

Article

Interpretation of Value Advantage and Sustainable Tourism Development for Railway Heritage in China Based on the Analytic Hierarchy Process

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Abstract: Railway heritage (RH) conservation protects significant industrial culture and can be instrumental in revitalizing post-industrial economies. China has abundant RH resources needing conservation to ensure their long-term survival. The purpose of this study was to define the value of RH based on an improved value evaluation system, discuss how the results influence RH tourism, and provide proposals for sustainable tourism accordingly. Firstly, the analytic hierarchy process (AHP) was used to evaluate the value of six RH sites from China's First Industrial Heritage List. Then, the value advantages of the RH sites were analyzed by making comparisons among the six in the view of sustainable development, and the correlative details were interpreted to demonstrate the strengths and advantages of each resource. Finally, recommendations for RH tourism development were put forward based on these value advantages. The findings indicate that analyzing value advantages among similar resources in a competitive setting strengthens conservation and development decisions. Thus, balanced and sustainable development of RH tourism can be accomplished.

Keywords: railway heritage (RH); analytic hierarchy process (AHP); value evaluation; value advantage; heritage tourism; sustainable development proposals

1. Introduction

From colonial to high-speed, railways have played an important role in the different historical periods of China. Whether in use or abandoned, their influence continues to evolve and expand. According to The International Committee for the Conservation of Industrial Heritage [1], railway heritage (RH) is the legacy of railway industrial culture that includes such features as tracks, locomotives, buildings, amenities, districts, and villages. The historic significance of the railway lies not only in the technical, military, and religious communication but also in the “route” [2]. Thus, taking all related elements as a whole, RH is a heritage landscape distributed in a linear space. The railway is the core that is lined by related functional, cultural, and historical heritage resources. In comparison to the significance of general, non-RH industrial heritage that display technological development, novel ways of production, and cultural continuity, RH is more strongly connected to distinct local cultural regions, because it adapted to challenging terrain, supported local production and exports, and helped maintain cultural continuity [3,4]. Railway heritage resources reflect historical changes in the landscape and were driving forces of urban landscape transformations [5,6]. Thus, it is necessary to protect RH for future generations. Furthermore, since RH tourism is a connection between the past and the present, developing RH tourism is a useful tool for sustainable heritage conservation including

regional economic and cultural improvement [7]. Because of more than thirteen RH sites in China, it is necessary to define the importance of them and provide an adaptive setting for long-term survival.

The importance of sustainable tourism has been globally recognized. It is becoming progressively important that the survival and financial development of heritage tourism as well as the conservation of heritage through sustainable planning becomes normative practice among planners [8]. Sustainability is regarded as a resource's long-lasting process or state in balance with similar elements. As Inskeep [9] demonstrates, "sustainable tourism can be regarded as meeting the current needs of tourists and host regions while protecting and enhancing opportunity for the future, and leading to management of all resources in such a way that we can fulfill economic, social and aesthetic needs while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems". In order to ensure the balanced development of RH tourism, the concept of sustainability needs to be introduced to tourism planning. From the perspectives on sustainable heritage tourism planning, two topics are nearly always discussed: the most suitable place for developing heritage tourism and the best way to manage heritage sites for sustainably [8]. Both "the most suitable" and "the best way" are based on a fundamental approach of value evaluation. Therefore, defining value is a key to achieving sustainability.

Generally speaking, the essence of heritage conservation is the preservation of heritage values. It involves value identification, evaluation, and utilization [10]. Value identification provides the cognitive basis for evaluation. Value evaluation offers a quantitative basis for conservation decision making. Value utilization is the effective conservation measure based on the full recognition of value. In these three aspects, value evaluation is fundamental, and there are various ways to do an evaluation. It not only realizes the importance and characteristics of heritage, but also provides scientific guidance for heritage conservation and development. Additionally, developing tourism is one of heritage conservation decisions. Since conservation decisions result from a series of value judgements [11], making a comparison among similar heritage values displays the importance of individual heritage relative to others. This information helps support heritage and conservation decisions.

Scholars have identified and interpreted the significance of Asian and Chinese RH that lays a solid foundation for value evaluation. While different scholars identified different value criteria, a review of each is helpful in constructing a more complete framework of value evaluation. Many RH resources have been investigated and reported. In an Indonesian study, the five values considered in the process of evaluation were historical, cultural and spiritual, scientific, physical design, and social. However, educational, economic, and recreational values were regarded important after heritage designation was achieved [12]. Viewing RH as a type of cultural route, Li [13] recorded and interpreted the progress and regularity of the cultural diffusion of architectural resources for the Chinese Eastern Railway to demonstrate the significance of the cultural communication of RH. In terms of value composition, Lee [14] concluded that significant RH sites in Asia displayed four necessary conditions including technical merit, economic value, political or social significance, and aesthetic characteristics. Bhati et al. [15], adopting Xie's [16] research methods, identified the five attributes of economic justification, community perception, stakeholder agreement, potential to succeed, and the ability to have authentic experiences as keys for outstanding RH tourism attractions. Pryce et al. [17] examined the perspective of tourists' interests and demands for three mountain RH sites in Asia. Tang [18] interpreted the meaning of RH value using the four aspects of engineering technology, engineers and builders, historical events, and improvements to society and the economy.

Building an objective system of value evaluation is important to providing a more scientific guidance of heritage conservation and development. Xu et al. [19] drafted Guidelines for Evaluation of China Industrial Heritage (Trial) which provided a reference for the study reported in this paper. Gao et al. [20] took social and cultural value and economic value as the framework to build an evaluation system for the Chinese Eastern Railway. They also graded heritage units and railway stations in a representative section in order to make objective conservation decisions. As an alternative view, Tang [21] built a three-level system of heritage resources, social settings, and development potential to examine the value of tourism development for the Chinese Eastern Railway thus serving to generate

a spatial pattern of tourism development that adapts to competition and cooperation. In addition, sustainability is one of the key points of assessing the continuing value of heritage. Weng et al. [22] proposed an evaluation indicator framework to assess the sustainability of heritage destination from the perspective of tourism. All of them laid a solid foundation for construction and expansion of the value evaluation system on railway heritage. Above all, most of the reviewed research applied subjective methods to make evaluations and lacked detailed data to support their conclusions. Therefore, it is necessary to add quantized data to make evaluation methods more objective and scientific. The authors hope that an increase in studies incorporating quantitative data will make value assessment of RH resources more appealing.

