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Conservation and Sustainable Tourism Development of the Natural World Heritage Site Based on Aesthetic Value Identification: A Case Study of the Libo Karst

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Abstract: The conservation and sustainable tourism development of natural World Heritage has been one of the most challenging topics worldwide. One topic based on the identification of sites' outstanding universal value is gradually forming a trend. Aesthetic value as a criteria for WH is an important driving force for the tourism development of most natural World Heritage sites and plays a vital role in the sustainable tourism development of heritage sites. However, due to the subjective consciousness involved in the assessment of aesthetic value, it is difficult to quantify. This means that the content of the protection of the aesthetic value of heritage sites is too general, and the exhibition of aesthetic value is inadequate, posing a threat to the sustainable development of heritage sites. This study selected the Libo Karst Heritage Site as the research area, identified and extracted the carriers and characteristics of the aesthetic value of the Karst heritage site through the combination of online text big data, landscape beauty evaluation, and ArcGIS spatial analysis, and analyzed the content and objectives of aesthetic value protection, clarified the scope of the conversation and tourism exhibits, and, finally, puts forward a conservation and sustainable tourism development strategy based on aesthetic value identification. This study was carried out using interdisciplinary technologies and methods, which provide a valuable reference for the construction of a quantitative evaluation system for the aesthetic value of natural World Heritage sites and the protection of outstanding universal value. This study contributes to filling the research gap regarding the comprehensive evaluation of the aesthetic value and protection and tourism development based on the outstanding aesthetic value identification of natural World Heritage sites. The strategy of cooperation between protection and sustainable tourism development based on prominent universal value recognition can be applied to other forms of conservation and development in other World Heritage sites with similar problems.

Keywords: aesthetic value; carrier identification; protection; sustainable tourism; Libo Karst



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1. Introduction

The conservation of the outstanding universal value (OUV) of natural World Heritage sites (WNHSs) and sustainable tourism development have become some of the most important issues worldwide [1]. WNHSs are internationally recognized as nature reserves of the highest order and provide the best area and background reference for the human perception of natural evolution, biodiversity, biological and ecological processes, and natural landscape beauty. OUV is at the heart of WNHSs conservation efforts. Aesthetic values are an important part of OUV and the primary driver of tourist and recreational visitation to the natural area, thus, they can produce critical economic benefits [2,3]. However, tourism to natural landscape resources with outstanding aesthetic value is both a vital pathway of sustainable development and a main cause of the threats to WNHSs [4,5]. At the same time, according to the International Union for Conservation of Nature's (IUCN) key result regarding IUCN World Heritage Outlook 2014, 2017, and 2020, tourism is the most common

current threat to WNHSSs at present except for climate change and invasive alien species [6]. The unreasonable construction of tourism facilities, overloaded reception of tourists, and vandalism by tourists led to the destruction of the natural beauty and resources of the landscape and the visual effects of WNHSSs. This has, in turn, affected the aesthetic value of the WNHSSs and reduced their attractiveness to visitors [7], as well as exerting adverse effects on the development of heritage sites.

In recent years, the aesthetic value of natural landscapes has become a research hotspot in ecology, geography, landscape architecture, and other disciplines [8]. Aesthetics has long been the focus of philosophers [9] and is defined as “the science of sensory knowledge directed toward beauty” [10]. In the 19th and 20th centuries, scholars gradually combined aesthetics with the natural experience of the masses and believed that aesthetic value was related to the choice of tourism and protected places [11,12]. Aesthetic value appears and prevails in the fields of the natural environment with the belief that a comprehensive knowledge of geology, ecology, and other comprehensive disciplines reveals the natural beauty of the environment [13,14]. Aesthetics has become the driving force behind the protection of the natural environment, and scholars have paid attention to the sensory response of the interaction between people and landscapes. This viewpoint is closely related to the definition of WNHSSs’ aesthetic value. The definition of the aesthetic value of WH was initially used to give a cultural, and subjective and socially constructed, element to the concept of natural beauty [15], which led to controversy over the resolution to distinguish between the “cultural” and “natural” criteria for development in the initial stage [16]. Subsequently, through the continuous practice in the WH, aesthetic value of WNHSSs is clearly defined in the Operational Guidelines for the Implementation of the World Heritage Convention (hereinafter referred to as “Operational Guidelines”) as “superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance” [17]. It can also draw on methods from other fields of landscape preference research [18,19], such as visual resource management and scenery management system methods in the United States, the landscape character assessment guideline in England, and other methods [20]. The identification and evaluation of aesthetic value is the key to carrying out the synergy between the protection of aesthetic value and sustainable tourism of WNHSSs.

The importance of conserving aesthetic value in nature has become acknowledged in the context of sustainable development [21]. A decline in the quality of the aesthetic value of natural landscapes can reduce human well-being [22]. Incorporating the identification and conservation of the aesthetic value of natural landscapes into the conservation management objectives of WNHSSs will not only maximize the contribution of aesthetic value to human society but also enhance the conservation and sustainable development of the ecological environment [23]. As of the 44th Heritage Conference 2021, there are 257 natural and mixed sites on the World Heritage List (WHL), of which 146 are of aesthetic value (also called criterion vii), 120 are WNHSSs, and 26 are mixed sites, representing approximately 56.8% of the total number of natural and mixed sites [24]. This means that most natural and mixed World Heritage sites are characterized by outstanding natural phenomena or rare natural beauty. The uniqueness, rarity, natural beauty, and aesthetic value of WNHSSs often also have significant tourism value [25,26]. However, the assessment of aesthetic value is affected by many factors, and it is difficult to quantify this evaluation. Most scholars prefer to pay more attention to qualitative description of declared WNHSSs, which leads to an inaccurate understanding of the aesthetic value of WNHSSs in the management process, inappropriate identification methods, and blurred conservation boundaries, such as confusing the existence value and use value of WNHSSs, failing to establish the relationship between value and carriers, and being too general in conservation [20]. This results in long-term threats to the aesthetic value, which is not conducive to the protection of the aesthetic value and sustainable tourism development of WNHSSs.

In view of the problems of the unclear identification of the aesthetic value elements of WNHSSs, unclear protection objectives and insufficient tourism display, empirical analysis based on case studies is an important scientific issue that urgently needs to be solved [27].

Globally, karst landscapes cover about 12% of the total land area [28], nurturing beautiful natural scenery and constituting a unique and diverse natural landscape with solid ornamental value. The South China Karst provides the best example of karst landforms and natural landscapes, with conspicuous landscape aesthetic value and tourism value [29,30]. However, due to the fragility of the karst environment and the influence of human factors, the environment of the karst area has been damaged to a great extent, resulting in many environmental problems, including rocky desertification [31,32]. Because of the uniqueness, fragility, and complexity of the ecological environment of World Heritage karst sites (WHKSs) [33], it is necessary to identify the aesthetic value carriers and their characteristics, research and explore the conservation based on value identification, and clarify the boundaries of aesthetic value conservation and utilization to achieve the sustainable conservation and development of WHKSs. In this paper, combined with the tutor's topic, the Libo Karst World Heritage site (hereinafter referred to as "the Libo Karst"), with high aesthetic value and obvious tourism benefits, was selected as the research object. A comprehensive analytical approach was used to identify and extract the aesthetic value carriers of heritage sites and their characteristics, to clarify the content of aesthetic value conservation, to clarify the scope and primary relationship between conservation and tourism, and to propose targeted strategies for heritage site conservation and tourism development.

Since WNHSs are becoming "golden signboards" in the development of tourism industries in various countries or regions, especially in developing countries, outstanding aesthetic value is an important driving force for their transformation into economic benefits [34,35]. Through heritage tourism, aesthetic practice of heritage sites can be enhanced, and the aesthetic value of heritage resources can be promoted and protected. As a result, the aesthetic value of WNHSs and their explicit aesthetic value protection need to be explored and studied to achieve sustainable conservation and tourism development. Quantitative assessment of the aesthetic value of the heritage sites is subjective due to the different cultural backgrounds of those involved, and it is necessary to include the value of different stakeholders in the assessment of aesthetic value. However, there is little empirical evidence to quantify the aesthetic value derived from multiple stakeholders and comprehensive analysis methods, clarify the content of aesthetic value protection, clarify the scope and primary relationship between conservation and tourism, and then propose targeted heritage site protection and tourism development strategies. In this study, Libo Karst, a famous WHKSs tourism destination in Guizhou, China, was selected as a case study. Comprehensive analysis methods involved in this article include the following: (1) using big data to obtain tourists' evaluation of heritage sites from relevant websites, screening out representative landscape resource points, (2) using landscape beauty estimation (SBE) method to evaluate landscape resource points by integrating different stakeholders, screening out aesthetic value carriers of heritage sites, and clarifying the aesthetic value protection content, (3) using ArcGIS to clarify the scope of aesthetic value protection and tourism.

