*Article*

# Sustainability Assessment of Cultural Heritage in Shandong Province

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**Abstract:** Although the sustainability of cultural heritage plays important roles in the inheritance of humans' civilization and history, assessments of such fields is still limited. In this paper, the spatiotemporal analysis method and coupling coordination model were applied to assess the sustainability of cultural heritage in Shandong Province. Results show that (1) the National Key Cultural Relics Protection Units ("cultural units" hereinafter) of Shandong Province have obvious convergence of spatiotemporal and city distribution; (2) although the tourism response degree of each city vary greatly, their tourism income exhibits positive correlation (i.e., correlation coefficient reaches 0.6639) with cultural units; (3) the coordination between cultural units, capital inputs, and tourism income in different cities is different, mainly shows three levels of well coordination (Jinan, Jining, Qingdao, Yantai, Weifang, and Zibo), general coordination (Zaozhuang, Weihai, Tai'an, Liaocheng, Heze, Linyi, and Rizhao), and poor coordination (Dezhou, Binzhou, and Dongying). These findings imply that the SDGs 11.4.1 is an effective indicator to promote the sustainable development of cultural heritage. However, there are still shortcomings at the city level, and the distribution of heritage and tourism response in the area should be considered in the future.

**Keywords:** cultural heritage; tourism development; capital input; sustainability; Shandong province

## 1. Introduction

Since the concept of "sustainable development" came out in the United Nations Committee on the Human Environment held in 1972, its importance on resource conservation and environment improvement has attracted increasing attention [1]. Through the unremitting efforts of various organizations and institutions during the past decades, the connotation of sustainable development is more and more clear, comprehensive, and directional [2,3]. Especially, a total of 17 specific goals, i.e., Sustainable Development Goals (SDGs), were put forward at the United Nations Conference on Sustainable Development held in September, 2015. These goals were formed based on the 2030 agenda from nearly 200 countries all over the world, which focused on multiple social issues involving ecological environment, human residents, poverty, hunger, disease, education, health, employment, and among others [4]. At present, investigations on the spatiotemporal distribution and dynamic information related to these social issues of concern, which help to accurately grasp the social status and develop effective coping strategies, have become research hotpots [5–7].

Among the 17 SDGs, SDG 11, which aims to "make cities and human settlements inclusive, safe, resilient and sustainable", demonstrates a strong focus on social activities

and human daily life and has been especially widely investigated. For instance, in accordance with the detailed description of SDG 11.1 which focuses on urban housing and basic social service, Kuffer et al. has studied the scope of earth-observation to improve the consistency of the SDG slum indicator, and suggested that a global layer of areas with deprived living conditions and related population estimates should be established in support of the SDG indicator 11.1.1 [8]. Refer to the connotation of SDG 11.2 and 11.3 which refer to urban management and public transportation, Gabriela et al. analyzed how the mass public transport system in the Guadalajara Metropolitan Area, covers transport social needs [9], Melchiorri et al. provided evidence to suggest that SDG 11.3.1 could be raised from its Tier II classification [10]. With respect to SDG 11.5 which concerns disasters and their social impacts, Ranjbari et al. built a fuzzy surface based on the experts' opinion and suggested that SDG 11.5 has the highest priorities for action to support the SDGs achievement post COVID-19 in Iran [11]. In addition, related investigations have also been executed by Regina, Taher, and Philipp according to the commutation of 11.6 and 11.7, respectively [12–14]. However, compared to these aforementioned social issues, another precious social resource mentioned in SDG 11.4, i.e., world cultural and natural heritage, have been investigated relatively seldomly.

Cultural heritage, including material cultural heritage and intangible cultural heritage, are pivotal existence with historical, artistic, and scientific value left by human beings in social activities [15–17]. SDG 11.4, which refers to "strengthen efforts to protect and safeguard the world's cultural and natural heritage", was put forward aiming to the protection and sustainable development of world heritage [5,18]. As the only extension of this goal, SDG 11.4.1 describes "total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)" [6,7,19]. This is the first time that world heritage protection has been formally put forward in the form of SDGs [19–21]. However, SDG 11.4.1 only reflects the status of heritage protection and development from the perspective of capital inputs. Therefore, most of the existing studies focus on the measurement and evaluation of indicators [8,22]. The previous researchers mostly focused on the sustainability of world heritage at large scales of national, continental, and even global, e.g., David Simon et al. [3] who defined indicators for assessing the cultural heritage and natural heritage, and James et al. [23] who quantified the impact of human disturbance on world natural heritage. In general, the conclusions of these existing research are relatively macroscopic and difficult to reveal the interior spatiotemporal differences from a microscopic perspective. In view of the research methods, the GIS spatial analysis and regression analysis have been proven great availability and potential in such studies. For instance, Wang et al. proposed that using "expenditure per unit area" instead of "expenditure per capita" can better reflect the scientific nature of indicators [6]. However, as a pivotal social poles of the cultural heritage, their tourism development, and economic income are lowly understood to date. Moreover, most existing research ignore the coupling relationships between culture heritage and capital investment.

Beyond that, the budget for heritage protection needs to vary from place to place. The distributions, types, and tourism attractions are important factors affecting the capital inputs for heritage protection [24,25]. According to the statistics in China [26], the capital inputs for ancient architectural heritage protection were the highest among all types of world cultural heritage in 2020, followed by the ancient ruins and ancient tombs, and the cave temples and stone carvings were the lowest. In many developed countries, e.g., the United Kingdom, Rome, and Poland which have many famous historic buildings with high tourism attraction, the economic appraisal of major investment projects in preservation and restoration work of historic buildings has formed long standing traditions [27,28]. In the case of insufficient public capital inputs in heritage sites, it is a realistic choice for almost

all cultural heritage sites to obtain protection inputs through the development of tourism to solve the financial constraints in some countries [29,30]. For instance, in purpose of encouraging the protection of cultural heritages, the Spain Government allowed to re-utilize the cultural heritages, including but not limited to develop tourist and hotel business [31]. From this point of view, the transformation relationship between cultural heritage and tourism is also related to the budgets for the sustainable development and protection of cultural heritage. To sum up, if we want to assess the sustainability of cultural heritages, we should comprehensively consider the conditions of spatial distribution, types, tourism attractions, and among other aspects, especially their coupling coordination relationships with the capital input of heritage, which are often neglected. Meantime, research and analysis at the smaller scales needs to be paid more attention, and the interpretation of the factors affecting the heritage protection inputs also needs to be deepened.

In this study, we plan to execute a sustainability assessment of cultural heritage at city level. Selecting cities in Shandong Province as the study area, we aim to accomplish three major tasks: (1) Characterizing the spatiotemporal distribution of cultural heritage in Shandong Province along with the long history of humans' civilization; (2) investigating the tourism development and capital input in response to cultural units; and (3) analyzing their coupling coordination. Results of the assessment can contribute to the planning of SDGs and the development path of cultural heritage in Shandong Province, the realization of coordinated development of economic society and heritage protection, and can also provide research ideas and reference basis for the construction of SDGs indicators on a regional scale, which is of great significance to promoting the realization of SDGs in China.