In China, there is an abundance of RH resources competing for heritage tourism development. This paper examined six of them. This study intended to present a positive competitive relationship among the six RH sites and to magnify the merits of each. Thus, building a system for value evaluation as the main mission of this study was to define the importance of them. Furthermore, comparative method is another effective way to make an evaluation, especially from a sustainable perspective. It can provide a more complete understanding of the similarities and differences of the six and which heritage sites contain prominent or superior resources. The results from a comparative approach can provide a framework for the coordinated development of similar heritage and help investors and managers make sustainable and cost-benefit decisions regarding heritage tourism development. The win-win goal is to have an effective conservation strategy for each and the sustainable development for all.

2. Materials and Methods

2.1. Research Area

China's First Industrial Heritage List, released in 2018, includes 100 industrial heritage sites. Fortunately, as a typical type of industrial heritage, six outstanding railways were selected. The analysis of these six RH sites were the focus of this research. They were Chinese Eastern Railway (CER), Beijing–Zhangjiakou Railway (BZ), Jinan–Qingdao Railway (JQ), Baoji–Chengdu Railway (BC), Dian–Vietnam Railway (DV), and Ba Shi Railway (BS). The spatial distribution of the six is shown in Figure 1.



Figure 1. The spatial distribution of the six railways.

2.2. Methodology

The development of RH is affected by many factors including intrinsic and extrinsic ones. Thus, it was necessary to conduct a synthetical evaluation on RH to make appropriate decisions on development positioning. Synthetical evaluation refers to evaluate attributes of an object with many indicators or evaluate attributes of many objects for ordering. There are some typical and common approaches to synthetical evaluation such as the analytical hierarchy process (AHP) and technique for order preference by similarity to an ideal solution (TOPSIS) [23]. Compared to the other method, the advantages of AHP are manifested in two aspects. On the one hand, the AHP method is easy to operate and enables a clear reading of the relationship among indicators which can make a horizontal comparison as well as a vertical analysis. On the other hand, determining the weights hierarchically contributes to reducing the bias caused by subjective evaluation in order to have a more scientific result. The TOPSIS aims at choosing the best alternative of the sorting which is suitable for dealing with the issue of multi-objective decisions. However, the sorting, as a result, cannot reflect the advantages and disadvantages. In terms of this research, the main goal was not to choose which is the best or the worst but to determine the advantage of each relative to the others. Thus, AHP was a more appropriate method to conduct this research owing to matching with the characteristics of RH.

Analytical hierarchy process is a widely used method for decision analysis that combines qualitative and quantitative analysis. The AHP method transforms the complex, logical actions of decision-making into a mathematical process. By separating the decision-making problem into multiple layers (i.e., target, criterion, indicator, and program), the essence, influencing factors, and intrinsic relationship of the problem are analyzed [24]. This method is appropriate for constructing a framework for value evaluation as demonstrated by Ma et al. [25] and Turskis et al. [26]. In this research, building an AHP framework was equivalent to determining the importance and significance of RH. Based on the AHP methodology, large amounts of quantitative data were introduced into the construction progress of the value evaluation system so as to minimize the subjective influence on the results. First, the authors chose relative indicators to establish the hierarchical framework for the value evaluation system. Then, a judgement matrix was created using the Delphi method [27], and consistency tests were performed. Next, we calculated the weights of each indicator at each of the layers. Then, guided by the research goals, we graded each indicator of the six railways according to the investigators' suggestions and the results of the objective data conversion. The final score of each indicator for each RH provided a foundation for comparison. Finally, the comparative analysis of the six RH sites was reported. In addition, a software called YAAHP [28] was used in the process of constructing a value evaluation framework.

The comparative view can be applied to the research on sustainable development and can be utilized for processing many research objects of the same or similar type. Therefore, according to the six items in this study, we plan to make comparisons of the analysis of the relative advantage of each RH.

2.2.1. Selection of Indicators

Generally, there are two common ways to develop valuable railway heritage. The first is to preserve and maintain the status quo. The second is to propose a rational and sustainable reuse. Supply (i.e., what the heritage provides) and demand (i.e., what the public needs) are key issues to consider. Therefore, seeking the most appropriate value-based development was the main goal of this research.

Actually, many scholars have been engaged in building a framework for heritage value evaluation. However, the various indicators depend on the characteristics of different heritage sites. Railway heritage presents a form of industrial heritage. According to the Nizhny Tagil Charter [1], industrial heritage sites are of historical, technological, social, architectural or scientific value. On the other hand, RH is a kind of linear cultural heritage such as a cultural route. The main value of a cultural route includes scientific, route-specific, economic, and protection and conservation [29]. Especially on the attribute of a cultural route, the function of communication is one of the most important parts to demonstrate the evidential value for the diverse types of culture and social development in the past.

Above all, to define the value features of the six RH sites in this study, four categories of 20 indicators were defined: Technical Difficulty (B_1), Physical Evidence (B_2), Cultural Communication (B_3), and Social Impact (B_4) (Table 1). The Technical Difficulty indicator (B_1) consisted of 10 technical elements important to defining RH sites (listed in Table 2) and the era the railway was constructed. The Physical Evidence indicator (B_2) was selected with the consideration of the RH sites' authenticity and integrity. Cultural Communication criteria (B_3) reflect the characteristics of cultural changes along the railway resulting from colonialism. Social Impact Criteria (B_4) were selected based on the historic and current social development and the demand for the railway.