2. Related Work

Sustainable tourism is an inevitable solution to conflict between site conservation and development [36]. Responsible sustainable tourism contributes to the preservation of WNHSs [37,38]. To ease the relationship between WH conservation and tourism, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations World Tourism Organization (UNWTO) proposed the World Heritage and Sustainable Tourism Programme (WH + ST), seeking a win-win path between world heritage conservation and tourism development in 2012. The program emphasizes the study and understanding of OUV of WH. Its core aims are the conservation of heritage value and their carriers, the definition of conservation management objectives and targets, and the development of sustainable tourism approaches and strategies that focus on the recognition, conservation, communication, presentation, and experience of heritage value. Sustainable tourism methods and strategies are proposed, with the recognition, conservation, transmission, exhibit, and experience of heritage value as their core [39]. In

addition, “Value-Based Conservation” is an emerging idea internationally [40–42]. The International Council on Monuments and Sites (ICOMOS) has also proposed that OUV should be understood in terms of vectors and vector characteristics, and that threats should be identified so that the principles of conservation measures can be developed and implemented [43]. James Thorsell, the senior advisor at the IUCN, also stressed the importance of protecting aesthetic value through value carriers and describing aesthetic characteristics [44]. For our research, this process includes two aspects of work: on the one hand, quantitative identification of aesthetic value, and on the other hand, the research on construction of systems and collaborative development of protection and tourism based on the identification of aesthetic value.

2.1. Quantitative Assessment of the Aesthetic Value of WNHSs

The proper identification and clarification of the aesthetic value carriers and characteristics of WNHSs are crucial for conservation and leveraging benefits. For WNHSs that meet the aesthetic value criteria, the identification and extraction of aesthetic value carriers and their characteristics are the cornerstone for the formulation of scientific conservation management and sustainable tourism development strategies, are an essential basis for managers and decision makers to solve problems of “what to protect, why to protect, what to use and how to use”, and serve as a prerequisite for responsible behavior regarding tourism activities at heritage sites and proper coordination between the conservation of aesthetic value and tourism development [45]. In recent years, mainstream research frameworks for the evaluation of aesthetic value is the summary study of the deductive development of aesthetic value recognition criteria since the promulgation by Mitchell et al. in 2013, and the release of the criterion vii identification research guide “Study on the application of Criterion VII, IUCN World Heritage Study” [16]. A comparative study of the property with properties of the same type or inscribed on the WHL through the “analogy” method yielded the most “aesthetic” characteristics, Won-Sok Jon et al., and Xu Ruiyao et al. use this framework to globally integrate a comparison of Mt. Kungang and Karakoram-Pamir with other properties of the same type and show that these two areas meet outstanding aesthetic value and provide the prerequisites for their inscription on the WHL [46,47].

SBE was proposed by Daniel and Boster in 1976 [48]; this method combines the measurement of aesthetic attitudes with the quantitative analysis of the landscape to ensure the objectivity and accuracy of data collection and measurement. In China, this method is one of the most frequently used methods in academia for evaluating the aesthetic value of a landscape, and it is a relatively mature beauty analysis method [49,50]. In the practice of aesthetic value evaluation of world WNHSs, DI et al. used the SBE method to quantitatively analyze the aesthetic value of the Kanas nature conservation in Xinjiang, China, which provided the basic conditions for Kanas to meet the WNHS’s creation vii [51]. Taking the Tianshan in Xinjiang as an example, Ha et al. constructed an evaluation framework on “natural beauty and aesthetic importance” in the aesthetic value of the WNHSs by taking the characteristics and attributes of the aesthetic value elements of WNHSs, the IUCN aesthetic value evaluation method theory, and the geomorphological landscape and biological landscape as aesthetic evaluation factors [52]. In addition, analytical methods for evaluating the aesthetic value of WNHSs using a combination of the applied SBE method and the Semantic Difference (SD) method are included [53–55].

In addition to the SBE method, for the evaluation of the value of aesthetics, some scholars take the Great Barrier Reef in Australia as an example to quantitatively assess aesthetic value by examining the aesthetic preferences of different stakeholders [56,57]. Vercelloni et al. constructed a Bayesian hierarchical logistic regression model using virtual reality (VR) to achieve the quantitative identification of aesthetic value attributes [58]. Additionally, “3S” (remote sensing, geographic information systems, and global positioning systems) spatial analysis techniques are increasingly being used to evaluate the aesthetic value of WNHSs [59–62]. Identifying and extracting OUV carriers and the characteristics

of WNHSS characteristics is an essential prerequisite for constructing value systems and sustainable conservation and development [52].

Among the relevant studies involved, the IUCN considers the visual factor of the landscape to be an important part of natural value [63], and it is generally believed that the stronger the sensibility brought by visual beauty, the greater aesthetic value of the natural landscape [64]. As mentioned in the IUCN 2007 Assessment Report, the Geomunoreum lava tube system in Jeju Island, South Korea, is considered to be the best cave system in the world. There is a prominent visual impact even for those who have experienced this phenomenon, and in practice, since vision is a highly developed sense, attention is often paid to visual quality [16]. In our work, we mainly use SBE method to quantitatively evaluate the aesthetic value of the Libo Karst from the visual senses of different stakeholders.

2.2. Value-Based Conservation

Identifying the carriers of aesthetic value and their characteristics and transforming them into protection objects is conducive to formulating sustainable measures and strategies for the protection and development of aesthetic value. Based on the aesthetic perspective of traditional Chinese landscapes, Xu constructed the key steps, methods, and indicators of the aesthetic value recognition framework according to the perspective of different aesthetic subjects through comprehensive analysis and constructed an aesthetic value protection framework based on value identification [20]. However, in her research, only the identification of aesthetic value was proposed, and the role of aesthetic value in tourism development was missing. In view of the other OUV of WNHSS, Ma took Wulingyuan in China as an example, combined qualitative and quantitative analysis methods, and carried out research on the coordinated development of biodiversity value conservation and the tourism development of heritage sites against the background of an ecological environment threshold.

In addition, based on similar studies on the identification and conservation of OUV of WNHSS, scholars selected outstanding biodiversity value as objects, identified and extracted their carriers and characteristics, and proposed sustainable development measures in parallel with conservation and tourism [65–69]. Only a few scholars clarified the carriers of aesthetic value and their characteristics [1,5,6] or the indicators of aesthetic value protection [70] or proposed macro-protection and technical management measures based on a textual description of aesthetic value in the inscription, such as fixed-point monitoring of the list of aesthetic landscape heritage [71–74] and the adoption of zoning protection strategies [75–78]. No scholars have carried out research on tourism protection and sustainable development based on aesthetic value identity.

3. Materials and Methods

3.1. Location and Characterization of the Studied Areas

Libo Karst (25°13'15" N, 107°58'30" E) is located in Libo County, China. In view of its exceptional natural beauty and aesthetic importance that meets criterion vii, on 27 June 2007, the World Heritage Committee (WHC) added an extension of the South China Karst (phase I) to UNESCO's WHL in the 31th session of the WHC. The South China Karst covers a total area of 97,125 hectares, with a buffer zone of 176,228 hectares, while the Libo Karst consists of two core areas surrounded by a common buffer, the Daqikong, Xiaoqikong Scenic Area section and Maolan Natural Reserve section (Figure 1), which cover an area of 29,518 hectares with a buffer zone of 43,498 hectares [79]. The cone-peaked monomer and Fengcong karst combination forms, long river caves, rivers, and lakes, as well as the karsts, ecosystems, and local ethnic minorities, are the basis for Libo Karst's natural beauty and distinctive and beautiful landscape. This area is considered a world reference site that exhibits karst features and landscapes [80], attracting many tourists and making it a famous tourist destination. Since Libo Karst was inscribed on the WHL, the management department of the site has adhered to the concept of ecological development, and scholars have proposed a sustainable development model of Libo Karst conservation

and tourism [81,82], which has provided a guarantee that regional tourism development will create considerable economic and social benefits. In turn, revenue generated by tourism provides an important source of funding for the conservation of the heritage sites.

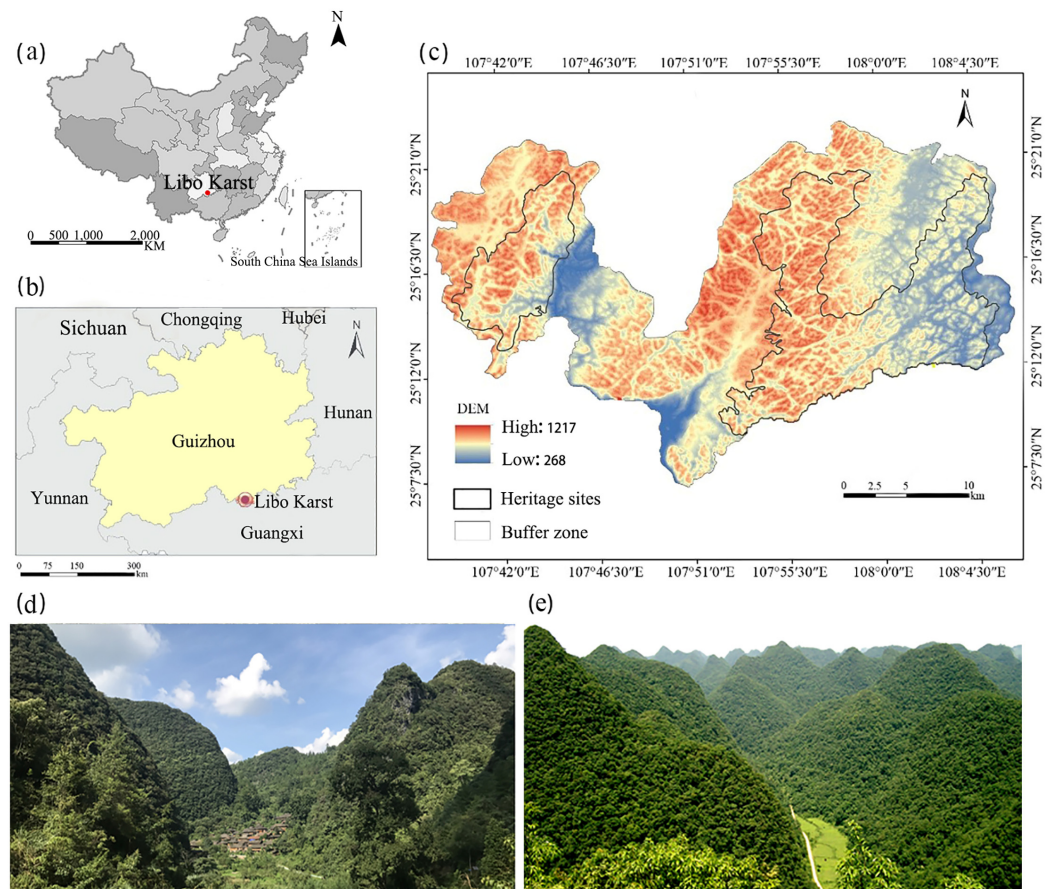


Figure 1. Study area and location of Libo Karst. (a) Location of Guizhou Province, China; (b) The location of Libo County in Guizhou; (c) Map of Libo Karst; (d,e) the Landscape of Libo Karst.

