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Assessment of Yellow River Region Cultural Heritage Value and Corridor Construction across Urban Scales: A Case Study in Shaanxi, China

He Zhang †, Yutong Wang *,†, Yu Qi, Siwei Chen and Zhengkai Zhang

College of Landscape Architecture and Art, Northwest Agriculture and Forestry University, Yangling 712100, China; hezhang@nwafu.edu.cn (H.Z.); qiyu.1@nwafu.edu.cn (Y.Q.); siweic@nwafu.edu.cn (S.C.); zkzhang@nwafu.edu.cn (Z.Z.)

* Correspondence: upwangyutong@nwafu.edu.cn

† These authors contributed equally to the work.

Abstract: Heritage corridors play a pivotal role in preserving linear cultural heritage, especially in economically underdeveloped regions like the Yellow River area. These corridors not only serve as a primary method for safeguarding cultural heritage, but also act as catalysts for enhancing regional economic vitality. The widespread distribution of cultural heritage in the Yellow River region emphasizes the need for targeted protection and utilization at the regional level. To facilitate graded protection and the utilization of regional cultural heritage, this study introduces a method for constructing graded heritage corridors based on the comprehensive value of cultural heritage, thereby establishing a framework for comprehensive assessments. Through leveraging multi-source data, this study assesses cultural heritage's comprehensive value by integrating the service capacity of heritage sites. Subsequently, this study constructs graded heritage corridors using the minimum cumulative resistance model. The findings reveal a concentrated distribution of cultural heritage in Shaanxi within the Yellow River region, where 19.8% of the sites in the economically and ecologically thriving southern regions were rated as high value (fourth or fifth grades). Finally, this study identifies distinct corridor themes by integrating regional cultural characteristics, thereby forming a cultural heritage region network that propels the overall protection and utilization in the area. The proposed cultural heritage assessment framework and corridor construction method are also applicable to various linear heritage types dispersed across diverse regions.

Keywords: graded cultural heritage corridor; minimum cumulative resistance model; Yellow River region; revitalization and utilization; across urban scale

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1. Introduction

Natural and cultural environments have gradually become viewed as a holistic entity with the emergence of cultural ecology in the early 20th century [1]. In 1972, the United Nations Educational, Scientific and Cultural Organization (UNESCO) formulated the "Convention Concerning the Protection of the World Cultural and Natural Heritage", which formally proposed the joint protection of natural and cultural heritage as assets of universal value [2]. In this context, numerous countries have combined natural and cultural heritage together to facilitate regional heritage conservation [3], such as heritage corridors in the United States [4], cultural routes in Europe [5], as well as concepts such as heritage canals and heritage routes within the international heritage conservation domain [6]. While most of these practices have taken place in developed countries—wherein small-scale heritage sites were incorporated into heritage corridors for management and protection (which can enhance the diversity and sustainability of tourism products and drive the development of the regional tourism economy)—for developing countries, this represents an urgent issue [7]. For example, in the context of the New Silk Road strategy, the UNESCO-listed Silk Road connects 33 heritage sites across three nations, thereby fostering regional cultural and trade exchanges [8]. Similarly, the Grand Canal integrates tourism resources from 22 cities along its path, thus enhancing the overall tourism value of cultural heritage in the region [9]. Despite numerous studies having explored the construction methods of heritage corridors, including qualitative and quantitative analysis methods [10,11], such as the minimum cumulative resistance (MCR) model [12–14], two research gaps can still be identified.

First, the existing research has primarily focused on the categorization of ecological corridors [15–17] while ignoring the classification of heritage corridors. Certain studies have proposed a hierarchical classification of heritage corridors based on the level of connectivity [18,19] or the suitability of heritage distribution and corridor construction [20]. Nevertheless, this method may inadvertently neglect the influence of the inherent value of heritage resources. The heritage value assessment provides a critical foundation for developing protective measures [21], and it enables targeted protection based on evaluation outcomes. Developing graded heritage corridors for assessing the cultural heritage of different value levels is advantageous for linking high-value cultural heritage sites; identifying primary and secondary corridors; forming powerful cores and network areas [22]; avoiding redundant development; and promoting the conservation of regional cultural heritage and economic development. For high-value cultural heritage, the primary emphasis lies on preservation and restoration, accompanied by the judicious development of tourism initiatives. Conversely, low-value cultural heritage involves the exploration of cultural elements, the innovative development of utilization strategies, and the realization of sustainable growth.

Second, the current research on cultural heritage assessment has predominantly highlighted the cultural and economic values that are intrinsic to the heritage itself [23], thus frequently neglecting the natural and cultural environments, as well as the service capacity of the heritage locations. A general cultural value assessment is to adopt the sorts of methods used by heritage professionals [24], while the assessment of economic value often relies on the utilization of the revealed-preference and stated-preference methods. Throsby et al. (2005) [25] conducted a systematic evaluation of cultural and economic value using methods such as online surveys and expert appraisals. Nevertheless, for heritage corridors that encompass a multitude of culturally significant sites spread across extensive regions, the previously mentioned methods entail a significant workload and might encounter limitations that stem from the subjective nature of participants' responses. Therefore, several scholars have employed methodologies such as the analytic hierarchy process (AHP) and entropy weight to establish an index system for the evaluation of heritage sites or heritage regions [26,27]. While the research examining value assessments in conjunction with the service capacity of cultural heritage sites, such as transportation and commerce, is relatively limited; most studies, in the selection of evaluation criteria, have traditionally centered on three dimensions: cultural, ecological, and socio-economic (the latter of which relies on government-provided official statistics like the GDP and population [28]). However, given the maturation of remote sensing technologies and big data, emerging data sources like Night Lights and point of interest (POI) information can offer more precise and timely insights into economic development levels and human activities [29–31]. Corridors that traverse urbanized regions can promote socio-economic development and human activities [32]; however, research that integrates such data into a comprehensive evaluation of cultural heritage utilization values remains relatively scarce.

To fill in the above research gaps, this article utilized multi-source data to establish an evaluation system for assessing the value of cultural heritage. This study involved the evaluation and categorization of tangible cultural heritage within linear cultural regions by integrating the service supply capacity of cultural heritage sites. It aimed to integrate regional resources and transcend urban boundaries in order to establish a graded cultural heritage corridor. Taking the Yellow River as an example, it demonstrated a comprehensive assessment of the utilization value of cultural heritage and the construction of graded heritage corridors.

The Yellow River traverses nine provinces, boasting abundant cultural heritage resources. However, existing research on the evaluation of a cultural heritage resource value and the construction of heritage corridors in this region is relatively scarce. The current regional, segmented, and unit-based protection models have resulted in the fragmentation and isolation of heritage conservation efforts [33]. Constructing graded heritage corridors is crucial for fostering the coordinated development of the cultural tourism industry in the area. To achieve this goal, this paper proposes an approach to constructing the graded heritage corridors based on the comprehensive value of cultural heritage. In utilizing multi-source data and integrating the comprehensive service capacity of heritage sites, it comprehensively assesses the utilization value of cultural heritage. As such, by building upon this, this paper establishes a graded protection system for regional heritage corridors and explores planning strategies.

2. Materials and Methods

2.1. Study Area

The spatial scope of the Shaanxi Yellow River area, defined according to Shaanxi Provincial Yellow River Ecological Urban Belt Planning (2015–2030), specifically includes Tongguan County and Dali County, i.e., a total of 13 counties (cities) and a total area of 2.98 million square kilometers (Figure 1). The region is rich in natural and human resources, including 72 scenic areas and 3A-level scenic areas. In addition, there are also 86 national-level tangible cultural heritage sites (accounting for 18.42% of those at the same level in the province, hereafter collectively referred to as cultural heritage sites) and 259 provincial-level cultural heritage sites (accounting for 17.55% of those at the same level in the province), including historical and cultural cities (HCCs), towns (HCTs), and villages (HCVs) (17 items); traditional villages (150 items); cultural relic protection units (CRPUs) (178 items); and other heritage types (Table 1) with relatively clear cultural value.

