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Establishment of the management effectiveness assessment system of world natural heritage and empirical analysis—a case study of Fanjingshan

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Abstract

Although there are more than 270,000 protected areas worldwide, there is currently little data on their protection and management effectiveness. As a kind of protected area, natural world heritage (WH) sites are small but represent some of the most important natural landscapes, covering a very large area. But natural WH is threatened by climate change, natural disasters and human activities. Therefore, to achieve the sustainable development of WH sites, it is very important to analyze the management status of WH sites. Based on this, the study extracts inspiration from *Enhancing our Heritage Toolkit: Assessing management effectiveness of natural World Heritage sites*. An assessment system of the management effectiveness (ME) of natural WH sites has been established, which has three dimensions (including management foundation, management measures, and management performances) and 21 indexes. The reliability and validity of the index system are tested using the exploratory factor analysis method, and the results show that the index system has good reliability and validity. Then principal component analysis and comprehensive assessment methods are used to analyze the ME of the Fanjingshan WH site. The results show that the management effectiveness of the Fanjingshan WH Site is relatively excellent, but it still faces challenges from tourism development and community participation.

Keywords Management effectiveness, Natural world heritage, Assessment system, Fanjingshan

Introduction

A World Heritage (WH) Site is an irreplaceable precious resource with outstanding universal value [1, 2], a significant contributor to the sense of local and national identity and pride, and a key link to demonstrate our common history, social development, and scientific progress

[3]. By 2022, there are 1154 world heritage sites on the World Heritage List, distributed in 167 States parties [5]. Despite the high praise given to the WH sites, it has become a fact that they are under threat. According to the World Heritage Centre in 2021, one third of the world natural heritage sites are facing the threats of climate change, mountain fires, coral reef degradation, extreme weather, and drought, which brought an impact on natural heritage sites and mixed sites. At the same time, these risk factors caused an inevitable potential crisis in the protection and management of heritage [6]. In addition to the above threats of natural factors, the interference of human activities has also caused a certain impact on the natural WH sites. In particular, the tourism economic development brought by the brand effect of WH sites has

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increased the number of visitors in heritage tourism destinations, causing environmental pollution to a certain extent [4]. Therefore, countries worldwide spend a lot of money and make efforts to maintain world heritage sites so that they can be preserved, presented, and transferred to future generations [7]. Whether the expenditure of funds and energy is worth, it needs to be reflected by the status of conservation and management of WH sites, which is usually achieved by management effectiveness (ME) assessment.

ME assessment aims to achieve adaptive management and efficient resource allocation, promote accountability and transparency in a changing environment, and maintain the value of protected areas [8]. Its assessment system is also relatively perfect, and it provides some assessment tools based on three commonly used assessment frameworks (the World Commission on Protected Areas (WCPA) assessment framework, the International Union for Conservation of Nature (IUCN) Green List assessment criteria, and China Natural Protected Areas assessment framework) [9, 10]. Such assessment tools include Rapid Assessment and Priority of Protected Area Management (RAPPAM), Management Effectiveness Tracking Tool (METT), Enhancing Our Heritage toolkit (EOH), and Guidelines for Assessment of Effectiveness of Marine Protected Areas Management, among others [11–14]. UNESCO's EOH toolkit looks closer at individual world heritage sites than the other assessment tools. The toolkit contains twelve utility tools, including Identifying Site Values and Management Objectives Tool; Identifying Threats Tool; Relationships with Stakeholders Tool; Review of National Context Tool; Assessment of Management Planning Tool; Design Assessment Tool; Assessment of Management Needs and Inputs Tool; Assessment of Management Processes Tool; Assessment of Management Plan Implementation Tool; Work/Site Output Indicators Tool; Assessing the Outcomes of Management Tool; and Review of Management Effectiveness Assessment Results. These tools document the status of WH sites in tabular form. They are designed to help conservation managers bring together the elements of a comprehensive management framework, including building targeted monitoring strategies. It is committed to help World Heritage site managers and others involved in managing protected areas to improve their capacity to achieve management objectives for the benefit of the global community [55]. While the EOH Toolkit assessing ME of natural WH sites is relatively comprehensive in its assessment, the evaluation results are not conducive to horizontal comparative analysis among heritage sites.

