DOI 10.15302/J-SSCAE-2020.06.021

Potential Measurement and Mode Selection of Tourism Development at Mining Sites of Coal Resource-Based Cities in China

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Abstract: Tourism development is an important channel for realizing the economic transformation of closed coal mines. The suitability and modes of tourism development at mining sites in coal resource-based cities are determined by their tourism development potential. Measuring the tourism development potential of mine sites and identifying their development types has become an urgent research topic in the field of tourism development. In this study, we established a model to measure the tourism development potential of mine sites from three aspects: mine tourism resources, mine development conditions, and urban development environment; we also conducted empirical research on the tourism development potential of mine sites in China's coal resource-based cities. The results show that mine sites in such cities have distinctive tourism development potential, and the top 10 cities with the highest potential are Xuzhou, Handan, Zaozhuang, Xingtai, Jiaozuo, Zhangjiakou, Datong, Huainan, Pingdingshan, and Fushun. The spatial pattern of development potential is represented as two core regions and three centers. Therefore, coal resource-based cities should select their development modes based on resource values, development potentials, and spatial patterns. Tourism development plans for mine sites should be formulated timeously, guided by the government and supported through multilateral cooperation.
Keywords: coal resource-based city; industrial heritage; tourism development; potential measurement; development mode

1 Introduction

At present, due to the continuing decline in economic growth, the demand for coal is shrinking, leading to oversupply and an increase in coal mine closures annually, thereby undermining the sustainable development of coal resource-based cities in China. It has become a necessary and urgent task to seek alternative emerging industries and to promote the economic transformation of coal resource-based cities.

Tourism development is an important channel for the economic transformation of mining sites in resource-based cities. The northern part of Manchester City, the Ruhr District of Germany, the Lorraine District of France, and other historic industrial areas have realized the sustainable development of regional economy through tourism development of abandoned mines [1]. Since 2004, China has begun to explore the development of tourism industry at abandoned mines to support tourism development of resource-based cities. China has approved the establishment of 88 national mining parks and issued various policy documents, including the *Outline for the Development of*

Received date: May 19, 2019; **Revised date:** June 24, 2020
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Funding program: CAE Advisory Project "Research on China's Coal Mine Safety and Exploitation and Utilization Strategy of Abandoned Coal Mines (Phase II)" (2020-XZ-13)
Chinese version: Strategic Study of CAE 2020, 22 (6): 158–166
Cited item: Wang Qiuju et al. Potential Measurement and Mode Selection of Tourism Development at Mining Sites of Coal Resource-Based Cities in China. *Strategic Study of CAE*, https://doi.org/10.15302/J-SSCAE-2020.06.021

National Industrial Tourism (2016–2025) (Draft for Public Opinion), the *13th Five-Year Plan for Tourism Development*, and *Opinions on Exploring the Use of Marketization to Promote Mine Ecological Restoration*. Over time, the coal tourism industry resources have evolved, and the value and condition of these tourism resources vary. Therefore, the overall tourism development potential of mine sites in coal resource-based cities in China varies, and suitable development modes also vary. In this context, it is necessary to strengthen research on the measurement of tourism potential and the identification of suitable tourism product types and modes of mining site tourism development in coal resource-based cities.

There has been extensive research on the investigation and protection of industrial heritage and the value and development mode of mining tourism resources [2–7]. However, from the perspective of resource-based cities, the measurement of mining site tourism development potential is relatively limited, with some deficiencies: (1) Existing studies assess the potential of mine tourism resources from the perspective of resources. There is inadequate research and evaluation on the conditions for tourism development, specifically in terms of the external conditions on which mines depend; (2) There has been growing research on models for mining site tourism development [8]. However, the tourism development mode of coal mining industrial sites is seldom studied from the perspective of coal resource cities. Although research results are cited, these have not been linked with the tourism development potential of the mining site and do not provide a scientific basis for screening the development mode of mining site tourism in coal resource-based cities.