Table 1. Statistics of cultural heritage in the Yellow River region of Shaanxi Province.

County (City)	Traditional Villages	Cultural Relics Protection Units	Historical and Cultural Cities	Historical and Cultural Towns	Historical and Cultural Villages	Sum	Proportion/%
Fugu County	8	14	1	1	2	26	7.54
Shenmu City	3	19	1	1	0	24	6.96
Jia County	9	14	1	1	1	26	7.54
Wubao County	4	3	0	0	0	7	2.03
Suide County	30	6	1	0	2	39	11.3
Qingjian County	6	3	0	0	0	9	2.61
Yanchuan County	22	13	0	0	1	36	10.43
Yanchang County	3	5	0	0	0	8	2.32
Yichuan County	5	9	0	0	0	14	4.06
Hancheng City	20	48	1	0	1	70	20.29
Heyang County	25	19	0	0	0	44	12.75
Dali County	11	19	0	0	0	30	8.7
Tongguan County	4	6	0	0	2	12	3.48
Sum	150	178	5	3	9	345	100
Proportion in the province (%)	32.26	12.71	29.41	9.68	30	17.76	——

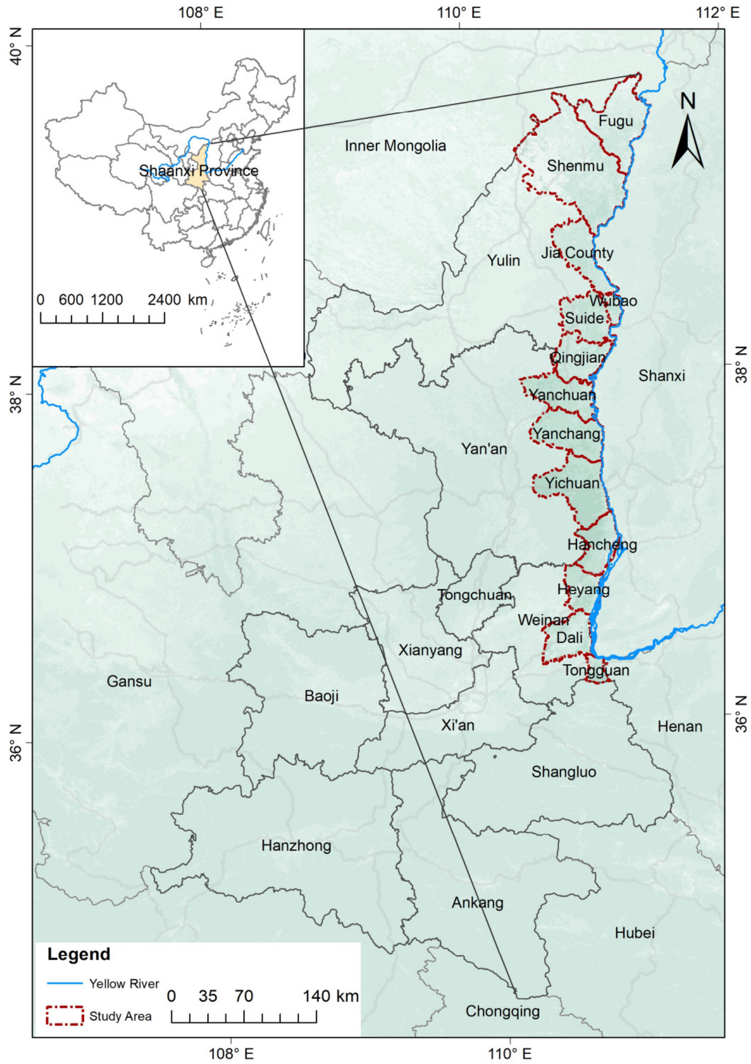


Figure 1. Study area.

2.2. Research Framework

This study aimed to integrate cultural heritage resources in Shaanxi's Yellow River region by establishing a hierarchical heritage corridor. This initiative transcends urban boundaries and works to create a collaboration of significant cultural and tourism projects, thereby fostering the comprehensive preservation and activation of the region's tangible cultural heritage. The research framework consisted of three main steps (Figure 2):

First, the distribution of heritage sites was analyzed, and the information on cultural heritage resources in the region was compiled. The distribution characteristics and factors influencing tangible cultural heritage were identified through spatial analysis.

Second, the value of the heritage resources was evaluated with a comprehensive assessment system, and this was categorized into five levels according to factors such as the natural environment and accessibility. Given that CRPUs are often included in HCTs, HCVs, and traditional villages, and due to the actual situation of cultural heritage in Shaanxi along the Yellow River, we primarily evaluated HCTs, HCVs, and traditional villages.

Third, the primary heritage corridor was constructed by a selection of higher-value heritage sites (fourth and fifth grades) as sources. The MCR model was used to extract the corridor, spanning urban boundaries, to establish a regional-scale system for heritage preservation and utilization. This system, combined with cultural and landscape zoning, provides a comprehensive framework for cultural heritage tourism and preservation.

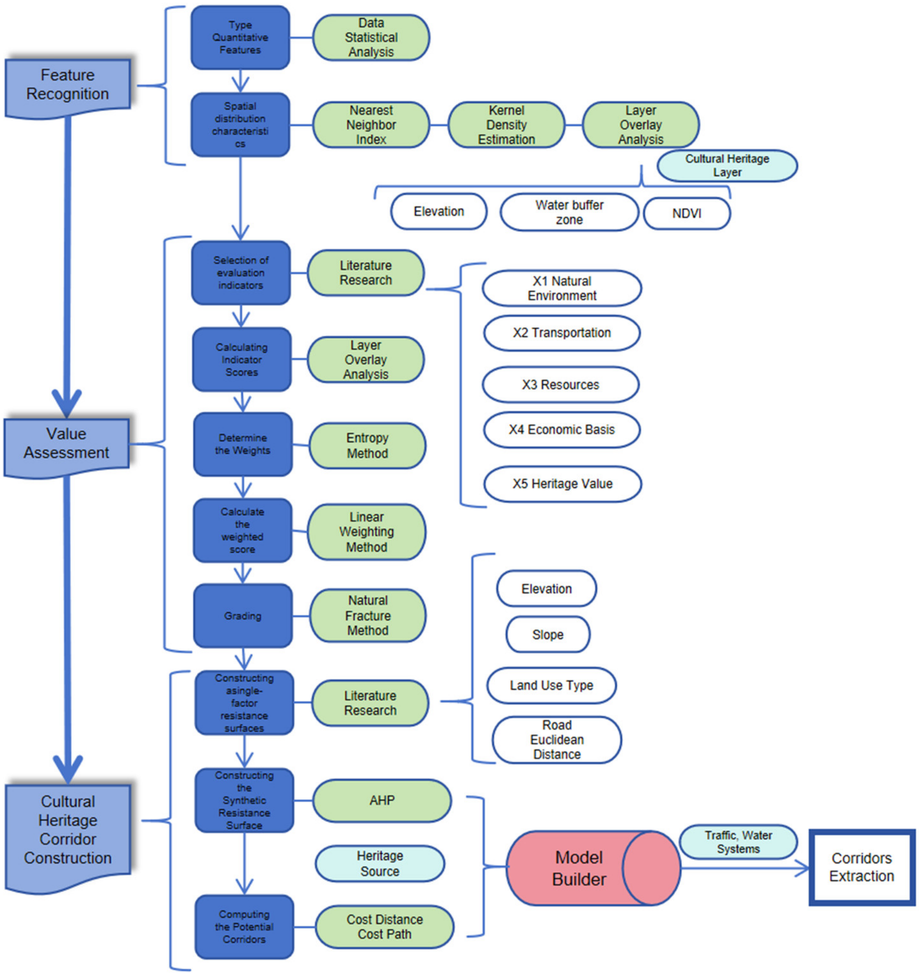


Figure 2. Search framework.

