

Cultural route perspective: heritage tourism value evaluation and route optimization of the Silk Road (Shaanxi section)

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Abstract

Spanning millennia, the Silk Road connected Eastern and Western civilizations. Xi'an served as its eastern terminus, while the Shaanxi province segment stands as the core protection zone for the route. Existing research often focuses on isolated heritage sites, neglecting their historical links to the route and undermining its cultural integrity. From the perspective of cultural routes, the study identifies 82 potential heritage sites and establishes a three-tier evaluation system. The tourism value of each heritage resource is quantified through an analytical model incorporating historical significance, route connectivity, and visitor experience metrics. Through quantitative analysis, we assess their tourism value and optimize routes to enhance visitor experiences, strengthen cultural coherence, and offer a model for global cultural route tourism planning.

Keywords: cultural routes, silk road, tourism value evaluation

1. Introduction

The Silk Road emerged during the reign of Emperor Wu of the Western Han Dynasty (141–87 BC), with its eastern terminus at Han Chang'an City (present-day Weiyang District, Xi'an) ^[1]. As the historical starting point and core economic zone of the Silk Road, Shaanxi Province hosts an extensive network of routes and abundant cultural heritage along its course, bearing witness to the thoroughfare's origins, growth, and prosperity ^[2,3]. In recent years, the rapid expansion of cultural heritage tourism has seen a proliferation of Silk Road-themed cultural tourism projects. However, existing tourism activities remain predominantly concentrated at iconic heritage sites such as the Big Wild Goose Pagoda and Little Wild Goose Pagoda, resulting in tourists' limited ability to grasp the overall historical context and cultural connotations of the Silk Road systemically.

As a key catalyst for socioeconomic development, tourism activities undertake a dual mandate: cultural heritage dissemination and heritage conservation. While existing research on Silk Road heritage tourism has focused primarily on heritage value, tourism development, and tourist experience, comprehensive investigations into the intrinsic value of heritage tourism remain limited ^[4]. Conducting systematic evaluations of heritage tourism value not only clarifies development potentials but also identifies challenges in historical and cultural heritage management, enabling the formulation of targeted activation strategies.

As a distinct category of cultural heritage, cultural routes embody the exchange of cultures, ideas, knowledge, and values arising from human cross-regional interactions, forming dynamic systems intertwined with their historical contexts and cultural legacies. The Silk Road, as a paradigmatic cultural route heritage, not only exhibits the characteristics of conventional cultural heritage but also demonstrates distinct integrity and systemicity owing to its linear spatial configuration.

Current academic research on the tourism value of the Silk Road primarily relies on theoretical frameworks for evaluating traditional cultural heritage. However, it fails to fully address the unique attributes of linear cultural heritage, which differ from dotted and planar heritage forms, and lacks a holistic perspective in the value assessment process ^[5,6]. Consequently, developing a tourism value evaluation model aligned with the characteristics of cultural route heritage represents a critical theoretical priority in contemporary heritage tourism research.

This study focuses on the Shaanxi segment of the Silk Road, constructing a three-tier evaluation system—comprising target layer, criterion layer, and index layer—tailored to the tourism value assessment of cultural route heritage. By integrating the analytic hierarchy process (AHP) and geographic information system (GIS) technology, we conduct systematic value assessments for 82 heritage sites in Shaanxi. On this basis, we optimize tourism

route planning through spatial visualization tools, aiming to expand heritage experience options for tourists and enhance their holistic understanding of the Silk Road's historical connotations. The research results provide theoretical support and practical guidance for the sustainable development of heritage tourism in the Shaanxi segment of the Silk Road.

2. Research methods and data sources

2.1 Evaluation method of heritage tourism value

This study employs a mixed-methods approach, integrating qualitative and quantitative research, to systematically develop an evaluation system for the heritage tourism value of the Silk Road (Shaanxi segment). In the qualitative research stage, a systematic literature review is conducted to synthesize international cultural heritage protection frameworks and relevant domestic and foreign research, from which initial evaluation indicators are extracted. Building on the typical characteristics of cultural routes, such as historical continuity and spatial connectivity, characteristic indicators are systematically refined and expanded through thematic analysis. The process concludes with multiple rounds of expert consultation using the Delphi method, ultimately leading to the establishment of an evaluation system comprising 4 criterion layers and 12 index layers. During the quantitative research phase, the Analytic Hierarchy Process (AHP) is employed to assign weights to evaluation indices, while kernel density estimation and weighted overlay analysis using the ArcGIS platform are utilized to visually represent the assessment results. The study culminates in the optimization of cultural tourism routes based on the evaluation outcomes.