Gunn proposes the theory of tourism development potential, which considers tourism resources and development conditions as important factors in the evaluation of tourism development [9] and lays a theoretical foundation for the measurement of the tourism development potential and identification of the type of tourism product in resource-based cities. Therefore, based on the theory of tourism development potential, this study focuses on mining tourism resources, mining development conditions, urban development environment, and other dimensions, as well as conducts research on the identification model of mining sites' tourism development potential of coal resource-based cities. For key coal mines, the entropy method is adopted to comprehensively evaluate the tourism development potential of several mine sites and identify their potential types. The development mode and suggestions of mine sites in coal resource-based cities are introduced to provide theoretical reference for promoting the economic transformation of coal resource-based cities.

2 Mining site tourism development potential model for coal resource-based cities

The mining site tourism development potential of coal resource-based cities is evaluated to assess whether the city has the necessary conditions for tourism development. Based on existing research and the theory of tourism development potential, a tourism development potential model of mining sites in coal resource-based cities is constructed (Fig. 1).

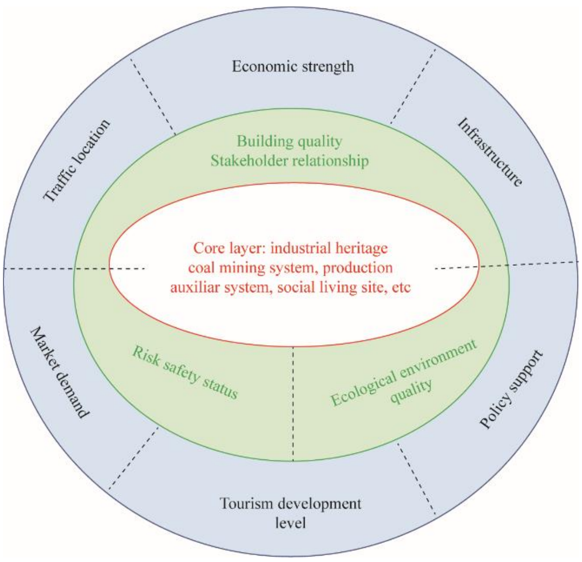

Fig. 1. Potential model of mining sites tourism development.

The core layer of the model is the mining site tourism resource, which is the precondition for tourism development.

DOI 10.15302/J-SSCAE-2020.06.021

Mine tourism resources are divided into three primary categories: industrial heritage, mining production of undisturbed natural and cultural resources, and general land resources regarded as potential tourism resources. Industrial heritage has the highest value in terms of the mining tourism resources, represented by industrial cultural relics with historical, technical, social, architectural, or scientific values [10]. These resources include coal mine open pits, mine production buildings, coal preparation plants, screening plants, raw coal loading and storage/transportation systems, drainage and water supply systems, ventilation systems, lighting systems, power equipment (such as substations, engine rooms, pump rooms, compressor rooms, and boiler rooms), and social activity sites associated with the coal mines [11]. Moreover, higher value industrial heritage resources are more appealing to tourists.

The middle layer of the model is the mine development condition. Coal mining directly impacts significant land resources, including the ecological environment and stability of the geology and soil, thereby causing soil erosion, mine surface collapse, mining slope landslides, debris flow, and other geological disasters [12]. Mining site tourism development must consider the site's ecological environment quality and risk safety status. The greater the ecological environment quality and risk safety status and the lower the development cost, the more conducive the site is to tourism development. The quality of buildings on the mine sites is another important factor affecting the tourism development of mine sites. The better the safety condition of the building structures and the lower the cost of reuse and restoration, the greater the potential for tourism development. Development enterprises, local governments, foreign tourists, residents, and other stakeholders play an important role in the process of industrial heritage protection, utilization, and management. The degree of collaboration and participation of stakeholders will directly affect the feasibility and success of tourism development.

The outer layer of the model relates to the urban development environment. The tourism industry depends on and influences the macro-environment. Its development depends on the source market, and its operation involves many other sectors, including food, accommodation, transportation, tourism, shopping, and entertainment Mining site tourism is supported by a diverse tourism market and the urban public infrastructure and social service system.