2.3. Research Methods

In this section, the methods used included nearest neighbor distance analysis and kernel density analysis in ArcGIS 10.8, as well as the entropy method. These methods were used to comprehensively excavate and analyze the distribution characteristics and utilization value of the existing cultural heritage in Shaanxi along the Yellow River. The MCR model was used to construct the Shaanxi cultural heritage corridor along the Yellow River.

2.3.1. GIS Spatial Analysis Methods

Cultural heritage is usually passed between generations within certain areas, and it is continually recreated during its adaptation to the surrounding natural environment and history to enhance respect or a sense of identity for cultural diversity and human creativity in a specific place. Therefore, cultural heritage usually has clear geographical features. To explore its specific spatial distribution characteristics, this article draws on the research methods of Wang et al. [34], Luo et al. [35], and others, as well as used methods such as the nearest neighbor index (NNI) and kernel density estimation (KDE) for analysis.

(1) Nearest neighbor index

The NNI was primarily used to detect the global spatial agglomeration characteristics of features [36], that is, to measure the average distance between features and their neighbors. If the average distance was less than (or greater than) the average distance in the hypothetical random distribution, then the sample elements were globally aggregated (dispersed). If the average distance was equal to the average distance of the random distribution, the spatial distribution of the sample was random. The formula is as follows:

$$ANN = \frac{D_O}{D_E} = \frac{\frac{1}{n}\sum_{i=1}^{n} d_i}{0.5 * \sqrt{A/n}}, \tag{1}$$

where D_O is the average distance between the element and the nearest element, D_E is the expected average distance between elements in the random mode, d_i is the distance between the element and the nearest element, and A is the research area of all elements.

(2) Kernel density estimation

The KDE method reflects the concentrated area of the distribution of research objects [35] and has the advantages of intuition, simplicity, and high precision [37]. The calculation formula is as follows:

$$g(x) = \frac{\sum_{i=1}^{n} k\left(\frac{x-x_i}{h}\right)}{nh}, \tag{2}$$

where x_i is the coordinate of I; h is the bandwidth; k is the kernel function, which is used to estimate the number and concentration of the cultural heritage points; and $(x - x_i)$ is the distance from the estimated value, which indicates the measured point. With traditional villages, cultural heritage units, and other cultural heritage as input elements, NNI and KDE analysis were performed to assess the spatial distribution characteristics of the cultural heritage along the Yellow River area of Shaanxi.

2.3.2. Entropy Method and Linear Weighting Method

We used the entropy method [38] to determine the weights of the heritage value assessment indicators. This method determines the weights according to the relationships between indicators, which reflect the inherent characteristics of these indicators and can effectively avoid subjective factors [39]. The specific formulas are as follows:

$$W_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{3}$$

$$d_j = 1 - e_j \tag{4}$$

$$e_j = -K * \sum_{i=1}^{n} \left(P_{ij} * \ln\left(P_{ij}\right)\right) \tag{5}$$

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}, \tag{6}$$

where m is the number of indicators, n is the number of samples, W_j is the weight value of the j-th indicator, d_j is the difference coefficient, e_j is the entropy value, P_{ij} is the proportion of the i-th sample under the j-th indicator to this indicator, X_{ij} is the value of the j-th indicator of the i-th sample, and $K = 1/\ln(n)$.

On the basis of the principles of scientificity and operability (combined with the research of Ma et al. [26,27,40,41] and starting from the five dimensions including the natural environment, location, and transportation), we selected ten evaluation indicators to construct the cultural heritage evaluation system in Shaanxi along the Yellow River. The entropy method was used to calculate the weight of the indexes, and the calculation results are shown in Table 2.

Table 2. Evaluation indicators and weights.

First-Level Indicators	Secondary Indicators	Weights
X1 natural environment	X11 elevation	0.66
	X12 distance to the nearest river	0.13
	X13 normalized difference vegetation index (NDVI)	0.05
X2 transportation	X21 distance to the county center	0.01
	X22 distance to the nearest expressway entrance and exit	0.01
X3 resources	X31 number of 3A-level and above scenic spots within the county	0.01
X4 economic basis	X41 the total value of Night Lights in the county	0.02
	X42 number of commercial POIs in county areas	0.09
X5 heritage value	X51 cultural heritage level	0.19
	X52 cultural heritage type	0.44

Afterwards, on the basis of the linear weighting method, we calculated the comprehensive utilization value of the cultural heritage in Shaanxi along the Yellow River. The calculation formula is as follows:

$$Z_j = \sum_{j=1}^{m} W_j X_{ij}, \tag{7}$$

where Z_i is the comprehensive utilization value score of the cultural heritage in Shaanxi along the Yellow River, W_j is the weight value of the j-th index, and X_{ij} is the score value of the j-th index of the i-th sample.

2.3.3. Minimum Cumulative Resistance Model

The MCR model was first proposed by Knaapen [42]. On the basis of the different resistance distributions of land use attributes and heritage sources, this model simulates the distribution of spatial resistance that must be overcome to reach the heritage sources. The greater the resistance, the lower the spatial suitability of the corridor construction in the area, and vice versa [43]. The calculation formula for MCR is as follows:

$$\text{MCR} = \int min \sum_{j=n}^{i=m} (D_{ij} * R_i), \tag{8}$$

where $\int$ represents the positive correlation between the cumulative resistance and the movement process, D_{ij} is the distance from a certain heritage point j to a certain landscape unit i, and R_i is the resistance of the location to the movement of the heritage.

Drawing on the research results of previous studies [13,44], we selected the land use type, elevation, slope, and road distance as resistance factors, as well as determined the resistance value and weight of each resistance factor with the AHP (Table 3). Afterward, with the ArcGIS platform, we used tools such as reclassification and the raster calculator to calculate the comprehensive resistance surface. Then, we imported the comprehensive resistance surface and heritage source, cost distance, cost path, and other tools into the Model Builder to construct the MCR model and extract the connecting corridors between cultural heritage. Our aim was to provide support for optimizing the spatial pattern of the cultural heritage in Shaanxi along the Yellow River.

Table 3. The assignment and weight of the resistance factors.

Resistance Factors	Assign Values to Different Levels	Weights
Elevation	Below 300 m = 10; 301–500 m = 20; 501–1000 m = 50; 1001–2000 m = 80; More than 2001 m = 100	0.21
Slope	Below 8° = 10; 9–15° = 20; 16–25° = 40; 26–50° = 80; above 51° = 100	0.25
Land use type	Urban and rural industrial, mining and residential land = 20; Unused land = 40; water area = 60; grassland = 80; forest land = 80; cultivated land = 100	0.36
Road Euclidean distance	Within 5000 m = 10; 5001–10,000 m = 20; 10,001–20,000 m = 40; 20,001–40,000 m = 80; beyond 40,000 m = 100	0.18

2.4. Data Sources

We obtained the list of cultural heritage sites from sources that included the official websites of the State Council and the Shaanxi Provincial Department of Housing and Urban-Rural Development (Table 4). According to the list, we obtained the coordinates of the cultural heritage points with the Gaode map API coordinate picker [45,46]. The administrative boundaries of Shaanxi along the Yellow River were determined from the national basic geographic information data in 2022. The digital elevation model (DEM) was downloaded from the geospatial data cloud. Basic data, such as that for the roads and for water systems, were downloaded from OpenStreetMap. The normalized difference vegetation index (NDVI) data came from the resources and environment of the Chinese Academy of Sciences Science Data Center, and the commercial POI data came from Gaode Maps. Night Lights came from the Earth Observation Group platform (Earth Observation Group).

Table 4. Data sources.