2.2 Evaluation index data sources

The research data is sourced from multiple verified channels, including (1) topographic maps obtained from the Standard Map Service System of the National Administration of Surveying, Mapping and Geoinformation; (2) road network data provided by the Resource and Environmental Science Data Center of the Chinese Academy of Sciences; (3) heritage site lists and attribute information derived from the Shaanxi Provincial Cultural Relics Bureau's cultural relics census; (4) POI data for public service facilities such as dining, hotels, and parking lots collected via the Baidu Maps platform; (5) historical records including Hanshu and Tangshu retrieved from the Chinese Basic Ancient Books Library; (6) and results from structured questionnaires administered to experts and tourists.

3. Construction of tourism value evaluation system

3.1 Selection of evaluation indicators

In constructing the evaluation index system, this study adheres to the principles of hierarchy, guidance, and simplicity, adopting a three-tiered structure consisting of a target layer, criterion layer, and index layer. This framework ensures both systematic evaluation and precise measurement across hierarchical levels. The target layer focuses on assessing the heritage tourism value of the Silk Road (Shaanxi segment) through a cultural route lens. The criterion layer delineates key evaluation dimensions, while the index layer operationalizes these dimensions into quantifiable metrics. The final index system was finalized via the Delphi method, involving multiple rounds of expert consultation for indicator screening and categorization. The evaluation index system is presented in Fig. 1.

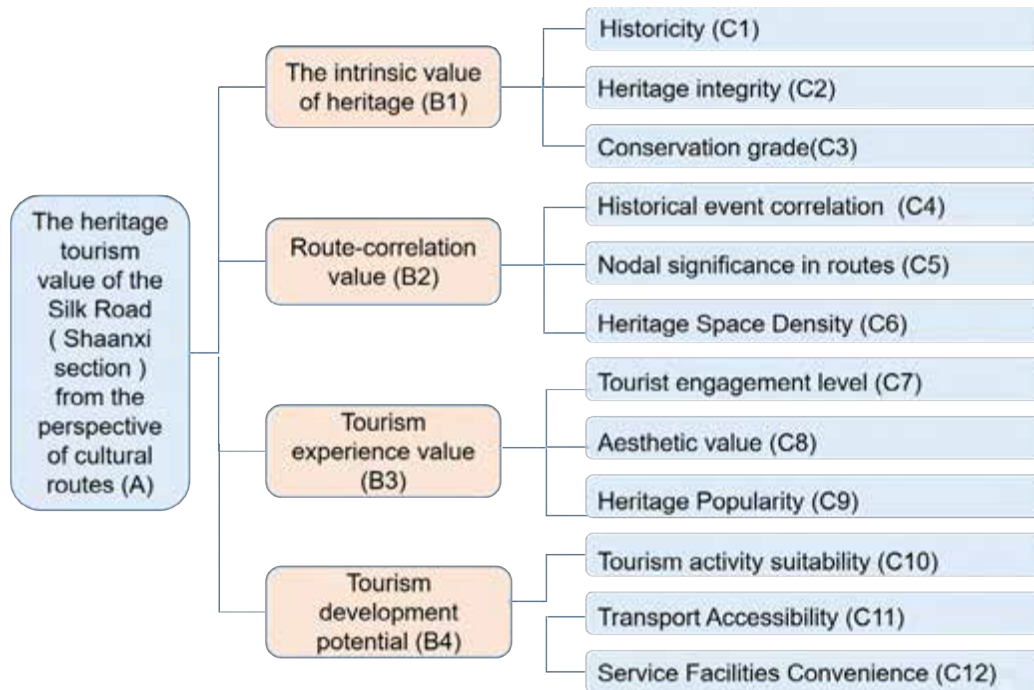


Figure.1 Evaluation System for the Tourism Value of the Silk Road Heritage in Shaanxi from the Perspective of Cultural Routes