3.2. Data Collection

In 2013, the IUCN published the Study on the Application of Criterion vii, IUCN World Heritage Study, which identifies the aesthetic value of the natural landscape heritage category in terms of “superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance” [16]. To identify superlative natural phenomena, this paper uses a comparative analysis approach based on predecessors’ research [30,82] to construct a framework for identification and extraction.

There are various ways to obtain tourist destination information, including brochures, tour guides, online information, government propaganda, and other channels. Before conducting this study, we conducted a questionnaire survey in Libo Karst in October 2021 on the access to information on landscape resource points of heritage sites. Questionnaires are conducted anonymously, and uniform training in question inquiry is conducted before the survey. Respondents are informed orally in advance that the purpose of the questionnaire is for scientific research only, and precautions are attached at the beginning of the questionnaire so that the respondent is familiar with the survey process and content so as to ensure the right of all participants to know. Among them, we designed the problem of obtaining information about the karst tourist attractions in the questionnaire, and we provided tourists with “travel agencies, online reviews, family and friends introduction, government publicity, and others” fixed options, we distributed a total of 200 questionnaires, and after screening, a total of 186 valid questionnaires were obtained, with an effective rate of 93%. The final results showed that a total of 31 people learned about Libo Karst through travel

agencies, accounting for 16.7% of the total, 98 people learned about Libo Karst through the Internet, accounting for 52.7% of the total, 39 people were introduced by relatives and friends, accounting for 21% of the total, a total of 11 people learned about Libo Karst through government publicity, accounting for 5.9% of the total, and a total of 7 people learned about Libo Karst through other channels such as books, accounting for 3.6% of the total. It can be seen that the number of people who know about the Libo Karst through online comments is the largest. However, due to the impact of the COVID-19 crisis policy, we did not have sufficient questionnaire data to support our research. After comprehensive consideration, we chose to obtain online review information as the source of information for aesthetic value evaluation.

For areas of exceptional natural beauty and aesthetic importance, this study uses an integrated analytical approach to identify and extract the aesthetic value carriers. This consists three key steps, as shown in Table 1.

Table 1. Extraction steps of aesthetic value carriers and its characteristics.

Sequence Number	Method	Main Content
Step 1	Online comment text analysis based on Big data	1-1: Data preparation and preprocessing, identify review data source sites and search terms.
		1-2: Conducting word frequency analysis, identifying typical landscape resource sites.
Step 2	Scenic beauty estimation method	2-1: Identify the main stakeholders and their weights.
		2-2: Determine the evaluation index system for each type of aesthetic carrier, establish the corresponding identification methods and indicators, and the corresponding quantification and calculation methods.
Step 3	ArcGIS	3-1: Determine the location of value carriers. Determine the coordinates of each landscape resource site with the location of existing conservation management plans within the heritage site.
		3-2: Determine the value carrier characteristics. Combining satellite remote sensing images and fieldwork data, the carrier characteristics were derived with the help of ArcGIS platform.

Step 1: Online review data reflects peoples' objective and realistic perceptions of the review data and have the characteristics of being documentary, open, free, shared, and constantly updated. This can ensure the timeliness of the acquired data [83,84]. A content analysis of online reviews was conducted to analyze the frequency of words in the data [85,86]. Octopus' third-party software platform that does not involve personal privacy data scraping was mainly used to capture the online review data text of Ctrip (<https://www.ctrip.com> (accessed on 23 August 2022)), Qunar (<https://www.qunar.com> (accessed on 23 August 2022)), and Mafengwo (<http://www.mafengwo.cn/> (accessed on 23 August 2022)), three of the more mainstream travel websites in China. Using "Maolan Natural Reserve section", "Daqikong Scenic Area", and "Xaoqikong Scenic Area" as the keywords, the three tourism websites were used to study the evaluation data of tourists after use, download the search results, and obtain information including user rating, title, time, and evaluation. The search results were then pre-processed using Excel software to remove identical and blank information from the samples, and the resulting documents were converted to a text format recognizable by the ROST CM6 software. A total of 6908 good tourist reviews were obtained after processing, including 211 from "Mafengwo", 2026 from "Where to Go", and 4671 from "Ctrip". Finally, the text data were analyzed using the "word frequency analysis" function in the ROST CM 6.0 software.

Step 2: Drawing on the SBE beauty evaluation method, the evaluation index system of various aesthetic carriers was determined, the corresponding quantitative methods and calculation formulas were established, and an aesthetic value evaluation of a series of

landscape resource points of screened natural landscape heritage sites was carried out. The resource points with evaluation value above the average value were used as representative landscapes to establish the aesthetic value of the natural landscape heritage site and as OUV characterization elements for the aesthetic value of the natural landscape heritage site. According to the word frequency analysis in Step 1 and the list of value properties screened by experts in the application text, the typical landscape resource points representing the aesthetic value of the Libo Karst were determined. In October 2021, May, and August 2022, photos were taken at each resource point, and the same camera was used to take pre-selected landscape samples by selecting similar weather with clear and high visibility, maintaining a certain depth of field during the shooting process and ensuring that the chromaticity of each photo was similar. Expert groups, tourist groups, scenic spot managers, and community residents were taken as the main body of the aesthetic value evaluation of heritage sites. Inquiries and surveys that do not involve personal privacy issues when informing the evaluation method and purpose of the survey in advance by the relevant parties of different use. We used the SBE method. After marking the corresponding indicators of the photos of each landscape resource point, we screened 3 slides of each landscape resource point, and only the investigators will randomly show the slides of the consultation subjects and record the scoring situation, and set each slide to play 7s and not play back to reduce human error.

Step 3: With the help of ArcGIS, the relationship between the location of the Libo Karst aesthetic value carriers in the existing hierarchical conservation of the heritage site was clarified [27], which provided an important basis for formulating strategies and measures for scientific conservation and tourism development strategies and measures.

4. Results

4.1. Identification and Extraction of Aesthetic Value Carrier

The identification and extraction of value carriers and their characteristics is key to establishing the objectives of aesthetic value protection in the Libo Karst. Only by clarifying the relationship between aesthetic value carriers and other value carriers can we clarify the relationship between aesthetic value protection objects and other value protection objects. In the research on the identification of aesthetic value, Xu took China's famous mountains with heritage site attributes as an example in the construction of an aesthetic value identification framework system. She believes that aesthetic value = (aesthetic subject, aesthetic object (carrier and its characteristics), subject-object role) [5]. The identification of aesthetic value carriers cannot be separated from aesthetic subjects, and the aesthetic subjects of heritage sites should include different stakeholders such as experts, community residents, tourists, and managers [20]. The aesthetic object is the carrier and characteristics of aesthetic value and the inherent existence value of the heritage site, including the material entities and forms such as mountains, rivers, and forests, as well as the aesthetic characteristics such as rhythm and harmony.

The South China Karst was inscribed on the WHL to preserve its aesthetic and geomorphological value. Its value as an aesthetic subject was mainly determined by an expert. During the inscription process, the experts judged whether the site met requirements for aesthetic value according to the Operational Guidelines by the IUCN and listed the property as having significant aesthetic value carriers. However, this evaluation method was single-minded and subjective.

The list of aesthetic value of the the Libo Karst is not separated from the list of geomorphological value provided in the application materials. This means that conservation management is too general, as is the monitoring work carried out at a later stage. It also leads to unclear content in the conservation of aesthetic value, failure to establish targeted conservation management measures, and an unclear scope for the conservation of aesthetic value and tourism exhibition. In the long term, this will not be conducive to the sustainable development of the Libo Karst. Therefore, identifying the carriers of aesthetic value and the characteristics of the karst is of great significance for conserving these value, as well

as for the sustainable development of the site. It also has a reference value for conserving other sites that are the same type of OUV.

4.1.1. Superlative Natural Phenomena

Superlative natural phenomena are focused on natural features that can be objectively measured and represent the highest level of excellence worldwide [87,88], such as Iguazu Falls being the widest waterfall in the world, Mammoth Cave in the United States being the longest cave in the world, and Australia's Great Barrier Reef being the largest and longest coral reef group in the world. In addition, large-scale biological aggregation and migration and magnificent and complex geological processes are also regarded as some of the most advanced natural phenomena, such as the large-scale migration of monarch butterflies in Mexico and the complex underground hydrological system of the Unianga lakes in Chad [24]. The criteria for identifying value in this section can be derived by comparing the aesthetic "best" features with those of similar heritage types in the world or local area or with inscribed WNHSSs.

