilliant national folk cultures. These factors, intertwined with each other, have promoted the development of the culture, sports, and tourism industry in the area, making it the earliest treasure trove of tourism resources in China [2]. Gordon Clark views tourism as a combination of multiple resources in a region. The Yellow River Basin boasts magnificent and towering famous mountains such as Helan Mountain, Liupan Mountain, Taihang Mountain, etc. as well as Longyangxia, Jishixia, Liujiaxia, Sanmenxia, and other crisscrossing canyons [3]. In addition, it is rich in sports tourism resources. In the symposium on ecological protection and high-quality development in the Yellow River Basin, President Xi Jinping clearly put forward that the Yellow River Basin was in urgent need of ecological protection and high-quality development. Like Beijing-Tianjin-Hebei collaborative integration, the Yangtze River Economic Belt, the construction of the Guangdong-Hong Kong-Macao Greater Bay Area, and the Yangtze River Delta Economic Belt, the development of the Yellow River Basin Economic Belt has been lifted to the major development strategy of national height. Lu Dadao believes that the key to high-quality development of the Yellow River Basin lies in the use of clean energy, development under local conditions, and protection of cultivated land resources. A Shuwei holds that the key to the efficient development of culture, sports, and tourism resources in the Yellow River Basin relies on the coordinated development of both ecological efficiency and regional economy.

The high-quality growth of the Yellow River Basin is a typical example of the integrated development of regional culture, sports, and tourism [4]. The study area, characterized by its belt-like rivers, is different from other regional economic belts, thus with few relevant studies. Li Donghua deems that there is a lack of overall interpretation and review of the new development concepts of the basin under the background of culture, sports, and tourism integration [5]. Therefore, conducting research on the construction of the Yellow River Basin Economic Belt under this background is worth the effort, and crucial to the high-quality development of the basin. Gong Yuanyuan used the Super-SBM model to measure the economic development level of each province in the basin. In her study, the industrial structure was taken as the starting value, and environmental constraints were taken as the threshold restriction. The results showed that there was an inverted U-shaped relationship between the regulation of culture, sports, and tourism resources and the high-quality economic growth [6]. Sun Jianguo employed the Malmquist index and PVAR model to measure the eco-economic efficiency and scientific and technological innovation rate of the three resources in the study area, and found that there was a significant positive correlation between the eco-economic efficiency of the industry, the prod-

activity of the industry and the rate of science and technology innovation. Zhao Jianji explored the influencing factors between urbanization and tourism ecological subsystem by using the urbanization and environmental coupling coordination model combined with the random panel Tobit model [7]. It was found that the coupling coordination degree of new urbanization and tourism resources increased and then decreased [8]. With the global effective nearest distance model (MinDS model), Liu Huajun explored the global situation of water resource utilization in the basin. It was found that there was a correlation between the utilization rate of water resources in the basin, the culture, sports, and tourism resources, and the ecological environment. Besides, the water consumption rate in the middle and lower reaches was greater than that in the middle and upper reaches, and the polarization phenomenon was found in different places [9]. Zhang Xincheng used the health distance model to analyze the evolution characteristics of tourism industry mismatch in the nine provinces of the Yellow River Basin, and explained its causes with a qualitative comparison method. It was found that the mismatch showed a downward trend, decreasing from west to east, and the regional imbalance was prominent. Lu Lin interpreted the concept of regional culture, sports, and tourism resources and the concept of tourism development with the term “rustic-ecological” city group. It was also the basis of the great governance of the basin. Xu Hui believes that it is necessary to establish a structure of development indicators for the study area to provide scientific predictions for high-quality development. Starting from the theory, this paper analyzed the connotation and characteristics of the integrated development of culture, sports, and tourism in the basin, and identified the geographical location and spatial scope. Based on the analysis, it summarized the overall spatial layout and resource agglomeration characteristics of the development of the three resources in the basin, and guided the future direction of high-quality development in the area, so as to help revitalize the economic belt in the basin [10].

2. The Era Characteristics of High-Quality Development in the Yellow River Basin from the Perspective of Culture, Sports and Tourism

Connotation of High-Quality Development in the Yellow River Basin

The Yellow River Basin is a representative of the development of China’s central and western regions. From the BaYanKaLa Mountains in Qinghai Province to the Bohai Sea in the east, it runs through Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan, and Shandong. The basin, covering nearly 79.5 km², is an important geographical environmental protection barrier and economic development area in China [4] (**Figure 1**). Yellow River enjoys the reputation of China’s mother river and is the birthplace of a long-standing historical and cultural landscape [11] [12] [13]. The agriculture, rituals, architectures, and customs in China are well represented in this place, with a rich variety of tourism and

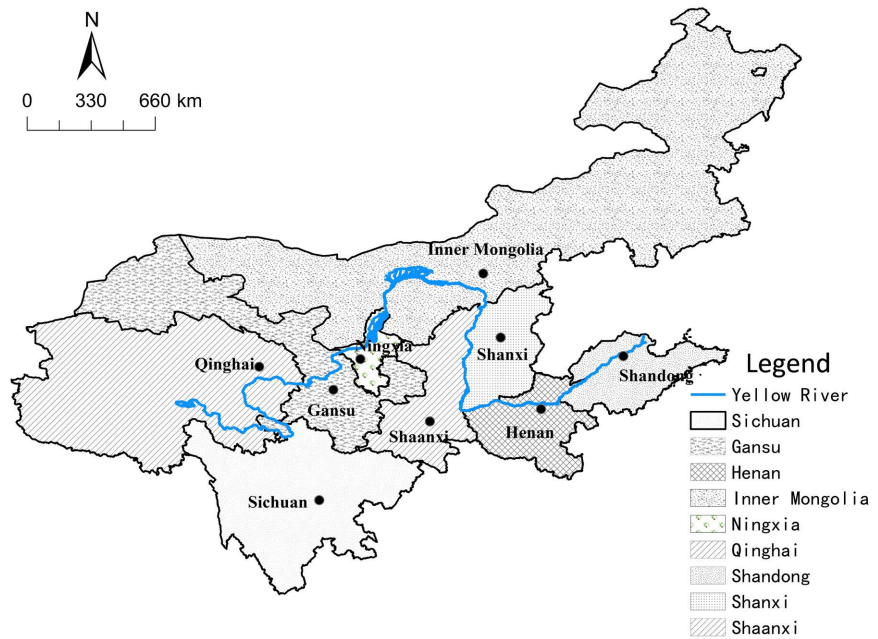


Figure 1. Location map of the Yellow River Basin.

unique cultural resources in the watershed. The river flows through the desert, forest, waterfall, canyon, meadow, and some other natural scenery, and is rich in distinct resources.

The overall development of the Yellow River Basin is based not only on its natural geographical features, but also on its historical and realistic opportunities. In terms of the mainline of space, the development of the tourism belt in the basin shows the spatial change of resources. Xining, Lanzhou, Yinchuan, and Hohhot are the centers in the upstream of the basin, and Xi'an, Zhengzhou, Taiyuan, and Jinan are centers in the downstream, forming a block-shaped economic zone of tourism with scattered resources distribution. Theoretical studies have shown that the best form of overall development in the basin is the “band-shaped” development [6]. This kind of tourism belt can strengthen the transportation linkage, with the main railroad and highway transportation routes in the basin as the main axis. Other less developed areas will be driven by transportation, too. Therefore, a band-shaped economic development area is formed, promoting the organic cooperation of multiple industries in the basin [14]. From the perspective of the timeline, the high-quality development of the basin was achieved in the context of the national strategy of ecological protection, resource conservation, and the rise of central China [15]. Taking the 14th Five-Year Plan as the guide and the construction of a local tourism economic belt as the focus, the basin integrates sports, culture, and tourism resources to form a new development pattern and establishes a coordinated development model [16]. Viewing from the mainline of transportation, the Yellow River Basin can be divided into three transportation subsystems, with the Baotou-Lanzhou Railway, Longhai Railway, and the Yellow River Highway as the axes and the driving forces. The transportation line could unite the cultural, sports, tourism, economic and political re-

sources in the region. The interaction and integration of the subsystems and resources are emphasized. Efforts to build a green, convenient and safe integrated transportation network are needed [17] (Figure 2). In the light of connotation, the high-quality development of the basin is a spatial industrial cluster formed under the background of the agglomeration of economic, political, cultural, scientific and technological, ecological, and other resources [18] [19] [20].