Table 1. The framework of the value evaluation and the interpretation of the indicators.

Target	Criterion	Indicator	Interpretation
Heritage Value (A)	Technical Difficulty (B_1)	10 Technical elements (C_1)	The elements represent the difficulty of railway construction
		The year of construction (C_2)	The earlier the construction, the more technically difficult
	Physical Evidence (B_2)	Degree of retention of function (C_3)	Still in use, partially in use, or no longer in use, (including the original locomotive technology)
		Degree of retention of the track (C_4)	Retains the original line, or partially retains the original line
		Number of remains (C_5)	Richness of heritage
		Degree of change of the route (C_6)	Retains the original line and historic additions to the line
		Degree of route abandonment (C_7)	The route is intact or partially abandoned
		Number of important events (C_8)	Historical importance
	Cultural Communication (B_3)	Colonial time (C_9)	How many years did the colonists control the railway? The longer the colonial time, the more prominent the cultural feature
		Number of colonial countries (C_{10})	Types of foreign culture
		Number of ethnic minorities (C_{11})	Types of minority culture in China
		Degree of foreign participation in the process of railway construction (C_{12})	Western methods of construction and design are evident in engineering projects
	Social Impact (B_4)	Number of provinces (C_{13})	Spatial extent of social impact
		Total number of stations (C_{14})	The influence on the people who lived near the stations
		The impact of railway construction on social productivity (C_{15})	The vital impact on social and economic development (such as a driving force on transforming rural agricultural society into industrial urban society)
		The historic need of railway transportation (C_{16})	The historic functional importance of a railway
		The current need of railway transportation (C_{17})	The present functional importance of a railway
		Degree of public acceptance (C_{18})	The current public attitude on RH including history, heritage, and conservation
		The annual freight volume at the time of construction (C_{19})	The importance of the railway to production (economy)
		The annual volume of passenger transport at the time of construction (C_{20})	The importance of railway to livelihood (connectivity)

Table 2. The technical index of six railways.

No.	Indicator	Name					
		CER	DV	JQ	BZ	BC	BS
D ₁	Average annual temperature/°C	4.9	15.5	13.9	12.9	16	16
D ₂	Length/km	1480	465	384.2	201.2	669	19.84
D ₃	Number of tunnels	13	155	0	4	304	6
D ₄	Total length of tunnels/km	10.99	167.4	0	1.644	84	0.905
D ₅	Number of bridges	214	425	955	125	1001	0
D ₆	Total length of bridges/km	6	4.115	8.5	2.3	28	0
D ₇	Maximum height difference/m	510.87	1823.6		600	817	238.1
D ₈	Slope/‰	15	26.75	9	33.33	33	36.14
D ₉	Gauge/mm	1524	1000	1435	1435	1435	762
D ₁₀	Minimum radius of curve/m	217	80	300	182.5	300	70

Abbreviation of names: Chinese Eastern Railway (CER); Dian–Vietnam Railway (DV); Jinan–Qingdao Railway (JQ); Beijing–Zhangjiakou Railway (BZ); Baoji–Chengdu Railway (BC); Ba Shi Railway (BS).

In order to facilitate the comparison, the units of these indexes in Table 2 need to be removed, that is, dimension unification. Thus, according to the relationship between the indicator and the difficulty for construction, the indicators were divided into three types to conduct normalization separately.

Positive correlation indicator: those with a value that had a positive correlation with technical difficulty, which means that the bigger the indicator value, the more technical difficulty. The indicators of D₂, D₃, D₄, D₅, D₆, D₇, and D₈ were positive. The normalization formula for them was:

$$x' = \frac{x - \min}{\max - \min} \quad (1)$$

in which x is the original value of the indicator and x' is the normalized date. Min is the minimum value of this indicator, and max is the maximum value.

Negative correlation indicator: those with value that had a negative correlation with technical difficulty, which means that the smaller the indicator value, the more technical difficulty. The indicators of D₁ and D₁₀ belonged to the negative correlation indicator. The normalization formula for this kind indicators was:

$$y' = \frac{\max - y}{\max - \min} \quad (2)$$

in which y is the original value of the indicator, y' is the normalized data, and min and max are the minimum and maximum values of this indicator, respectively.

The other positive correlation indicator was where the difference between the value of this indicator and the reference value had positive correlation with technical difficulty, which means that the bigger the gap value, the more technical difficulty. Gauge (D₉) belonged to this type. Taking the standard gauge (1435 mm) as the reference value, the normalization formula was:

$$z' = \frac{|z - z_0|}{\max|z - z_0|} \quad (3)$$

in which z is the original value of the indicator, z_0 is the reference value, and z' is the normalized data, $|z - z_0|$ is the absolute value between the original data and the reference data, and max means the maximum value of this indicator.

The normalized data are listed in Table 3. The closer the value was to 1, the greater the technical difficulty. Conversely, the closer the value was to 0, the lower the technical difficulty. The sum of all values of indicators (the last row in Table 3) means the comprehensive difficulty of each railway. The bigger the sum, the greater the overall technical difficulty.

Table 3. The normalization results of the 10 technical elements.

No.	CER	DV	JQ	BZ	BC	BS
D ₁	1.00000	0.04505	0.18919	0.27928	0.00000	0.00000
D ₂	1.00000	0.30487	0.24953	0.12421	0.44458	0.00000
D ₃	0.04276	0.50987	0.00000	0.01316	1.00000	0.01974
D ₄	0.06565	1.00000	0.00000	0.00982	0.50180	0.00540
D ₅	0.21378	0.42458	0.95404	0.12488	1.00000	0.00000
D ₆	0.21429	0.14696	0.30357	0.08214	1.00000	0.00000
D ₇	0.28014	1.00000	0.00000	0.32902	0.44801	0.13057
D ₈	0.22108	0.65402	0.00000	0.89646	0.88430	1.00000
D ₉	0.13220	0.64640	0.00000	0.00000	0.00000	1.00000
D ₁₀	0.36087	0.95652	0.00000	0.51087	0.00000	1.00000
The summation on normalized data of six railways (C ₁)	3.53077	5.68827	1.70633	2.36984	5.27869	3.15571

2.2.2. Determination of the Weights of Indicators

In this stage, eighteen experts from academics, tourism marketing companies, and professionals in landscape architecture, industrial heritage conservation, architectural history urban planning, and tourism were invited to give suggestions and judge the weighting of items. There were several reasons to include these experts. They have been engaged in related research for more than five years and six of them have more than fifteen years of research experience. Most have rich fieldwork experience in railway heritage including measuring, investigating, and on-site inquiry. All of them have been a member of practical heritage projects on conservation planning, restoration, and reconstruction. This experience allows them to provide professional and objective decisions.