Although there are many tools to assess management effectiveness [56], the literature on assessing the ME of natural WH management is few. We searched for articles,

papers and conferences on CNKI and Web of Science to identify relevant research. In the CNKI database, “subject” is used as the search term and “world natural heritage” is used as the search term for the first search. In search results, “management effectiveness” is the second search keyword. In the Web of Science Core database, the first search term was “world natural heritage” and the second was “management effectiveness”. The query time range is the maximum time range of the database. A total of 8 Chinese and English literature were found. It can be seen that the assessment of the effectiveness of world natural heritage management has not received enough attention. In addition to the eight existing articles on assessing the effectiveness of world natural heritage management, the effectiveness of the management of the current world natural heritage sites is evaluated in the form of reports every three years from the IUCN *World Heritage Conservation Outlook* (IUCN, 2020). The EOH Toolkit and the World Heritage Conservation Outlook provide qualitative descriptions to demonstrate the ME of world natural heritage sites.

In the context of exponential growth in the number and area of natural protected areas worldwide, many protected areas have not been effectively managed [15]. Global biodiversity is still in a downward trend [16, 17]. The natural WH accounts for 8% of the global protected sites. Data since 2017 shows that there are more deteriorated sites than improved ones among these natural heritage sites, and only half of them have been effectively protected and managed [18]. Therefore, in this context, the current management effectiveness of natural WH sites is studied in this paper. Taking EOH assessing ME of natural WH sites and China's Assessment Standards for Natural Protected Areas as a reference, an index system suitable for assessing the effectiveness of natural WH management is established in the paper. Fanjingshan WH Site is chosen as the object of empirical analysis to sort out the current status of the effectiveness of the management of Fanjingshan WH Site. The assessment index of the effectiveness of natural WH management proposed in this paper contains comprehensive information on the evaluated heritage sites. This assessment system solves the problem that the evaluation results of WH sites cannot be compared horizontally.

Meanwhile, the evaluation results of this paper review the conservation and management of the Fanjingshan WH Site. To further assist the Administration of Fanjingshan World Heritage in clarifying its advantages and disadvantages in WH management, improve the management level, and promote the management process to be more scientific and reasonable, a scientific basis for the protection and management authorities of Fanjingshan WH is also provided in this paper to formulate

more scientific and reasonable management policies and sustainable development of the WH site. Hopefully, this study can provide ideas and methods for ME assessment of natural WH in China and the world.

Study area and data sources

Study area

Located in Tongren City, Guizhou Province, South-western China, Fanjingshan WNH Site and buffer zone across Jiangkou, Yinjiang and Songtao counties, covering a total area of 77,514 hectares (Fig. 1). Because of its unique geographical location and landform features, superior climate conditions and little human interference, Fanjingshan WH site has an extremely rich biodiversity, preserved habitats for a large number of an ancient relic, endangered and endemic species. It is the only natural habitat and the key site for local protection of Fanjingshan Fir (*Abies fanjingshanensis*) and the Guizhou Snub-nosed Monkey (*Rhinopithecus brelichi*); it is the protection area of primeval beech forest which has outstanding universal protection value and scientific value [22–25]. At the 42nd session of the World Heritage Committee on July 2, 2018, Fanjingshan was approved by

the UNESCO World Heritage Committee to be inscribed on the World Heritage List, making it the 53rd World Heritage Site and the 13th natural WH site in China. The World Heritage Committee inscribed Fanjingshan on the World Heritage List based on **Criterion (x)**: Fanjingshan is characterized by an exceptional richness in bryophytes, with 791 species, of which 74 are endemic to China. The property also has one of the richest concentrations of gymnosperms in the world, with 36 species. A significant number of endemic species are distributed inside the property, including 46 local endemic and 1010 Chinese endemic plant species, as well as 4 locally endemic vertebrate species. The most notable of these is the endangered Guizhou Snub-nosed Monkey, which is found only in Fanjingshan and nowhere else in the world. Another prominent endemic species is Fanjingshan Fir, which is also restricted to this property. The property contains 64 plant and 38 animal species that are listed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) on the IUCN Red List, most notably Guizhou Snub-nosed Monkey, Chinese Giant Salamander, Forest Musk Deer, Reeves’s Pheasant, Asiatic Black Bear, and *Bretschneidera Sinensis*.