3. Investigations on the Related Work of Culture, Sports and Tourism Resources in the Yellow River Basin

3.1. Analysis of Traffic Location in the Yellow River Basin

From the perspective of geographical spatial aggregation, the Yellow River Basin is connected by railway and highway trunk lines, and the distribution of culture, sports and tourism industry is based on transportation. The basin takes Xining, Lanzhou, Yinchuan, Hohhot, Taiyuan, Xi'an, Zhengzhou, and Jinan as the regional core points, with railroads and highways as connecting lines. The basin extends to the east and northwest, from the trail adventure tourism area with snowy mountains on the Tibetan plateau in the west to the Confucian and Mencian cultural tourism area in the east, via the exotic Silk Road tourism area, Chinese Antiquities and Treasure Tourist Area and Red Cultural Revolution Tourist Area [21]. In the basin, the west-middle-east traffic trunk line is the development axis, including the west axis Baolan line, the middle axis along the Yellow River highway, and the east axis Longhai line (Figure 3).

Taking the urban area as the unit, the tourism belt of the basin covers a total of 32 prefecture-level and above urban areas, with the Baotou-Lanzhou line, the Yellow River highway, and the Longhai line as the driving forces, influencing the surrounding areas and the hinterland of the basin [22]. The Baotou-Lanzhou

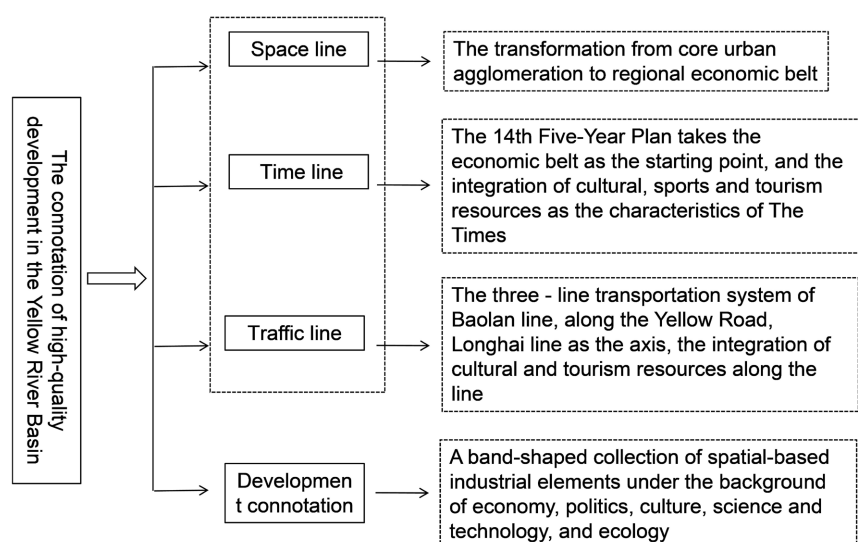


Figure 2. Framework diagram of the overall connotation of high-quality development in the Yellow River Basin.

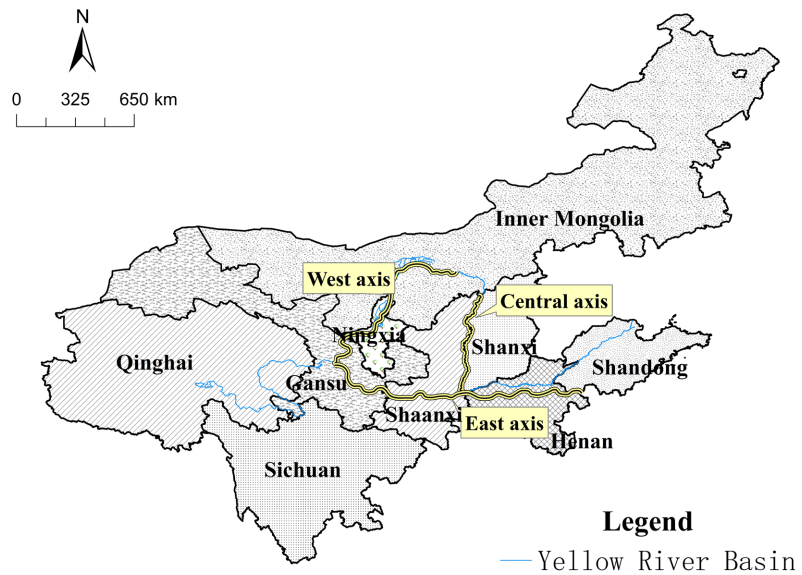


Figure 3. Axis map of spatial scope of the Yellow River Basin.

line connects the main axis of Lanzhou, Yinchuan, and Baotou in the upper reaches of the basin, and brings along the central and eastern parts of Gansu Province, northern Ningxia, and southern Inner Mongolia. The traffic line passes through deserts, canyons, and ethnic minority areas, which provides rich sports tourism resources. The highway along the Yellow River connects the middle reaches of the basin, starting from Fugu in Yulin, Shaanxi Province in the north to Weinan at the foot of Mount Hua in the south. The middle reach of the Yellow River basin takes Taiyuan and central Xi'an as two core axes, radiating western Shanxi, eastern Shaanxi, and northern Henan region. The river flows southward along the Loess Plateau, passing through ancient temples, famous mountains, and pavilions, forming rich cultural tourism resources. The Longhai Line connects Lanzhou, Xi'an, and Zhengzhou axis, radiating eastern Shandong, north-central Henan, and eastern Shaanxi. The river in this region flows slowly. With large rivers and streams all around the basin and beautiful scenery, it is rich in water and tourism resources (**Table 1**).

3.2. Distribution of Culture and Sports Tourism Resources in the Yellow River Basin

3.2.1. Types and Definitions of Resources

According to the current situation of resources in the Yellow River Basin and the requirements for high-quality development of the basin, the existing resources are classified and discussed. According to the characteristics of the basin resources, the resources are divided into four categories, including sports, tourism, culture, and mixed resources. In this article, culture resources refer to historical, cultural, and tourism landscapes, heritage sites, and other objective explicit or implicit resources that can form cultural output. Sports resources refer to the general term of resources associated with sports, including sports infrastructure,

Table 1. Regional table of the coverage area of the Yellow River Basin axis transportation lines.

Traffic routes	Cities and counties in area	Axis location
Baolan railway	Lanzhou, Baiyin, Jingtai, Zhongwei, Zhongning, Qingtongxia, Yinchuan, Pingluo, Shizuishan, Wuhai, Linhe, Baotou	Core axis: Lanzhou, Yinchuan Main nodes: Baotou, Wuhai, baiyin
Road along Yellow River	Weinan, Yanan, Yulin, Hancheng, Fugu County, Shenmu County, Jia County, Wupu County, Qingjian County, Yanchuan County, Yanchang County, Yichuan County, Heyang County, Dali County, Tongguan County	Core axis: Taiyuan, Xi'an (Basin Coverage area) Main nodes: Weinan, Yanan, Yulin
Long Hai railway	Lianyungang, Xuzhou, Shangqiu, Kaifeng, Zhengzhou, Luoyang, Sanmenxia, Weinan, Xi'an, Xianyang, Baoji, Tianshui, Dingxi, Lanzhou	Core axis: Zhengzhou, Lanzhou, Xi'an (Basin Coverage area) Main nodes: Sanmenxia, Luoyang, Weinan

scenic resources for sports tourism activities such as canyons, glaciers, forests, rivers, and other sceneries, and places, spaces, and various sports equipment for sports activities [23]. The scope of tourism resources is relatively wide, which is a complex and inclusive concept. It contains a variety of physical resources with social and natural attributes, with historical and cultural relics, mountains, rivers, and other natural objects, and various artificial objects. Mixed resources here refer to two or more resources, and are a concept of resource aggregation.