Name	Data Sources
National historical and cultural cities	https://www.gov.cn/ accessed on 26 November 2022
National historical and cultural towns National historical and cultural villages	https://www.mohurd.gov.cn/?medium=01 accessed on 26 November 2022
Provincial historical and cultural cities	http://www.shaanxi.gov.cn/ http://wwj.shaanxi.gov.cn/ accessed on 27 November 2022
Provincial historical and cultural towns Provincial historical and cultural villages Provincial historical and cultural blocks	http://www.shaanxi.gov.cn/ accessed on 27 November 2022
National traditional villages	https://dmctv.cn/directories.aspx https://www.gov.cn/ accessed on 8 January 2023
Provincial traditional villages	https://js.shaanxi.gov.cn/ accessed on 7 January 2023
Administrative boundaries	https://www.ngcc.cn/ngcc/html/1/391/392/16114.html accessed on 10 September 2022
DEM	https://www.gscloud.cn/search accessed on 12 September 2022
roads, water system	https://www.openstreetmap.org accessed on 16 September 2022
NDVI	https://www.resdc.cn/ accessed on 20 December 2022
POI	https://ditu.amap.com/ accessed on 17 December 2022
Night Lights (VIIRS)	https://eogdata.mines.edu/products/vnl/ accessed on 18 December 2022

3. Results

3.1. Identification of the Characteristics of Cultural Heritage Resources

3.1.1. Type and Quantity Features

After compiling the HCCs, HCTs, HCVs, traditional villages, and cultural heritage sites in the Shaanxi region along the Yellow River—including national- and provincial-level traditional villages, as well as national- and provincial-level HCVs (with each village only counted once)—we identified, as of January 2023, a total of 345 cultural heritage sites, which accounted for approximately 17.76% of the total cultural heritage items in Shaanxi Province. Among them, we identified 150 traditional villages (accounting for 32.26% of those in the entire province); 178 cultural heritage sites (accounting for 12.71% of those in the entire province); 5 HCCs (accounting for 29.41% of those in the entire province); 3 HCTs (accounting for 9.68% of those in the entire province); and 9 HCVs (accounting for 30% of those in the entire province). In terms of grade and quantity, we identified 86 national-level cultural heritage items (accounting for 18.42% of those of the same grade in the entire province) and 259 provincial-level cultural heritage items (accounting for 17.55% of those of the same grade in the entire province). Thus, the Shaanxi region along the Yellow River has significant cultural heritage value.

Through the integration of cultural heritage resources along the Yellow River in Shaanxi and conducting sampling field surveys, we determined that the natural landscapes and types of cultural heritage vary from north to south in each county. In northern regions such as Shenmu City, Fugu County, and Jia County, the areas primarily consist of a mixture of loess hills and gullies, sandy areas, as well as cultural heritage sites that primarily include the remains of the Ming Great Wall, grottoes, and cave dwellings. In places such as Yanchang County, Yanchuan County, and Qingjian County, the areas are primarily characterized by loess plateau gullies, and significant cultural heritage is associated with the Red Revolution culture and cave dwellings. Most southern areas, such as Dali County and Heyang County, belong to the Guanzhong Plain, and the predominant cultural heritage type is courtyard houses. On the basis of the above findings, the Shaanxi region along the Yellow River can be divided into three major regional landscape areas: the sandy area and loess hills region, the loess plateau gullies region, and the Guanzhong Plain region (Table 5).

Table 5. Regional landscape division table of the Shaanxi areas along the Yellow River.

Regional Landscape Area	County (City)	Natural Landforms	Significant Cultural Heritage
Sandy beach and loess hilly area	Shenmu City Fugu County	Southern loess hilly and gully area, northern windy sand and grass beach area	Shimao Ruins, Ming Great Wall Ruins Ming Great Wall Ruins, Cave Courtyards
	Jia County	Northern end of loess Liangmao hilly area in northern Shaanxi, southern edge of Mu Us Desert	Grottoes and cave dwellings
Loess plateau gully area	Wubao County	Loess plateau gully area	Cave dwellings (stone kilns), Wubao Stone City
	Suide County Qingjian County Yanchang County Yanchuan County Yichuan County		Red Revolution history, cave dwellings
Guanzhong plain area	Dali County Heyang County	Guanzhong Plain	Siheyuan (traditional courtyard house)
	Hancheng City	Transition zone of loess plateau	Siheyuan (traditional courtyard house), representative of Dangjia Village
	Tongguan County	Southern Qinling Mountains, northern Guanzhong Plain	Siheyuan (traditional courtyard house)

3.1.2. Spatial Distribution Characteristics

(1) Overall features

The overall number (345) of cultural heritage sites in the Shaanxi region along the Yellow River is considerable, but the spatial distribution is uneven (Figure 3). Among the administrative units, Hancheng City (70 of 345) has the highest number of cultural heritage sites, accounting for 20.29% of the total, and this is followed by Heyang County (44 of 345), Suide County (39 of 345), Yanchuan County (36 of 345), and Dali County (30 of 345), with percentages of 12.75%, 11.3%, 10.43%, and 8.7%, respectively. In comparison, Wubu County, Yanchang County, Qingjian County, Tongguan County, and Yichuan County have relatively fewer cultural heritage sites, with percentages of 2.03%, 2.32%, 2.61%, 3.48%, and 4.06%, respectively. Through a buffering and overlay analysis of cultural heritage sites with natural elevation, river systems, the NDVI, and other factors (Figure 4), we determined that most of the cultural heritage is distributed in low mountain areas, such as Hancheng City (200–500 m, 31.59%); middle mountain areas, such as Yanchuan County (500–1000 m, 51.59%); and areas with rich water systems, such as Qingjian County, Suide County, Hancheng City, and Heyang County, which are characterized by abundant vegetation cover.