Relevant articles have been published comparing the aesthetic value of the Libo Karst with that of similar karst landscapes worldwide [82]. Consequently, directly using the description of aesthetic value of the karst in the section on "superb natural phenomena" in the relevant literature and official sources [79,89,90], we extracted the elements that characterize its aesthetic value. These include the main conical karsts (peak clusters, peak forests), which, either individually or in groups, can also be considered superb natural phenomena in the global context. (Figure 2).

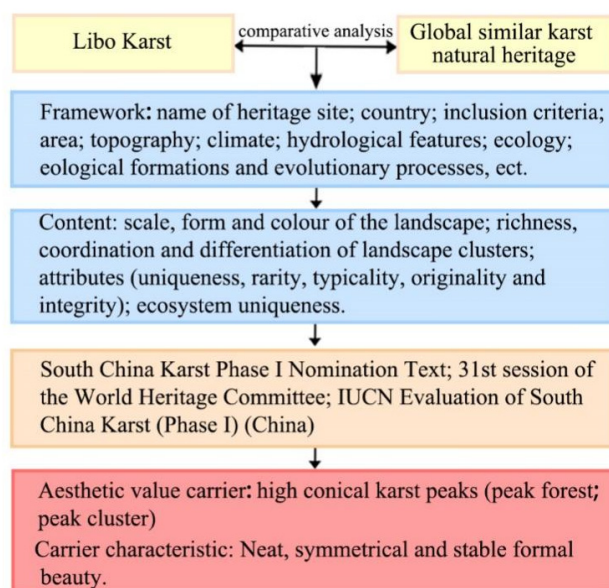


Figure 2. Extraction of the aesthetic value of the Libo Karst: Step 1.

4.1.2. Areas of Exceptional Natural Beauty and Aesthetic Importance

It is difficult to assess the "special natural beauty and aesthetic importance quantitatively" and the identification of this criterion is mainly based on the judgment of heritage experts at the time of inscription. Aesthetic awareness is affected by cultural background and other comprehensive factors. This value lacks scientific and objective quantitative research and rigor and systematization. At present, the description of the exceptional natural beauty and aesthetic importance of the Libo Karst is mainly based on the inscription text, IUCN Technical Evaluation Report and Resolution, and qualitative descriptive statements mentioned in some of the literature. Scientific, objective and systematic quantitative descriptions are lacking.

The text data obtained by the "Word Frequency Analysis" function of ROST CM6 software uniformly standardizes the words representing the same name and the same

meaning, such as “Good scenery”, “Beautiful scenery”, “Wonderful scenery”, and other terms uniformly represented by “Beautiful scenery”, and the word breaker is used to filter out high-frequency words such as “5 h”, “6 kilometers” and other high-frequency words that are not related to the analysis target, and finally the top 100 high-frequency words are obtained (Table 2). The top word frequency is mainly based on the travel experience of tourists, showing positive reviews. High-frequency words such as “Beautiful scenery”, “Natural oxygen bar”, and “Beautiful mountain and water” indicate that Libo’s natural landscape is one of the crucial factors attracting tourists. “68-Level Drop Waterfall”, “Golden Lion Cave”, “Qinglong Pond”, “Rock Forest” and other popular attractions that impress tourists. However, only some tourists mention that Libo Karst is a World Natural Heritage Site.

Table 2. High frequency vocabulary of Libo Karst area online comment text.

Ranking	High Frequency	Frequency	Ranking	High Frequency	Frequency
1	Beautiful scenery	1219	51	Mysterious	223
2	Worth recommending	929	52	Broken Bridge Waterfall	222
3	Overall superb	789	53	karst cave	222
4	Interesting and funny	646	54	Dense forests	222
5	Natural oxygen bar	633	55	Peculiar	221
6	Beautiful mountains and clear water	566	56	Maolan Karst primeval forest	209
7	Xiaoqikong Scenic Area	565	57	Turtle back mountain	199
8	Original	553	58	Ordinary scenery	119
9	68-level Drop Waterfall	542	59	Indulge in pleasures without stop	119
10	Golden Lion Cave	523	60	Inconvenient traffic	119
11	Water Forest	517	61	Beautiful and quiet	119
12	Wolong Pond	513	62	Difference scenery appears	119
13	Rock Forest	505	63	The water is green	119
14	Qinglong Waterfall	497	64	Magnificent	118
15	Laya Waterfall	493	65	Majestic and grand	118
16	Qinglong Pond	481	66	well-ordered	118
17	Xiaoqikong Scenic Area	476	67	Natural heritage sites	118
18	Yuanyang Lake	470	68	Emeralds on the Earth	117
19	Xiaoqikong Ancient Bridge	462	69	Worth touring	117
20	Crab Valley	360	70	Strong interest	117
21	Cave with waterfall	359	71	Fresh air	116
22	Latan Waterfall	359	72	Beautiful scenery	116
23	The scenery is huge	359	73	Reasonable price	116
24	Lake below the waterfall	357	74	Very comfortable	116
25	Tiansheng Bridge	357	75	Underground lake	115
26	Window on the Lake	351	76	Karst landform	80
27	Scenic spots scattered	350	77	Primary forest;	75
28	Cuigu Wetland;	349	78	Good environment	50
29	Kongbu Valley	347	79	Natural beauty	50
30	Landscape is dangerous and steep	345	80	Rich vegetation	47
31	Fast flowing water	344	81	Jagged rocks of grotesque shapes	45
32	Convenient	293	82	Lack of service	45
33	Jiudongtian Cave	239	83	Worth coming again	40
34	Arc de Triomphe Orient	239	84	Unique ethnic customs	40
35	Explanations thin	238	85	Different shapes	36
36	Grand and magnificent	237	86	Shuanglong Waterfall	32
37	Maolan Scenic Area	235	87	Well-deserved reputation	30
38	Die Forest	235	88	Fairyland on earth	30
39	Self-driving tour	235	89	Twists and turn	30
40	Super Bonsai	233	90	Orderly management	23
41	Aquatic forest	232	91	Radix Isatidis	20
42	Picturesque	230	92	With overlapping steep peaks	17
43	Boxwood Valley	228	93	Original karst cave	15
44	Observation Deck	228	94	Qinglong Stream	13
45	Sky Bell Cave	227	95	Karst funnel forest	13
46	Stream and Waterfall	226	96	Suitable for taking pictures	13
47	High mountains and deep valleys	226	97	Natural Reserve	11
48	Vertical and horizontal streams,	226	98	Paddy fields fish	10
49	Yaofeng cave	225	99	Water are crystal clear	10
50	Breathtaking and magic	224	100	Small Jiuzhaigou	10

Based on Master Plan of Libo Zhangjiang Scenic Area and Master Plan of Guizhou Maolan National Nature Reserve as reference bases, 26 tourism natural landscape resource points that overlap with the planning text were screened from the high-frequency words included in the network mentioned in this analysis text. The location of each landscape resource point within the heritage site are shown in Figure 3 alongside photos. The Maolan Karst Primeval Forest, Funnel Forest, Die Forest, 68-Level Waterfalls, Turtleback Mountain, Water Forest, Yuanyang Lake, Tiansheng Bridge, Wolong Pond, and Xiaoqikong Bridge were judged by experts to have high aesthetic and geological and geomorphic value during the application. These landscape resource points formed the content of the list of valuable properties in the application materials and are the focus of the value protection of heritage sites. However, due to the unicity of the evaluation subject, these landscape resource points cannot fully represent the outstanding aesthetic value of Libo Karst. In addition, aesthetic value and geomorphic value are mixed, so managers cannot establish targeted protection and management measures in practice. This is not conducive to the protection of the aesthetic value of the heritage site. However, the final results extracted from the above methods not only guarantee the objectivity of the evaluation of aesthetic value, but also provide a basis for managers' aesthetic value protection.