The intrinsic value of heritage (B1) manifests its irreplaceable and essential worth as a self-contained entity. Drawing on the cultural significance framework outlined in ICOMOS' Barra Charter (2013) ^[7], the criterion layer identifies indicators across three dimensions: Historic Evidence, Material Fabric, and Social Connections. The Historicity of heritage carry the Silk Road's diachronic value, while its Heritage integrity dictates the preservation state of these value-laden material carriers. conservation grade reflects societal institutional recognition of heritage value, serving as an important marker of the social consensus surrounding its cultural significance.

Route-correlation value (B2) constitutes the core dimension of heritage evaluation from the cultural route perspective. Its indicators encompass Historical event correlation, Nodal significance in routes, and Heritage Space Density. The historical event correlation index measures the extent to which a heritage site is connected to major historical processes. Drawing on Norbert Schulz's Place Theory ^[8], historical events infuse spaces with spiritual connotations, as the occurrence of significant historical milestones often endows specific locations with cultural significance transcending their material form. The nodal significance in routes assesses the functional role of heritage sites within the network, evaluating their position and influence in facilitating historical interactions and exchanges along the route. Building upon the central place theory in transportation geography ^[9], key nodes along cultural routes often exhibit higher accessibility and functional complexity, serving as critical markers of the routes' historical development and evolution. The heritage Space Density enables the quantification of spatial continuity along the route ^[10]. The spatial density index of heritage sites is derived using kernel density analysis in ArcGIS, calculating the number of heritage sites per square kilometer and their nearest neighbor index to determine the final evaluation score.

Tourism experience value (B3) evaluates heritage tourism products from the tourists' perspective, encompassing three indicators: Tourist engagement level, Aesthetic value, Heritage Popularity. Drawing on the World Tourism Organization's (UNWTO, 2018) research on tourist behavior, which indicates that 73% of travelers prefer culturally iconic destinations ^[11], popularity serves as a measure of public awareness of heritage and directly influences tourists' decision-making ^[12]. Engagement reflects the depth of tourists' participation and is a key metric for assessing the effectiveness of heritage tourism development ^[13]. Building on Berlyne's Aesthetic Response The-

ory (1971), visual stimuli directly impact tourists' emotional arousal and willingness to stay ^[14]. Heritage sites with stronger aesthetic appeal evoke tourists' aesthetic pleasure through visual salience, thereby enhancing the overall experience quality ^[15].

Tourism development potential (B4) are evaluated through three key dimensions: Tourism activity suitability, Transport accessibility, and Service facility convenience. Tourism activity suitability systematically assesses the environmental carrying capacity of the heritage site's surrounding area, reflecting the feasibility of developing heritage tourism under the premise of ecological sustainability and serving as a foundational indicator for tourism construction planning. Transport accessibility is measured by using ArcGIS to calculate the proximity of heritage sites to various road networks (expressways, national highways, provincial roads), thereby evaluating the ease with which tourists can reach their destinations. Service facility convenience, positively correlated with tourism experience quality, is determined through Kernel Density Estimation to analyze the agglomeration patterns of catering, accommodation, medical, and other supporting facilities, providing a quantitative measure of regional service accessibility ^[16].

3.2 Determination of index weight

In evaluation systems, index weights are quantitative values assigned to reflect the relative importance of each indicator, representing their contributions to the overall assessment ^[17]. Each weight is normalized such that the sum of all weights equals 1 (or 100%). Here, we employ the analytic hierarchy process (AHP) to determine index weights. First, a judgment matrix was constructed using the 1–9 scale method, and questionnaires were distributed to 24 experts specializing in tourism planning, heritage protection, and related disciplines. Twenty valid responses were received, yielding an 83.3% response rate. Consistency of the judgment matrices was verified using Yaahp software, confirming that all matrices satisfied the consistency ratio criterion ^[18]. Arithmetic means of the valid weighted judgments were calculated to derive the final weights for each index element, presented in Table 1.