3.2.2. Data Collection

The data involved in this paper consists of two parts. The first part is the data set of culture, sports, and tourism resources in 9 provinces of the Yellow River Basin, including 13 data items, all of which were collected from the website of the National Bureau of Statistics (<http://www.stats.gov.cn/>). Among them, the deadline for sports resources statistics was the year 2015. For culture and tourism resources, the deadline was 2018. The second type of data is the points of interest (POI) of sports, culture, tourism, and mixed resource (POI data is a real geographic information point data. Every POI data includes information like latitude and longitude coordinates, address information, classification labels, and names [24]). The POI data had two sources. First, it was collected from the Goethe map by Python, and keywords such as “sports”, “exercise”, “culture”, “heritage”, “tourism” and “scenic spot” were retrieved. The Goethe data packet is finally updated in April 2020. Second, it was collected from the official websites of the Department of Culture and Tourism of the nine provinces in the Yellow River Basin (data updated in September 2020). The data coordinates used in the retrieval were from Google Earth, and the data were verified and corrected by checking the Goethe map. In the POI data, ArcGIS analysis software was used for retrieval. A total of 113,953 primary data were collected, including 35,643 sports resources, 63,632 culture resources, 14,678 tourism resources, and 10,456

mixed resources. Then the biases were corrected and invalid data was deleted. Finally, the effective POI data includes 24,516 sports resources, 53,532 cultural resources, 9385 tourism resources, and 5387 mixed resources (including two or more resources), a total of 92,820 effective resources.

4. Research Methods

4.1. CRITIC

CRITIC (CRiteria Importance Through Intercriteria Correlation) method proposed by D. Diakoulaki is one of the weighting methods which determines objective weights for criteria [25]. This method includes the intensity of the contrast and the conflict in the structure of the decision-making problem.

First, is dimensionless quantitative processing.

$$\text{Positive indicators: } x'_{ij} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}} \quad \text{Reverse indicator: } x'_{ij} = \frac{x_{\max} - x_j}{x_{\max} - x_{\min}}$$

(The larger the value of the positive index is, the better the result is. The smaller the value of the negative index is, the better the result is.)

Second, using standard deviation as the variability measure standard, the larger the weight, the larger the standard deviation.

$$\begin{cases} \bar{x}_j = \frac{1}{n} \sum_{i=1}^n x_{ij} \\ S_j = \sqrt{\frac{\sum_{i=1}^n (x_{ij} - \bar{x}_j)^2}{n-1}} \end{cases} \quad (\text{Among them, } S_j \text{ represents the standard deviation}$$

of item j , and the standard deviation is used to represent the variation of the value in the CRITIC method. The size of the standard deviation represents the size of the variation of the index. The greater the standard deviation, the greater the difference, and the more information can be reflected. The evaluation intensity becomes stronger and the weight is heavier with the increase of the standard deviation.)

Third, the conflict is represented by the correlation coefficient between indicators. Conflict, weight, and the correlation between indicators are negatively correlated.

$$R_j = \sum_{i=1}^p (1 - r_{ij}) \quad (r_{ij} \text{ is the correlation coefficient between index } i \text{ and index } j,$$

using the correlation coefficient to represent the correlation of the index. The stronger the correlation is, the smaller the conflict of the index is, and the greater the amount of information is, the higher the repeatability is, which reduces the evaluation intensity of the index to a certain extent, so the weight of this index should be appropriately reduced.)

Fourth, the amount of information is calculated by the product of index variability and conflict.

$$C_j = S_j \sum_{i=1}^p (1 - r_{ij}) = S_j \times R_j \quad (\text{The importance of the } i \text{ index in the evaluation}$$

system is rising with the increase of the value of C_j , and more weight will be

allocated to the i index).

Fifth, the final normalization process to determine the weight.

$$W_j = \frac{C_j}{\sum_{i=1}^p C_j} \quad (\text{The weight of indicator } j \text{ is } W_j).$$

4.2. Fuzzy Comprehensive Evaluation

A fuzzy comprehensive evaluation is a method proposed by L. A. Zade for the evaluation of uncertain or complex things, which is derived from the set of fuzzy mathematics theories [26].

First, determine indicator set V and comment set U .

$V = (v_1, v_2, v_3, \dots, v_m)$ (v_i represents the i -th factor of the evaluation index, and usually, all factors contain uncertainty and complexity).

$U = (u_1, u_2, u_3, \dots, u_n)$ (u_i represents the results of the i -th evaluation, where we use the names of nine provinces of the Yellow River Basin to characterize).

Second, the membership function set and weight judgment matrix R are determined, and the membership degree and evaluation matrix R are obtained.

(If the first element in the index set V and the first element in the comment set U to compose the membership degree r_{i1} , then the single factor evaluation fuzzy set of the first element is: $R = (r_{i1}, r_{i2}, r_{i3}, \dots, r_{in})$. The matrix $R_{m \times n}$ is formed by m single factor evaluation sets, and finally the fuzzy comprehensive matrix is formed.)

Third, through matrix R , the weight set is calculated, and a comprehensive evaluation is concluded by the weight.

4.3. Entropy Weight TOPSIS Analysis

Entropy weight TOPSIS analysis is a comprehensive evaluation method combining the entropy method and TOPSIS method [27].

First, the entropy method is used to calculate the weight.

1) The original data matrix is composed of n evaluation samples and p evaluation indexes:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix} \quad (X_{ij} \text{ denotes the } j\text{-th index of sample } i).$$

2) Ratio $p_{ij} = \frac{x_{ij}}{\sum_{i=1}^n x_{ij}}$, information entropy $e_j = -\frac{1}{\ln n} \sum_{i=1}^n p_{ij} \ln p_{ij}$, $e_j \in [0, 1]$.

3) The calculation of information entropy redundancy: $d = 1 - e_j$, vector normalization standardization:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^n x_{ij}^2}}.$$

4) The construction of weighted degree matrix: $z_{ij}^* = z_{ij} \times w_j$. Then we get

$$\text{matrix } Z^* = \begin{bmatrix} z_{11} \cdot w_1 & z_{12} \cdot w_2 & \cdots & z_{1p} \cdot w_p \\ z_{21} \cdot w_1 & z_{22} \cdot w_2 & \cdots & z_{2p} \cdot w_p \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} \cdot w_1 & z_{n2} \cdot w_2 & \cdots & z_{np} \cdot w_p \end{bmatrix} \quad \text{to find the optimal and the worst}$$

solution: $\begin{cases} z_{ij}^{*+} = \max_{n,p} (z_1^{*+}, z_2^{*+}, \dots, z_p^{*+}) \\ z_{ij}^{*-} = \min_{n,p} (z_1^{*-}, z_2^{*-}, \dots, z_p^{*-}) \end{cases}$. The optimal worst distance is calculated:

$$D_i^+ = \sqrt{\sum_j (z_{ij}^* - z_j^{*+})^2} \quad D_i^- = \sqrt{\sum_j (z_{ij}^* - z_j^{*-})^2} . \text{ Relative proximity } C \text{ is calculated:}$$

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} .$$

5) The optimal solution is obtained by ranking the final proximity of C_i .