When determining the weights of indicators, five matrices for judgement amongst A–B_{*i*} and B_{*i*}–C_{*j*} were constructed (the general form of the judgement matrices is shown in Table 4). The judgement suggestions were provided by eighteen experts using a scale of 1–9 to judge relative importance, in which 1 represents unimportant and 9 represents most important [30]. The more positive the relationship between each indicator and its corresponding criterion level, the higher the scale value and vice versa. For each judgement matrix, the maximum eigenvalue λ_{max} , corresponding eigenvector W , and the consistency data CI were calculated. The consistency test was conducted using the following formula:

$$CR = CI/RI \quad (4)$$

After calculation, a result of $CR < 0.1$ indicated that the results were reasonable and effective. If not, the judgement matrix needed to be adjusted until $CR < 0.1$. Then, taking the criterion layer as an example, the weights of factors at this layer were calculated by Formulas (5) and (6), as shown below:

$$\beta_i = \frac{\sum_{j=1}^m b_{ij}}{\sum_{i=1}^m \sum_{j=1}^m b_{ij}} \quad (5)$$

$$\sum_{i=1}^m \beta_i = 1 \quad (6)$$

$\beta = (\beta_1, \beta_2, \beta_m)$ indicates the weight vector of the weighted factors in the criterion layer against the target one; m is the number of weighted factors in the criterion layer; b_{ij} is the importance of b_i relative to b_j . Similarly, the weight of each factor in the indicator layer was calculated. The results determine the framework of value evaluation as shown in Table 5.

Table 4. The general form of judgement matrices.

A	B_1	...	B_j	...	B_n
B_1	b_{11}	...	b_{1j}	...	b_{1n}
...
B_i	b_{i1}	...	b_{ij}	...	b_{in}
...
B_m	b_{m1}	...	b_{mj}	...	b_{mn}

Table 5. The value evaluation system for railway heritage (RH).

Target	Criterion B_i	Weight β_i	Indicator C_j	Weight γ_j	$\delta = \beta_i \cdot \gamma_j$	δ Ranking
A	B_1	0.1416	C_1	0.1214	0.017190	6
			C_2	0.0202	0.002860	19
			C_3	0.0283	0.006809	13
			C_4	0.0708	0.017034	7
			C_5	0.0844	0.020307	5
			C_6	0.0102	0.002454	20
			C_7	0.0122	0.002935	18
			C_8	0.0347	0.008349	11
	B_2	0.2406	C_9	0.1609	0.049702	1
			C_{10}	0.0373	0.011522	9
			C_{11}	0.0307	0.009483	10
			C_{12}	0.0800	0.024712	4
	B_3	0.3089	C_{13}	0.0098	0.003027	17
			C_{14}	0.0256	0.007908	12
			C_{15}	0.0968	0.029902	2
			C_{16}	0.0876	0.027060	3
			C_{17}	0.0150	0.004634	16
			C_{18}	0.0389	0.012016	8
			C_{19}	0.0174	0.005375	15
			C_{20}	0.0178	0.005498	14
	B_4	0.3089				

2.2.3. Value Evaluation of the Six Railway Heritage Sites

Depending on the framework of value evaluation, we engaged in degrading the value of each RH. Among all criteria, nine objective indicators (C_1 , C_2 , C_9 , C_{10} , C_{11} , C_{12} , C_{13} , C_{14} , C_{19} , and C_{20} in Table 6) were obtained by consulting relevant archival documents, yearbooks, local traffic chronicles, and research reports. Indicators C_3 through C_8 were derived from the results of the field study of RH resources. Thus, the above objective data can be normalized and converted into a score. The remaining four indicators (C_{15} through C_{18}) were scored by relevant RH scholars and the public through questionnaires. There were forty-eight investigators (including the eighteen experts) that participated in this survey. We were more inclined to choose those who had been to the railway or at least knew it. We designed a questionnaire with four questions regarding four indicators for each RH. The grading criteria for the indicators are listed in Table 7. Based on the evaluation system shown in Table 5, the target value (A) of the six RH sites and scores of different criteria (B_i) were calculated using Formulas (7) and (8) respectively, as interpreted in Table 8. The final scores of the six RH sites are listed in Table 9.

$$A_1 = \sum_{i=1}^4 B_i \cdot \beta_i \quad (7)$$

$$B_i = \sum_j C_j \cdot \gamma_j \quad (8)$$

Table 6. Data for quantitative evaluation factor.

No.	Factor	CER	DV	JQ	BZ	BC	BS
C ₁	The normalization results of 10 technical elements	3.53077	5.68827	1.70633	2.36984	5.27869	3.15571
C ₂	Years from beginning to present	122	116	120	114	67	60
C ₉	Colonial years	55	47	24	0	0	0
C ₁₀	Number of colonial countries	2	1	2	0	0	0
C ₁₁	Number of ethnic minorities	1	12	0	0	2	0
C ₁₃	Number of provinces	4	2	1	2	3	1
C ₁₄	Number of stations	104	34	56	10	76	10
C ₁₉	Annual freight volume at the beginning (/10 ⁷ kg)	32.59	6	61.9	40	74	37.2
C ₂₀	Annual volume of passenger transport at the beginning (/10k people)	175	30	80.3	41	43	28.9

Table 7. Grading criteria of indicators.