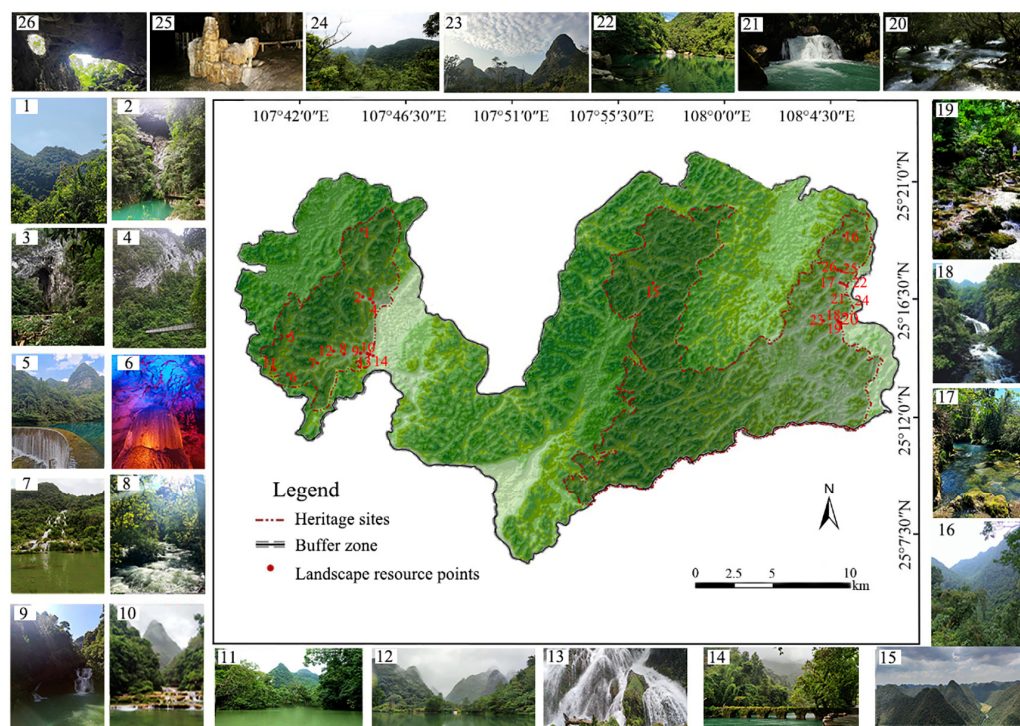


Figure 3. Location and photos of the Libo Karst landscape resource points. 1. Die Forest; 2. Yaofeng Cave; 3. Tiansheng Bridge; 4. Kongbu Valley; 5. Wolong Pond; 6. Sky Bell Cave; 7. Cuigu Wetland; 8. WaterForest; 9. Shuanglong Waterfall; 10. 68-level Drop Waterfall; 11. Yuanyang Lake; 12. Turtle back mountain; 13. Laya Waterfall; 14. Xiaoqikong Ancient Bridge; 15. Rock Forest; 16. Karst Funnel Forest; 17. Qinglong Stream; 18. Latan Waterfall; 19. Crab Vally; 20. Aquatic Forest; 21. Qinglong Waterfall; 22. Qinglong Pond; 23. Boxwood Valley; 24. Maolan Karst primeval forest; 25. Golden Lion Cave; 26. Jiudongtian Cave.

Based on the characteristics of the 26 landscape resource sites, the aesthetic value carriers are divided into three categories: environmental carriers, tourism experience carriers, and emotional imagination carriers, The pictures of each landscape resource site are evaluated on nine levels: originality, uniqueness, integrity, beauty, combination, seasonal variation, amenity, attractiveness, and spiritual symbolism. The evaluation scale uses the Litko 1–5 scale, and the aesthetic value of each landscape resource site is determined

according to the ratings given by each evaluation subject, combined with the evaluation weights of each aesthetic subject (Table 3).

Table 3. The index system of aesthetic value carrier of various landscape resources.

Evaluation System	Evaluation Indicator	Aesthetic Subject and Weighting
ecosystem carriers (EC)	originality a1 uniqueness a2 integrity a3	75% for specialist groups and 25% for managers
tourism experience carrier (TEC)	beauty b1 combination b2 seasonal variation b3	75% of the visitor group and 25% of the specialist group
emotional imagination carrier (EIC)	amenity c1 Attractiveness c2 spiritual symbolism c3	75% of visitor groups, 25% of community residents

Taking the environmental carrier class evaluation system as an example, if the landscape resource point belongs to this aesthetic carrier, its aesthetic value (V_I) is calculated by the formula:

$$V_I = \overline{M}_a * 0.25 + \overline{S}_a * 0.75$$

\overline{M}_a refers to the average rating of the indicators in the evaluation system I by the scenic area manager (M) and \overline{S}_a refers to the mean of the rating of the specialist (S) on the indicators in the evaluation system I .

The aesthetic landscape value scores of the 26 core landscape resource sites as measured are shown in Figure 4, with the internal sites ranked from highest to lowest beauty rating: Wolong Pond > Rock Forest > Xiaoqikong Ancient Bridge > 68-level Drop Waterfall > Yuanyang Lake > Tiansheng Bridge > Die Forest > Maolan Karst Primeval Forest > Karst Funnel Forest > Cuigu Wetland > Qinglong Waterfall > Sky Bell Cave > Laya Waterfall > Golden Lion Cave > Water Forest > Turtle back mountain > Qinglong Pond > Kongbu Valley > Jiudongtian Cave > Aquatic Forest > Qinglong Stream > Shuanglong Waterfall > Crab Valley > Latan Waterfall > Yaofeng Cave > Boxwood Valley. Those that exceed the mean value (4.46) or more are considered to be the aesthetic value carriers of the Libo Karst, which can be summarized as water features (Wolong Pond, 68-level Drop Waterfall, Yuanyang Lake, Qinglong Waterfall, Cuigu Wetland Qinglong Waterfall, Laya Waterfall), karst landforms (Tiansheng Bridge, Sky Bell Cave, Golden Lion Cave) and their biological features (Rock Forest, Di'e Forest, Maolan Karst Primeval Forest, Karst Funnel Forest, Water Forest, Turtle back mountain). The above-mentioned aesthetic value carrier monomer or its combination monomer has high integrity, uniqueness, and its landscape aesthetic value is outstanding. Consistent with the description of aesthetic value in the inscription text, "harmonious beauty composed of mountains and forests". Forests, water, and caves are essential components that constitute the OUV of the Libo Karst.

4.2. Identification of the Characteristics of Aesthetic Value Carriers and Analysis of the Current Situation

Clarifying the objectives of the conservation of aesthetic value is key to formulating scientific and reasonable conservation measures and strategies, including the identification of value carriers and their characteristics. By analyzing the current situation of the conservation of aesthetic value carriers, their characteristics, and their popularity as a tourism destination, corresponding solutions can be proposed for existing problems. The current situation analysis is integral to promoting the sustainable development of heritage sites. In addition, the scale division of value carriers aims to better control the type of facility construction and more strictly control the volume, location, type, and material of related infrastructures, according to the difference in scale, to ensure that the integrity of aesthetic value is not threatened. This research mainly used satellite remote sensing images and the ArcGIS platform to obtain the essential characteristics of aesthetic value carriers, further

verify carrier characteristics according to relevant data and field research, and analyze the conservation and tourism status of aesthetic value carriers (Table 4).

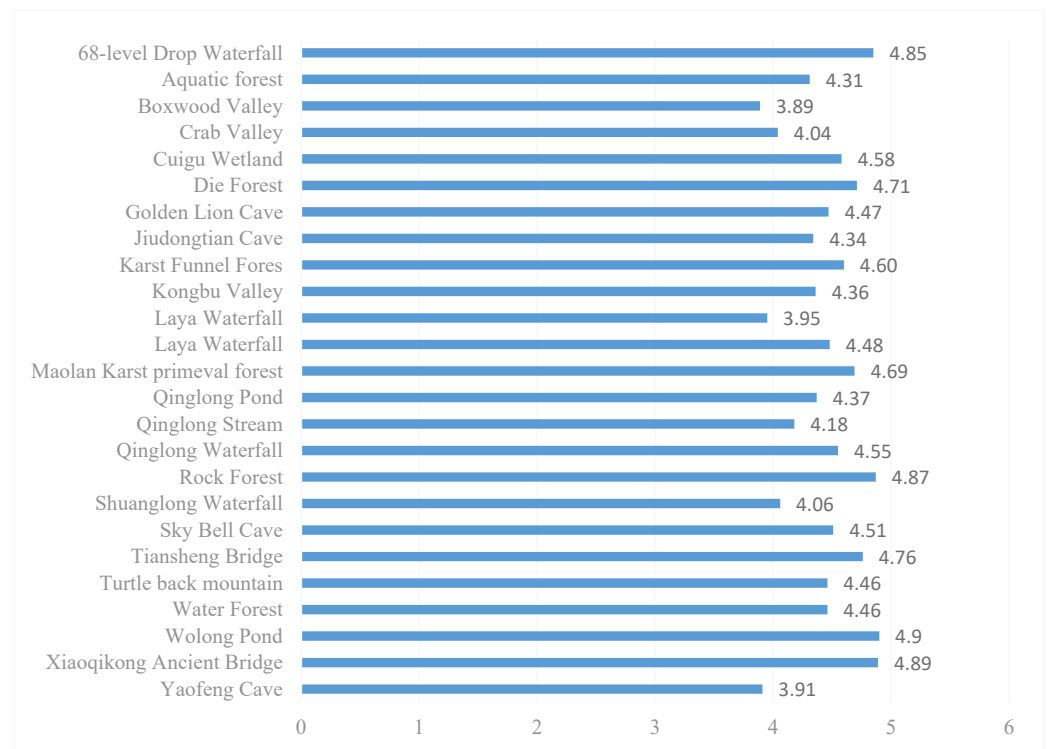


Figure 4. SBE aesthetic value score of each landscape resource point.

Table 4. Analysis of the types, characteristics and status quo of aesthetic value carriers.

Carrier	Type	Features	Current Situation Analysis
Rock Forest	EC, TEC, EIC	Trees grow on rocks, and roots grow in crevices. On the whole, the Cone Peak is continuous and undulating, with overlapping peaks, majestic and incomparable magnificent beauty. The shape of the cone front combination is neat, symmetrical, and stable.	Overlapping with the forbidden area of the national nature reserve, it has strict protection attributes and the overall aesthetic value protection status is better, but at the same time, the relevant landscape viewing points have been closed, which cannot fully exhibit its unique and magnificent beauty.
Karst Funnel Forest	EC, EIC	From the bottom of the funnel to the edge of the mountain, there is a dense jungle with overlapping layers. At the bottom of the funnel are hundreds of acres of green bamboo mixed in the woods, and the whole funnel is like a green whirlpool floating above the forest sea, with a quiet and far-reaching beauty.	Mainly eco-tourism, tourists can hike through the primeval forest on their own to feel its mystery and quiet beauty.
Maolan Karst primeval forest	EC, EIC	The rare residual forest with strong originality and a significant area of karst in the middle subtropical zone; The ecosystem formed by the combination of forests and conical karst landform presents a unique and original natural beauty.	The ecosystem formed by combining forest and conical karst landform has yet to develop fully, and small-scale research tourism is mainly used in the exhibition area and buffer zone.