4.4. The Nearest Point Index

The nearest point index can measure the mutual proximity of point elements in the geographic space, and determine the spatial layout attributes of point resources accurately [4]. Through Formulas (1) and (2) below, the spatial distribution of the culture, sports, and tourism resources in the Yellow River Basin are calculated. If R was less than 1, it indicates that the culture, sports, and tourism resources in the Yellow River Basin are distributed in a state of aggregation. If R is equal to 1, it indicates that the culture, sports, and tourism resources in the basin are randomly distributed. If R is greater than 1, it means the resources are evenly distributed.

(R represents the nearest neighbor index. r_E represents the ideal proximity index, r_i represents the actual proximity value, A represents the area, and n represents the number of statistical resources).

$$R = r_i / r_E \quad (1)$$

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

4.5. Kernel Density Estimation

Kernel density analysis can reflect the spatial agglomeration or dispersion characteristics of geographical elements more vividly [4] (h represents the location of scenic spot i in the geographical space coordinate of radius. s represents the location of pre-estimated scenic spots. s_i represents the range of scenic spots with s as the actual radius).

$$\lambda_h(s) = \sum_{i=1}^n \frac{3}{\pi h^4} \left[1 - \frac{(s - s_i)^2}{h^2} \lambda \right]^2$$

5. Current Development Level of Culture, Sports and Tourism Resources in the Yellow River Basin

5.1. CRITIC Weight Calculation of the Development Level of Culture, Sports, and Tourism Resources in the Basin

The culture, sports, and tourism resources in the Yellow River Basin directly influence its overall effect on high-quality development. In order to comprehen-

sively measure the three resources in the basin, it is necessary to analyze their characteristics and development status. Because the high-quality development of the basin has the characteristics of diversity and comprehensiveness, to evaluate the Yellow River Basin needs to calculate the indicators of the three resources. This paper selected the CRITIC method, and followed the principles of science, independence, ease of operation, and representativeness when selecting the evaluation index. Based on the spatial evolution and systematic change of culture, sports and tourism resources and the analysis of the national policy on the high-quality development of the basin, this paper has constructed a comprehensive evaluation system through a series of indicators and directions of development. The evaluation system contained the development level of culture, sports, and tourism resources and 13 secondary indexes including the number of art groups, museums, athletes, and tourism income. The weight of each index was calculated by the CRITIC method. All primary indexes had a positive correlation with secondary indexes. Among the 13 secondary evaluation indexes, the level of cultural resources was mainly measured by the number of art performance organizations, art performance venues, museums, public libraries, and the total collection number of public libraries. The level of sports resources was mainly measured by the number of Master Sportsmen and Women, first-class athletes, second-class athletes, and senior coaches. The level of tourism resources was mainly measured by the foreign exchange income of international tourists, the number of international tourists, and foreign tourists (The difference between foreign tourists and international tourists is whether they are Chinese residents or not) (**Table 2**).

CRITIC is a typical objective weighting method including two indicators, namely contrast intensity, and conflict. The contrast intensity is calculated by standard deviation which determines the size of volatility [28]. The greater the volatility is, the greater the weight is. Conflict represents the correlation coefficient. The larger the correlation coefficient is, the smaller the conflict is, and the smaller the weight is. In the weight calculation, the weight is calculated by comparing the product of contrast intensity and conflict index, and then making the data normalized.

Through the comprehensive calculation of the development level of culture, sports and tourism resources in the basin, it has been concluded that the highest weight was in Shaanxi Province, accounting for 34.66%, and the lowest was in Qinghai Province, accounting for 1.65%. Shaanxi Province boasts not only high GDP, but also rich culture and tourism resources. Qinghai Province is located in the central and western regions of China with underdeveloped economy, inconvenient traffic, and therefore has a low level of development of the three resources. So, there is an urgent need to develop Qinghai. It could be seen that the development level of culture, sports and tourism resources in the nine provinces of the Yellow River Basin varied greatly and the development imbalance was obvious.

Furthermore, the development level of cultural resources in the study area was calculated. According to the result, Henan ranked first, while Qinghai was

Table 2. Comprehensive evaluation table of development level of culture, sports and tourism resources in nine provinces of the Yellow River Basin.

First index	Second index	Qinghai	Sichuan	Gansu	Ningxia	Inner Mongolia	Shaanxi	Shanxi	Henan	Shandong
Culture resources Source level	Number of Art Performance Organizations	84	829	351	75	226	531	795	2017	828
	The Number of Art Performance Venues	27	110	44	6	54	102	125	155	106
	The Number of performances of art performance groups (ten thousand performances)	0.58	10.93	4.08	0.76	3.13	8.34	9.57	39.23	22.33
	The Number of museums	24	252	215	54	109	294	152	334	517
	The Number of public libraries	51	204	103	27	117	111	128	160	154
	Total collection of public libraries (ten thousand volumes)	478.89	3948.36	1559.95	732.30	1904.09	1892.74	1859.92	3168.70	6212.90
Sports Resources Resource Level	The Number of sports developments	0	100	17	4	49	33	25	70	134
	The Number of first-class athletes	135	523	151	128	276	195	356	613	907
	The Number of second-class athletes	162	1274	348	149	804	333	1015	1692	2944
	The Number of senior coaches	2	11	12	3	3	8	11	14	25
Tourism Resource Level	Foreign exchange income of international tourists (USD million)	36.13	1511.65	28.30	55.87	1272.10	3126.66	377.98	723.23	3292.82
	Reception of international tourists (millions)	0.07	3.70	0.10	0.09	1.88	4.37	0.71	1.67	4.22
	Reception of foreign visitors (millions)	0.05	2.76	0.06	0.03	1.79	3.07	0.47	1.05	3.06
Mean value		76.978	675.415	217.961	95.004	370.845	510.937	373.512	691.452	1165.410
Standard deviation		131.986	1105.122	422.589	197.899	595.856	935.682	550.263	992.601	1877.125
Variability of indices		131.986	1105.122	422.589	197.899	595.856	935.682	550.263	992.601	1877.125
Conflict of indicators		1.131	0.708	1.240	1.119	1.094	3.346	1.029	1.335	0.896
Information Content		149.314	782.405	523.992	221.456	651.780	3131.069	566.229	1325.443	1682.814
Weight		1.65%	8.66%	5.80%	2.45%	7.21%	34.66%	6.27%	14.67%	18.63%

the last. In addition, Shandong, Henan, and Shanxi were the top three, which were 43.44%, 19.86%, and 8.41% respectively. They are all located in the central region. In the western region, Sichuan is a province with outstanding performance accounting for 8.95%. Sichuan was also the first province with cultural resources weighing more than 8% in the western region (Table 3). In the calculation of sports resources, Shandong had the highest weight value of 38.33%. The lowest was in Gansu, accounting for 2.63%. Sichuan was the first province with

Table 3. Comprehensive evaluation table of development level of single culture resources in the Yellow River Basin.