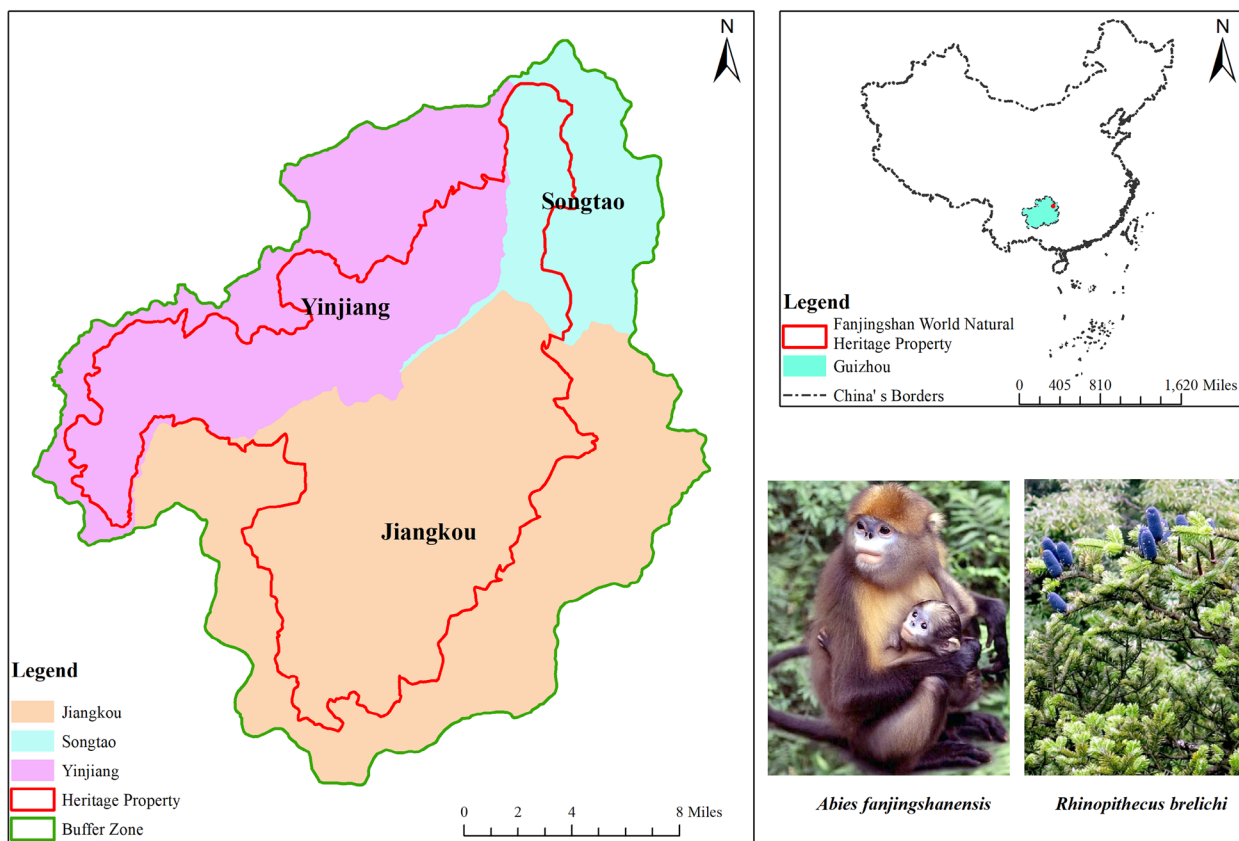


Fig. 1 Study area

Data collection/analysis

The data source of this study consists of two parts. The first part is a stakeholder questionnaire from the Fanjingshan WH Site (managers, visitors, local communities, and researchers) to rate the importance of ME indicators. The 5-point Likert scale is used for measurement. 1, 2, 3, 4, and 5 indicated ‘very unimportant,’ ‘unimportant,’ ‘general,’ ‘important,’ and ‘very important,’ respectively. This data is used to verify the scientific feasibility of the assessment index selection, and the data is also used to obtain the index weight. The questionnaire survey was conducted on June 3–7, 2022, and the survey sites were Jiangkou County, Yinjiang County, and Songtao County within the Fanjingshan WH Site. In the first part of the survey, the proportion of men and women was 51.2% and 48.8%, respectively; the age was mainly young and middle-aged, the 21–59 years old accounted for 82.4%; 74.8% of the respondents had college, undergraduate and postgraduate qualifications. The questionnaire includes cross-county Fanjingshan WH ME assessment indexes and demographic characteristics (including respondents’ gender, age, and education level), and 301 valid questionnaires were received. The second part of the data is the score (1 to 5 points) by the managers of the Fanjingshan WH site based on the ME of the assessment indexes. The staff from the Administration of Fanjingshan National Nature Reserve were entrusted with issuing 40 paper-based rating questionnaires, 40 valid questionnaires were taken back, and the effective recovery rate was 100%.