In developing the mining relic tourism development potential model for coal resource-based cities, this study adopts the principles of international and Chinese policy and standards, including the *Nizhny Tagil Charter for Industrial Heritage* (2003), *Dublin Guidelines* (2011), *Taipei Declaration on Asian Industrial Heritage* (2012), and a series of guidelines and policies issued recently by China (Table 1). (1) In terms of industrial heritage, five indexes, namely historical, scientific, aesthetic and spiritual, socio-cultural, and ornamental and recreational values were selected to reflect the value of tourism elements and resource influence; (2) in terms of mine development conditions, ecological environment quality, risk safety status, building quality, and stakeholder engagement were selected as indicators of the development conditions of the mine itself; (3) In terms of the urban development environment, six indicators, namely economic strength, traffic location, infrastructure, market demand, tourism development level, and policy support, were selected to reflect the macro supporting conditions for mining site tourism development.

Table 1. Measurement system of mining site tourism development potentials in coal resource-based cities.

Rule layer	Index layer	Specific index quantification standard
Industrial heritage	Historical value	Construction time of industrial heritage and its relevance to historical events or figures [13]
	Scientific value	Production process, technical originality, and influence [14]
	Aesthetic and spiritual value	Visual impact and spiritual value
	Socio-cultural value	Relevance with historical figures and events
	Ornamental and recreational value	Resource complementarity, personality, style, and visual elegance
Development condition of mining area	Ecological environment quality	Degree of natural resource protection, land pollution, water pollution, and air pollution
	Risk safety status	Geological and hydrological risks, and possibility of fire, explosion, collapse, etc.
	Building quality	Building structure and safety condition [15]
	Stakeholder engagement	Degree of participation
	Stakeholder collaboration	Relationship between landowners and stakeholders of the mining city
Urban development environment	Economic strength	Level of economic development
	Traffic location	Proximity of the mining area to the central city, proximity of the target market and accessibility
	Infrastructure	Level of municipal public engineering facilities and public service facilities [16]
	Market demand	Tourism market capacity, leisure time of tourist source, and income level
	Tourism development level	Tourism industry rationalization and development level
	Policy support	Laws and regulations for mine ecological restoration and tourism development

3 Measurement of potential of mining sites tourism in coal resource-based cities

3.1 Data source

According to the *National Sustainable Development Plan for Resource-Based Cities (2013–2020)*, China has 262 resource-based cities (73 coal resource-based cities), including 31 growing cities (14 coal resource-based cities), 141 mature cities (33 coal resource-based cities), 67 declining cities (23 coal resource-based cities), and 23 regenerative cities (3 coal resource-based cities). Due to insufficient data for Qiannan Buyi and Miao Autonomous Prefecture and Jiutai City (now Jiutai District of Changchun City), this study considers the mining site tourism development potential in the remaining 71 coal resource-based cities. Relevant data were sourced from the *China Statistical Yearbook*, *China Tourism Statistical Yearbook*, *China City Statistical Yearbook*, and local chronicles.

3.2 Tourism development potential measurement

As China lacks statistical data on the industrial heritage and mine development conditions of coal resource-based cities, this study focuses on the industrial heritage and urban development environment aspects. The age of key coal mining is selected as the evaluation standard to measure the industrial heritage dimension, considering the large scale and long history of key coal mines in coal resource-based cities, and the high value of corresponding industrial heritage. From the emergence of the modern coal industry to the founding of the People’s Republic of China (1840–1949), 0.8–1.0 points were assigned to the coal mines; further, 0.6–0.8 points were assigned for the initial development stage of the socialist coal industry of New China (1949–1958), 0.4–0.6 points were assigned during the period from the second Five-Year Plan to the third Five-Year Plan for the development of the socialist coal industry (1958–1970), and 0.2–0.4 points were assigned during the development of modern socialist coal industry (1970 to present).

Accordingly, 13 industry experts were invited to score the studied coal resource-based cities. The values were optimized and adjusted based on the degree of preservation of the coal mine industrial heritage. Table 2 presents the location and age of key coal mines in coal resource-based cities.