	Variability of indices	Conflict of indicators	Information content	Weight
Qinghai	182.477	0.189	34.469	1.49%
Sichuan	1524.208	0.137	208.285	8.98%
Gansu	591.826	0.148	87.430	3.77%
Ningxia	287.071	0.223	63.931	2.76%
Inner Mongolia	739.530	0.213	157.314	6.78%
Shaanxi	711.893	0.147	104.717	4.52%
Shanxi	717.807	0.272	195.051	8.41%
Henan	1305.462	0.772	1007.261	43.44%
Shandong	2422.543	0.190	460.541	19.86%

a sports resource weight of more than 10% in the western region. Shandong had obvious advantages in the number of athletes and senior coaches, which was the main reason for the high level of sports development. The gap between other provinces and Shandong was obvious (Table 4). In the calculation of tourism resources, Shandong, Shaanxi, and Inner Mongolia demonstrated a high level of tourism resources development, accounting for 31.60%, 25.57%, and 25.08 respectively, which were significantly ahead of other provinces. In the provinces with less developed tourism resources, Qinghai, Gansu and Ningxia accounted for 0.22%, 0.79%, and 0.68% respectively, all less than 1% on average. It can be seen that the development level of tourism resources in the Yellow River Basin was extremely unbalanced, and the gap between the western and central regions was obvious (Table 5).

5.2. Fuzzy Comprehensive Evaluation and Entropy Weight TOPSIS Analysis of the Development Level of Culture and Tourism Resources in the Yellow River Basin

Then comprehensive measurement of the development level of culture, sports, and tourism resources in the Yellow River Basin was carried out. Two evaluation models were used for secondary measurement. By comparing the current situation and development level of the three resources in nine provinces in the basin through different models, more accurate resource development evaluation and test values can be obtained.

A fuzzy comprehensive evaluation is a comprehensive method based on fuzzy mathematics, which can carry out quantitative comprehensive evaluation for some unclear boundaries and difficult quantitative factors. Therefore, we can use this method to measure the comprehensive development level of the resources in the basin. Before the fuzzy calculation, we optimized the 13 indicators by deleting and adding the same amount of evaluation indicators, so that the evaluation results can reflect the overall development level more accurately. The quantitative

Table 4. Comprehensive evaluation table of development level of individual sports resources in the Yellow River Basin.

	Variability of indices	Conflict of indicators	Information content	Weight
Qinghai	85.873	0.699	60.064	4.90%
Sichuan	576.371	0.226	130.527	10.66%
Gansu	157.736	0.204	32.222	2.63%
Ningxia	78.413	0.753	59.072	4.82%
Inner Mongolia	367.263	0.296	108.782	8.88%
Shaanxi	151.797	0.225	34.180	2.79%
Shanxi	470.034	0.271	127.505	10.41%
Henan	778.224	0.261	203.065	16.58%
Shandong	1352.571	0.347	469.599	38.33%

Table 5. Comprehensive evaluation table of development level of single tourism resources in the Yellow River Basin.

	Variability of indices	Conflict of indicators	Information content	Weight
Qinghai	20.825	0.000	0.000	0.22%
Sichuan	870.887	0.000	0.000	8.72%
Gansu	16.293	0.000	0.000	0.79%
Ningxia	32.222	0.000	0.000	0.68%
Inner Mongolia	733.388	0.000	0.001	25.08%
Shaanxi	1803.030	0.000	0.001	25.57%
Shanxi	217.886	0.000	0.000	2.17%
Henan	416.772	0.000	0.000	5.16%
Shandong	1899.009	0.000	0.002	31.60%

calculation was carried out through the sample size of 13 secondary indicators and the data of 9 comment sets. The M (., +) operator was used for the research. The vector matrix A of index weight and the 13×9 weight judgment matrix R were established.

By analyzing the weight results of nine comment sets, the top three with the highest weight were: Shandong (0.249), Henan (0.183), and Sichuan (0.166). Gansu, Qinghai, and Ningxia were 0.055, 0.018, and 0.018 respectively. Again, the results proved that the development level of culture, sports, and tourism resources was positively correlated with the level of economic development, resource conditions, and development degree (Table 6).

In the entropy weight TOPSIS analysis, we used the SPSSAU statistics tool. The entropy method is used to calculate the weight of all indicators. It is an objective

Table 6. Fuzzy synthetic evaluation table of the development level of culture, sports and tourism resources in the Yellow River Basin.

	Qinghai	Sichuan	Gansu	Ningxia	Inner Mongolia	Shaanxi	Shanxi	Henan	Shandong
Membership	0.018	0.166	0.055	0.018	0.085	0.133	0.093	0.183	0.249
Weight	0.018	0.166	0.055	0.018	0.085	0.133	0.093	0.183	0.249

assignment method, which can greatly reduce the influence of the deviation coefficient caused by subjective assignment. TOPSIS analysis is a common multi-objective and decision-making model, which is suitable for analyzing statistics with multi-objective and multi-index. Therefore, we can find sample indicators that reflect the measurement indicators or the most powerful indicators. According to the entropy method, the most influential indicator in the development of culture, sports, and tourism in the study area was the foreign exchange income of international tourists. The number of public library institutions, which belong to cultural resources, is the least influential indicator. Among the single weight values of culture, sports, and tourism resources, the development of tourism resources had the greatest influence on the overall development of the basin, and culture resources had the smallest influence. Among the comprehensive weights, the weight of cultural resources accounted for the highest proportion, reaching 34.39% (Table 7).

TOPSIS ranking analysis was carried out by using the obtained entropy weight, and the optimum and the worst solution of the three resources in the nine provinces of the Yellow River Basin were further analyzed. The development status of the nine provinces in the study area was respectively examined. Through calculation, Shandong, Henan, and Sichuan had the highest single ranking value while the lowest was in Qinghai, which is consistent with the results of the comprehensive fuzzy evaluation. According to the results obtained by different models, the overall characteristics showed that the development level of culture, sports, and tourism resources in the central and eastern regions of the study area was significantly better than that in the western region. It was mainly attributed to the convenient transportation and early development in the eastern region, and the driving effect of the core cities. The development level in Sichuan in the western region was better, which was closely related to its unique natural conditions and economic foundation (Table 8).

Comparing the development level of culture, sports, and tourism resources in the past five years horizontally, we found that the development level in the east was significantly better than that in the west, and this gap had gradually increased over time (Figure 4).

6. Spatial Distribution Pattern of Culture, Sports and Tourism Resources in the Yellow River Basin

6.1. Characteristics of Distribution Type

Based on the calculation of the current development of culture, sports and tourism

Table 7. Comprehensive evaluation table of culture, sports and tourism resources index by entropy method in the Yellow River Basin.

index	Information entropy e	Information utility value d	Weight
The Number of Art Performance Organizations	0.8363	0.1637	7.54%
The Number of Art Performance Venues	0.9085	0.0915	4.21%
The number of performances of art performance groups (ten thousand performances)	0.7686	0.2314	10.66%
The Number of museums	0.8921	0.1079	4.97%
The Number of public libraries	0.9506	0.0494	2.27%
Total collection of public libraries (ten thousand volumes)	0.8971	0.1029	4.74%
The Number of sports developments	0.8083	0.1917	8.83%
The Number of first-class athletes	0.8999	0.1001	4.61%
The Number of second-class athletes	0.8341	0.1659	7.65%
The Number of senior coaches	0.8943	0.1057	4.87%
Foreign exchange income of international tourists (USD million)	0.7423	0.2577	11.88%
Reception of international tourists (millions)	0.7827	0.2173	10.01%
Reception of foreign visitors (millions)	0.7755	0.2245	10.35%
GDP	0.8397	0.1603	7.39%

Table 8. TOPSIS evaluation table of the development level of culture, sports and tourism resources in the Yellow River Basin.