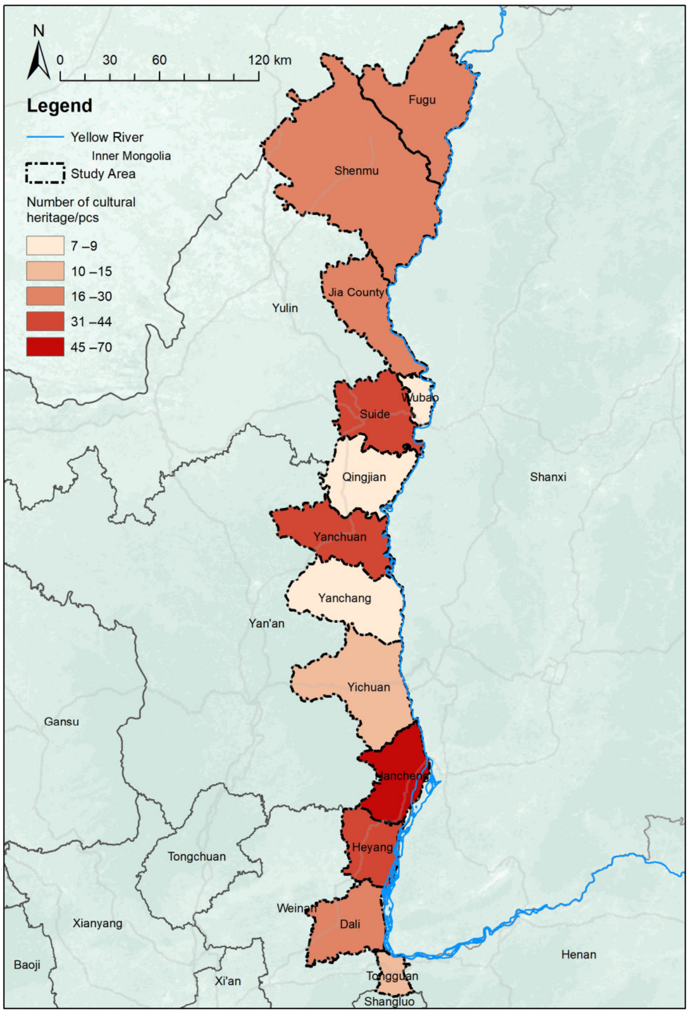
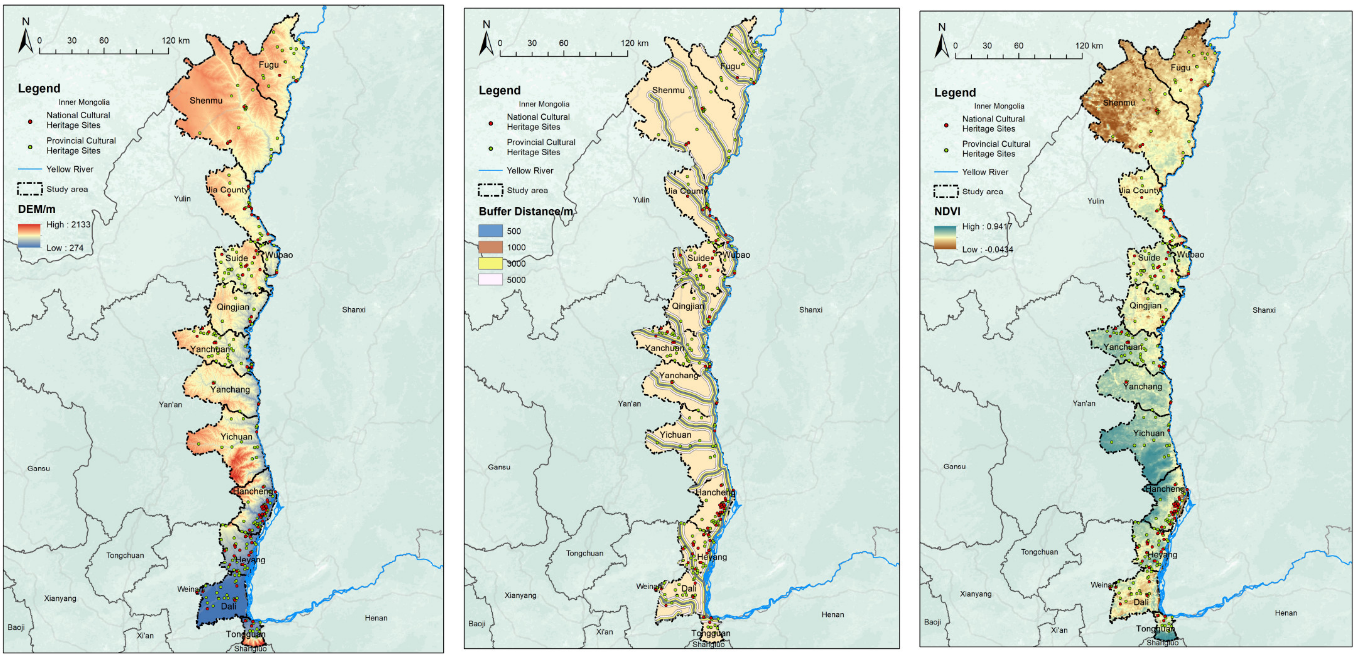


Figure 3. Spatial distribution of cultural heritage along the Yellow River in Shaanxi.



(**a**) (**b**) (**c**)

Figure 4. Overlay analysis of cultural heritage and natural factors in Shaanxi along the Yellow River: (**a**) overlay map of cultural heritage and elevation; (**b**) overlay map of cultural heritage and water system; and (**c**) overlay map of cultural heritage and NDVI.

Using ArcGIS, we found that the average nearest neighbor index R was 0.45 in the Shaanxi region along the Yellow River. This value of less than 1 indicates an overall agglomerative distribution pattern of cultural heritage in the area, with a "one main, two secondary" agglomeration trend. Hancheng City forms the main core agglomeration area, with a kernel density value ranging from 303.87 to 435.32, whereas Suide County–Wubu County and Yanchuan County form the secondary core agglomeration area with a kernel density value ranging from 104.14 to 187.79 (Figure 5). Regions such as Hancheng City and Heyang County have flat terrain, abundant natural resources, dense populations, and convenient transportation, which are conducive to the emergence and dissemination of culture, thus resulting in spatial aggregation.

Through kernel density, spatial overlay, and buffer zone analysis, we observed that most national-level (93.0%, 74.3%) and provincial-level (80.0%, 71.7%) cultural heritage sites are located less than 1000 m above sea level and within a 3000 m buffer zone from water systems (Figure 4a,b). The National and Provincial Cultural Heritage sites demonstrated closely comparable NDVI values, with average scores of 0.45 and 0.44, respectively. The NDVI values of vegetation in the areas containing national-level cultural heritage sites ranged from 0.14 to 0.73, and the average value was 0.45, whereas the NDVI values in areas with provincial-level cultural heritage sites ranged from 0.14 to 0.85, and the average value was 0.44 (Figure 4c). In general, national-level cultural heritage forms a main core agglomeration area that is centered around Hancheng City–Heyang County, as well as a secondary core agglomeration area centered around Suide County–Wubu County–Jia County. A main core agglomeration area of the provincial-level cultural heritage is centered around Hancheng City–Heyang County, two secondary core agglomeration areas are centered around Suide County and Yanchuan County, and additional agglomerations are present in Shenmu City and Fugu County (Figure 6).

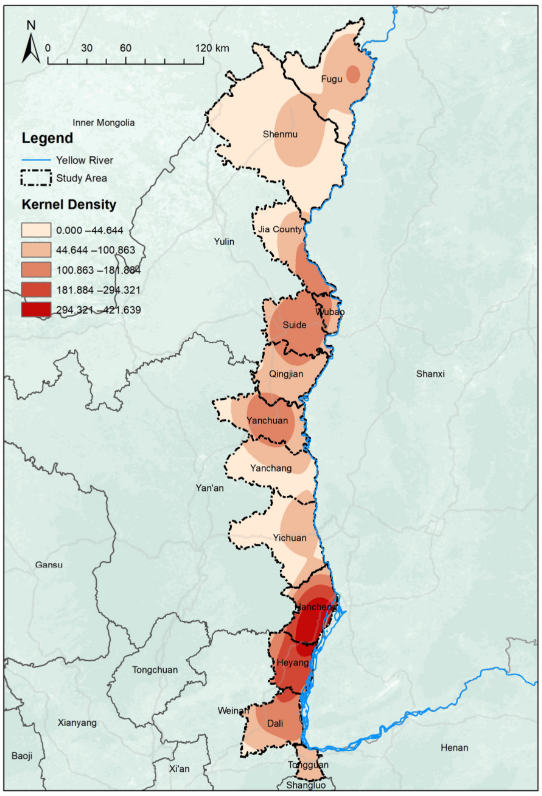
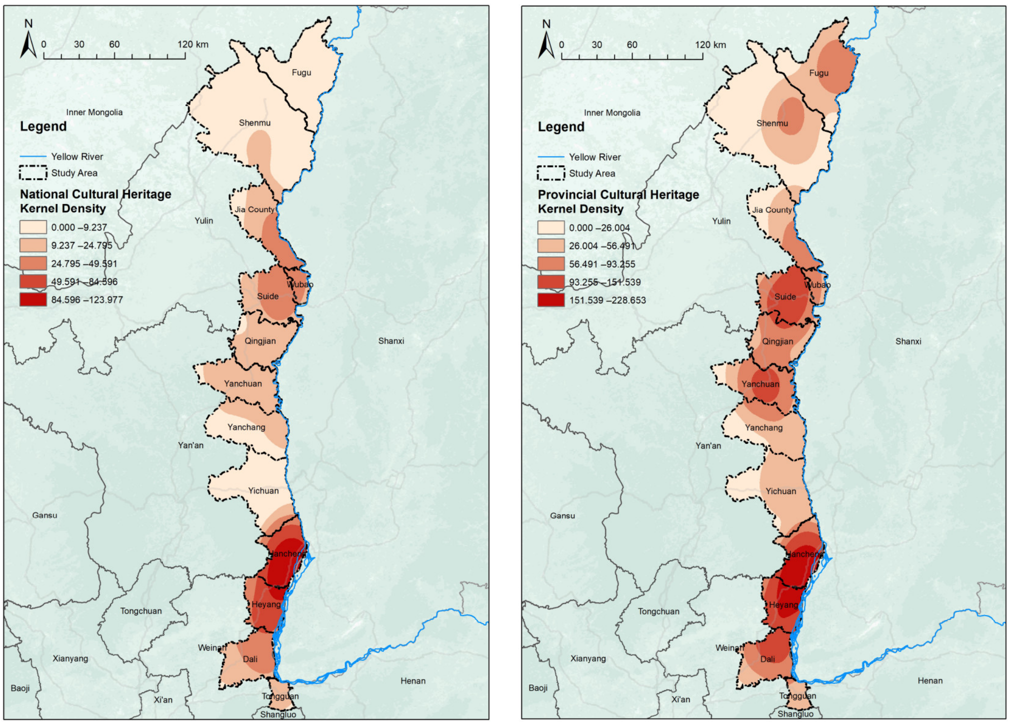