## 2. Study Area

Shandong Province, located in the eastern coast of China and the lower reaches of the Yellow River, is an important cradleland of Chinese civilization and Confucian culture (Figure 1). The terrestrial area of this province is about 155,800 km$^2$, ranging from $34°22.9'$ N and $114°47.5'$ E to $38°24.01'$ N and $122°42.3'$ E. The concentration of cultural heritage in Shandong Province happens to be one of the most intense human activities in the dynastic history of China. The Yellow River civilization and the Beijing-Hangzhou Grand Canal cultural belt multiply and blend here. Therefore, ancient humans left a large number of sites and relics in these areas. There are a total of 16 cities in Shandong Province. Among these 16 cities, Dezhou, Liaocheng, Tai'an, Jining, Heze, Zaozhuang, and Linyi Cities located in the western Shandong belong to the inland region, bordering Hebei, Henan, Anhui, and Jiangsu Provinces from north to south. These cities are all over hills and mountains, with relatively high elevations. The coastal cities in the eastern Shandong Province, including Binzhou, Dongying, Weifang, Qingdao, Yantai, Weihai, and Rizhao, are mainly distributed in flat terrains. The eastern peninsula is prominent in the Bohai Sea and the Yellow Sea, facing the Liaodong Peninsula. Along with the development of economy and society, a total of eight cities containing capital Jinan, Qingdao, Yantai, Weihai, Rizhao, Dongying, Weifang, and Zibo have grouped into an urbanization and economic belt, i.e., Shandong Peninsula Urban Agglomeration, with active productive potentiality. In total, the cultural relics resources in Shandong Province are widely distributed and high in number.
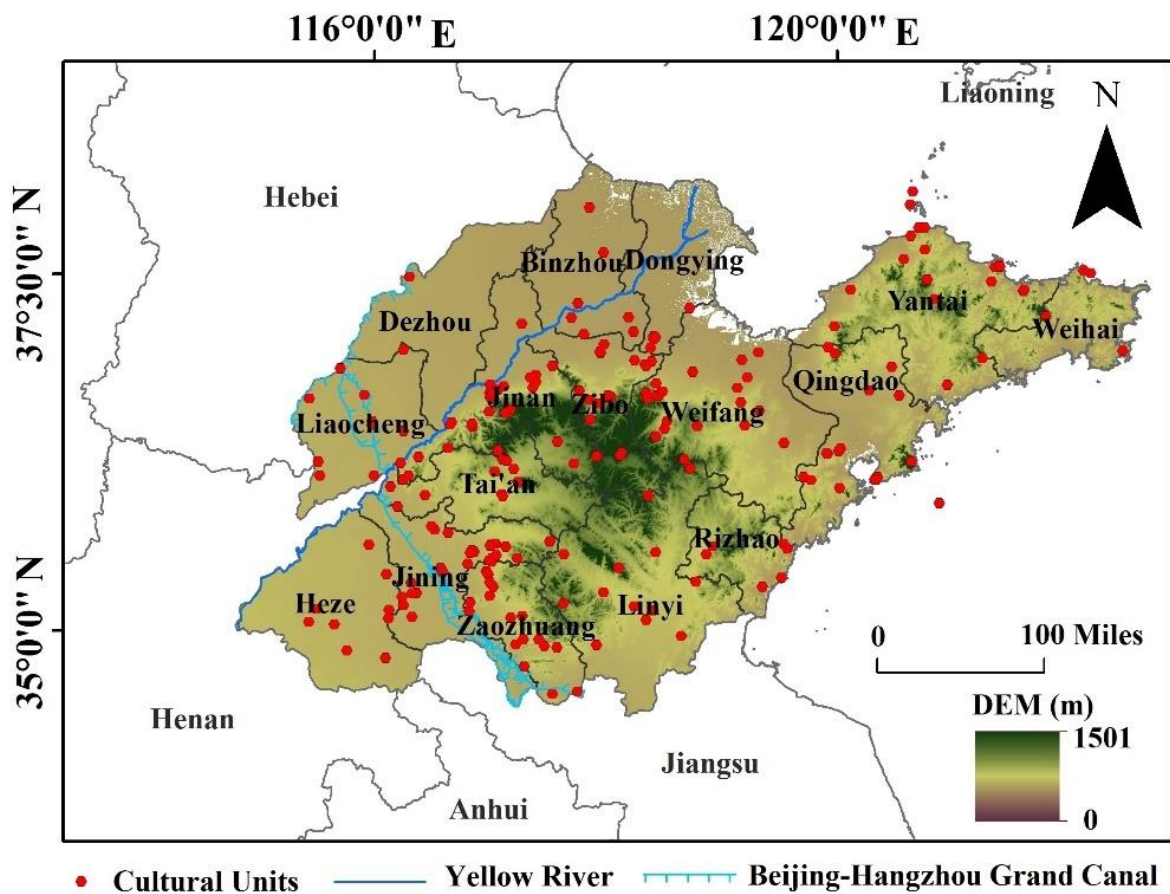
**Figure 1.** Distribution map of cultural units in Shandong Province.

## 3. Material and Methodology

### 3.1. Conceptual Framework for Sustainability Assessment of Cultural Heritage in Shandong Province

This study aims to assess the sustainability of cultural heritage across cities in Shandong Province. In accordance with the connotation of SDGs related to cultural heritage protection, we focused on three aspects of cultural heritage as shown in Figure 2. By deeply digging into the correlations of these three aspects, we try to comb their coupling coordination in purpose of achieving sustainable development.

In this study, the self-attributes mainly indicate the spatiotemporal distribution of cultural heritages in Shandong Province. The spatial distribution was mainly characterized by applying the kernel density spatial analysis method. The analysis on time domain was in accordance with history, archaeology, and the characteristics of cultural heritages, which divided the long history of humans' civilization into eight stages including the Prehistoric period, Pre-Qin period, Qin and Han period, Wei Jin Southern and Northern Dynasties period, Sui Tang and Five Dynasties period, Song and Yuan period, Ming and Qing Dynasties period and Modern period in this study. All spatiotemporal analysis were executed at the city level.

We understand the social role of cultural heritages as a potential tourism industry, i.e., its interaction with the public as an important tourism resource [32]. To date, numerous sites considered as cultural heritage have kept attracting tourists every day and developed into famous scenic spots, bringing economic effects to local government and residents. In order to comprehensively estimate the tourism development of Shandong Province in response to cultural units, we analyzed the correlations of cultural units with multiple indicators related to its industry scale, economic effect and social function.
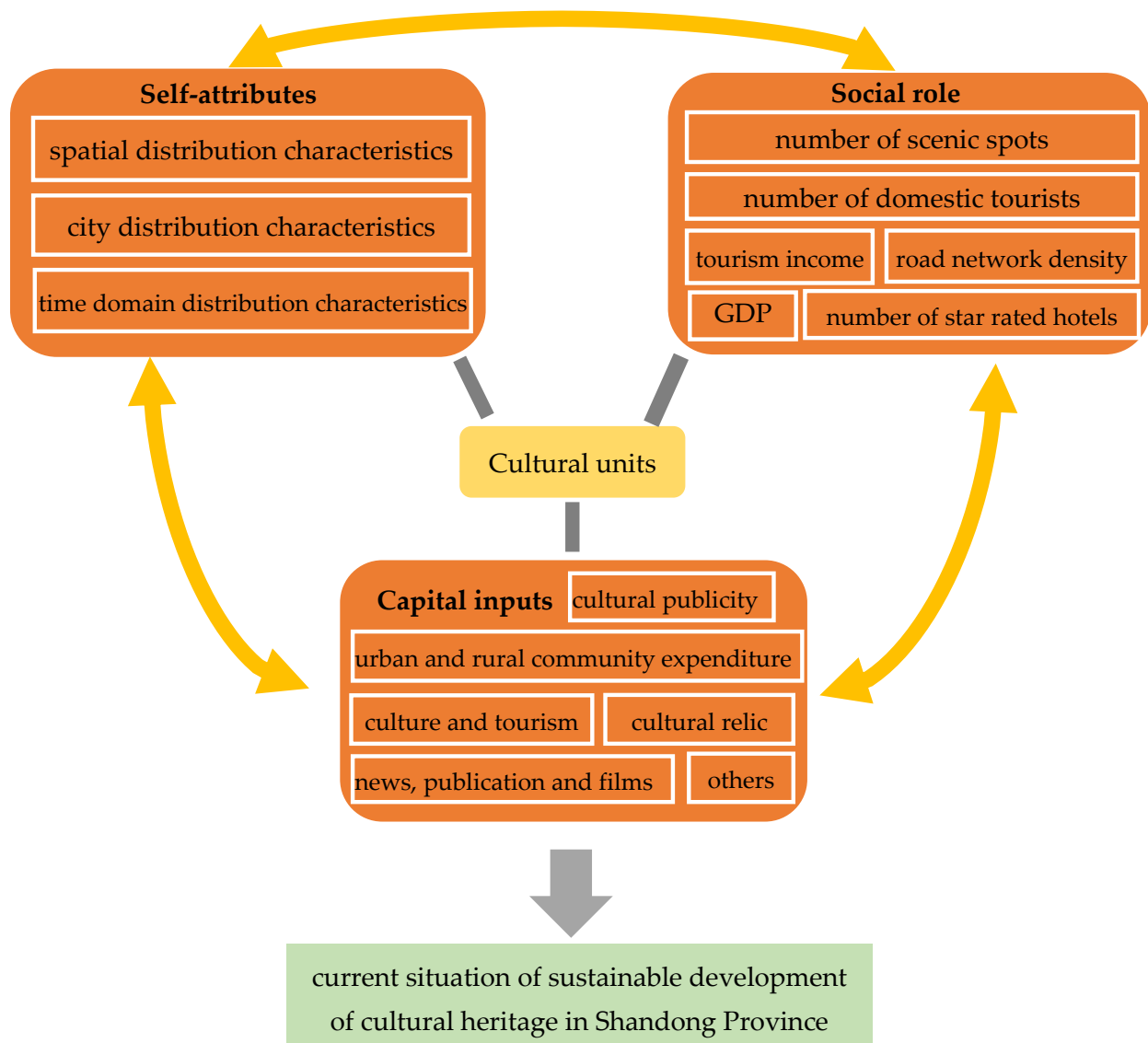
**Figure 2.** Conceptual framework for sustainability assessment of cultural heritage.