	Rational distance D^+	Negative distance D^-	Relative proximity C	Rank
Qinghai	5208.732	1.871	0.000	9
Sichuan	1834.509	3378.626	0.648	3
Gansu	4763.471	447.873	0.086	7
Ningxi	5140.789	68.727	0.013	8
Inner Mongolia	4137.799	1074.104	0.206	6
Shaanxi	3482.264	1753.008	0.335	4
Shanxi	4122.157	1088.268	0.209	5
Henan	1384.871	3848.761	0.735	2
Shandong	89.726	5207.111	0.983	1

resources in the Yellow River Basin, we can further explore the spatial distribution pattern of these resources and provide accurate information to guide the high-quality development of the basin. After classifying, filtering, modifying, and optimizing the resource data points, the spatial distribution data of culture, sports,

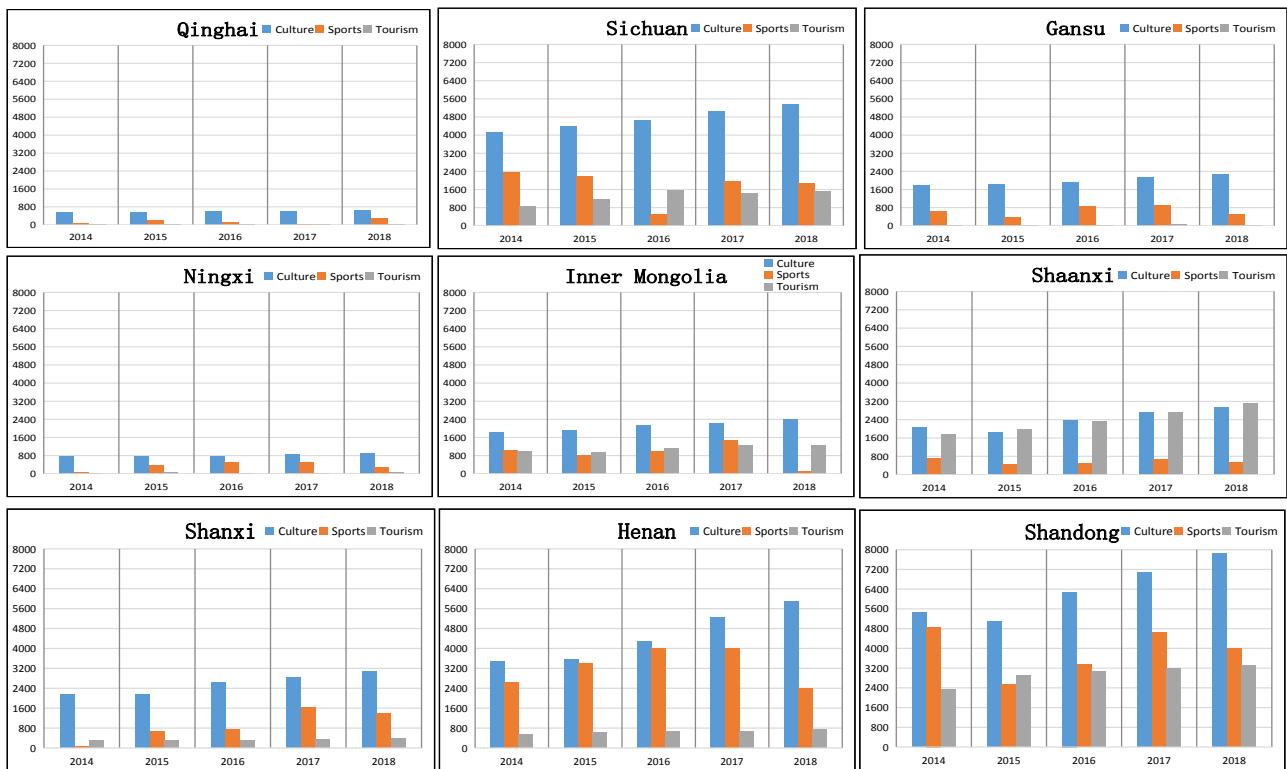


Figure 4. Bar graph of the development of culture, sports and tourism resources in Yellow River Basin from 2014 to 2018.

and tourism resources in the basin were collected, including 24,516 sports resources (26.4%), 53,532 culture resources (57.6%), 9385 tourism resources (10.1%) and 5387 mixed resources (6%), a total of 92,820 (Figure 5 & Figure 6). Culture resource points accounted for the largest proportion, which was a reflection of the long history and rich cultural connotation in the Yellow River Basin. Sports resources, tourism resources, and mixed resources ranked second, third and fourth respectively. The area has a good foundation for sports, tourism and sports heritage and relic resources because of the large differences in terrain and complex topography.

6.2. Resource Distribution Model

The overall spatial distribution of sports, culture, tourism and mixed resources are densely clustered (Table 9). The overall regional characteristic of the distribution was that the three resources aggregated along with the core cities and resource-concentrated areas. We used the average nearest neighbor analysis (ANNA), which can reflect the concentration of resources, to explore the spatial aggregation of resource points in the basin. The results showed that all nearest neighbor ratios of resource points were less than 1, indicating that the four types of resources in the basin were obviously clustered. The ANNA ratio of sports resource points was 0.091, showing the highest concentration. It was followed by mixed resources (0.180) and tourism resources (0.188). The ratio of culture resources was the lowest, which was 0.118.

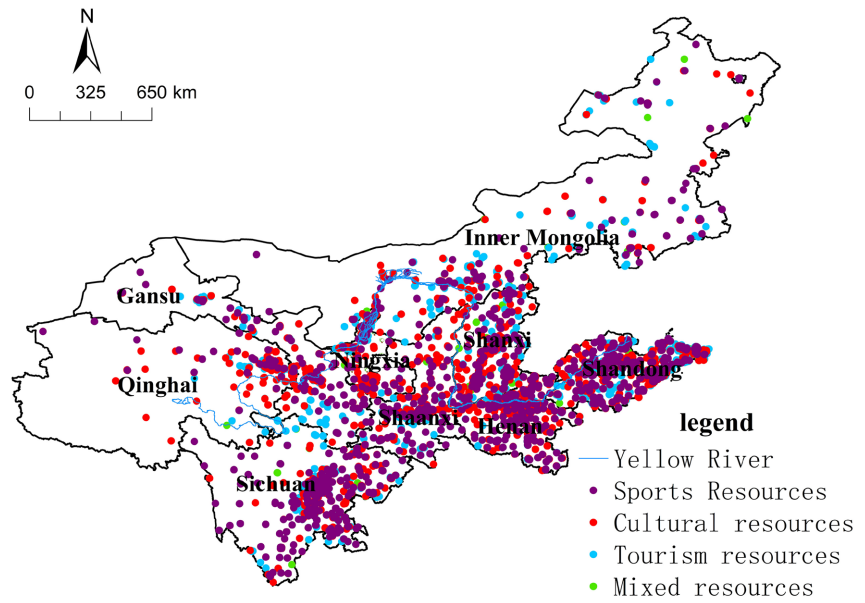


Figure 5. Spatial distribution map of various resource points in the Yellow River Basin.

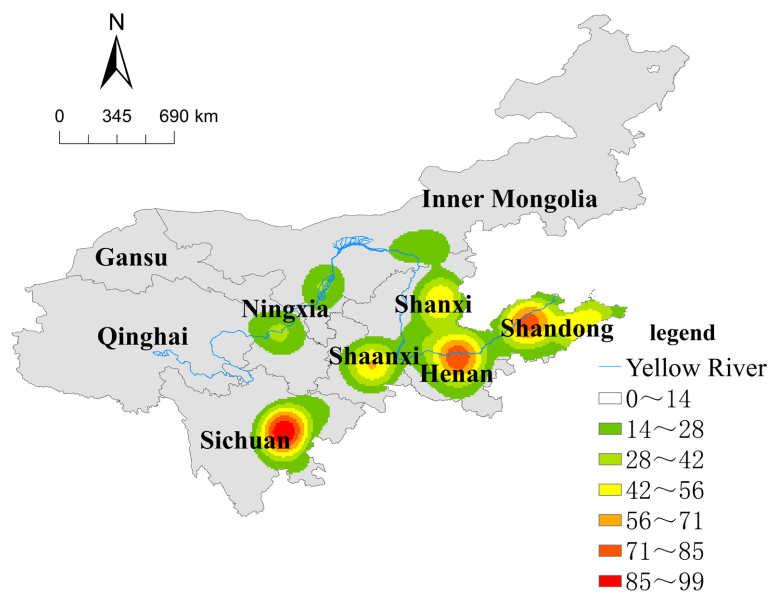


Figure 6. Kernel density map of the sports resource in the Yellow River Basin.