Table 2. Distribution of coal resource-based cities and key coal mines.

Type	City (key coal mine, year of construction)
Growth type	Prefecture-level cities: Shuozhou, Ordos, Liupanshui (Liuzhi Mining Area, 1965), Bijie, Qiannan Buyi and Miao Autonomous Prefecture, Zhaotong, Yulin; County-level cities: Holingol, Xilinhot, Yongcheng, Yuzhou, Lingwu, Hami, Fukang
Mature type	Prefecture-level cities: Zhangjiakou (Pagoda Mining Area, 1949), Xingtai (Lincheng Coal Mine, 1878), Handan (Fengfeng Coal Mine, 1953), Datong (Bao Jin Coal Company, 1907), Yangquan (Yangquan Three Ore,1907), Changzhi (Shigejie Coal Mine, 1920), Jincheng (Ancient Academy Mine, 1958), Xinzhou, Xinzhou Kiln, 1940), Jinzhong (Baojin Coal Mine, 1905), Linfen, Yuncheng, Lvliang, Jixi (Jixi Mining Area, 1914), Suzhou, Bozhou, Huainan (Huainan Coal Mine 1897), Jining, Sanmenxia (Coal Mine of the People’s Livelihood, 1920), Hebi (Shilihe Coal Mine, 1895), Pingdingshan (Pingdingshan Coal Mine, 1956), Loudi, Guangyuan (Guangwang Coal Mine, 1958), Dazhou, Anshun, Weinan, Pingliang; County-level cities: Gujiao, Diaobingshan, Dengfeng, Xinmi, Gongyi, Xingyang, Mianzhu
Recession type	Prefecture-level cities: Wuhai (Wuda Coal Mine, 1958), Fuxin (Fuxin Coal Mine, 1953), Fushun (Fushun West Strip Mine, 1901), Liaoyuan (Xi’an Coal Mine, 1912), Hegang (Hegang Coal Mine, 1917), Shuangyashan (Fujin Coal Mine, 1930), Qitaihe (Boli Coal Mine, 1958), Huaibei (Xiangcheng Coal City, 1958), Pingxiang (Anyuan Coal Mine, 1898), Zaozhuang (Zhongxing Coal Mine, 1879), Jiaozuo (Zhongfu Coal Mine, 1902), Tongchuan (Wangshiao Coal Mine, 1957), Shizuishan (Shitanjing Coal Mine, 1957); County-level cities: Huozhou (Huozhou Coal Mine, 1958), Beipiao (Beipiao Coal Mine, 1915), Jiutai (Yingcheng Coal City, 1908), Xintai (Xinyu Coal Mine, 1922), Leiyang, Zixing, Lengshuijiang (Xikuangshan Antimony Mine, 1860), Lianyuan (Lianshao Coal Mine, 1958), Heshan (Heshan Coal Mine, 1919), Huaying (Huayingshan Coal Mine, 1966)
Regeneration type	Prefecture-level cities: Tonghua (Tonghua Mining Bureau, 1948), Xuzhou (Jiawang Coal Mine, 1898); County-level city: Xiaoyi

Note: Data sources include local chronicles, local tourism development plans, relevant academic literature [17–19], official tourism websites, and field investigations, etc.

The per capita gross domestic product (GDP); traffic volume of highways, waterways, and civil aviation; urban

DOI 10.15302/J-SSCAE-2020.06.021

road area; total retail sales of social consumer goods; and the number of employees in culture, sports, and entertainment industries were selected as indicators of urban economic strength, traffic location, infrastructure, market demand, and tourism development level.

The entropy method was used to synthesize the indicators of the tourism development potential of coal resource-based cities. Initially, the extreme standardization method was adopted for coal resource-based urban mines (the value interval after processing is [0,1]), and the corresponding calculation formula is as follows:

$$X_{ij}^{'} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}; i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m \tag{1}$$

In Equation (1), X_{ij} is the i th mining site tourism development potential index of the j_{th} coal resource-based city, and $X_{ij}^{'}$ is the standardized index. Then, the information entropy value e_j and information effect value d_j are expressed as

$$e_j = -K \sum_{i=1}^{m} X_{ij}^{'} \ln X_{ij}^{'} \tag{2}$$

In Equation (2), K is related to the number of coal-resource-based cities, m. When m samples are in a completely disordered distribution state, $X_{ij} = 1/m$ and $K = -1/\ln m$. The information effect value d_j is the difference between e_j and 1. The larger the d_j value, the more important the indicator.