Table 1. Weighting of Heritage Tourism Value Indicators

Criterion layer	Indicator layer	Weight	Scoring standard				
			20	40	60	80	100
Heritage ontology value (B1) (0.21)	Historicity (C1)	0.06	Ming-Qing dynasty	Song-Yuan dynasty	Sui-Tang dynasty	Wei jin southern and northern dynasties	Han Dynasty and before
	Heritage integrity (C2)	0.07	Only the remains of the site	Local retention	Subject retention	Relatively complete	Complete
	Conservation grade (C3)	0.08	Unrated	Municipal	Provincial	National	World-class
Line correlation value (B2) (0.31)	Historical event correlation (C4)	0.12	Very poor	Poor	General	Important	Very important
	Nodal significance in routes (C5)	0.11	Very poor	Poor	General	Important	Very important
	Heritage Space Density (C6)	0.08	The nearest neighbor index (NNI) of cultural heritage points was calculated using kernel density analysis and normalized.				
Tour experience value (B3) (0.22)	Tourist engagement level (C7)	0.09	Very poor	Poor	General	Important	Very important
	Aesthetic value (C8)	0.07	Very poor	Poor	General	Important	Very important
	Heritage Popularity (C9)	0.06	Unknown	Regional famous	Province famous	Country famous	World famous
Tourism exploitation condition (B4) (0.26)	Tourism activity suitability (C10)	0.10	Very poor	Poor	General	Suitable	Very suitable
	Transport Accessibility (C11)	0.10	Very poor	Poor	General	Suitable	Very important
	Service Facilities Convenience (C12)	0.06	Very poor	Poor	General	Convenient	Very convenient

The results show that the connectivity of routes has the highest weight, which validates the core perspective of the cultural routes theory. The value of heritage is not only reflected in individual characteristics but more importantly in its interconnections within the route system. Meanwhile, the relatively high weight of tourism development conditions also indicates that, on the premise of prioritizing protection, rational tourism utilization is an important means of realizing the inheritance of heritage value.

4. Heritage identification and tourism value evaluation

4.1 Potential Heritage Identification

This study systematically compiles official datasets, including the Shaanxi Province Unmovable Cultural Relics List (2020 Edition), to conduct a comprehensive inventory of cultural heritage resources in Shaanxi Province. Multi-source data cross-validation ensures that each potential heritage site satisfies the following criteria: (1)

possesses physical remains confirmed by field surveys; (2) has complete cultural relics archive records; and (3) its historical context is traceable to periods relevant to the Silk Road. Extending spatial analysis across the entire province of Shaanxi to account for historical variations in the Silk Road's cultural influence, we identify heritage elements significantly associated with the route. A total of 82 core heritage sites are selected, including seven inscribed in the Silk Road: The Road Network of the Chang'an-Tianshan Corridor World Cultural Heritage list.

Table 2. Statistics of Potential Heritage Sites

Serial number	Heritage name	Dynasty	Seat	Type
1	Dayan Pagoda	Tang	Xi'an city	Ancient architecture
2	Small Wild Goose Pagoda	Tang	Xi'an city	Ancient architecture
3	Han Chang'an City Site	West-ern Han	Xi'an city	historic urban archaeological sites
4	Xingjiao Temple Pagoda	Tang	Xi'an city	Ancient architecture
5	Tomb of Zhang Qian	Han	Hanzhong city	Ancient burials
6	Maoling Mausoleum	West-ern Han	Xianyang city	Ancient burials
7	kumarajiva dagoba	Tang	Xi'an city	Ancient architecture

4.2 Evaluation of heritage tourism values

Using the evaluation framework for the heritage tourism value of the Silk Road (Shaanxi segment) established above, assessments are categorized as quantitative or qualitative based on data type. Quantitative indicators encompass C1 (Historicity), C3 (Conservation grade), C6 (Heritage Space Density), C11 (Transport Accessibility), and C12 (Service Facilities Convenience). For C1 and C3, data derived from the authors' field surveys and literature reviews were processed in SPSS for sorting, calculation, and dimensionless normalization^[19]. Spatial analyses for C6, C11, and C12 were performed using ArcGIS 10.8. Specifically, C6 employs kernel density estimation to quantify heritage clustering (Fig. 2(a)), while C11 utilizes multi-ring buffer analysis (3,000m/5,000m/10,000m/20,000m) to calculate road network coverage (Fig. 2(b))^[20]. C12 integrates POI kernel density and entropy weight methods to assess service facility distribution intensity (Fig. 2(c))^[21].