Table 9. The average nearest neighbor analysis table of different types of resources in the Yellow River Basin.

Landscape point type	Average observation distance	Predicted average distance	Average nearest neighbor ratio	Z score
Tourism resource points	1262.5337	6707.3994	0.1882	-150.4461
Sports Resource Point	393.0287	4318.4415	0.0910	-272.2789
Mixed resource points	515.0277	2849.9074	0.1807	-359.2333
Culture resource points	1021.4236	8601.7629	0.1188	-123.7387

6.3. Spatial Aggregation Degree Analysis of Resources

In order to reflect the spatial distribution pattern of different resources in the Yellow River Basin more clearly, the study used the Spatial Analyst Tools of ArcGIS10.2 to conduct kernel density analysis. The analysis results showed that the kernel density varied from resource to resource.

The kernel density of sports resources was the most aggregately distributed, with two large core aggregation areas. The results of the kernel density analysis of sports resources are the most concentrated. There are three large core aggregation areas. The radiation range includes eastern Qinghai, central Gansu, northern Ningxia, central and eastern Inner Mongolia, southern Shanxi, central and northern Henan, and eastern Shaanxi, Chengdu is the core density area. Sports resources are also the resources with the strongest aggregation and the widest coverage of the four types of resource centers. The resources are distributed along the Baolan line and the Longhai line, and the density of sports resources in Inner Mongolia and northern Shaanxi is the lowest (Figure 6).

The kernel density of tourism resources is the most scattered among the four types of core density, mainly concentrated in the three core areas of Chengdu, Zhengzhou, and Jinan, and the radiation range includes northern Ningxia, central Shanxi, and southeastern Shaanxi. Core area is rich in natural resources, with distinctive landform features and numerous famous mountains and rivers, laying a good foundation for cultural tourism and sports tourism. In Ningxia and Inner Mongolia, the distribution of tourism core density is relatively scattered and the degree of aggregation is small. The core density of tourism resources is also an intuitive reflection of the trend of natural resources in the basin (Figure 7).

The distribution of cultural resource kernel density is relatively scattered, slightly higher than the tourism core density. The distribution is mainly concentrated in Taiyuan, Zhengzhou, Jining, and Jinan, and concentrated in central Henan,

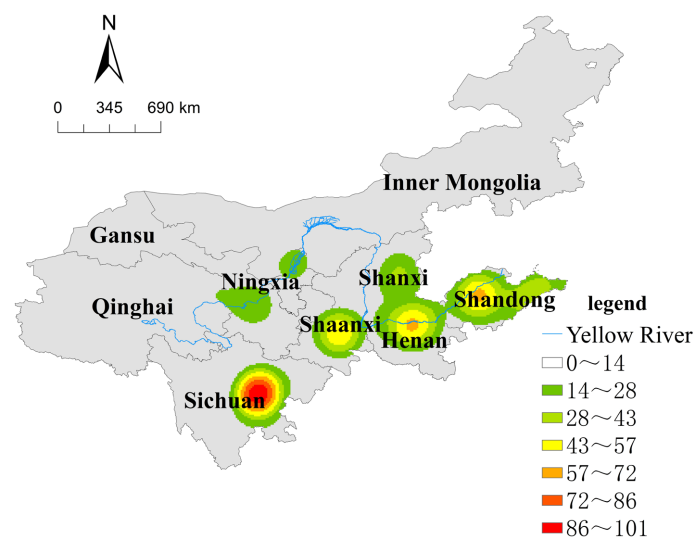


Figure 7. Kernel density map of the tourism resource in the Yellow River Basin.

central and eastern Shaanxi, and southern and western Shanxi. The reputation of the Dragon City in Taiyuan and the hometown of Confucius and Mencius in Shandong coincide with each other. Many historical sites and ancient architectural sites are important reasons for the cultural gathering of these cities. Among them, Inner Mongolia, Ningxia, Gansu, and other places have the lowest concentration of cultural resources (**Figure 8**).

The highest kernel density of mixed resources is concentrated in Zhengzhou, Taiyuan, and Xi'an, and concentrated in the central and southern parts of Shanxi, northern Henan, and central and eastern Shandong. In addition, the radiation range of the mixed kernel density has the greatest potential among the four types of resource kernel densities. Over time, the mixed kernel density will gradually increase with the development of resources and economic development (**Figure 9**).

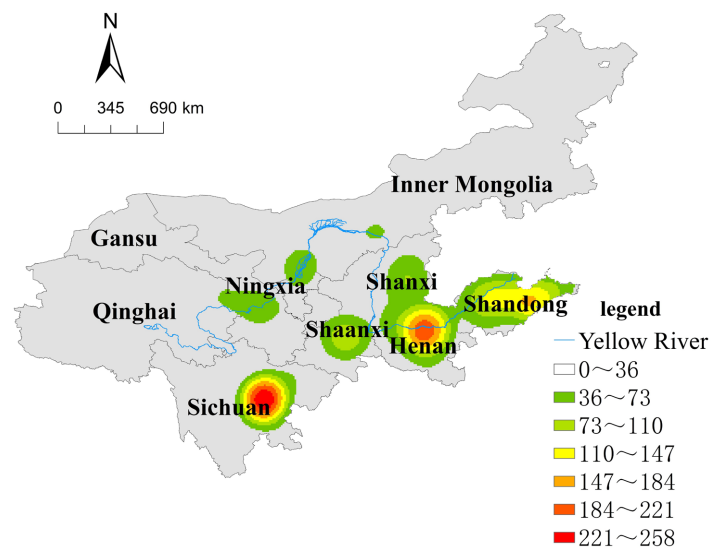


Figure 8. Kernel density map of the culture resource in the Yellow River Basin.

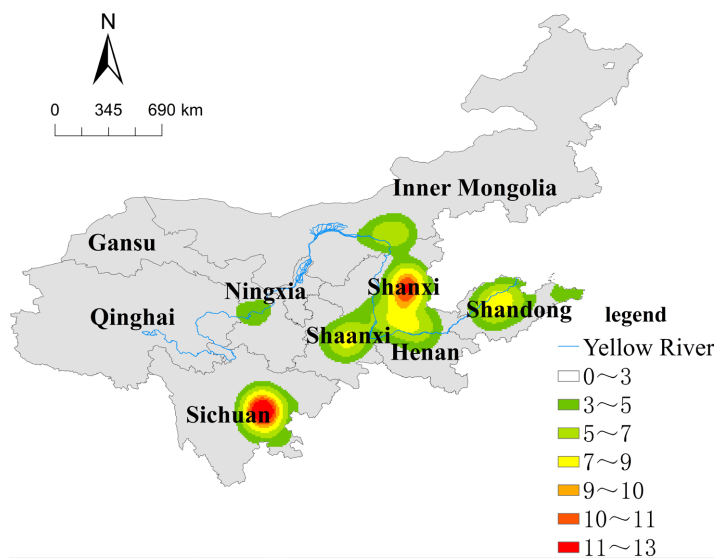


Figure 9. Kernel density map of the mixed resource in the Yellow River Basin.