Capital input was applied to assess whether the current investment of Shandong Province is balanced, coordinated and meets the demands of cultural heritage sustainability. By executing regression analysis and coupling coordination evaluation, the correlations between capital input and cultural heritage and tourism development was estimated. Subsequently, the major constrains and suggestions for sustainable development was proposed.

*3.2. Data Sources and Pre-Processing*

The National Key Cultural Relics Protection Units ("cultural units "hereinafter) located in Shandong Province is applied to characterize the spatiotemporal distribution of cultural heritages. The data were obtained from the 1~8 batches of cultural units published by the National Cultural Heritage Administration of China. Based on our statistics, a total of 225 cultural units in Shandong Province are recorded at present (Table 1). The geographical coordinates of 225 cultural units were obtained via a coordinate picker written in Python, and ArcGIS10.2 was used for data processing and analysis to produce the distribution map of cultural units in Shandong Province as shown in Figure 1.

**Table 1.** Statistics on the number and types of cultural units in Shandong Province.

| Type | Ancient Ruins | Ancient Tombs | Historic Buildings | Grotto Temples and Stone Carvings | Important Modern Historical Sites and Representative Buildings | Total |
|---|---|---|---|---|---|---|
| Number | 90 | 24 | 53 | 19 | 39 | 225 |

Considering three dimensions related to tourism development [33–36], a total of six indexes were applied in this study (see Table 2). These data were obtained from official channels such as the statistical yearbook of Chinese culture and tourism, the statistical yearbook of China and statistical bulletin of Shandong Province. We downloaded the road network information of Shandong Province from the OpenStreetMap website (http://download.geofabrik.de/, accessed on 20 September 2022), mainly including national roads, provincial roads, expressways, railways, and other categories. The data pre-processing mainly include clipping, dissolving, and format conversion.

**Table 2.** Tourism index system of cities in Shandong Province.

| Dimension | Tourism Industry Scale | | Tourism Economic Effect | | Tourism Social Function | |
|---|---|---|---|---|---|---|
| Index | number of scenic spots [37] | number of domestic tourists [38] | tourism income [39] | TI/GDP [40] | number of star hotels [41] | density of the road network [42] |

Note: TI is the abbreviation of tourism income; GDP is the abbreviation of gross domestic product.

*3.3. Methods*

3.3.1. Kernel Density Spatial Analysis

The kernel density estimation can reflect the degree and specific location of point elements. In this study, the cultural units in Shandong Province were taken as point elements. By analyzing the kernel density of all cultural units, the spatial agglomeration characteristics of cultural units were estimated and measured. The calculation formula was as follows:

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

where $k()$ indicates a kernel function; $h$ indicates the bandwidth; n indicates the number of cultural units; $x - x_i$ indicates the distance from the valuation point $x$ to the cultural unit $x_i$.

3.3.2. Spatiotemporal Regression Analysis

Regression analysis focused on the dependence between random variables. Its purpose is to find the relationship between dependent variable $y$ and independent variable $x$, so that one variable can predict another variable. The univariate linear regression analysis prediction model can be illustrated by the formula as follows:

$$Y_t = ax_t + b \tag{2}$$

where $x_t$ indicates the value of independent variable in $t$ period; $Y_t$ indicates the value of the dependent variable in period $t$; $a$ and $b$ indicate the parameters of a linear regression equation.

3.3.3. Coupling Coordination Evaluation Model

The coupling coordination evaluation model focuses on describing the interaction between two or more subsystems, which can well explain the sustainable development of systems [43]. Regarding cultural units, its self-attributes, social role, and capital inputs are recognized to form a symbiotic relationship of mutual influence, that is, the change of one single element might lead to an impact on the other two elements [44]. In this study, their

coupling coordination relationships across 16 cities were evaluated by five major steps as summarized in Figure 3.
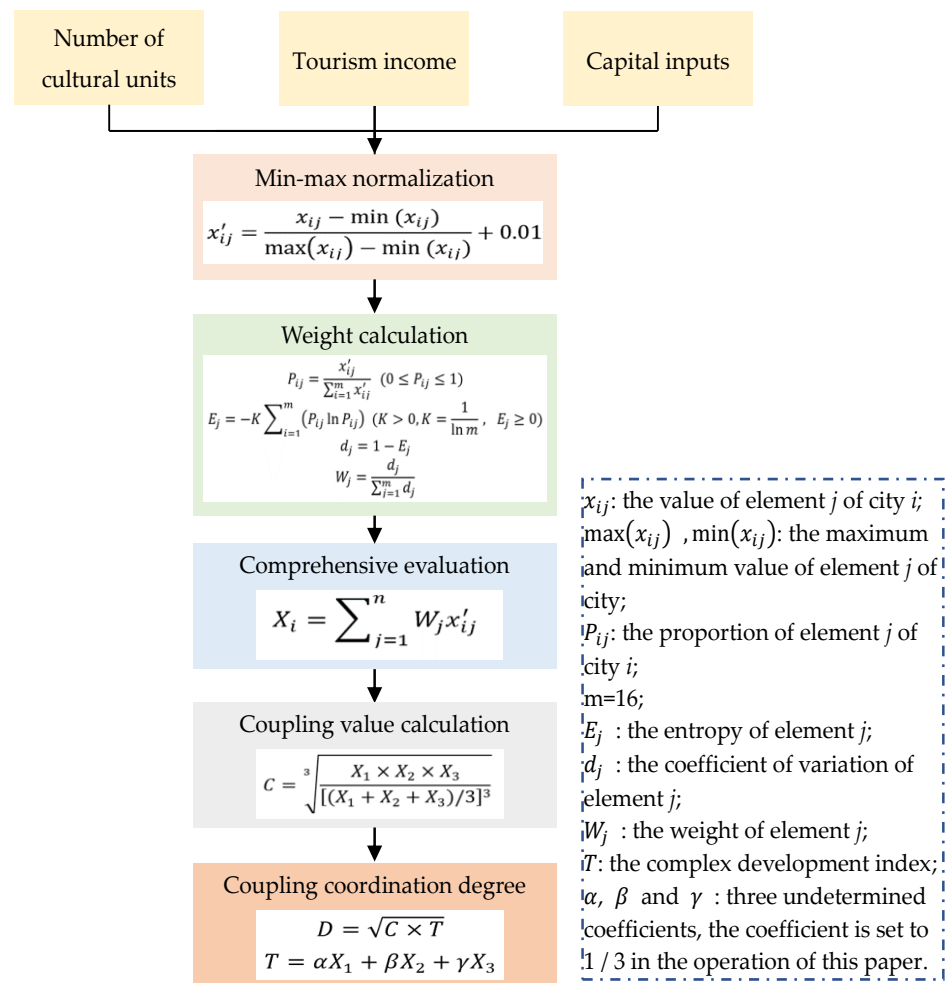


**Figure 3.** The flowchart of coupling coordination evaluation model.

The flowchart contains the following elements:

Inputs: Number of cultural units; Tourism income; Capital inputs

**Min-max normalization**

$$x'_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} + 0.01$$

**Weight calculation**

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^m x'_{ij}} \quad (0 \le P_{ij} \le 1)$$

$$E_j = -K \sum_{i=1}^m (P_{ij} \ln P_{ij}) \quad (K > 0, K = \frac{1}{\ln m}, \; E_j \ge 0)$$

$$d_j = 1 - E_j$$

$$W_j = \frac{d_j}{\sum_{j=1}^m d_j}$$

**Comprehensive evaluation**

$$X_i = \sum_{j=1}^n W_j x'_{ij}$$

**Coupling value calculation**

$$C = \sqrt[3]{\frac{X_1 \times X_2 \times X_3}{[(X_1 + X_2 + X_3)/3]^3}}$$

**Coupling coordination degree**

$$D = \sqrt{C \times T}$$

$$T = \alpha X_1 + \beta X_2 + \gamma X_3$$

$x_{ij}$: the value of element $j$ of city $i$;
$\max(x_{ij})$, $\min(x_{ij})$: the maximum and minimum value of element $j$ of city;
$P_{ij}$: the proportion of element $j$ of city $i$;
m=16;
$E_j$ : the entropy of element $j$;
$d_j$ : the coefficient of variation of element $j$;
$W_j$ : the weight of element $j$;
$T$: the complex development index;
$\alpha$, $\beta$ and $\gamma$ : three undetermined coefficients, the coefficient is set to 1 / 3 in the operation of this paper.