Finally, the weight of the tourism development potential of the j_{th} mine site and the tourism development potential of the i_{th} resource-based city are solved.

$$w_j = d / \sum_{j=1}^{m} d_j \tag{3}$$

$$s_{ij} = \sum_{j=1}^{m} w_j X_{ij}^{'} \tag{4}$$

The entropy method was adopted to obtain the development potential of 71 cities in terms of the urban development environment dimension and the comprehensive development potential based on a combination of the industrial heritage value and urban development environment dimensions (Table 3). Coal resource-based cities exhibit differences in industrial heritage, urban development environments, and comprehensive development potential. The top 10 cities in terms of the development potential of urban development environment dimension are: Xuzhou, Handan, Jining, Xingtai, Ordos, Zaozhuang, Zhangjiakou, Jiaozuo, Bijie, and Pingdingshan. The top 10 cities in terms of the comprehensive potential are: Xuzhou, Handan, Zaozhuang, Xingtai, Jiaozuo, Zhangjiakou, Datong, Huainan, Pingdingshan, and Fushun.

3.3 Spatial distribution of tourism development potential

The density analysis function module of ArcGIS10.1 software was used to perform kernel density analysis on the tourism development potential of mine sites in coal resource-based cities, thereby exploring the spatial distribution. In the calculation process, the mining site tourism development potential is regarded as a population field, and factors are weighted according to the degree of importance. Kernel density analysis is generally set at a certain point x, and $f(x)$ is calculated using the Rosenblatt–Parzen formula:

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^{n} k\left[\frac{x - x_i}{h}\right] \tag{5}$$

In Equation (5), $k\left[\frac{x - x_i}{h}\right]$ is the kernel function, $h > 0$ is the bandwidth, and $x - x_i$ is the distance from the estimation point to x the event point x_i.

To obtain better results, the search radius (200 km) was set several times during the analysis to perform the numerical tests. In China, the spatial distribution of mining sites tourism development potential in coal resource-based cities is characterized by agglomeration, with a spatial pattern of two cores and three centers. Two cores represent the high-value areas of mining site tourism development potential. The first is distributed in the northern part of East China, surrounding Zaozhuang, Jining, Xuzhou, Huainan, Huaibei, and other cities; the second is distributed in the southern part of North China and the northern part of Central China, surrounding Zhangjiakou, Handan, Xingtai, Jiaozuo, Jinzhong, Yangquan, Datong, and other cities. The three centers primarily refer to the northern part of Northeast China, the central part of Liaoning Province, and the middle part of regions south of the Yangtze River. The cities of Jixi, Hegang, Shuangyashan, and Qitaihe are in the northeast; Fushun, Fuxin, Liaoyuan, and Beipiao are in the central part of the Liaoning Province; and Pingxiang, Lengshuishan, Lianyuan, and Zixing are in the middle part of regions south of the Yangtze River.

Table 3. Results of evaluation of mining site tourism development potential of coal resource cities.