7. The Path of High-Quality Development in the Yellow River Basin from the Perspective of Culture, Sports, and Tourism

The Yellow River Basin has a high natural resources endowment. Only by bringing resources into the market and transforming them into the driving force of economic development can we facilitate the development of the region. The way of resource exploitation, the nature and structure of industries, and the combination of resources will have a direct impact on this process [29]. Taking the opportunity of the 14th Five-Year Plan, we should guide industrial and economic transformation in the Yellow River Basin and promote industrial integration based on the Strategy for the Rise of Central China, Big Data+, sports and cultural tourism, and other advantages (Figure 10). We should also give full play to the functions of local governments, guide consumer demand, build an industrial model with local characteristics, and practice the theory of sustainable development [26].

7.1. Theoretical Model of Development

Considering the shortcomings and the characteristics of spatial geographic aggregation in the area, we proposed four driving theoretical model for the development of the Yellow River Basin (Table 10). The demand-driven economic development model is a kind of model in which tourism demand dominates the economic development of the basin and promotes the development of tourism and the market [30]. The supply-driven economic development model is the model in which supply dominates economic development. Its development relies on the active provision of resources [31] [32] [33]. The intermediary-supported development model emphasizes the role of the intermediary system in regional economic development. It includes media, tour guides, travel agencies, tourism

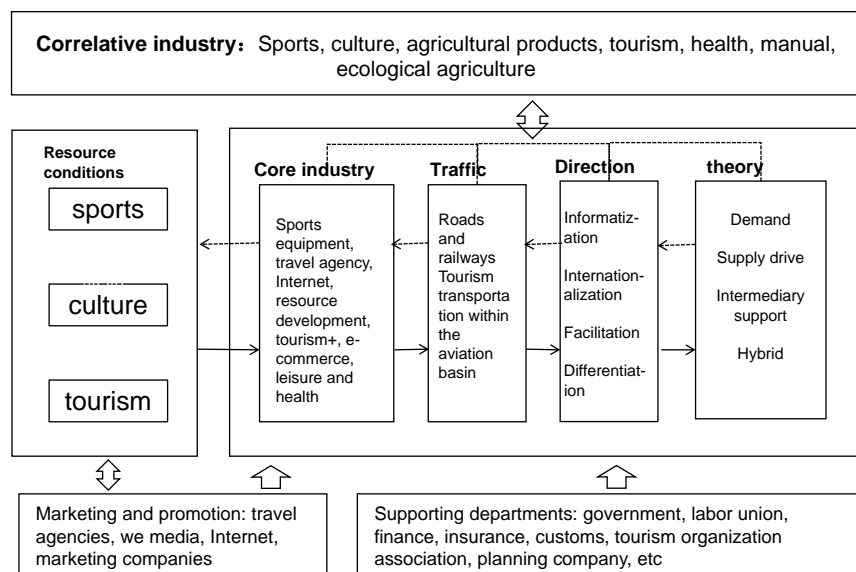


Figure 10. The transformation path of classified resources and products in the Yellow River Basin.

Table 10. Theoretical model of driving forces of Yellow River Basin system development.

Driving forces theory	Driving factors in the initial stage	Driving factors in mature stage
Supply driven (Supply system)	Natural resource endowment of river basin; Regional development policy and planning; The effect of tourism radiation in the surrounding area; Regional characteristic resource industry.	Infrastructure conditions in the basin; Re-utilization of culture, sports and tourism resources; The effect of advertisement and promotion; Income of economic effect; Policy encouragement and support; The development level of key resources.
Demand driven (Demand System)	Short-term economic benefits; Increase of residents' leisure time; Growth in ecological environment; Searching for different ways of life; Increase in residents' holiday time.	Economic income continues to increase; Increased leisure time; Demand for good ecological environment; Leisure party travel; Honey moon vacation.
Intermediary support (Intermediary system)	Arrangement of clothing, food, housing, transportation and other needs.	Income growth in the culture, sports and tourism market; Increased income from distributed resources; Profit space increases.
Hybrid driven (Support system)	Increasing citizens' income. Developing local characteristic tourism and building demonstration base.	Urban and rural coordinated development; Rural well-off level is improved; The level of urban integration construction is improved.

associations, we-media, and other intermediary organizations. Mixed-driven economic development model means that in the process of the economic development in the basin, the systems of supply, demand, and intermediary should drive the development as a whole. Each system has a similar proportion in this model, and we cannot tell which plays a more important role [16]. Only when these driving forces work together can we achieve the desired effect and promote high-quality development in the Yellow River Basin.

7.2. Directions for Development Change

Information integration and high-quality development in the Yellow River Basin is a major regional plan of the nation, and therefore high standards should be set [34]. The development of regional industries should achieve the goal of integration, too [35]. On this basis, regional communication and cooperation should be realized with the help of the dividend of development. The regional limitation of administration should be broken to build an integrated culture, sports, and tourism brand promotion model [36]. The convenience of traffic is necessary. The transportation location problem is the bottleneck restricting the development of the region, so the establishment of a basin-wide integrated transportation facility is imperative. Transportation is the endogenous driving force of development and an important way to promote the integration of culture, sports and tourism resources and regional development [37]. Achieving regional diversity is also vital. The homogenization of cultural, sports, and tourism resources within the Yellow River Basin is obvious, which hinders regional economic development. Therefore, it is necessary to boost the differentiated development of the area [38] [39]. To achieve brand internationalization, we should properly handle the relationship between international and domestic circular markets, and build the

culture and tourism integration belt, forming a new regional development pattern. Therefore, the high-quality development of the Yellow River Basin, together with the Silk Road and the development of the western region in China, can be built with international influence. To achieve this goal, it is necessary to continuously enhance communication and cooperation with the international market, shape the regional international brand of culture, sports, and tourism, and promote the high-quality development of the Yellow River Basin.

8. Conclusions

Ecological protection and high-quality development of the Yellow River Basin are important starting points for the strategy of the rise of central China and effective means to realize regional economic revitalization. The basin covers nine provinces, but there is a lack of research on the overall culture, sports, and tourism resources in the study area at this stage. This is the difference between the development of the Yellow River Basin and other regions. Therefore, this paper applied the CRITIC method model, comprehensive fuzzy evaluation model, and entropy weight TOPSIS analysis model to calculate the development level of the three resources in the Yellow River Basin. The weight of the development status of culture, sports, and tourism resources in the nine provinces was concluded. The study result revealed that the middle east regions were more developed than the central and western regions. The growth level of Shandong, Shaanxi, and Henan in the east was the highest, while the level of Qinghai, Ningxia, and Gansu in the western region was the lowest. Sichuan was the only province with a relatively good development level of the four resources in the western region. The characteristics of resources in the basin were further summarized, and the geographical spatial range was identified based on the big data of POI interest points. The resources in the basin were divided into four categories, namely sports, culture, tourism, and mixed resources. The nearest neighbor index analysis table of regional resources was generated by ArcGIS10.2. It could be seen from the table that the nearest neighbor index of sports resources was the highest and that of cultural resources was the lowest. The ratios of the nearest neighbor index of all four types of resources were less than 1, showing a strong aggregation. Then through the kernel density algorithm, we could estimate the degree of aggregation and dispersion of these resources. The kernel density map showed that the degree of aggregation of tourism resources was the strongest, and the cultural resources were the lowest. The kernel density of mixed resources had the largest potential to change in the four types of resources, which related to the local economy, policy, and resource utilization.

Through the above analysis, we made use of the demand-driven, supply-driven, intermediary support, and mixed-driven theories in the development theory to analyze the economic development of the Yellow River Basin, and guided the upgrading of industries and resources in the area. With the facilitation of internationalization, informationization, differentiation, and transportation, efforts could be

made to promote high-quality development and build a culture and tourism integration economic belt in the Yellow River Basin. The ultimate goal is to build a national demonstration area for sustainable development with good ecology, superior system, strong development, and innovation.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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