Indicator	Criteria	Score	Indicator	Criteria	Score
C ₁	C ₁ ≥ 5	8–9	C ₁₁	C ₁₁ > 5	6–9
	2 < C ₁ < 5	3–7		2 < C ₁₁ < 5	2–5
	C ₁ ≤ 2	1–2		C ₁₁ = 1	1
C ₂	before 1949	6–9	C ₁₂	C ₁₂ > 70%	7–9
	In 1949	5		30% ≤ C ₁₂ ≤ 70%	4–6
	After 1949	1–4		C ₁₂ < 30%	1–3
C ₃	C ₃ > 70%	7–9	C ₁₃	C ₁₃ = 5	9
	30% ≤ C ₃ ≤ 70%	4–6		C ₁₃ = 2, 3, 4	2, 5, 7
	C ₃ < 30%	1–3		C ₁₃ = 1	1
C ₄	C ₄ > 70%	7–9	C ₁₄	C ₁₄ > 100	9
	30% ≤ C ₄ ≤ 70%	4–6		100 ≤ C ₁₄ < 10	2–8
	C ₄ < 30%	1–3		C ₁₄ ≤ 10	1
C ₅	C ₅ > 100	8–9	C ₁₅	High	7–9
	10 ≤ C ₅ ≤ 100	3–7		Medium	4–6
	C ₅ < 10	1–2		Low	1–3
C ₆	C ₆ < 30%	7–9	C ₁₆	High	7–9
	30% ≤ C ₆ ≤ 70%	4–6		Medium	4–6
	C ₆ > 70%	1–3		Low	1–3
C ₇	C ₇ < 30%	7–9	C ₁₇	High	7–9
	30% ≤ C ₇ ≤ 70%	4–6		Medium	4–6
	C ₇ > 70%	1–3		Low	1–3
C ₈	More	7–9	C ₁₈	High	7–9
	Medium	4–6		Medium	4–6
	Less	1–3		Low	1–3
C ₉	C ₉ > 50	8–9	C ₁₉	C ₁₉ > 50	8–9
	20 ≤ C ₉ ≤ 5	3–7		10 ≤ C ₁₉ ≤ 50	3–7
	C ₉ < 20	1–2		C ₁₉ < 10	1–2
C ₁₀	C ₁₀ ≥ 2	9	C ₂₀	C ₂₀ > 100	8–9
	C ₁₀ = 1	5		20 ≤ C ₂₀ ≤ 100	3–7
	C ₁₀ = 0	1		C ₂₀ < 20	1–2

Table 8. The interpretation by formula.

Evaluation System	Value	Weight	Sequence Parameters
Target layer	A	-	-
Criterion layer	B _i	β _i	i = 1–4
Indicator layer	C _j	γ _j	i = 1, j = 1, 2
			i = 2, j = 3–8
			i = 3, j = 9–12
			i = 4, j = 13–20

Table 9. The final score of the heritage value of the six RH sites.

Indicator	CER	DV	JQ	BZ	BC	BS
C ₁	0.7284	1.0926	0.2428	0.3642	0.9712	0.6070
C ₂	0.1818	0.1414	0.1616	0.1212	0.0606	0.0404
C ₃	0.2264	0.0283	0.0283	0.1415	0.1132	0.2547
C ₄	0.4956	0.2832	0.2832	0.3540	0.4248	0.5664
C ₅	0.7596	0.5908	0.5908	0.4220	0.3376	0.2532
C ₆	0.0816	0.0816	0.0306	0.0510	0.0204	0.0918
C ₇	0.0976	0.0122	0.0244	0.0366	0.0366	0.1098
C ₈	0.3123	0.2082	0.2429	0.1735	0.1041	0.0694
C ₉	1.4481	1.1263	0.6436	0.1609	0.1609	0.1609
C ₁₀	0.3357	0.1865	0.3357	0.0373	0.0373	0.0373
C ₁₁	0.0614	0.2763	0.0307	0.0307	0.0921	0.0307
C ₁₂	0.6400	0.6400	0.6400	0.0800	0.1600	0.0800
C ₁₃	0.0686	0.0196	0.0098	0.0196	0.0490	0.0098
C ₁₄	0.2304	0.0768	0.1280	0.0256	0.1792	0.0256
C ₁₅	0.8712	0.7744	0.7744	0.4840	0.484	0.2904
C ₁₆	0.7884	0.7884	0.7008	0.7008	0.7008	0.5256
C ₁₇	0.1200	0.0150	0.0300	0.0300	0.0300	0.0450
C ₁₈	0.1556	0.2334	0.1556	0.3501	0.3112	0.3112
C ₁₉	0.0522	0.0174	0.1218	0.0870	0.1392	0.0696
C ₂₀	0.1602	0.0712	0.1246	0.0890	0.0890	0.0534
<hr/>						
$A = \sum_{i=1}^4 B_i \beta_i$	7.8151	6.6636	5.2996	3.7590	4.5012	3.6322
$B_1 = \sum_{j=1}^2 C_j \gamma_j$	0.9102	1.2340	0.4044	0.4854	1.0318	0.6474
$B_2 = \sum_{j=3}^8 C_j \gamma_j$	1.9731	1.2043	1.2002	1.1786	1.0367	1.3453
$B_3 = \sum_{j=9}^{12} C_j \gamma_j$	2.4852	2.2291	1.6500	0.3089	0.4503	0.3089
$B_4 = \sum_{j=13}^{20} C_j \gamma_j$	2.4466	1.9962	2.0450	1.7861	1.9824	1.3306

3. Results

It can be seen from the β in Table 5 that B_3 and B_4 were the most prominent factors in the system of value evaluation. γ presents the degree of influence that the indicators have for each of the criterion layers. That is, the higher the value, the more decisive it is to the criterion layer. Therefore, C_1 had a decisive role in the technical difficulty; C_4 and C_5 were the key factors on judging the evidential value; the impact of C_9 on cultural communication was far more influential than others; C_{15} and C_{16} were helpful in assessing the social value of a RH. From a holistic perspective, δ was the result of multiplying the weight of the criterion layer by the weight of the indicator, meaning the extent to which indicators had an influence on the target (the overall value evaluation). For example, C_9 , C_{15} , and C_{16} played the most significant role in assessing the heritage value.