Method

The interview is the research method used in selecting assessment indexes in this paper. The questionnaire survey method is used to obtain data, and the methods used in data analysis include exploratory factor analysis, principal component analysis, and comprehensive evaluation methods. The following work is carried out: establishing an evaluation index system, carrying out index weight calculation, and comprehensively assessing the management effectiveness of the Fanjingshan WH site.

Index system establishment

First, at the beginning of index establishment, according to the EOH Toolkit assessing ME of natural WH sites and China’s Assessment Standards for Natural Protected Areas, it is found that the assessment of ME mainly involves the recognition of Outstanding Universal Values of WH sites, management objectives, management planning, management staff, management input funds and budgets, threats faced by heritage sites, and the relationship between heritage sites and stakeholders. According to the commonness of nature reserve evaluation and natural heritage

management effectiveness evaluation content and the characteristics of natural WH, a total of 27 assessment indexes of WH management effectiveness were extracted. In addition, the author’s research team (composed of five people whose research fields are related to heritage conservation management, including four graduate students and one professor) conducted a group discussion on how to assess the effectiveness of natural WH management. At the same time, the assessment indexes that may cause ambiguity, unclear/reasonable expression, repetition/similarity and omission should be deleted and supplemented. Finally, 22 evaluation indexes of the WH of natural WH were obtained as the questions of the first questionnaire survey. The first part of the questionnaire sample is used for exploratory factor analysis to determine the dimensions and indicators of the assessment of the effectiveness of natural WH management.

Index weight analysis

The principal component analysis method is used to determine the weight of the assessment index of the ME of natural WH sites. Since the data is obtained by the scale of the questionnaire, it is consistence, and the data standardization operation is no longer carried out. The cumulative variance contribution rate obtained by SPSS analysis is 87.32% (greater than 85%), indicating that the principal component method is suitable for weight analysis [29]. The specific calculation process of index weight is as follows [30, 31]:

$$T_{jp} = \frac{|\partial_{jp}|}{\sum_{j=1}^m |\partial_{jp}|} \tag{1}$$

where: T_{jp} is the weight of the j index in the p component ($j = 1, 2, \dots, m$), $|\partial_{jp}|$ is the absolute value of the factor loading of the j indicator on the p component; $\sum_{j=1}^m |\partial_{jp}|$ is the algebraic sum of the absolute values of all factor loadings in this component.

$$w_j = \frac{\sum_{p=1}^k T_{jp} \lambda_p}{\sum_{p=1}^k \lambda_p} \tag{2}$$

where: w_j is the weight of the j index, and λ_p is the contribution rate of p component; $\sum_{p=1}^k \lambda_p$ is the cumulative contribution rate of k principal components; the weight coefficient obtained by the formula needs to be normalized to obtain the final weight y_j of the j index. The normalization formula is as follows:

$$y_j = \frac{w_j}{\sum_{j=1}^m w_j} \tag{3}$$

Comprehensive assessment ME of Fanjingshan

According to the 40 questionnaires from the Administration of Fanjingshan National Nature Reserve scored in the second part, the index-weighted comprehensive assessment method was used to score the management effectiveness of the Fanjingshan WH. Firstly, the assessment grade was established. According to the relevant research [21, 57], this paper’s assessment grade was determined, divided into four grades, namely ‘excellent, good, medium and poor.’ The management effectiveness score for world natural heritage sites ranges from 1 to 5. Secondly, the effectiveness level of the world heritage site management is divided according to the grading standard. The assessment criteria for 1–2 points represent ‘poor’; 2–3 scores represent ‘medium’; 3–4 scores represent ‘good’; 4–5 scores represent ‘excellent.’ Finally, the effectiveness of the comprehensive assessment was conducted. The assessment formula is as follows:

$$EM = \sum_{j=1}^{40} y_j \times C_j \tag{4}$$

where: *EM* represents the management effectiveness of world natural heritage, and *C_j* is the average score by the managers of the *j* index.