Table 4. Cont.

Carrier	Type	Features	Current Situation Analysis
Die Forest	EC, EIC	The densely wooded primitive karst slot valley forest is shaded by the sun; the high peaks on both sides of the river form a deep and tranquil natural landscape of beauty.	Long distances from major scenic viewpoints, low visitation rates, and easily overlooked value.
Water Forest	EC, EIC	The river valley is overgrown with dense trees and shrubs, acting like an emerald barrier. The clear water of the river gushes down through the woods, creating a spectacle of “water flowing on stones and trees growing in water”	Greatly affected by the climate, the overall water flow is reduced; Tourists are forbidden to enter during the flood season, and the overall beauty is reduced during the dry period
Turtle back mountain	EC	The epitome of the wonders of the karst primeval forest. Densely forested, ancient forests are full of rare tree species, and most of them grow on cliffs and exposed limestone, or on collapsed debris.	Due to the adjustment of sightseeing routes, the visit rate is low, and the value is easy to be overlooked
Qinglong Waterfall	EC, EIC	The waterfall is majestic, distinct, powerfully layered, and loud, presenting a unique soundscape beauty.	The waterfall is far away from the swim line, and the sound of the waterfall is loud and not easily affected by human noise.
Laya Waterfall	TEC, EIC	The Laya waterfall is 10 m wide, with an undulation of 30 m, spouting in the air, the head of the waterfall hanging in the blue sky next to the white clouds. The landscape is very magnificent.	With the waterfall on the side of the road and people underneath, people can directly experience the aural, visual, and tactile beauty of the waterfall.
Yuanyang Lake	TEC, EIC	The two large lakes and four small lakes form an excellent water network with jagged shores, thick enclosures, interlocking harbors and branches, and a meandering maze known as the “water maze”.	The climate influences the water volume, and the aesthetic value is unstable; too many boats on the lake threaten the overall landscape vision.
Wolong Pond	EC, TEC	The dark underground river, the outlet of the Wolong River—gushes out of sight from the bottom of the cliff. The karst cone peaks jutting out of the pool, and the trees that cover the lake are extraordinarily green.	The landscape is unique, with mountains, water, and woods blended into one, with a high aesthetic value; there is a guard to prohibit visitors from entering the water and fishing, and the aesthetic value is protected.
68-level Drop Waterfall	EC, TEC, EIC	The 3 km-long section of the river forms multi-stage calcareous deposits, and the river flows through, forming a landscape of multi-stage cascading waterfalls with different forms, presenting the beauty of dynamic landscape painting.	The wooden walkway along the water body is incompatible with the overall environment and affects the landscape harmony of the plunge waterfall.
Cuigu Wetland	TEC	The waterfall reaches about 60 m and is an enclosed crested lowland. The mountains and rivers are lush and green, and the wilderness is lush, hence the name of the Cui Valley.	The water around the waterfall is shallow and available for visitors to play with, receiving a large artificial influence, but the waterfall itself is inaccessible, and its value is well protected.

Table 4. Cont.

Carrier	Type	Features	Current Situation Analysis
Xiaoqikong Ancient Bridge	TEC, EIC	The ancient bridge reflects the water and is covered with vines and vines. The ancient bridge, water, and trees blend into one, reflecting poetry and harmony.	The overall landscape is harmonious and of high ornamental value, with minor human damage but more frequent trampling by tourists.
Golden Lion Cave	TEC, EIC	Various sedimentary types such as stalagmites, stalactites, and stone slow in the cave, and their different combinations of shape, scale, size, monomers and groups form underground spaces with different scenery; The cave hall is tall, the corridor is circuitous, typical of the development of karst caves, the travertine accumulation in the cave is rich and concentrated, or like a beast or like a thing, lifelike, beautiful.	In order to display the rich stalagmites, stalactites, stone mantles and other cave sediments in the cave, Sky Bell Cave uses warm light lighting, causing cave color pollution; Golden Lion Cave is mainly primitive explorations, but artificial lighting and photographic flashes will have an impact on the development and evolution of the cave.
Sky Bell Cave	TIC, EIC		
Tiansheng Bridge	EC, TIC	The natural boulders stand high in the dome and across the river valley, reflecting their majestic beauty.	Naturally occurring, massive, and less disturbed by man.

Clarifying the spatial information and information distribution of aesthetic value carriers is key to formulating targeted conservation measures and sustainable tourism utilization. In 2015, in Conservation and Management Plan of South China Karst (hereinafter referred to as “the Plan”), the Libo Karst was divided into a heritage site and a buffer zone. These included strictly protected areas, heritage exhibition zones, and community coordination areas [91]. The Plan can be used to determine the location of each value carrier and other core landscape resource points, clarify their relationship with the existing hierarchical conservation management (Figure 5), and adjust the primary and secondary relationship between the protection and display of aesthetic value to ensure that the integrity of aesthetic value is protected and displayed. The value carrier located in the forbidden area should be a priority for protection, tourism should be restricted, and the value carrier located in the exhibition area must be suitable for appropriate tourism conditions while remaining under strict protection. Additionally the tourism display of the value carrier in the buffer zone should be focused.

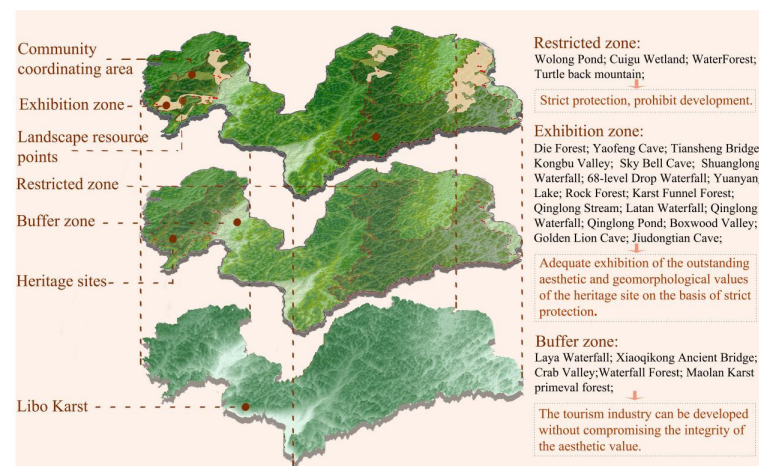


Figure 5. Aesthetic value carriers and other core landscape resource sites in relation to the existing hierarchical conservation system.

4.3. Conservation and Tourism Exhibition Strategies Based on the Identification of Aesthetic Value

WHKSs are a unique and complex landscape resource complex, and the landscape beauty they present is a unique tourism resource, which could allow for the area to enjoy the economic benefits generated by its aesthetic value. However, it must also bear the corresponding conservation responsibilities. Formulating targeted conservation and exhibition measures based on the identification of aesthetic value carriers and their characteristics is crucial to realizing the sustainable development of the benefits of heritage sites.

4.3.1. Existence Value

Particular and stable forest ecosystems, natural biological resource gene banks, and unique hydrogeological binary structures constitute the background value of the Libo Karst (Figure 6). As they are the intrinsic value of the site, these underlying values should be strictly and permanently protected and not threatened or damaged. Simultaneously, we should exhibit and utilize the existing value by using various measures and technologies.

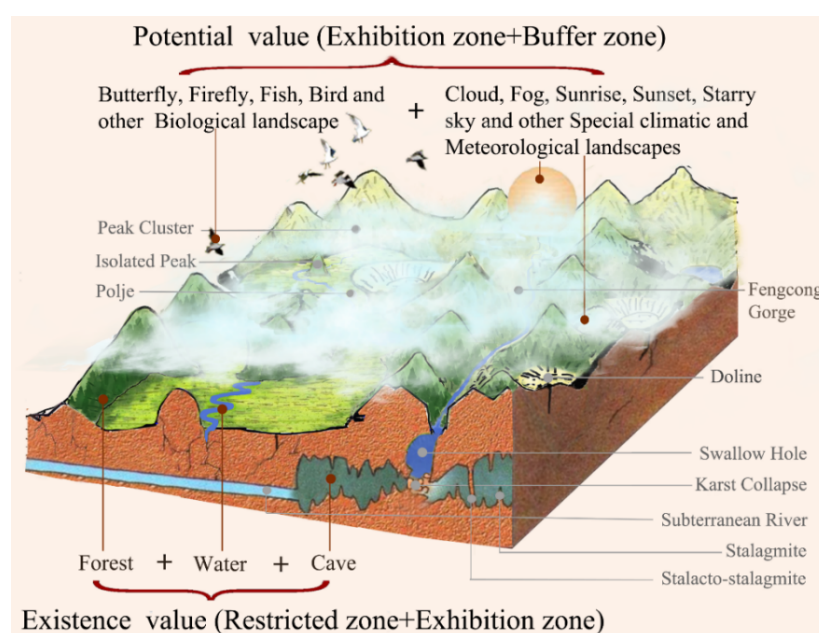


Figure 6. Components of the Libo Karst value system.