Table 9 indicates the results of the value evaluation for each RH. The comprehensive value (A) for the RH sites were ranked as follows: CER, DV, JQ, BC, BZ, and BS. By comparing the data in Table 9, the value advantages for each RH can be interpreted.

In terms of technical difficulty (B_1), the scores of DV ($B_1 = 1.2340$) and BC ($B_1 = 1.0318$) were considerably higher than the other four. Railway civil engineering projects, such as bridges, tunnels, and line extensions, were the carriers of the technical level. They are elaborately designed and constructed to ensure that trains successfully transverse mountains, rivers, and valleys. Therefore, these higher scores represent the extreme challenges of topography and climate showing on the structure and form of railway engineering projects, such as the Baizhai and Wujiashai railway bridges of the Dian–Vietnam Railway (Figure 2) and the Qin Ling line extension of the Baoji–Chengdu Railway

(Figure 3). Because of the complicated environment in which these sites exist, railway engineering heritage projects have always had a close relationship with the natural environment. As a result, the technical landscape and natural environment form a scenic cultural landscape which is a tourism attraction with high appreciation value.



Figure 2. Railway bridges of DV: (a) Baizhai railway bridge [31]; (b) Wujiashai railway bridge [32].

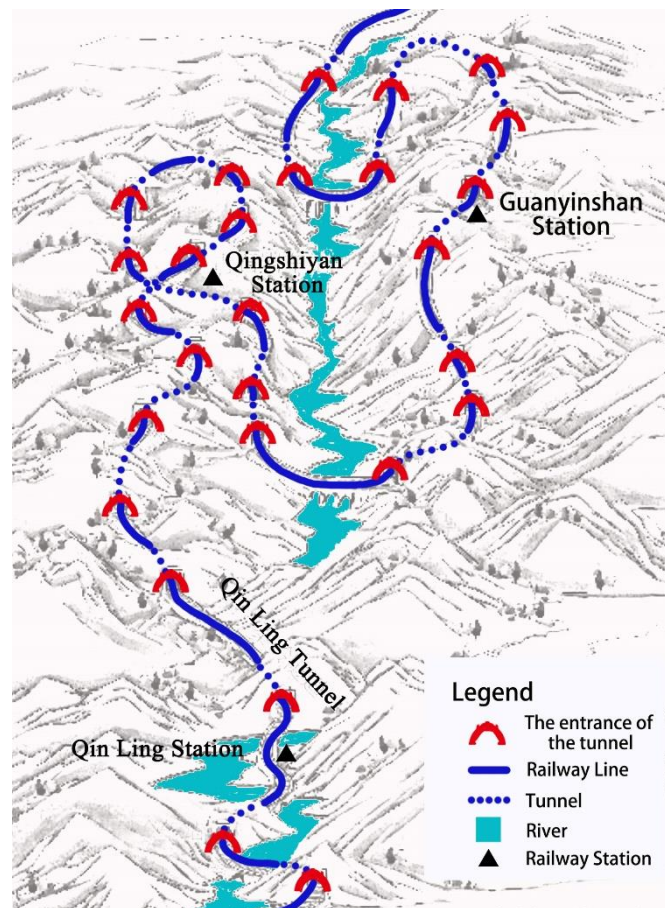


Figure 3. Qin Ling part of the BC.

With regard to the evidential value, the Chinese Eastern Railway ($B_2 = 1.9731$) and the Ba Shi Railway ($B_2 = 1.3453$) ranked as the top two. For CER, C_5 had the highest score because of the huge number and abundant types of heritage remains such as Hengdaohezi Village (Figure 4). Both C_3 and C_7 of the BS were higher than the other RH sites, demonstrating its high integrity. Furthermore, the BS is still in operation using the traditional power mode (Figure 5), addressing its authenticity supported by the score of C_3 (0.2547) and C_4 (0.5664). Therefore, both of them denoted that RH evidential value

can be judged by authenticity and integrity. In addition, if the heritage is rare, complete, and authentic, it could be a treasure of scientific research, especially for historians, archaeologists, and preservationists.

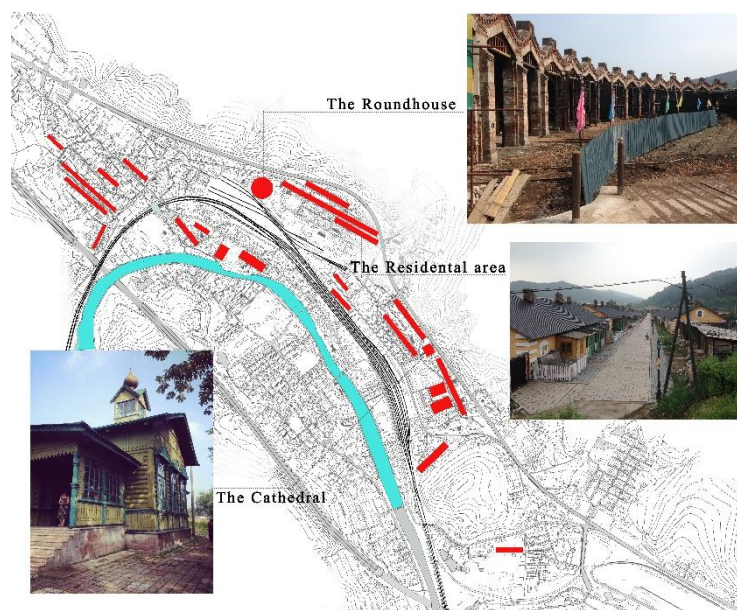


Figure 4. The heritage distribution of Hengdaohezi Village of the CER.