Results

Index system and weight

When establishing a scientific assessment index system, exploratory factor analysis was carried out on the data collected in the first part of the questionnaire to test the reliability and validity of the index system. First, the need is to analyze the validity of the Questionnaire data. The analysis results are shown in Table 1. The KMO statistic is 0.978, and the probability p-value of the Bartlett spheroid test is 0.000, indicating the high validity of the Questionnaire data. Then, the principal component analysis method was used to extract factors in SPSS software, and factors with eigenvalues greater than 1 were selected, and the maximum variance method was used to carry out orthogonal rotation of factor load matrix, so as to make factor naming more explanatory [28]. The output structure matrix in Table 2 and the total variance interpretation rate (Table.3). According to the results

Table 2 Principal component matrix after rotation

Measurement index	Component		
	1	2	3
1 World heritage value identification			0.572
2 Boundary delineation			0.874
3 Protection management target recognition			0.860
4 Fundamentals of law			0.851
5 Working system			0.849
6 Manning level			0.858
7 Financial management			0.868
8 Infrastructure			0.873
9 Resources investigation	0.850		
10 Scientific research	0.847		
11 Publicity and education	0.833		
12 Patrol law enforcement			
13 Tourism management	0.845		
14 Community management	0.827		
15 Cross-regional collaborative management	0.840		
16 Formulation and implementation of planning	0.842		
17 Monitoring and evaluation	0.803		
18 Integrity of World Natural Heritage			0.687
19 Community welfare			0.763
20 Community participation			0.646
21 conflict reduction level			0.784
22 Tourism development			0.698

shown in Table 2, three common factors with eigenvalues greater than 1 were extracted. The author summarized according to the connotation of indicators contained in each common factor and named common factor 1 as management measures, common factor 2 as management foundation and common factor 3 as management performance. These three common factors constituted the three dimensions of assessment indexes. The corresponding value of each indicator in Table 2 is the factor load. According to the result, it can be seen that the twelfth index patrol law enforcement cannot belong to any dimension, so this indicator is deleted. According to Table 3, the extracted three common factors can explain 87.32% of the total Variance of the original variable, indicating a good effect of factor extraction. Finally,

Table 1 Validity test

KMO and Bartlett test			
KMO			0.978
Bartlett’s Test of Sphericity	Approx. Chi-Square		7144.035
	df		210
	p		0.000

Table 3 Extract the factor to explain the variance

Component	Extraction sums of squared loadings		
	Total	% of variance	Cumulative %
1	7.233	34.443	34.443
2	7.017	33.416	67.859
3	4.088	19.466	87.325

a reliability test on the dimensions divided by indicators was conducted. According to the results in Table 4, Cronbach’s α values of the three dimensions were all greater than 0.90, indicating that the index system established in this paper has good reliability [26, 27].

Based on the above analysis, a natural WH ME assessment system with three dimensions (management foundation, management measures, management performance) including 21 evaluation indexes is finally established. The dimension of management foundation includes eight indexes: world heritage value identification, boundary delineation, protection management target recognition, fundamentals of law, working system, manning level, financial management and infrastructure. In order to facilitate the analysis, A1-A8 is used to replace the indicators. Management measures include resources investigation, scientific research, publicity and education, tourism management, community management, cross-regional collaborative management, formulation and implementation of planning, monitoring and evaluation. The indexes in this dimension are replaced by B1-B9 (excluding B4). The dimension of management performance includes the integrity of natural WH, community welfare, community participation, conflict reduction level, and tourism development. C1-C5 replaces the index of this dimension. Then, the weight analysis was carried out

according to the principal component, and the results were shown in Fig. 2. In Fig. 2, the central circle represents the assessment objective, the second circle represents the dimension of the assessment system, the third circle represents the assessment index, and the last