## 4. Results

### 4.1. Spatiotemporal Distribution and Dynamics of Cultural Units in Shandong Province

4.1.1. Spatial Distribution Characteristics of Different Types of Cultural Units

The cultural units in Shandong Province distributed unevenly in space. The maximum number were found in Jining, while the minimum number in Dezhou. Figure 4 shows the spatial distributions of cultural units at five density levels by executing nuclear density analysis. The high density areas were concentrated in three cities of Jinan, Jining, and Zibo, with their distribution formed a "semi-circle" structure along the Yellow River and the Beijing-Hangzhou Grand Canal. According to statistics, there are 18 cultural units located within the 10 km distance from the Yellow River and seven within the 10 km buffer zone of the Beijing-Hangzhou Grand Canal. In addition, there are four other medium density areas scatted in the northwest coastal of Yantai, Northeast of Weifang and central-south of Qingdao. Compared to other cities distributed in low density and medium-low density areas, these abovementioned cities have more complex terrains and richer civilization origin. For instance, Jinan is known as the "Spring City" in China. Aside from abundant springs, it also has multiple mountains, lakes, rivers, and landforms within the limited administrative boundary. Such diverse terrains carry a large number of cultural units related to different natural and historical backgrounds, e.g., Lingyan Temple, Mountain Qianfoshan, Baotu Spring Groups, etc.
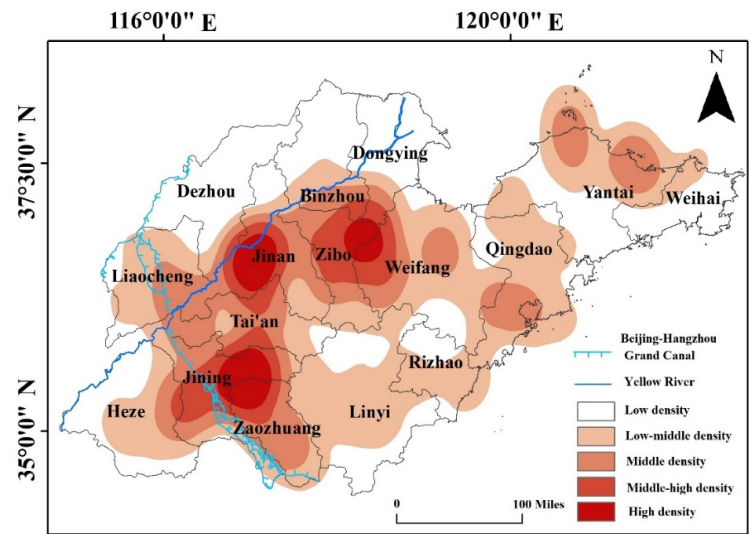
**Figure 4.** Spatial distribution of cultural units in Shandong Province at five density levels by executing nuclear density analysis.

Figures 5 and 6 exhibit the distributions of five cultural unit types in Shandong Province. Among the five types, the ancient ruins have the largest number and mainly distributed in Jining, Jinan, Qingdao, Weifang, and Zibo. Three clusters can be found in its nuclear density analysis result (Figure 6a), carrying the largest number of ancient ruins of Shandong Province. The number of historic buildings took the second place. Among them, over 1/3 were distributed in Jining, where concentric circles are present with the high density in the center (Figure 6b). Dezhou, Linyi, Rizhao, and Weiha were recognized as low density area of historic buildings. The number of important modern historical sites and representative buildings rank three among the five types (Figure 6c). They mainly are distributed in Jinan, Yantai, and Qingdao. The number of ancient tombs is 24, concentrated in 10 cities of Shandong Provinces (Figure 6d). Jining has the most ancient tombs with a number of five, while Dezhou has only one named the "Tomb of King Sulu". It is also the only cultural unit of Dezhou. The number of grotto temples and stone carvings were the least, mostly distributed in Tai'an followed by Jinan (Figure 6e).
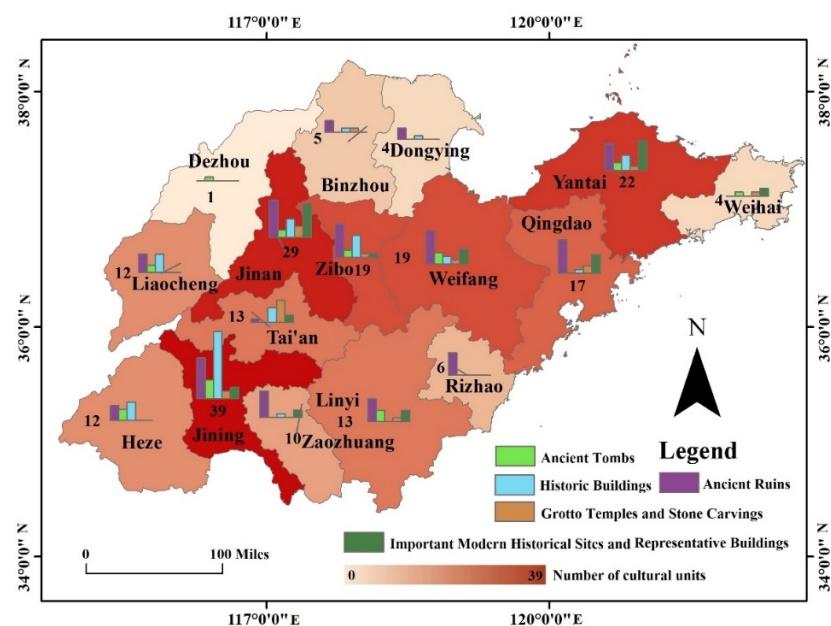


**Figure 5.** Spatial distribution of five cultural unit types in Shandong Province.
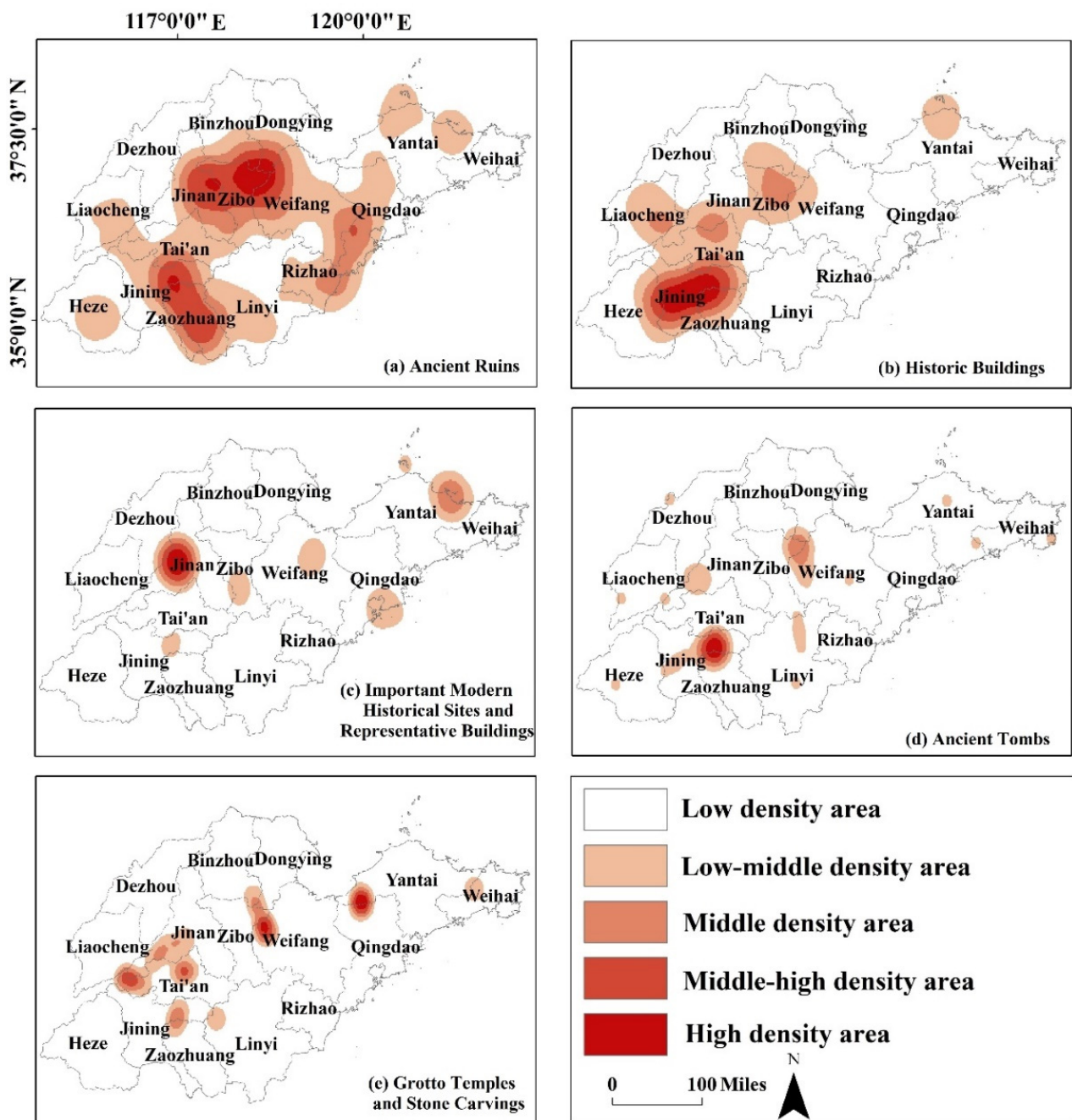
**Figure 6.** Spatial distribution of different cultural unit types in Shandong Province at five density levels by executing nuclear density analysis.