Figure 5. Ba Shi Railway that is still in operation [33].

In the matter of cultural communication, it is a special item of RH because of the function of transportation. Coincidentally, it matches the attribute of cultural route. According to Table 9, B₃ of CER, DV, and JQ far exceeded the remaining three. The common character uniting the three was their colonial connections (French, Russian, and German, respectively). Furthermore, DV is a cross-border

railway between China and Vietnam and CER is the Chinese section of the Siberian Railway that extends into Russia. Thus, they are excellent examples of the cultural diffusion of railways. While the railways share colonial histories, their cultural traits differ based upon the origins of their colonizers. For instance, DV not only carries French colonial genes, but it also goes through a landscape inhabited by twelve different ethnic groups. Its cultural diversity is much more prominent than others. Above all, regardless of the origins, urban landscapes along the railway were the important harbors of transplanted culture, especially as seen in the architectural styles displayed in historic structures like railway stations, administrative offices, and public buildings (Figure 6).

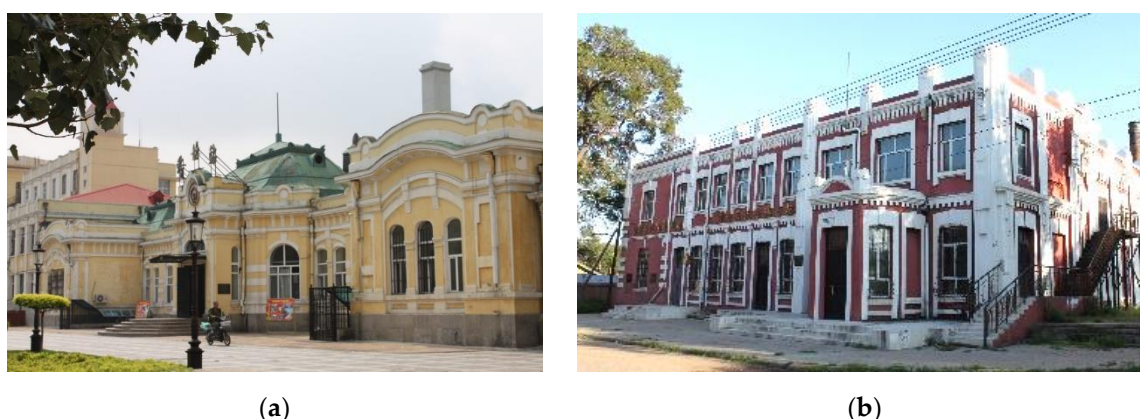


Figure 6. Different styles of architecture: (a) the railway station of CER in Harbin; (b) the Workers Club of CER in Angangxi.

It can be seen from B_4 in Table 9 that CER and JQ ranked in the top two and DV and BC followed. Combined with the results in Table 5, C_{15} and C_{16} had a positive influence on assessing social value. Besides that, C_{18} presented a higher score in the field of social impact, especially on DV and BZ. Taking CER as an example, the value of C_{14} (0.2304) was positively correlated with B_4 (2.4466). In conclusion, there were two facets to the social impact of railways. On the one hand, it refers to the transportation and economic contributions to a region of a railway like the meanings of C_{15} and C_{16} . To an extent, it is proof of the evidential value of cultural, political, and economic improvement. On the other hand, social impact can be expressed from the attitude of the public (C_{18}). For instance, the public recognition of and the emotional connection to this history of transportation. Compared with the other three value types, social impact mainly reflects the intangible layers of heritage, spirit, and emotion.

4. Discussion

According to the analysis reported in Table 9, we obtained the value advantage by comparing the value of B of each RH shown in Table 10. There is an abundance of RH resources in China competing for heritage tourism development. The benefit of developing RH tourism in a sustainable way is the capacity to transform a depressed region into a sustainable tourism-based economy [16]. Thus, from the perspective of heritage tourism development, we put forward development proposals that match the potential of RH based on the result of the comparison shown in Table 10.

Table 10. The value advantage of the six RH sites.

The Value Advantage	CER	DV	JQ	BZ	BC	BS
B_1 Technical Difficulty		1			2	
B_2 Physical Evidence	1					2
B_3 Cultural Communication	2	1				
B_4 Social Impact	1		2			

Notes: “1” represents the first ranking of value advantage; “2” represents the second ranking of value advantage.

4.1. Chinese Eastern Railway (CER)

As you can see from Table 10, B₂ Physical Evidence and B₄ Social Impact occupy the top rating, and B₃ Cultural Communication is ranked second. That is, CER is a RH with comprehensive advantages. The CER is regarded as the initial evidence of the modernization of the northeast of China [34] because of the multiple architectural heritage sites, the large numbers of historic infrastructures, etc. To some extent, physical evidence supports and demonstrates facets of social impact. Thus, the advantage of physical evidence and social impact can be integrated. Meanwhile, according to the scores of the indicators (C₃–C₈) in Table 9 that affect physical evidence, the authenticity of CER demonstrates the advantage of evidence such as the historic operating train and the historic station. In other words, since CER maintains its historical qualities, it can provide a more realistic historical environment for visiting, appreciation, and reflection. With regards to tourism, CER has the potential to provide an opportunity to learn regional history by train and experience the exotic landscape along the route. Additionally, the Russian colonial experience is a hook that needs to be included in thematic planning.

4.2. Dian–Viet Railway (DV)

Both B₁ Technical Difficulty and B₃ Cultural Communication are two prominent advantages of the Dian–Viet Railway as shown in Table 10. However, technology is often so abstract that it is hard to understand or appreciate without interpretation. We can best interpret technological sites with the help of the environment in which the projects are located. As can be seen in Tables 2 and 3, these indexes depict the complexity of the DV construction environment. Generally speaking, the more complex the natural environment, the more dramatic and scenic the landscape. Certainly, accessibility to tourism will also be correspondingly challenged. The DV spans three river systems and three climates zones that connect visitors to rich natural resources with great scenic value. That is, the technical advantage often coexists with a high appreciation value of the site in which heritage are located. Thus, engineering heritage projects and the natural environment are integrated perfectly as a cultural landscape, laying the foundation for heritage tourism development. This way, heritage and environment combine as an effective strategy towards sustainable development of heritage tourism.