City	Industrial heritage	Development environment	Comprehensive potential	City	Industrial heritage	Development environment	Comprehensive potential
Shuozhou	0.412	0.202	0.385	Anshun	0.246	0.215	0.299
Erdos	0.433	0.580	0.554	Weinan	0.253	0.410	0.382
Liupanshui	0.671	0.322	0.593	Pingliang	0.356	0.188	0.345
Bijie	0.215	0.472	0.377	Gujiao	0.482	0.074	0.375
Zhaotong	0.241	0.309	0.326	Diaobingshan	0.274	0.296	0.349
Yulin	0.436	0.330	0.451	Dengfeng	0.291	0.249	0.296
Holingol	0.228	0.414	0.368	Xinmi	0.245	0.256	0.299
Xilinhot	0.221	0.187	0.265	Gongyi	0.216	0.261	0.302
Yongcheng	0.654	0.222	0.564	Xingyang	0.285	0.268	0.305
Yuzhou	0.287	0.244	0.323	Mianzhu	0.288	0.192	0.267
Lingwu	0.246	0.312	0.337	Wuhai	0.443	0.268	0.411
Hami	0.245	0.256	0.299	Fuxin	0.896	0.272	0.624
Fukang	0.216	0.202	0.272	Fushun	0.993	0.353	0.747
Zhangjiakou	0.843	0.545	0.787	Liaoyuan	0.912	0.330	0.683
Xingtai	0.842	0.668	0.836	Hegang	0.876	0.249	0.602
Handan	0.865	0.880	0.930	Shuangyashan	0.954	0.269	0.657
Datong	0.991	0.278	0.758	Qitaihe	0.848	0.242	0.597
Yangquan	0.995	0.177	0.735	Huaibei	0.823	0.290	0.618
Changzhi	0.902	0.301	0.733	Pingxiang	0.991	0.311	0.728
Jincheng	0.853	0.248	0.677	Zaozhuang	0.997	0.557	0.852
Xinzhou	0.743	0.253	0.607	Jiaozuo	0.993	0.544	0.820
Jinzhong	0.908	0.285	0.725	Tongchuan	0.964	0.143	0.597
Linfen	0.203	0.314	0.308	Shizuishan	0.823	0.177	0.560
Yuncheng	0.206	0.346	0.327	Huozhou	0.621	0.240	0.497
Lvliang	0.269	0.279	0.332	Beipiao	0.932	0.291	0.669
Jixi	0.903	0.277	0.714	Xintai	0.925	0.331	0.687
Suzhou	0.236	0.435	0.379	Leiyang	0.213	0.218	0.280
Bozhou	0.498	0.401	0.519	Zixing	0.735	0.234	0.535
Huainan	0.943	0.333	0.755	Lengshuijiang	0.854	0.220	0.572
Jining	0.434	0.806	0.646	Lianyuan	0.695	0.192	0.526
Sanmenxia	0.801	0.370	0.682	Heshan	0.965	0.145	0.645
Hebi	0.932	0.193	0.692	Huaying	0.649	0.181	0.525
Pingdingshan	0.843	0.451	0.748	Tonghua	0.845	0.371	0.717
Loudi	0.226	0.376	0.349	Xuzhou	0.928	0.971	0.998
Guangyuan	0.665	0.210	0.557	Xiaoyi	0.427	0.152	0.374
Dazhou	0.493	0.392	0.507				

4 Selection of mining site tourism development model in coal resource-based cities

4.1 Type of tourism development potential

The conditions and suitability for mining site tourism development differ depending on the coal resource endowments in various resource-based cities. To determine the tourism development mode, the potential of industrial heritage value and urban development environment was divided into two categories of high and low values based on the natural discontinuous point classification method, with boundary values of 0.602 and 0.272, respectively. Thus, four types of urban tourism development are obtained: high-value and high-potential cities, high-value and low-potential cities, low-value and high-potential cities, and low-value and low-potential cities.

(1) The high-value and high-potential cities included 20 cities: Liupanshui, Zhangjiakou, Xingtai, Handan,

DOI 10.15302/J-SSCAE-2020.06.021

Datong, Changzhi, Jixi, Huainan, Sanmenxia, Hebi, Pingdingshan, Fuxin, Fushun, Liaoyuan, Huaibei, Pingxiang, Zaozhuang, Jiaozuo, Tonghua, and Xuzhou.

(2) The cities with high value and low potential included 19 cities: Yongcheng, Yangquan, Jincheng, Xinzhou, Jinzhong, Guangyuan, Hegang, Shuangyashan, Qitaihe, Tongchuan, Shizuishan, Huozhou, Beipiao, Xintai, Zixing, Lengshuijiang, Lianyuan, Heshan, and Huaying.