### 4.1.2. Time Domain Dynamics of Different Types of Cultural Units

Figure 7 shows the quantities and their types of newly built cultural units in these historical periods. In total, the quantity of newly built cultural units in the eight periods suffered a "decrease first, and rise up afterwards" trend. Meantime, the types of cultural units tended to be diverse across the entire history. There is a meaningful finding, i.e., the quantity of newly built ancient tomb shows a decreasing trend from nine in Pre-Qin Dynasty to three in Ming and Qing Dynasties. Meanwhile, the number of newly constructed historic buildings soared from two in Qin and Han Dynasties to 30 in Ming and Qing Dynasties. This phenomenon reflects the transformation of people's pursuit and the progress of human civilization.
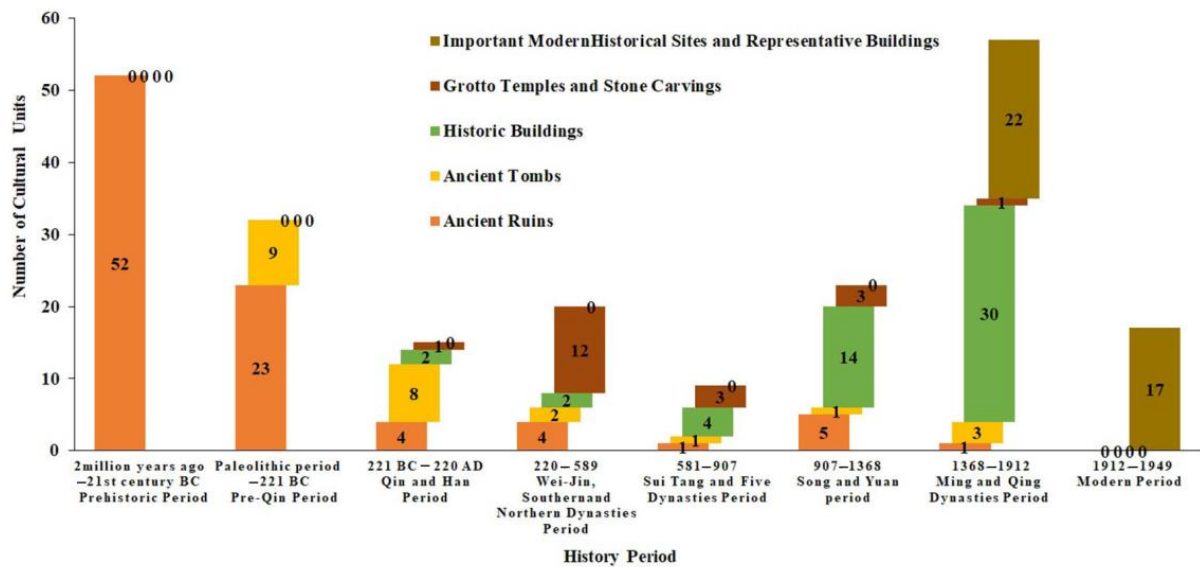
**Figure 7.** Time domain quantity and type statistics of cultural units in Shandong Province. Notes: Some cultural units have gone through multiple dynasties, such as the ancient ruin–Longhua Temple site has gone through multiple periods from the Southern and Northern Dynasties to the Qing Dynasty. When counting the number, the cultural unit is counted as one, that is, it is classified as the earliest period.

Table 3 shows more details. As the oldest and longest period, the Prehistoric period has a large quantity of ancient ruins, accounting for nearly 23.22% of the total cultural units. Examples are the Dawenkou, Chengziya, Xixiahou sites, and among others. These sites are important evidence of the history of China's civilization, e.g., the Longshan culture in Jinan and the Beixin culture in Jining. Afterwards, although the quantity of newly generated cultural units dropped down slightly due to multiple factors such as wars, the types became rich in diversity along with civilization development. The quantities of the following five periods separately accounted for 14.22%, 6.67%, 8.89%, 4.00%, and 10.22% of the total number of cultural units. Meanwhile, the new types include ancient tombs, grotto temples and stone carvings, and historic buildings. The famous cultural units include but not limited to Han Lu King's tomb, Jiliang Mountain, Zhangba Buddha, and Dai Temple. By the Ming and Qing Dynasties period, the technology of ancient architecture had been relatively mature, and the interval between ancient architecture and modern architecture was relatively short. Therefore, a large number of historic buildings were preserved. The quantity of newly generated historic buildings reached 30, accounting for 53% of the total number of cultural units in this period and 58% of the total number of historic buildings in Shandong Province. Since entering the Modern period, the important modern historical sites and representative buildings became the absolutely dominant type of cultural units. Affected by the Second Opium War, the closed state of Shandong Province was broken, and the number of cultural units in coastal areas increased quickly. Most of them were recognized as the relics of war. In general, in Prehistoric period and Ming and Qing Dynasties period, the number of cultural units in each city was relatively balanced.

**Table 3.** Statistics on the number of cultural units in different historical period.

| City | Prehistoric Period | Pre Qin Period | Qin and Han Period | Wei-Jin, Southern and Northern Dynasties Period | Sui Tang and Five Dynasties Period | Song and Yuan Period | Ming and Qing Dynasties Period | Modern Period |
|------|------|------|------|------|------|------|------|------|
| Jinan | 6 | 3 | 3 | 2 | 3 | 0 | 7 | 5 |
| Zibo | 5 | 4 | 0 | 2 | 1 | 1 | 6 | 0 |
| Dongying | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Binzhou | 1 | 1 | 0 | 2 | 0 | 0 | 1 | 0 |
| Dezhou | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Liaocheng | 3 | 0 | 1 | 0 | 1 | 3 | 4 | 0 |
| Tai'an | 1 | 0 | 0 | 3 | 1 | 3 | 3 | 2 |
| Heze | 3 | 0 | 3 | 0 | 2 | 1 | 3 | 0 |
| Jining | 6 | 6 | 3 | 2 | 1 | 10 | 10 | 1 |
| Zaozhuang | 4 | 2 | 0 | 1 | 0 | 0 | 2 | 1 |
| Linyi | 2 | 5 | 2 | 1 | 0 | 0 | 0 | 3 |
| Rizhao | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Qingdao | 4 | 2 | 2 | 1 | 0 | 3 | 4 | 1 |
| Weihai | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 |
| Yantai | 4 | 5 | 0 | 1 | 0 | 0 | 10 | 2 |
| Weifang | 5 | 3 | 1 | 3 | 0 | 1 | 4 | 2 |

### 4.2. Tourism Development of Shandong Province in Response to Cultural Units

#### 4.2.1. The Tourism Development Degree of Cultural Units

The development from cultural heritage into scenic spots (i.e., attractive for tourism, including natural and artificial construction [45]) can be ascribed to multiple factors, such as the convenience of local traffic, safety environment, tourist attractions, financial supports, manager decisions, and among others [46]. The tourism development degree of cultural units was measured by the ratio of the number of scenic spots to the number of cultural units. In Shandong Province, a total of 134 cultural units have been recognized as scenic spots at present. Therefore, the overall tourism development degree of cultural units in Shandong Province was calculated as nearly 59.6% (Table 4). Among the five cultural unit types, the important modern historical sites show the highest tourism development degree of 84.6%, followed by the historic buildings, grotto temples, and stone carvings and ancient tomb with their tourism development degree ranging from 54.2~77.4%. As for ancient ruins, although the high values of cultural relics have been proven by the increasing archaeological research, they have attracted much less tourists compared to other four types. One vital reason could be ascribed to that the ancient ruins are mostly located in rural farmland or suburban with poor surrounding facilities, which is difficult to develop for tourism. Therefore, the ancient ruins show the lowest tourism development degree of only 36.7%.