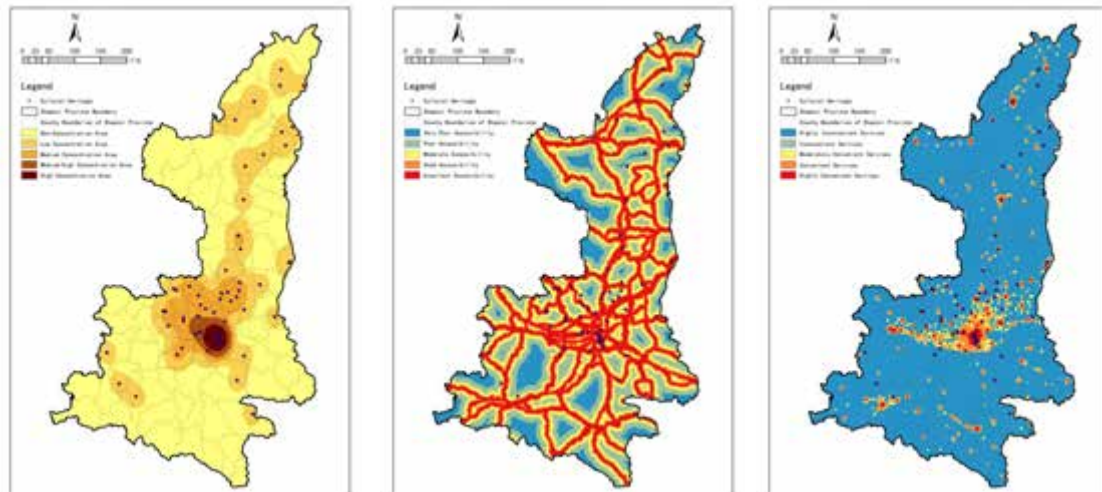


Figure 2. (a) Spatial Density Evaluation of Heritage Sites (b) Road Network Accessibility (c) Service

Facility Convenience Assessment

Qualitative indicators encompass C2 (Heritage integrity), C4 (Historical event correlation), C5 (Nodal significance in routes), C7 (Tourist engagement level), C8 (Aesthetic value), C9 (Heritage Popularity), and C10 (Tourism activity suitability). C2, C4, and C5 were determined via the Delphi method, involving three rounds of Likert 5-scale scoring by six experts with expertise in Silk Road heritage. For C7–C9, data were collected through online surveys, yielding 36 valid responses. C10 was assessed using the Limits of Acceptable Change (LAC) framework, where three ecological experts integrated remote sensing imagery, field monitoring data, and construction carrying capacity analyses to evaluate biological sensitivity^[22].

4.3 Analysis of value evaluation results

Using the developed comprehensive evaluation framework, this study systematically assesses the tourism value of 82 heritage sites in the Shaanxi segment of the Silk Road, classifying them into three categories based on weighted scores (Fig. 3).