Figure 5. Kernel density analysis map of cultural heritage space along the Yellow River in Shaanxi—hierarchical features.



(**a**) (**b**)

Figure 6. Analysis map of spatial kernel density of different levels of cultural heritage in Shaanxi along the Yellow River: (**a**) national; and (**b**) provincial.

3.2. Extraction of Cultural Heritage Corridors

3.2.1. Assessment of Heritage Value

The cultural heritage in the Shaanxi region along the Yellow River encompasses various types, including HCCs, HCTs, HCVs, traditional villages, and cultural heritage sites. Among them, cultural heritage sites and other heritage sites are often contained in space: for instance, Hancheng, an HCC, contains numerous cultural heritage sites. Therefore, we focused on evaluating the value of three heritage types: HCTs, HCVs, and traditional villages. On the basis of the methods detailed in Section 2.3.3 and the natural break method in ArcGIS, we divided the cultural heritage utilization value into five grades (Figure 7).

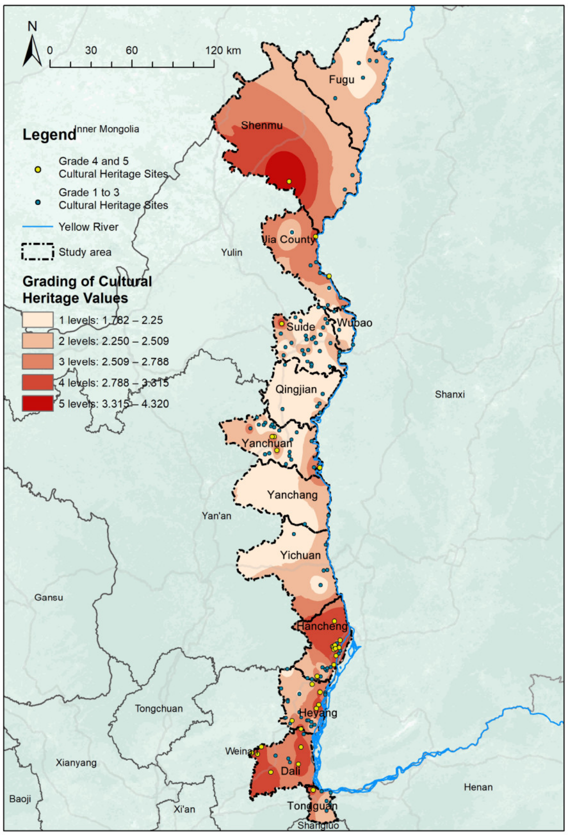


Figure 7. Classification map of cultural heritage value in Shaanxi along the Yellow River.

The results revealed that the proportion of cultural heritage with high utilization value (fourth and fifth grades) was 19.8% of the total. This heritage is concentrated in southern regions, such as Dali County, Heyang County, Hancheng City, and the central area of Yanchuan County, including villages such as Dangjia Village, Dongbaichi Village, and towns such as Mutouyu. Scattered high-value cultural heritage sites are also present in the northern region, such as Gaojiabao Town in Shenmu City, Nihegou Village in Jia County, and Aijiagou Village in Suide County. A well-connected transportation network and high population density in plain regions are more conducive to the inheritance and development of cultural heritage.

The moderate utilization value (third grade) accounted for 21.6% of the total and showed a relatively even distribution, with small clusters formed in Jia County and Suide County, such as Liujiaping Village in Jia County. The first and second levels had the highest proportions, accounting for 58.6% of the total, and they formed extensive clusters in the central regions of Qingjian County, Suide County, Yanchang County, and Yichuan County, such as Hekou Village in Qingjian County and San Shili Pu Village in Suide County.

Nearly half of the cultural heritage in the Shaanxi region along the Yellow River has moderate or higher utilization value, thus indicating the significant cultural value of these areas. Therefore, a systematic protection system must be established for these cultural heritage sites.

3.2.2. Extraction of Main Corridors

Using the methods detailed in Section 2.3.3, we conducted a least-cost path analysis in ArcGIS to extract the significant spatial pathways of the cultural heritage corridor in the Shaanxi region along the Yellow River. The cost paths of high-value cultural heritage sites (fourth and fifth grades) originate in the southern region from Tongguan County, and they form relatively dense pathways in Dali County, Heyang County, and Hancheng City. From there, they proceed northward through Hancheng City, Yichuan County, and Yanchang County, thereby converging in the central region of Yanchuan County. From Yanchuan County, the paths split into two routes: one continues northward along the eastern part of the Yellow River region, passing through various counties until reaching Shenmu City; whereas the other route proceeds northward through the main roads in the central and western regions, crossing through Qingjian County, Suide County, Wubu County, and then finally converging with the first path in the eastern part of Jia County (Figure 8). Meanwhile, we took the transportation network into account for the operability of the corridor.

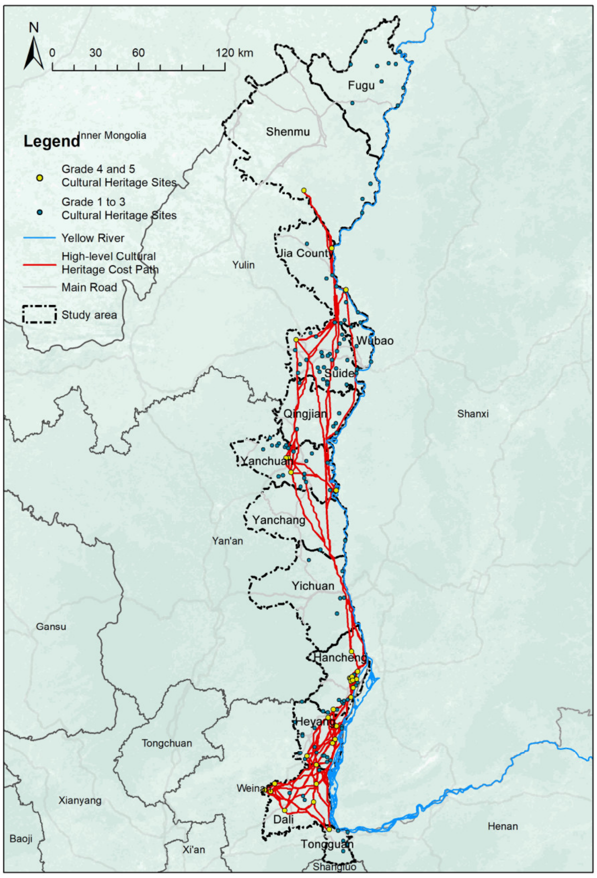


Figure 8. Schematic diagram of cultural heritage cost path extraction.