(3) Low-value and high-potential cities include 15 cities: Ordos, Bijie, Zhaotong, Yulin, Holingol, Lingwu, Linfen, Yuncheng, Lvliang, Suzhou, Bozhou, Jining, Loudi, Dazhou, and Weinan.

(4) The cities with low value and low potential include 17 cities: Shuozhou, Xilinhot, Yuzhou, Hami, Fukang, Anshun, Pingliang, Gujiao, Diaobingshan, Dengfeng, Xinmi, Gongyi, Xingyang, Mianzhu, Wuhai, Leiyang, and Xiaoyi.

4.2 Optimal selection of tourism development mode

The coal resource-based cities differ in terms of suitable mining site tourism development modes. The optimization of the tourism development mode involves determining the market service scope, tourism products, and other aspects (Table 4) by (1) defining the major customer groups of tourism services: residents, tourists, or shared by the two; (2) determining the development theme based on the type and value level of abandoned mine tourism resources, which can be industrial heritage, natural and cultural resources, or artificially themed landscapes.

Table 4. Mining site tourism development mode of coal resource-based cities.

<table>
<tr><th>City type</th><th>High value and high potential</th><th>High value and low potential</th><th>Low value and high potential</th><th>Low value and low potential</th></tr>
<tr><td rowspan="3">Service groups</td><td colspan="2">Mainly by tourists, supplemented by local residents</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Mainly by local residents, shared by local residents and tourists</td><td></td></tr>
<tr><td></td><td></td><td colspan="2">Mainly by tourists, supplemented by local residents</td></tr>
<tr><td rowspan="3">Developing tourism products</td><td colspan="2">Building on the industrial heritage</td><td></td><td></td></tr>
<tr><td></td><td></td><td>Based on artificially themed landscape</td><td></td></tr>
<tr><td></td><td colspan="3">Based on natural and cultural landscape</td></tr>
</table>

The industrial heritage of high-value and high-potential cities has a high resource value and an appropriate external development environment. These cities should utilize coal mining industrial sites to create tourism products based on industrial heritage and aim at achieving economic and social benefits. Specific development modes include national mine parks, museums, and leisure and recreation tourism complexes, which primarily serve tourists and are supplemented by residents. For example, under the premise of protecting industrial heritage, the national mine park model displays the mining relic landscape as a theme and forms a regional space integrating sightseeing, industrial memory, scientific investigation, and popularization of scientific knowledge, which provides satisfactory economic and social comprehensive benefits.

Although the resource value of the industrial heritage of high-value and low-potential cities is high, the external development environment is poor. These cities can protect the industrial heritage by employing it as a basis to create tourism products using coal mining industrial sites. Specific development modes include museums and public recreation spaces. The primary target groups of services are residents, supplemented by tourists. For example, considering industrial heritage protection and ecological restoration and reconstruction of abandoned mines, the public recreation space model provides leisure and entertainment places for residents through functional reconstruction and landscape reconstruction of site features.

The industrial heritage of low-value and high-potential cities has a low resource value but a beneficial external development environment. Such cities should create artificial theme landscapes as tourism products using coal mining industrial sites. Specific development modes include cultural and creative parks and business service centers, and the developed tourist destinations become recreational spaces shared by hosts and guests. For example, the cultural and creative park model utilizes factory buildings and production facilities of mine sites to introduce elements of creativity, art, fashion, and high technology, thereby renovating and transforming the surrounding environment and deriving tourism products with high added value.

The industrial heritage of low-value and low-potential cities has a low resource value and poor external development conditions. Such cities can develop scientific research, exploration, and other forms of tourism products for small groups with special interests. For example, research tourism products can be developed using the ecological structure, geological profile, ancient mining sites, typical geological disaster relics, modern mines, and typical mineral deposits of severely damaged abandoned mines, thereby providing opportunities for researchers in ecological restoration, geological research, mining, and other fields. Furthermore, the features and landforms formed by abandoned mines are utilized to develop tourism products, such as mine exploration and mine disaster escape.