**Table 4.** Tourism development degrees of five cultural unit types in Shandong Province.

| | Ancient Ruins | Historic Buildings | Ancient Tombs | Grotto Temples and Stone Carvings | Important Modern Historical Sites and Representative Buildings | All Cultural Units |
|------|------|------|------|------|------|------|
| Scenic Spots | 33 | 41 | 13 | 14 | 33 | 134 |
| Tourism Development Degree (%) | 36.7 | 77.4 | 54.2 | 73.7 | 84.6 | 59.6 |

Figure 8 shows the tourism development degree of cultural units in 16 cities of Shandong Province. In Rizhao, Heze, and Linyi, there are less than half of cultural units approved as scenic spots. The cultural units in these three cities are majorly ancient ruins constructed in the Prehistoric period, which are less attractive to tourists. Other cities show relatively high tourism development degree exceeding 50%. In Dezhou, there is only one cultural unit named Sulu King Tomb. It is a typical representative of Chinese and Filipino culture. This cultural unit drove the development of Sulu King Tomb Museum in Dezhou and tapped the potential and development path of tourism market economy. Thereby, the tourism development degree of Dezhou is 100%. Tai'an had the second highest degree

of tourism development, owing to the fact that the cultural units in Tai'an were mainly historic buildings, grottoes, and stone carvings. Although Yantai, Jinan, Jining, and Weifang have large quantities of cultural units, their tourism development degrees are not as high as Weihai, Dongying and Zibo. This indicates that the tourism development degree of each city is related to the types of local cultural units to a certain degree.
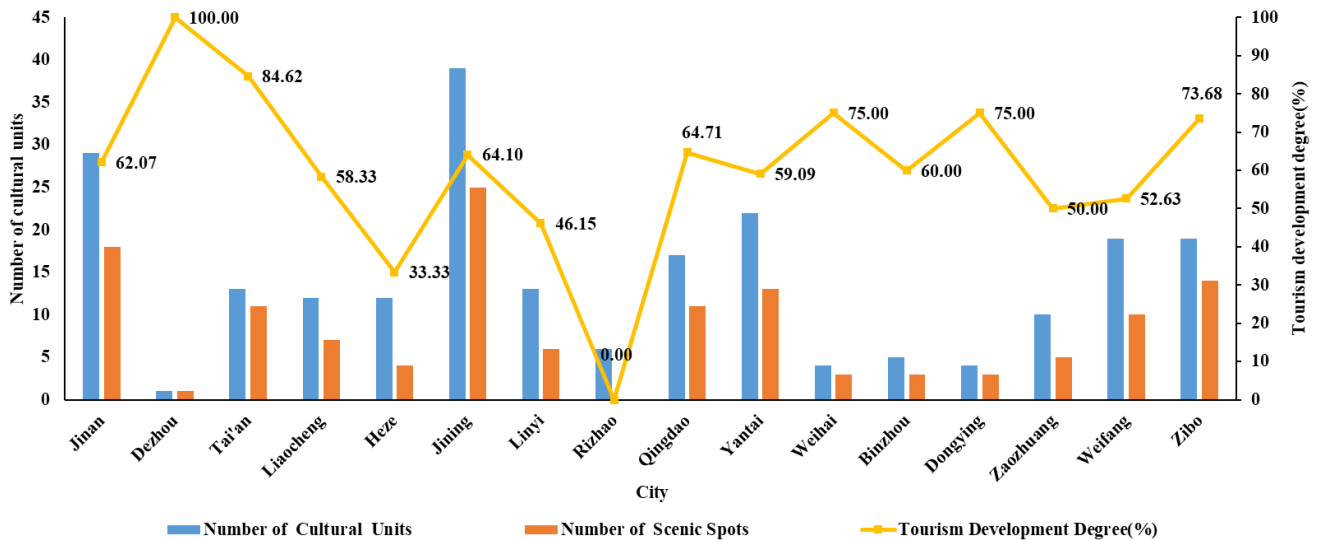


**Figure 8.** Comparison of tourism development degree of municipal cultural units.

### 4.2.2. The Influence of Cultural Units on Tourism Development

Table 5 lists the indicators, related to regional tourism development, and their correlations with the quantity of cultural units in Shandong Province. According to the results of regression analysis, all indicators show positive correlation with the quantity of local cultural units. Among these six indicators, the tourism income has the highest positive correlation with the quantity of local cultural units. Their F-test coefficient exceeds 0.66, followed by those between the quantity of cultural units and domestic tourists, scenic spots, star-rated hotels and road network density. Moreover, *p* values between the quantities of the cultural units and scenic spots, domestic tourists, tourism income, and star rated hotels are lower than 0.05, implying their correlations are significant. This phenomenon indicates that the cultural units (independent variables) can predict the variation of resource endowment, tourism market demand, tourism revenue benefit, and tourism infrastructure construction scale (dependent variables) to a certain extent. Moreover, the higher density of cultural units is always accompanied with a stronger tourism industry.

**Table 5.** Regression analysis between cultural units and regional tourism development.

| Area | Tourism Industry Scale | | Tourism Economic Effect | | Tourism Social Function | |
|---|---|---|---|---|---|---|
| | Number of Scenic Spots | Number of Domestic Tourists (Million) | Tourism Income(billion) | TI/GDP (%) | Number of Star Rated Hotels | Road Network Density |
| Jinan | 112 | 9980.30 | 1266.90 | 12.74 | 49 | 13.97 |
| Dezhou | 62 | 3393.36 | 226.42 | 7.49 | 9 | 10.61 |
| Tai'an | 79 | 8262.70 | 894.40 | 33.57 | 24 | 13.20 |
| Liaocheng | 53 | 2708.47 | 226.61 | 10.02 | 17 | 12.41 |
| Heze | 29 | 2365.33 | 220.62 | 6.46 | 11 | 10.90 |

**Table 5.** *Cont.*

| Area | Tourism Industry Scale | | Tourism Economic Effect | | Tourism Social Function | |
|---|---|---|---|---|---|---|
| | Number of Scenic Spots | Number of Domestic Tourists (Million) | Tourism Income(billion) | TI/GDP (%) | Number of Star Rated Hotels | Road Network Density |
| Jining | 139 | 8012.41 | 867.54 | 19.85 | 20 | 11.13 |
| Linyi | 182 | 8151.00 | 844.70 | 18.36 | 28 | 17.29 |
| Rizhao | 78 | 5375.96 | 416.56 | 21.36 | 12 | 17.20 |
| Qingdao | 166 | 11,132.58 | 1897.2 | 16.15 | 89 | 12.56 |
| Yantai | 123 | 8624.41 | 1177.76 | 15.38 | 62 | 17.22 |
| Weihai | 44 | 5099.72 | 671.33 | 22.65 | 42 | 13.65 |
| Binzhou | 69 | 1998.41 | 196.25 | 7.98 | 23 | 9.56 |
| Dongying | 70 | 2010.59 | 202.56 | 6.94 | 24 | 9.52 |
| Zaozhuang | 60 | 2712 | 245.39 | 14.48 | 14 | 15.83 |
| Weifang | 90 | 8213.5 | 911.7 | 16.02 | 38 | 14.79 |
| Zibo | 68 | 6370.3 | 739.7 | 20.3 | 26 | 14.12 |
| $R^2$ | 0.3341 | 0.5459 | 0.6639 | 0.0853 | 0.2963 | 0.2436 |
| $p$ | 0.0304 * | 0.0017 * | 0.0012 * | 0.3109 | 0.0442 * | 0.0729 |

$R^2$ indicates the R-squared coefficient of regression. $p$ indicates the $p$-value for statistical significance. * Significant at the 5% level.

Compared to other indicators, the TI/GDP shows the lowest $R^2$ determination coefficients with the quantity of cultural units, i.e., less than 0.09. Moreover, their F-test coefficient is not significant with the $p$ value exceeding 0.05. However, this does not mean cultural units are useless for local GDP increase. Despite their contribution of direct income by developing tourism industry as scenic spots, the existing of cultural units can also drive the development of other related industries, e.g., local catering, hotels, souvenirs trading, transportation, etc. It is therefore necessary to further increase tourism publicity and improve the development of cultural units to scenic spots in rational ways.