Finally, two main corridors were constructed. One was the corridor along the Yellow River Highway, in which the eastern borders of the counties were connected in series. The other was a corridor along expressways and national and provincial roads. (Figure 9). At the county level, relying on the value rating of cultural heritage, roads, water system distribution, and other factors, five secondary corridors were identified, namely the corridor of Fugu County and Shenmu City; Jia County; Suide County; Yanchuan County; and Dali County.

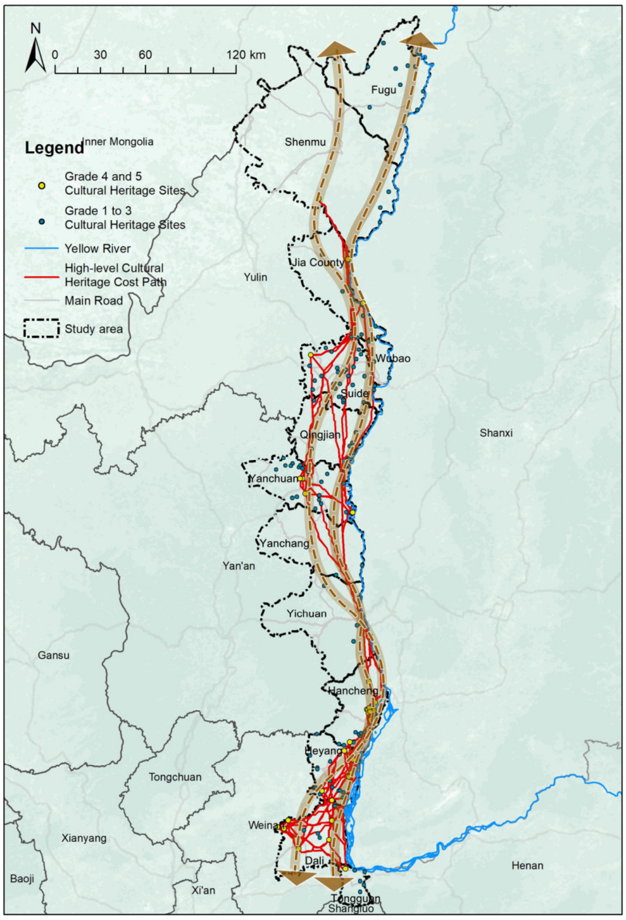


Figure 9. Schematic diagram of main corridor extraction.

3.2.3. Construction of Conservation Patterns

The spatial pattern of cultural heritage corridors along the Yellow River in Shaanxi is integrated according to the principle of "integration, differentiation, clustering, and balance". Finally, based on factors such as cultural zoning, corridor distribution, and transportation network distribution, etc., we constructed a development model with three cultural zones, two main corridors, and multiple heritage gathering points (Figure 10). Specifically, the three cultural zones include the Great Wall Frontier Defense Cultural Zone in the north, the Red Revolutionary Heritage Inheritance Zone in the middle, and the Guanzhong Traditional Culture Display Zone in the south. The two corridors were the main corridors that were identified in Section 3.2.2, and they run through the entire study area from south to north. The cultural gathering points are distributed along two main corridors. Specifically, the core areas of these corridors (within a 5 km buffer) cover 65.2% of the cultural heritage sites (225 sites), the radiating areas (within a 10 km buffer) cover 83.8% of the heritage sites (289 sites), and the peripheral areas (within a 15 km buffer) cover 92.2% of the heritage sites (318 sites). The remaining cultural heritage sites (27 sites) are interconnected through five secondary corridors. This pattern provides support for a cross-regional and hierarchical protection of cultural heritage in the Shaanxi region along the Yellow River.

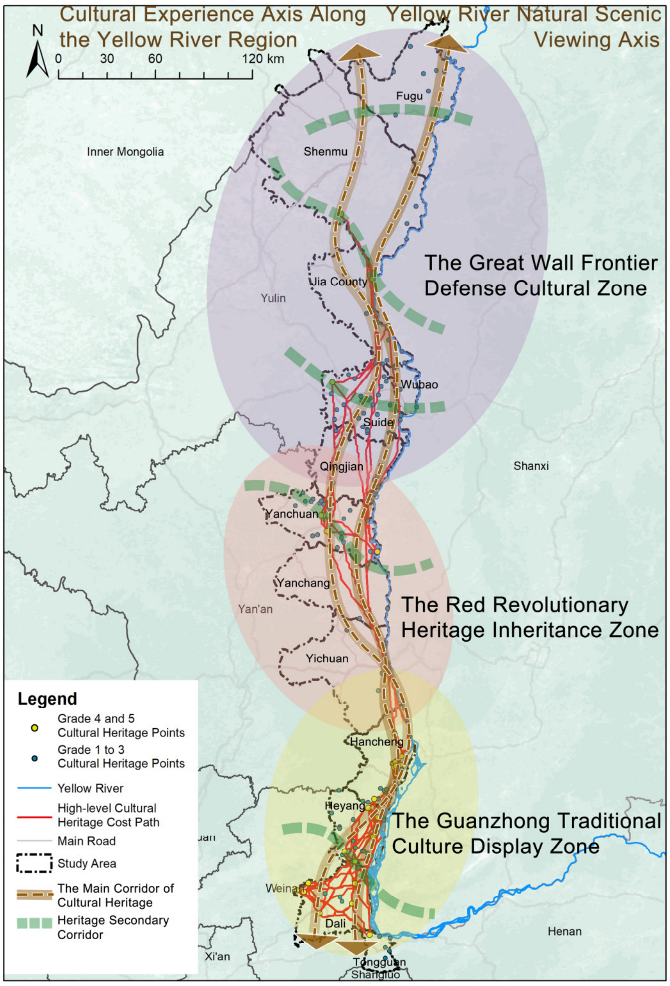


Figure 10. Spatial pattern of cultural heritage in Shaanxi along the Yellow River.

4. Discussion

4.1. Approach for Constructing a Graded Corridor

In the current research, there is a predominant focus on the classification of ecological corridors [15–17], while the classification of cultural heritage corridors remains relatively underexplored. Certain scholars have employed spatial syntax techniques for heritage corridor classification, wherein the corridor's grade correlates positively with its level of connectivity [18]. However, this approach may inadvertently lead to the oversight of culturally significant heritage sites. This study aims to address this gap by focusing on the valuation of cultural heritage. Based on this foundation, we explored the development of a hierarchical corridor classification system and proposed graded strategies for corridor preservation and utilization.

There are not only studies on cultural heritage assessment that evaluate the existing hierarchy [25], but ones that also delve into the potential for sustainable development in the region [28]. However, there is a relative scarcity of research concerning the assessment of cultural heritage's value in regional tourism development. Therefore, this study's valuation framework takes into account not only the intrinsic attributes of heritage, such as its classification and type along with natural environmental factors, but it also considers the transportation networks, tourism resources, and socio-economic conditions in the area. This comprehensive approach provides a more holistic and objective reflection of the corridor's capacity to offer associated services.

Furthermore, this study employs a combination of remote sensing, GIS information data, and spatial big data. When selecting specific evaluation indicators, we prefer Night Lights data to traditional government statistics such as GDP and population figures. Night

Lights data offer a more accurate reflection of actual human activity intensity and the vitality of a service sector's economic development [29], thereby avoiding the phenomenon of "false prosperity" in data, which is caused by capital-intensive industries in certain regions. Additionally, we utilized commercial POI to gauge the development level of the economic service sector [30,31] and the NDVI for vegetation coverage [47], which both better capture regional-scale vegetation growth conditions and account for natural environmental variations.

4.2. Planning Strategies: Constructing Hierarchical Cultural Heritage Corridors across Urban Boundaries

We used the MCR model to construct a cultural heritage corridor in the Shaanxi region along the Yellow River by building upon the evaluation of cultural heritage value and spatial resistance analysis in the Yellow River region. Two main cultural heritage corridors were constructed by integrating the distribution of cultural heritage and transportation networks in the area. Furthermore, the hierarchical zoning of heritage corridors provided a basis for precise spatial management.