(1) The Libo Karst preserves the world's most giant karst primeval forest. This is a vast ecological space, rich in animal and plant species and genetic germplasm resources, and has remarkable biodiversity. For the carriers of the aesthetic value of forest landscapes such as the Maolan primeval forest, Die forest, and stone forest, appropriate excursions are allowed. With the aim of protecting the original landscape and ecological environment of the forest, professional, scientific researchers are hired to carry out appropriate scientific research investigations, while the eco-tourism of popular science education and the number of overall tourists are strictly limited. Tourist activities are limited to viewing and touring. For such macro-scenarios, the construction and site selection of facilities should be hidden in the forest, the height should not be higher than the average tree height, and the construction method and material settings that are integrated into the environment should be simple. Basic service facilities should be established, such as conservation posts, sanitation facilities, science and education points, and signs with high harmony and similar aesthetics to the environment should be adopted.

Popular science education and aesthetic guidance should be strengthened. Information science and technology should be combined, the diversification of interpretation methods should be strengthened, and intelligent scenic spots should be created. Using a variety of interpretation methods, this paper establishes a popular science education regarding the formation of the natural beauty of the unique forest landscape of the Libo Karst so that the

public can understand the importance of this extraordinary forest landscape on barren and fragile rocks, enhancing tourists' awareness and enthusiasm for the conservation of forest ecosystems and their aesthetic value. At the same time, with the help of modern science and information technology, an intelligent explanation platform should be built to show the public the mysterious beauty of the internal landscape of the funnel forest, as well as the magnificent beauty of the cone-shaped karst represented by the stone forest. Virtual technology could be used to display the forest ecosystem scene so the public can experience the feeling of being in it.

Different interpretation content could be created for the environmental carriers, corresponding to different aesthetics. For example, for the unique forest ecosystem and natural biological resource gene bank in the Libo Karst, tourists can see Maolan's endemic wildlife in specific places, and there is an introduction to related resources. Through pictures, visitors are introduced to the distribution characteristics and aesthetic characteristics of the vegetation and animal communities of the Libo Karst, as well as the relationship between animal and plant resources and the surrounding environment. This may help them to indirectly understand the status of rare and endangered animal and plant resources in Libo Karst, receive a popular science education on ecological and environmental conservation, master the basic knowledge of biodiversity conservation and sustainable development, and achieve an environmental education while enjoying the beautiful scenery of Libo Karst.

(2) For natural hydrological resource carriers such as Wolong Pond, Yuanyang Lake, and 68-Level Waterfalls, the hydrology of the entire river basin should be protected, and the pollution of water resources by domestic water such as hotels, restaurants, toilets, and other domestic water upstream of the water body should be controlled. The pollution of water resources by chemicals and industrial sewage in the buffer zone upstream of the hydrological system should be prevented. The construction of the necessary infrastructure around the water landscape needs to be fully demonstrated in terms of viewing effect, visual impact, safety, and the harmony of the overall landscape. It is forbidden for tourists to wash their faces and feet, feed, breed, catch, or carry out other acts that would require them to touch the water body, and it is forbidden to use gas cruise ships to drive on the water. Only opportunities for small-scale ecological tours are provided, offering a memorable experience of the sound and touch of water features.

The Libo Karst has rich water landscape types, and tourists should be provided with more opportunities for water landscape appreciation through rich tour route planning. The appearance of the wooden plank road on the waterfront, which is not harmonious with the environment and affects the overall visual landscape should be improved, such as by placing artificial plants on the wooden platform or planting flowers and plants for decoration. This would make the wooden plank road more natural and enhance its ornamentation. The existing plank road should not be widened.

The water landscape of the Libo Karst is rich and diverse, providing tourists with different experiences in terms of sight, hearing, and touch. Tourists should be provided with the opportunity to appreciate the rich colors and dynamic beauty of the site. Visitors should be encouraged to learn about the water features of Libo Karst on foot, and guided to understand the different types of water landscapes, such as underground rivers, rivers, lakes, pools, waterfalls, and streams. Their impression of each water landscape should be deepened, and they should be offered the chance to develop the skills required to appreciate the auditory, visual and tactile beauty of different water bodies. Special content to help visitors interpret the karst geomorphological hydrology and process should be set up to explain the scientific causes of the water resources' color, situation, and volume, and comprehensively explain the surrounding natural environment and climates. Finally, education should be provided on the particularity of karst water resources and the importance of conservation, and tourists will be provided with particular explanations regarding the conservation and utilization of water resources.

(3) For karst cave landscape carriers, protective measures were taken in order of importance. For the developed caves, these measures were taken according to the degree of

tourism impact, rotational rest, or direct closure. For undeveloped caves located in heritage sites, caves with development potential in the buffer zone should be strictly developed based on conservational needs, and small-scale original ecological tourism should be carried out on the premise of ensuring the safety of tourists to avoid damaging the cave system through the use of excessive lighting equipment.

Cave conservation regulations should be formulated, the publicity regarding cave conservation knowledge should be strengthened, and tourist caves should be developed or managed. It is necessary to equip or hire cave-related professional and technical personnel to participate in this process, formulate cave environmental functional zoning and corresponding environmental conservation quality indicators, and establish cave monitoring systems.

4.3.2. Potential Value

In addition to the inherent aesthetic value carriers that have been exhibited to the public, the Libo Karst has other potential landscape aesthetic value (Figure 6). The potential aesthetic value refers to the value of the Libo Karst that is easy to ignore, and may receive less publicity regarding the links between conservation and tourism exhibitions. However, these value and inherent background value constitute the uniqueness and integrity of Libo Karst's outstanding aesthetic value. For example, the meteorological landscape deepens the mystery and spectacular beauty of the Libo cone karst cluster and peak forest, the diverse species add to the wild beauty of the heritage site, and the cultural style of the ethnic minority groups native to these sites reflect the unique harmonious beauty of the Libo Karst (Figure 7). Finding, protecting and utilizing potential aesthetic value is of great significance to the preservation, integrity and attractiveness of the Libo Karst.

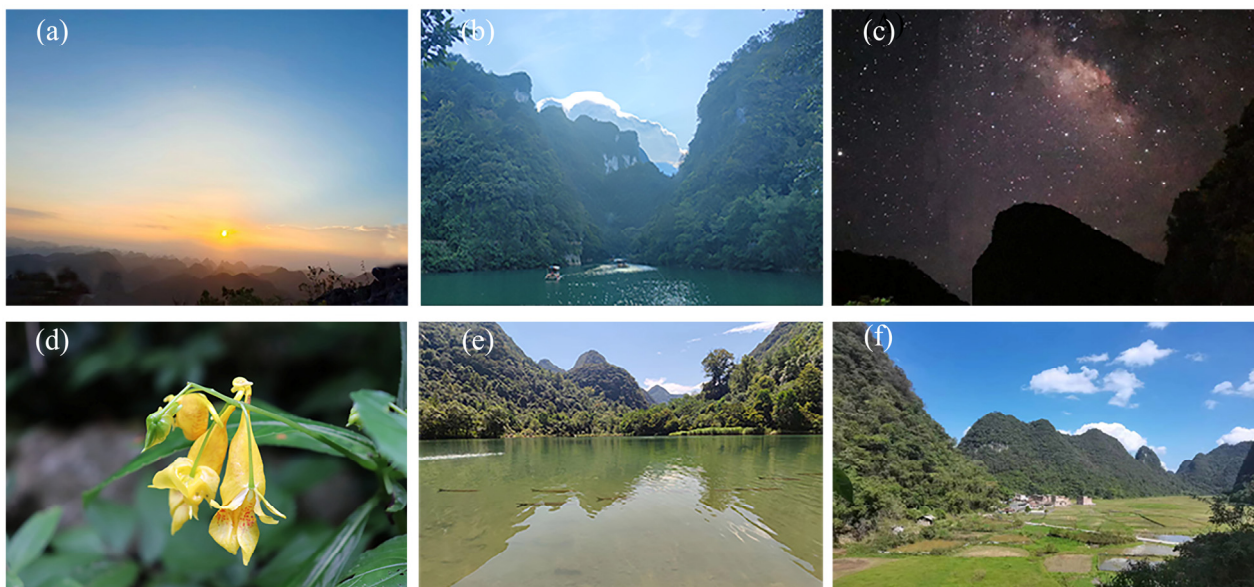


Figure 7. Potential aesthetic value of the Libo Karst: (a) Sunset landscape; (b) Exceptional meteorological landscape; (c) Starry sky landscape; (d,e) Biological landscape; (f) Landscape of the harmony between human beings and nature.

A starry sky, unique meteorological landscapes, biodiversity, and unique national customs constitute potential aesthetic value that must be strictly protected, publicized, and utilized to ensure the comprehensive management of atmospheric resources and landscape resources. At night, lighting that destroys the starscape should not be set up unless essential, to maintain the natural state of starlight. Large-scale live landscape performances are not allowed in the scenery to control noise and lighting. Small-scale natural aesthetic interpretations, such as natural starlight, moonlight, fireflies, and other interpretation planning, can be carried out at nighttime. For special meteorological landscapes, explanatory

boards are added by the extraordinary karst landscapes. Science popularization education is based on the remarkable astronomical phenomena and climatic landscapes to improve tourists' understanding of the celestial phenomena and climate tourism resources. Professional equipment for viewing celestial landscapes should be increased to improve the visitor experience.

For wild plant resources, according to local conditions, appropriate planting or domestication should be introduced in buffer zones in which appropriate tourism activities carried out. Ecological restoration and ecological conservation should enrich the visual elements of the buffer zone without affecting the integrity of the aesthetic value of heritage sites. It is necessary to strictly protect the overall ecological environment of heritage sites, especially as they may be home to unique wild animals. Tourism activities that interfere with the inherent habitat of these animals should be avoided, the status of legal conservation should be improved, law enforcement should be strengthened, and regular monitoring should be carried out. However, these unique wildlife resources can be exhibited through the interpretation system, combined with pictures, and popular science education can be offered.