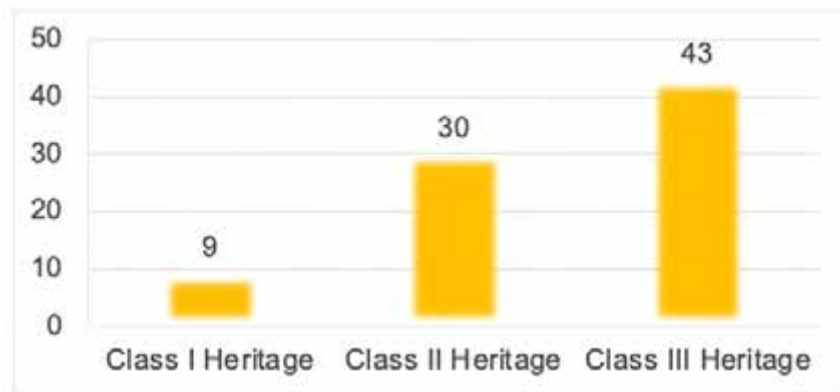


Figure 3. Statistical Results of Heritage Evaluation

Class I Heritage (≥ 80 points) includes 9 sites, comprising 11.0% of the total. These are core heritage sites with outstanding historical value and tourism development potential, such as the Han Chang'an City Ruins (92.6 points) and the Giant Wild Goose Pagoda (92.4 points). These sites hold an irreplaceable important position in the development of Silk Road tourism. Class II Heritage (70–80 points) includes 30 sites, accounting for 36.6%. These sites have medium tourism value and can serve as important supplements to the Silk Road tourism routes, such as Zhang Qian's Tomb (79.2 points) and the Daxingshan Temple (79.2 points). Class III Heritage (≤ 70 points) includes 43 sites, accounting for 52.4%. These sites have relatively limited tourism development value and can be considered as optional visiting points.

Spatially, Class I Heritages exhibit pronounced clustering, predominantly concentrated in the core region of Xi'an (Fig. 4). Class II Heritages are primarily distributed in peripheral regions of Xi'an and Xianyang cities, while Class III Heritages are scattered along historical ancient roads. This distribution pattern strongly aligns with the historical commercial routes and regional development priorities of the Silk Road, reflecting the intrinsic link between heritage value and historical context.

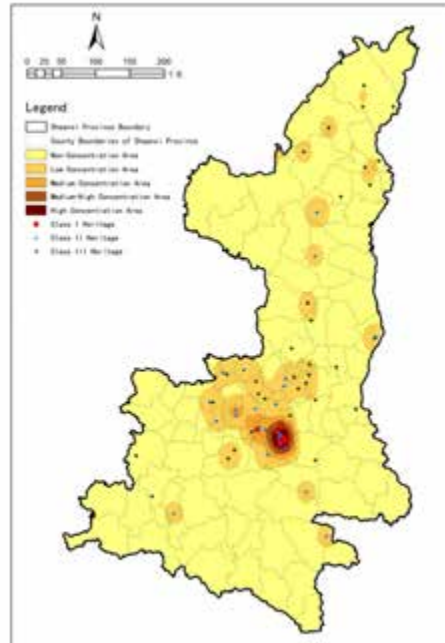


Figure 4. Comprehensive Heritage Evaluation Results

5. Optimization of tourist route

Leveraging systematic evaluations of 82 heritage sites, this study uses ArcGIS network analysis tools to incorporate national and provincial transport network data (expressways, national highways, provincial roads) to optimize Silk Road tourism routes. By designating Class I Heritage sites as mandatory nodes and Class II and Class III Heritage sites as optional nodes, and optimizing for the shortest path while integrating constraints such as road classification and traffic capacity, we employ ArcGIS network analysis to model route configurations. Following iterative model runs and manual refinement, a complete cultural tourism route for the Silk Road (Shaanxi segment) is finalized (Fig. 5). The route efficiently connects 9 core heritages, 12 secondary heritages, and 8 tertiary heritages, enabling systematic exploration of diverse heritage resources and immersive engagement with the historical and cultural continuum of the ancient Silk Road.



Figure 5. Cultural Tourism Route of the Silk Road (Shaanxi Section)

6. Conclusion

This study introduces an innovative framework for evaluating heritage tourism value, systematically constructing a multidimensional assessment system. Compared with conventional approaches, it features three distinct advances: (1) Emphasizing the overall value of cultural routes, it quantifies the historical connections between heritage sites and routes, fully presenting the characteristic of cultural routes that “the whole is greater than the sum of its parts.” (2) It establishes a multidisciplinary evaluation dimension, comprehensively considering factors such as nodal significance in routes, tourism development, and visitor experience need. (3) By utilizing the ArcGIS platform for geospatial quantitative analysis, it significantly enhances the scientific rigor of evaluations.

This study still has limitations, including insufficient objectivity in the evaluation process and limited representativeness of evaluation subjects. Future research should focus on improving quantitative methods for indicators, establishing a multi-stakeholder participation mechanism, and expanding the scope of case applications. These improvements will enhance the scientific rigor and generalizability of the evaluation system, thereby providing more robust theoretical support and practical guidance for the sustainable development of cultural route heritage tourism.

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