Although tangible cultural heritage originates from the past, the revitalization and utilization of cultural heritage involve the practice of organizing future spaces [48], which is known as the "new heritage" paradigm [49]. The construction of cultural corridors significantly contributes to regional development [50]. Thus, creating themed routes adds fun, allure, and diversity to heritage tourism. Meanwhile, interpretive systems for themed routes are essential components of heritage corridor construction [51]. These systems help the public gain a deeper understanding of the essence of cultural heritage corridors, as well as enhance the sense of experience and engagement, by integrating and protecting heritage resources with similar geographical environments, historical backgrounds, and cultural meanings [13,52,53].

The two primary corridors link high-value cultural heritage sites, and they span three landscape zones. Within this region, there exists a considerable number of national and provincial-level cultural heritage sites. The central approach in the core area prioritizes protection, and it encompasses the restoration, conservation, exhibition, and development of cultural heritage. The primary heritage corridors adopts a holistic preservation strategy, in which the exploration of historical narratives is emphasized, interpretive systems are refined, and excessive development is cautioned against. The northern segment (the Great Wall Frontier Defense Cultural Zone) encompasses significant cultural heritage sites such as the Shimao Site, the Ming Great Wall Site, and cave dwelling structures. It is essential to protect and restore such cultural heritage, along with regular inspections and assessments. This area has long been a site of resistance against external invasions in the Central Plains. The frontier landscape and distinct regional features make the area suitable for the development of tourism products such as scenario-based performances, educational activities, and folk experiences. Integrating rich intangible cultural heritage, such as traditional hand-pulled noodle craftsmanship, into an interpretive system can enhance the diversity of tourism products and enrich the cultural experience of cultural tourism. The middle segment (the Red Revolutionary Heritage Inheritance Zone) is situated in the sacred land of the Chinese revolution. The predominant cultural heritage types are associated with the Red Revolutionary history and yaodong (cave dwelling) structures. The area has seen the mature development of Red education and tourism. Red education study tours and the establishment of cave dwelling accommodations will be focused upon. The southern section (the Guanzhong Traditional Culture Display Zone) is situated in the Guanzhong Plain. This region is characterized by its wealth of cultural heritage resources and a comparatively dense population. It is essential to optimize tourism infrastructure in this region by providing an array of sophisticated tourism products that encompass diverse offerings such as harvest festivals, historical research-oriented excursions, folk experiences, camping activities, and designated areas for film and television production. It is also suitable for developing folk parks or villages with flexible and diverse experiential forms, thus providing a significant gathering place for cultural experiences.

Five secondary corridors link cultural heritage sites with a lower value and service capacity. Furthermore, tourism infrastructure will be enhanced under the principles of prioritizing conservation while promoting rational utilization. This entails integrating folk culture development with corridor-themed tourism projects, upgrading external transportation, establishing internal pedestrian networks, and constructing cycling pathways. The enhancement of commercial service capabilities and the development of unique boutique accommodations are also central objectives. The primary and secondary corridors will, in unison, contribute to the establishment of a comprehensive system for the preservation and utilization of cultural heritage in the Shaanxi Yellow River region.

The preservation and establishment of heritage corridors across regions may encounter a range of challenges. Issues such as cross-regional corridor infrastructure development, fundraising disputes, and resource allocation controversies may arise. Differences in the preservation and development standards and philosophies of cultural heritage in different regions could contribute to these challenges. Furthermore, the difficulty of coordination among governments and institutions in various areas is a significant hurdle. To effectively address these challenges, it is recommended to establish a joint management committee or cross-regional cooperative organization. This entity should work toward formulating common protection and construction standards, and should be accompanied by a well-thought-out resource allocation plan. This approach aims to ensure seamless information sharing and efficient resource coordination. Additionally, fostering more cultural exchange activities can play a pivotal role in promoting mutual understanding between regions, mitigating conflicts, and facilitating the effective and sustainable advancement of cross-regional cultural heritage protection efforts.

4.3. Limitations

It must be noted that, firstly, our work has not delved deeply into the utilitarian value of corridor cultural heritage, such as political function [54]. The derived value of heritage corridors is of the utmost importance in helping establish cultural identity, local attachment, and consequently guiding the establishment of a stable and sustainable local cultural environment and socio-economic framework. Due to the difficulties in quantifying these value characteristics, as well as the diverse perceptions of their value across society, these aspects were not comprehensively examined in this study; however, they will be addressed in future research through methods such as surveys and interviews, which will be used to conduct investigations and to enhance the evaluation framework. Secondly, the entropy method judges the weight according to only the entropy distribution of the data and may ignore the actual value of the evaluation index itself. However, excessive reliance on the expert scoring method introduces subjectivity. In the future, a comprehensive weighting method based on objectivity and subjectivity may be explored. Thirdly, this study only identified the tangible cultural heritage and built a heritage corridor in the Yellow River area of Shaanxi, a region that also has an abundance of many types of intangible cultural heritage. Incorporating intangible cultural heritage into the research system to enrich the connotation of the heritage corridor and improve the strategy of activation and utilization will be a focus of follow-up work.

5. Conclusions

This study employed the entropy weight method and linear weighted regression technique to establish a comprehensive evaluation system that encompasses natural, cultural, socio-economic, transportation, and resource factors. The research involved an assessment and categorization of the tangible cultural heritage within linear cultural regions via the integration of the service supply capacity of the heritage sites. Based on this foundation, the MCR model, while also investigating graded corridor regeneration and utilization models, was utilized to create heritage corridors for high-value cultural heritage sites. The research integrated remote sensing, GIS information data, and big data, thereby significantly enhancing the study's objectivity, reliability, and precision. In taking the Shaanxi Yellow River region as a case study, the following outcomes were indicated:

Firstly, although the overall quantity of heritage was found to be high, the spatial distribution was uneven. The cultural heritage in this region exhibited a concentrated distribution pattern that was characterized by one main and two secondary clusters. Secondly, by integrating the service supply capacity of cultural heritage sites for a value assessment, cultural heritage with a high value (4th or 5th grades) constituted 19.8% of the total, and they were predominantly concentrated in the southern part of the research area with favorable socio-economic and environmental conditions. Lastly, this study identified two primary cultural heritage corridors and five secondary corridors as strategic pathways for protection and development by leveraging the value grades of cultural heritage and the regional transportation network. This pattern supported the cultural heritage systematic protection in the Yellow River region of Shaanxi.

The study makes several significant contributions. Firstly, it introduces an innovative approach for constructing heritage corridors, thus addressing the urgent need for managing and protecting small-scale cultural heritage sites within developing countries. While existing research often focuses on developed nations, this paper proposes a graded heritage corridor construction method based on the intrinsic value of cultural heritage. This method not only connects high-value cultural heritage sites, but also minimizes redundant development, thereby fostering synergies between regional cultural heritage and economic development. Secondly, in order to comprehensively assess the utilitarian value of cultural heritage, this study integrated multiple data sources, including Night Lights, the NDVI, POI, etc., using remote sensing techniques and big data. This novel method offers a more accurate and timely understanding of economic development levels and human activities, thus providing a fresh perspective for the comprehensive evaluation of the utilization value of cultural heritage. Lastly, through empirical research in the Yellow River region of Shaanxi, this study established a comprehensive framework for cultural heritage assessment and corridor construction. This framework includes spatial analysis, comprehensive evaluation, and the establishment of a cross-regional graded protection system for heritage corridors. It effectively promotes the graded protection, utilization, and sustainable development of cultural heritage in the region. Simultaneously, this article provides a practical construction method and theoretical support for the hierarchical protection system of cultural heritage corridors in regions beyond Shaanxi. It offers a flexible and adjustable reference model for subsequent research in this field, which can be improved and applied according to the nature, geography, culture, and economic differences of different locations.

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