The Libo Karst is home to ethnic minorities such as the Shui and Yao ethnic groups, and their rich and unique ethnic minority customs have contributed to the harmony and beauty of the people and land in the heritage site. These cultures offer a typical example of sustainable development and the use of deforestation-free forest products. In order to maintain the sustainable development of people and nature in these heritage sites, it is necessary to establish a sound guarantee mechanism to provide community residents with economic benefits and valuable opportunities and guide residents' willingness to protect the natural landscape beauty of heritage sites.

In general, the tourism of WNHSs needs to update the tourism concept, establish a "conservation-based" development concept, strictly prohibit excessive development and illegal utilization, and strictly abide by the red line of heritage conservation and utilization. All developments must respect and protect the OUV of WNHSs [78]. Every responsible subject in the conservation and tourism process should understand the importance of OUV and the conservation of the WNHSs. For WNHSs that meet the criteria for aesthetic value, their unique aesthetic value carrier resources should be used to create a uniquely branded Internet Protocol, and online information platforms should be used for publicity. Based on the carriers of aesthetic value located in different hierarchical conservation management areas, strict conservation measures and different degrees of tourism exhibition were adopted to achieve the sustainable development of the heritage sites.

5. Discussion

In recent years, the aesthetic value of WNHSs as an important driver of tourism development has attracted the attention of researchers and the scientific community [57]. Conservation has OUV has always been the original intention of the United Nations World Heritage Committee to establish a WH conservation management system [92]. However, this concern is mostly limited to descriptions of OUV and the submission of conservation management regulations prior to inscription, or to the status of conservation in periodic conservation management monitoring reports that OUV of heritage sites in the Convention. In fact, highlighting universal value is not only the focus of heritage protection, but also the key medium for economic benefits of heritage sites as tourist attractions [93], and for most people, the purpose of tourism is to feel and experience the beauty of various landscapes in the process of appreciation, so it is necessary to promote the sustainable development of heritage sites through collaborative research on conservation and tourism development based on value identification. In our study, taking WHKSs as a case site, based on the identification of aesthetic value carriers, a framework system of aesthetic value protection and tourism coordinated development of "aesthetic value identification-carrier and its characteristics-value system-protection and tourism" was constructed. Our research

has enriched many previous theoretical systems of protection and tourism synergistic development of heritage site.

The use of aesthetic value standards is controversial, and the process of identifying their value is, to a certain extent, an evaluation of the amount of aesthetic value realized. Most scholars have adopted the SBE method to calculate the aesthetic value of heritage sites, with few studies evaluating the object from the perspective of multiple stakeholders. In contrast, in this study, each landscape resource point was selected by combining the list of sites identified by experts, the landscape resource points in the government department's Plan of Libo Zhangjiang Scenic Area, and the web text analysis data that were directly perceived and evaluated by tourists. The selection and evaluation of these landscape resource points were not limited to a single aesthetic subject. The aesthetic value of the Libo Karst was calculated by giving different aesthetic weights to the aesthetic subjects, combined with the SBE method, making the evaluation results more comprehensive and objective in representing the aesthetic perceptions of different groups of people. This method can provide a reference for quantitative evaluations of the aesthetic value of other WNHSSs.

The identification of aesthetic value carriers and their characteristics makes the conservation objectives of heritage sites clearer and the conservation content more specific, clarifies the primary and secondary relationship between the conservation and utilization of aesthetic value, provides a basis for the division of the scope of conservation and tourism utilization, helps planners and decision-makers to strategically deploy tourism facilities in corresponding scenic spots, and formulates scientific and reasonable conservation management and planning to promote the sustainable development of heritage sites. In addition, the analysis of the results of the online text data provided by tourists visiting the Libo Karst can help to reflect tourists' perception of the destination. In general, most tourists have a high opinion of the natural beauty exhibited at the Libo Karst. However, there are also problems, such as insufficient interpretation, inconvenient transportation, and a lack of services. This can inform planners and decision-makers focused on the presentation of the aesthetic value of heritage sites. This study is of practical significance for the conservation and sustainable tourism development of the Libo Karst.

It is worth mentioning, apart from the landscape mentioned above, which contains resource points with high aesthetic value, other areas with high-sensitivity and high-quality ecological and natural landscape resources are not public exhibition areas and tourists are prohibited from sightseeing. Most of the landscapes located in the exhibition area in this study also have strict controls regarding the number of tourists. However, the aesthetic value of Libo Karst mostly pertains to the beauty of the combination of mountains, water, forests, and other natural landscapes, which could be emphasized from a macro-perspective, such as views overlooking the stone forest, karst primeval forest, 68 waterfalls, and other continuous tower-like peaks and cascading water bodies. This will offer a more visual experience and greater sense of awe. Therefore, scientific and technological means are recommended to show the beauty of natural landscapes to the public in their entirety. Unmanned Aerial Vehicle are used for sightseeing in the nearest non-restricted areas for instance, as well as observation decks, large-scale immersive experience halls, hot balls and other aerial sightseeing tools.

This study has the following challenges and future improvements: Firstly, the paper obtains aesthetic value landscape resource points based on the word frequency analysis of online text, although it has a certain objectivity, but this conclusion as an aesthetic value identification is inevitably too simple, and mainly based on the evaluation of tourists, to a certain extent, there is subjectivity, should expand the subject of evaluation, so that the evaluation should be more comprehensive. Secondly, whether the SBE method used in the quantitative evaluation of aesthetic value has universal applicability in different cultural contexts is debatable, and only focuses on the visual senses of the aesthetic subject in the evaluation process, while the aesthetic response of human beings to the environment is a holistic sense [94], including the pleasure evoked by related experiences such as smell,

touch, and hearing [95]. In future research, it is necessary to integrate the comprehensive sensory aesthetic value experience of the aesthetic subject's hearing, smell, and touch. Thirdly, due to the limited attention of respondents, only 30 sample points were selected for subjective landscape aesthetic value evaluation, which was not enough to represent the entire region. At the same time, in order to avoid the subjectivity brought by photography, each sampling point was required to have the same specifications for image collection from different dimensions, but different landscape types, especially the combined features of the landscape, are located in different environments, and the final presented image may deviate from the perception of the aesthetic subject actually being in it, affecting the final evaluation results. In future studies, it is possible to consider acquiring images based on the combination of space-space-ground. Finally, the applicability of the extraction method of representation elements generated in this study needs to be further tested in a wider range of work in the future, in view of the particularity of WHKSs, the limited information available to the authors and the difficulty of conducting a census, no corresponding nationwide comparative research indicators are given in this paper, and it is hoped that this comparative framework will be gradually established in the practice of industry peers in the future.

The synergy between the protection of aesthetic value and tourism development requires the establishment of a sound research system to form a virtuous circle in which heritage protection promotes tourism development, and tourism development feeds back the interaction between heritage protection. This truly guides the sustainable development of heritage sites, so in future studies this can be achieved in several ways. Firstly, the technology used to monitor the aesthetic value of the heritage sites is mostly still undergoing qualitative research and analysis; no perfect value monitoring system has been formed. We aim to construct quantitative monitoring indicators and a monitoring technology system to determine the OUV of the aesthetic value of the heritage sites, as well as forming scientific quantitative research methods and monitoring and evaluation models. Secondly, to solve the problem of difficulties coordinate the conservation of the aesthetic value of the WNHSs and tourism development, we aim to adopt technologies and measures to achieve a "win-win" situation for both factors, such as the use of "5G" and "VR" technology to exhibit large scenes and combined landscapes with high aesthetic value that cannot be entered by tourists. Finally, focusing on the lack of research on the coordinated development of a model of aesthetic value and tourism for WNHSs, we aim to strengthen the case studies of heritage sites that meet the aesthetic value standards and establish an exemplary coordination model of conservation and development.

6. Conclusions

In this study, we focused on promoting the sustainable development of heritage sites by studying conservation and tourism development based on aesthetic value identification, using WHKSs as case studies. Specifically, through a combination of big data commentary and SBE, we synthesized different stakeholders of the site as the aesthetic subjects to quantitatively evaluate the aesthetic value, which broadens the idea of a quantitative assessment of the aesthetic value of WNHSs. On this basis, through comprehensive analysis methods, we constructed a framework system of "aesthetic value identification-carrier and its characteristics-value system-protection and tourism" of WNHSs, which provided a reference for the value-based protection and tourism development of WHKSs and other similar WNHSs, promoting the sustainable development of heritage sites. In addition, this study refined the aesthetic value protection content of Libo Karst, and clarified and put forward the synergistic strategy of protection and tourism development, which has important reference value for the local government to protect and manage the world's natural origins, as well as important practical significance.

The COVID-19 crisis has exposed the fragility of the World Heritage tourism system, where the monitoring, maintenance and management of WNHSs has been stalled for a time, impacting the conservation and exhibition of OUV of most WNHSs. At the same

time, in the face of the threat of unknown man-made or natural disasters to the OUV of WNHSSs, it is urgent to rethink the sustainable development of World Heritage sites to enhance their resilience. In the future, the conservation and sustainable development of tourism at WNHSSs can be integrated into the application of new technologies such as big data and artificial intelligence in planning and conservation management, making full use of space technology and improving the monitoring and control system. Focusing on the improvement of the management capacity and willfulness of heritage sites has promoted the sustainable development of WNHSSs.

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