*4.3. The Capital Input for Cultural Unit Protection and Tourism Development*

According to the financial disclosure information of the municipal cultural and tourism bureaus (http://whhly.shandong.gov.cn/, accessed on 20 September 2022), the capital input of Shandong Province was high to 2869.77 million in total, with 179.36 million per city in average. Significant difference in the investment of cultural tourism existed at city scales (Figure 9). Among the 16 cities in Shandong Province, nearly half of the cities acquired relatively higher capital input above the average. The highest capital input was found in Qingdao, followed by Jining, Jinan, Yantai, and Weihai. Their capital input ranged from 239.72 million to 420.34 million. Other cities acquired lower capital input ranging from 9.08 million to 215.20 million. Dezhou acquired the lowest capital input. It is worth noting that the number of cultural units in Dezhou is also the lowest.

According to the results of regression analysis, capital input and the number of cultural units have significantly positive correlation ($p < 0.01$) with the $R^2$ determination coefficient of 0.87. Moreover, the significantly positive correlation can also be found between capital input and tourism income, with the $R^2$ determination coefficient of 0.88. This implies that the expenditure input was larger in cities with denser cultural units, accompanied with higher income by developing tourism industry. However, how much expenditure input is invested in heritage protection varies from region to region. Take Jining as an example, the expenditure is mainly used for culture and tourism promotion, cultural relic, news, publication and films, cultural publicity, urban and rural community expenditure, and others. In 2019, the total expenditure on culture, tourism, sports, and media was 314.64 million yuan in Jining, of which 50.85% was spent on urban and rural communities, followed by cultural and tourism publicity, accounting for 40.74% of the total expenditure. The capital inputs for cultural relics are 18.2764 million yuan, including

cultural relics protection and museums, accounting for 18.28% of the total capital inputs (Figure 10). From the reality, the investment is not all used for heritage protection in Jining, but mostly for urban and rural community expenditure and tourism publicity. Therefore, it is not comprehensive to evaluate the sustainable development of heritage only from the perspective of capital inputs.
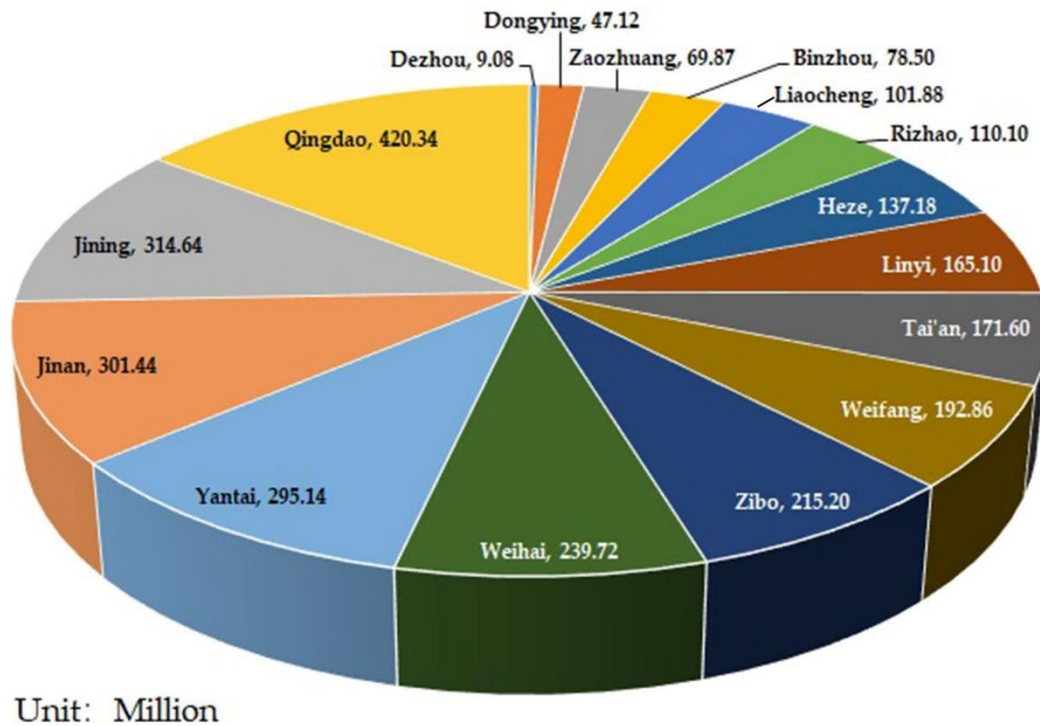


**Figure 9.** Map of capital investment for cultural tourism development of Shandong Province to cities in 2019.
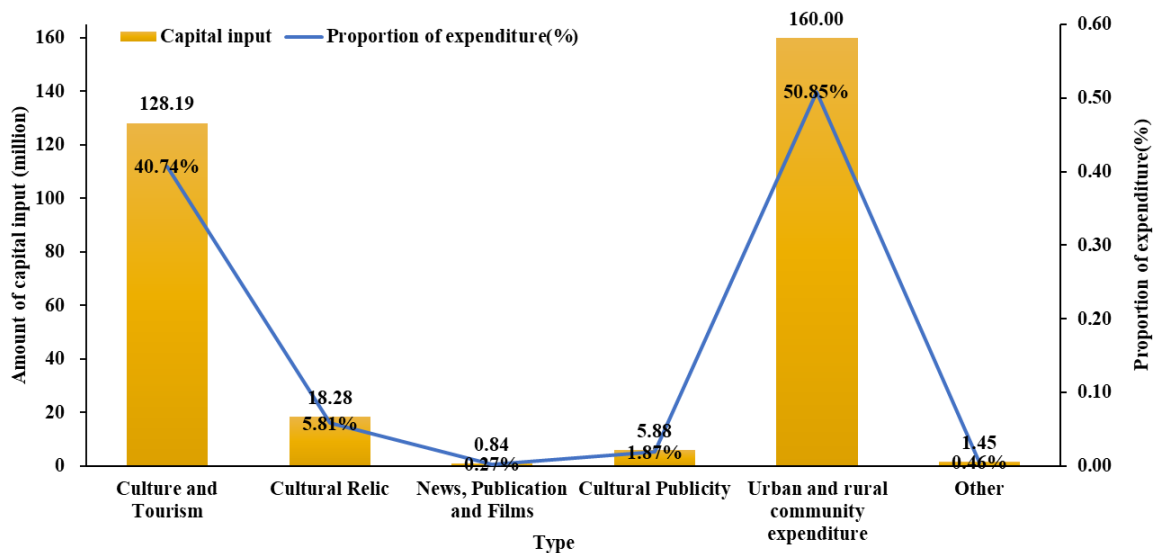


**Figure 10.** Distribution of heritage protection inputs of Jining in 2019.

### 4.4. The Coordinated Development of Cultural Units, Tourism Income and Capital Input

The comprehensive development index and the coupling coordination scheduling of tourism income, number of cultural units and capital investment of heritage protection in Shandong Province are calculated. Based on the equal division method, cities in Shandong Province were divided into three coupling coordination levels: 0.1~0.3 for poor coupling

coordination, 0.3~0.5 for general coupling coordination, and 0.5~−0.7 for well coupling coordination. Table 6 shows the coupling coordination of capital input, cultural units, and tourism income in Shandong Province.

**Table 6.** Coupling coordination of capital input, cultural units, and tourism income in Shandong Province.

| City | Composite Index | | | Coupling Value | Coordination Value | Level | Main Constraints |
|------|-----|-----|-----|-----|-----|-----|-----|
| | X1 | X2 | X3 | | | | |
| Jinan | 0.170 | 0.216 | 0.303 | 0.972 | 0.607 | well | X1 |
| Dezhou | 0.002 | 0.003 | 0.013 | 0.730 | 0.165 | poor | X1 |
| Tai'an | 0.096 | 0.094 | 0.199 | 0.937 | 0.495 | general | X2 |
| Liaocheng | 0.056 | 0.087 | 0.013 | 0.771 | 0.342 | general | X3 |
| Heze | 0.076 | 0.087 | 0.012 | 0.730 | 0.349 | general | X3 |
| Jining | 0.178 | 0.292 | 0.192 | 0.976 | 0.599 | well | X1 |
| Linyi | 0.092 | 0.094 | 0.186 | 0.945 | 0.489 | general | X1 |
| Rizhao | 0.060 | 0.041 | 0.066 | 0.980 | 0.380 | general | X2 |
| Qingdao | 0.239 | 0.125 | 0.479 | 0.863 | 0.624 | well | X2 |
| Yantai | 0.167 | 0.163 | 0.278 | 0.968 | 0.581 | well | X2 |
| Weihai | 0.135 | 0.026 | 0.137 | 0.786 | 0.427 | general | X2 |
| Binzhou | 0.042 | 0.033 | 0.005 | 0.703 | 0.266 | poor | X3 |
| Dongying | 0.024 | 0.026 | 0.007 | 0.847 | 0.252 | poor | X3 |
| Zaozhuang | 0.037 | 0.071 | 0.018 | 0.864 | 0.332 | general | X3 |
| Weifang | 0.108 | 0.140 | 0.204 | 0.966 | 0.526 | well | X1 |
| Zibo | 0.121 | 0.140 | 0.156 | 0.995 | 0.517 | well | X1 |

X1, X2, and X3 indicate capital input, number of cultural units, and tourism in-come, respectively.