4.3 Cross-regional mining site tourism development model

In the process of mining site tourism development, regional barriers should be dissolved and multiple sites should be developed as a whole and connected organically, which is called a trans-regional mine. The spatial distribution of mining site tourism development potential in China is characterized by agglomeration as two cores and three centers, which forms the basic conditions for the tourism development of cross-regional mining sites. The cross-regional tourism development models with different themes can be created using the common cultural background formed during the development of coal resource-based cities and the internal relevance of industries.

First, the industrial culture route integrates several mining sites with similar or related cultural background to form distinctive tourism functional areas. For example, based on the 25 coal industrial projects aided by the former Soviet Union, Hegang, Jixi, Shuangyashan, Liaoyuan, Fuxin, Fushun, and Tonghua in Northeast China can be integrated with Datong, Pingdingshan, Jiaozuo, Huainan, and Tongchuan in the Midwest China, to form a mining site tourism functional area that highlights the achievements during the 1st Five-Year Plan period of the coal mining industry.

Second, the industrial chain extends to form a cross-regional mining site tourism belt, including mining, washing, power generation, and high energy consumption industry. For example, the raw material transportation, product sales, and material migration routes of the Hanyeping Coal and Iron Factory and Mining Co., Ltd. can be connected with Chongqing, Huangshi, Pingxiang, and other key cities to create a Hanyeping diversified industrial heritage tourism belt.

5 Conclusion

5.1 Research conclusion

In this study, a measurement model and an evaluation index system are established for mining site tourism development of coal resource-based cities from the aspects of tourist resources, mining development conditions, and urban development environment , thereby expanding the measuring methods for mining site tourism development and providing references for mining site tourism development.

The study found that the 10 cities with the highest development potential were Xuzhou, Handan, Jining, Xingtai, Ordos, Zaozhuang, Zhangjiakou, Jiaozuo, Bijie, and Pindingshan; the top 10 cities in terms of comprehensive potential were Xuzhou, Zaozhuang, Handan, Xingtai, Jiaozuo, Zhangjiakou, Datong, Huainan, Pingdingshan, and Fushun.

The tourism development potential of 71 coal resource-based cities in China was assessed, and four categories have been identified: high value and high potential, high value and low potential, low value and high potential, and low value and low potential. The various tourism development modes have been discussed.

The spatial distribution of mining site development potential in coal resource cities in China is characterized by agglomeration as two cores and three centers Therefore, cross-regional mining sites tourism functional areas and tourism belts can be established based on industrial culture or industrial chain routes.

5.2 Development suggestions

First, the corresponding development mode should be selected based on the development potential of urban tourism resources. There are significant differences in the mine site tourism development potential across the coal resource-based cities in China. This is influenced by the resources endowment, conditions of mining area development, and urban development environment. Tourism development should be adapted to local conditions, and multi-functional, integrated tourism development and cross-regional tourism zones should be considered.

Second, a mining site tourism development plan should be developed to realize the integrated development of the mining city. Mining site tourism development should be included in the development planning of coal resource-based cities, considered as a whole with urban renewal construction, and developed in line with urban culture promotion and spatial integration. Under the framework of urban planning, the integrated utilization of tourism resources of coal mining industrial sites and surrounding natural and cultural tourism resources will be promoted to stimulate the transformation of the tourism industry and other related industries. Coal mine industrial sites can be

DOI 10.15302/J-SSCAE-2020.06.021

developed into leisure and recreational spaces that are in harmony with urban culture, consistent in architectural style, and complementary to production, living, and ecological functions, thereby promoting the integrated development of the mining city.

Third, we should explore and implement a new mechanism of mining site tourism development led by the government and multi-party cooperation. Due to the large resource input in the short term and high maintenance cost in the long term, mining site tourism development and its operation and management cannot be sustained only by one party's efforts. Government should play an active role in guiding and supporting tourism development at closed mine sites, through the introduction of government and social capital (PPP) and other incentives for cooperation and collaboration with mining enterprises, government social investors, and the public.

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