In terms of cultural communication, DV is similar to CER. The biggest variance is the different dominant cultures, since DV was built and managed by the French. Moreover, the railway passes through a landscape representing twelve ethnic minorities in the Yunnan Province of China. All these conditions bring about a high level of cultural diversity, while the dimension of experience will be more abundant. Currently, the railway is abandoned but maintained. Given these limitations and merits, choosing a section of this railway rich in heritage and natural resource as a tourism attraction that creates a cultural trail for bikes, walkers, and other forms of non-motorized transportation is a feasible way.

4.3. Jinan–Qingdao Railway (JQ)

The Jinan–Qingdao Railway scored second highest in B₄ Social Impact by virtue of the higher C₁₅ and C₁₆ scores. The role of the railway in the historic and social development of Shan Dong Province provides an argument for tourism based on Social Impact. Although it is a colonial railway like CER and DV, historic resources are scarce, and most are abandoned, confined to urban areas and are considerably fewer than the colonial resources of the CER and DV railways. Therefore, it seems most suitable to develop heritage tourism based around urban landscapes along the railway with their distinct social history. Certainly, the German feature of the urban landscape also has the opportunity to provide an exotic tourism experience.

4.4. Beijing–Zhangjiakou Railway (BZ)

The Beijing–Zhanjiakou Railway has no apparent value advantages (Table 10) when compared to the other five railways. However, that does not mean that it lacks special RH features. Actually, in an

overview of China railway heritage, BZ is indeed an important representative of the localization of foreign technology [35], and its railway history is highly regarded. In Table 9, we found that the score for public acceptance and identity ($C_{18} = 0.3501$) was much higher than the other five railways. This is likely based upon BZ being the first railway designed and built by China alone. Moreover, because it traverses the Chinese capital, it is widely recognized. It is worth mentioning that the engineer of BZ, Tianyou Zhan, is known as the father of the Chinese railway, and descriptions of his career are included in school textbooks as encouragement for young students. Therefore, based on its unique location and the reputation it carries, it has the unique potential to create an educational place like a series of museums that display the history of national railways.

4.5. Baoji–Chengdu Railway (BC)

The Baoji–Chengdu Railway scored second highest for B_1 Technical Difficulty. As can be seen in Tables 2 and 3, the data on the minimum radius of curve and the number of tunnels and bridges exceeded the other railways. It demonstrates the complexity of the site. According to the historic record, its builders spent over half a century surveying, conceiving, and designing the railway, and it is considered a milestone in Chinese transportation history. Nowadays, it is nearly abandoned because of the rapid development of newer, advanced technologies. However, the engineering and construction heritage should be preserved. Highlighting so many outstanding engineering projects, such as tunnels and bridges, with rich tourist experiences can be a basis for developing a series of heritage. At the same time, its partial abandonment provides opportunities for linear bike and pedestrian trails to appreciate these engineering projects.

4.6. Ba Shi Railway (BS)

The Ba Shi Railway scored second highest in B_2 Physical Evidence. As can be seen from C_3 , C_4 , C_6 , and C_7 in Table 9, it provided sufficient evidence of outstanding integrity and authenticity. As a rare narrow-gauge railway, it is widely known for its authenticity, operating steam engines, and global reputation for being a living fossil of the industrial revolution and has the potential for providing research sites for study by historians, preservationists, and industrial archaeologists. This means that physical evidence determines the advantage of integrity and authenticity of the RH which contributes to the improvement of a tourism attraction. Definitely, maintaining the original running mode is a sustainable way to hold its integrity for heritage conservation. In light of the suitable railway's length and the comfortable running speed, developing a steam railway tourism route that combines historic steam engines, the scenic landscape, and transportation is a win–win for preserving heritage with economic benefits.

5. Conclusions

The motivation for this research was our concern for the survival of the large numbers of RH sites in China, how to make these heritage sites last, and how to plan for sustainable sites and tourist experiences. Prior work has documented effective approaches in developing and protecting RH sites. However, taking RH into a broader context has been more or less neglected, and this is an essential part of the sustainable development of RH. This paper provides a comprehensive approach on how to define a focus on sustainable RH tourism development. We tried to find the merit of each RH site which contributed to development individually and differently.

According to the value of A in Table 9, the comprehensive value of the six was sorted in descending order: CER, DV, JQ, BC, BZ, and BS. Although BS ranked at the bottom, it does not mean that BS loses the opportunity to be developed or protected. That is, the ranking cannot be completely used as a sole criterion for evaluating RH or making decisions, especially in sustainable tourism development. Applying the AHP method was an effective way to reveal the importance of each indicator and the relationships among these indicators which laid a solid foundation for analyzing the advantages of each RH by comparison, aimed at choosing the best of the best rather than judging good or bad. The findings

indicated that the value advantage of a RH site can be regarded as a comparative advantage which has the potential to guide the positioning of tourism development or support decision making, especially in a fiercely competitive environment. Practically, it helps to fundamentally avoid the probability of homogenization of RH tourism regarding sustainable tourism development. This approach also has potential in broader areas such as linear heritage.

In addition, acknowledging the limitations of this study will provide guidance for future research. In this study, we did our best to minimize the subjective limitations of the AHP method. However, there is still a need for improvement such as the quantification of indicators. Moreover, only six RH sites were selected in this research. With the anticipated gradual increase in the number of global RH sites, we are not sure that the advantage of each can be obtained clearly by just relying on value comparison. That is, further research should use this method with modifications to examine whether the findings are effective and replicable.

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