According to the statistical results, a total of six cities are recognized as the well coupling coordination level, including Jinan, Jining, Qingdao, Yantai, Weifang, and Zibo. For these cities, the capital input, cultural units, and tourism income are keeping a relatively stable and balanced status at present. This implies that their capital input is rational for applying to cultural heritage protection. Meantime, the tourism income is normal at least. A total of seven cities, i.e., Zaozhuang, Weihai, Tai'an, Liaocheng, Heze, Linyi, and Rizhao are recognized as the general coupling coordination level. Moreover, the poor coupling coordination level occurred in Dezhou, Binzhou, and Dongying. Compared to the other six cities at well coupling coordination level, these cities face more difficulties in achieving sustainability of cultural heritage. Their major constrains are diverse as shown in Table 6. Taking Dongying as an example, the main factor affecting the degree of coupling coordination is tourism income, because Dongying mainly takes oil exploitation as its main economic pillar, and tourism development is relatively backward, increasing tourism publicity and tourism revenue, making cultural heritage protection and tourism revenue coordinated, so as to promote the sustainable development of Dongying's cultural heritage.

## 5. Discussion

Implementation of SDGs greatly implanted the importance of sustainable cultural heritage in humans' mind. However, to date, knowledge of sustainability of cultural heritage is still limited, i.e., research focus more on large scales (e.g., national, continental, and global) than small scales (e.g., regional, local). Therefore, the conclusions of the existing research are relatively macroscopic and difficult to reveal the interior spatiotemporal differences from a microscopic perspective. Against this background, we proposed a conceptual framework of cultural heritage sustainability assessment and paid attention to city scales. Cities in Shandong Province were selected as the study area.

### 5.1. Culture Heritage Protection in Shandong Province Compared to Other Regions

The wealth created by the comprehensive protection and utilization of cultural heritage is re-invested in the protection of cultural heritage, which has become one of the important sources of protection inputs. It should be noted that a considerable part of the profits generated by the tourism development is directly tied to the cultural heritage of

those cultural units [26]. Previous research points out that cultural and natural heritage gained an increasing significance at different levels of the economy and that regions may build competitiveness leveraging their heritage [30]. In the European Union, tourism and economic deficit complement each other. The competitiveness of the European tourism industry is closely interconnected to its sustainability, as the quality of tourist destinations is strongly influenced by their cultural heritage [47]. Along with the rising concerns of the inheritance of humans' civilization and history, increasing capital inputs have become vital measures to promote the sustainability of cultural heritages. In addition to the examples listed in the Section 1, there are also some other empirical implementations worldwide. Case cities, e.g., Paris, Lyons, and Rome [48–50], have performed a series of measures involving designating the protected areas of cultural heritages and organizing 'Cultural Preservation Week' activities, which could help to obtain income for cultural heritage protection. Especially, in purpose of encouraging the protection of private cultural heritages, the governments of Spain and France allowed the development of hotel business and committed to support half of the repair fees, respectively [51,52]. Results of our research show that tourism income has significantly positive correlation with the quantity of scenic spots in Shandong Province. However, the total tourism development degree of cultural units in Shandong Province is not high, only reaching 59.6. That means, there are still nearly half cultural heritages that cannot obtain income by developing tourism industry. Based on the recent statistic, the ratio of tourism income to total GDP in Shandong Province only reached 0.084. This ratio was much lower than that of other provinces with similar number of cultural units, such as Shaanxi Province (0.28). The phenomenon indicates that the tourism industry in Shandong Province is relatively weak compared to other regions. Meanwhile, Shandong Province still has great potential and space for rationally utilizing the cultural heritage by developing the tourism industry, which aims to bring back more income for their protection. Therefore, we suggest policy-makers pay attention to balance the tourism development of cultural units in Shandong Province and design more suitable capital input measures for each city.

*5.2. Suggestions on the Assessment of Sustainable Development of Culture Heritage in Shandong Province*

The pillar industries in Shandong Province are dominated by the second industry like chemical, metallurgy, and mining. Therefore, developing tourism industry of cultural units has not obtained enough attention for case cities due to their relatively limited contribution to the total GDP. According to our assessment, only less than one half of cities, along the Yellow River and the famous Beijing-Hangzhou Grand Canal, show well coupling coordination of capital input, cultural units, and tourism income. This might be attributed to their superior natural and history conditions. For instance, Jinan is the capital of Shandong Province with a complex modern historical background, which determines that its important modern historical sites and representative buildings are the largest in Shandong Province. These important modern historical sites and representative buildings show high potentiality to develop into the scenic spots, thereby attracting numerous tourists and promoting the prosperity of surrounding transportation, accommodation and commodity trades. Similar situations could be seen in Jining, which is the "capital of canals" and the "hometown of Confucius and Mencius" and has a profound cultural heritage and is rich in ancient tombs and ancient ruins. The other 10 cities exhibit general or low coupling coordination of capital input, cultural units, and tourism income. With the purpose of sustainability development in the future, the constrains listed in Table 6 should be strengthened in an efficient and feasible way.

Sustainability has great potential for bringing heritage preservation, tourism, and economic development into a balanced and constructive connection, as it is recognized that the mistaken neglect of the important economic and social dimensions of heritage in many cases has led to the irreversible decay and destruction of heritage assets. In this study, the sustainability assessment of cultural heritages only considered three aspects of their

self-attributes, social roles, and capital input, which could be regarded as a preliminary work for localizing the SDG 11.4.1 indicator. Actually, indicators which might affect the sustainability of cultural heritages are diverse, including but not limited to these three. In the next work, more indicators (e.g., climate, eco-environment, human interference, etc.,) should be considered and applied to build a comprehensive framework for estimating the sustainability of cultural heritages.

## 6. Conclusions

This study analyzed the distribution characteristics of the cultural units in Shandong Province, assessed the coupling coordination of cultural units. The results show that: (1) The spatial distribution differentiation of cultural units in Shandong Province was obvious. On a per city basis, the number of cultural units in Jining was the largest, and the number of cultural units in Dezhou was the least. In terms of time-domain quantity distribution, the number of cultural units was the largest from the Ming and Qing Dynasties period and from Prehistoric periods, and the least from the Sui Tang and Five Dynasties period. The nuclear density of cultural units in Shandong Province showed a concentrated distribution trend, forming a high density area extending from the middle to the southwest, which was closely related to the Yellow River, Beijing-Hangzhou Grand Canal, and others. (2) There were differences in tourism response between cultural units and tourism industry scale, tourism economic effect and tourism social function. The areas with a high concentration of cultural units did not have comparative advantages in terms of tourism industry status and tourism infrastructure, but in terms of tourism resource endowment, tourism market demand, and tourism income benefits, that is, the number of scenic spots, domestic tourists, and tourism income in the areas where cultural units were concentrated were relatively high. (3) The amount of heritage and tourism income directly determine the amount of heritage protection inputs in each city. Therefore, we suggest that information on heritage distribution and heritage tourism should be included in the assessment of sustainable development of heritage in Shandong Province. These findings contribute to enriching the research on the spatial characteristics of cultural units from a geographical perspective. From the cultural heritage perspective of sustainable development, through the analysis of the self-attributes, social role, and protection inputs, it can be seen the intercontinental differences in cultural heritage type, tourism development degree, and capital inputs in different cities. In short, the level of city development restricts the protection and utilization of cultural heritage. In future, attention should be paid to the imbalance in city level development limitations, cultural heritage management, and preservation in different cities. In addition, establishing a more scientific, comprehensive, multi-index, small-scale sustainable development assessment system for cultural heritage appears indispensable.

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