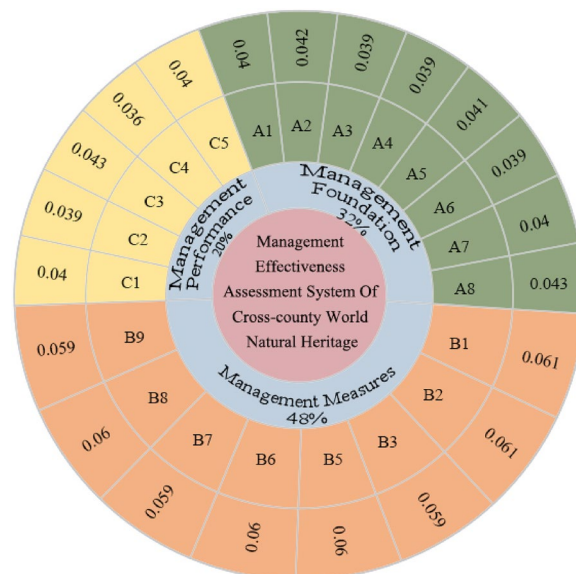


Fig. 2 Assessment system index weight allocation

Table 4 Reliability test

Dimension	Index	Project quantity	Cronbach's α
Management Foundation	World heritage value identification	8	0.979
	Boundary delineation		
	Protection management target recognition		
	Fundamentals of law		
	Working system		
	Manning level		
	Financial management		
	Infrastructure		
Management measures	Resources investigation	8	0.988
	Scientific research		
	Publicity and education		
	Tourism management		
	Community management		
	Cross-regional collaborative management		
	Formulation and implementation of planning		
	Monitoring and evaluation		
Management Performance	Integrity of World Natural Heritage	5	0.925
	Community welfare		
	Community participation		
	Conflict reduction level		
	Tourism development		

circle represents the weight value of each index. First of all, it can be seen that the weight values of the last circle are similar, which means that the assessment of these 21 indicators greatly impacts the assessment of the ME of natural WH. Secondly, the weight of management measures is $0.479 >$ the weight of management foundation which is $0.323 >$ the weight of management performance which is 0.198 , indicating that effective protection and management actions are crucial for the effectiveness of world heritage management. The inspection of management measures can intuitively show the activities and practice methods that affect the effectiveness assessment of the estate management, quickly identify the current excellent practice scheme of the estate management, and reflect on the effectiveness assessment of the estate management whether the current management actions need to be improved.

When establishing the assessment indexes, it is considered in this paper that the world natural heritage sites cover a large range due to its ecological or geological integrity requirements, and are prone to cross administrative boundaries [38]. Therefore, indexes not measured in previous management effectiveness are added: B7 (cross-regional collaborative management) and C4 (conflict reduction level). B7 is a review of collaborative management actions, while C4 is a review of collaborative management results. Figure 2 shows that the weights of B7 and C4 are 0.059 and 0.036 respectively, which indicates that the review of collaborative management is also relatively important in the ME assessment of natural WH sites. Among the assessment indexes, B1 (resource investigation) and B2 (scientific research) have the most prominent weights, accounting for 0.061 . It can be seen that the premise of effective management of natural world heritage sites is to investigate the rare resources of plants and animals in the sites to identify key protected species. At the same time, continuous scientific research activities can promote the stakeholders of the heritage site to understand the rare animal and plant resources. At the same time, scientific research activities can promote the continuous and positive transfer of natural materials to human society. First of all, managers carry out conservation management based on research. Community residents respect the regulations on the protection and management of animals and plants, and natural heritage sites can obtain ecological and environmental health, which feedbacks to the continuous economic income and good living environment of human beings. Therefore, to some extent, scientific research activities can promote the sustainable development of WH sites and the beautiful vision of harmonious coexistence between human and nature.

MEA of Fanjingshan world natural heritage

According to the comprehensive assessment research method and scientific calculation, the assessment score of the management effectiveness of Fanjingshan WH is finally obtained shown in Table 4. The comprehensive assessment score is about 4.210 , between 4 and 5. Therefore, the assessment grade of the management effectiveness of Fanjingshan World Natural Heritage is “excellent”. By comparing the assessment results with the conclusion of the Fanjingshan 2020 Conservation Outlook Assessment, it is found that the assessment results in this paper are consistent with the Fanjingshan 2020 Conservation Outlook Assessment. The Fanjingshan 2020 Conservation Outlook Assessment, with 15 aspects assessed. Among them, 10 assessment contents of management system, effectiveness of management system, boundary, legal framework, sustainable use, capital, staff ability, education and publicity, monitoring and research were rated as “Mostly Effective”. The report concludes that the protection and management of the Fanjingshan World Heritage site is mostly effective.

The results were analyzed according to Table 4. First of all, it is found that the most outstanding performance is the management measures of the work done; second, the management foundation is also excellent. Among the average scores of the measured indicators, the best ones are the protection status of the Fanjingshan World Heritage A1 (world heritage value identification), A2 (boundary delineation), A4 (fundamentals of law), A7 (financial management), B6 (community management), B9 (monitoring and assessment) and C1 (integrity of World Natural Heritage) (Table 5). The average scores of these seven indexes are all above 4.3 . The high score of these seven items is attributable to the efforts made by Chinese governments at all levels, business departments, expert teams, Fanjingshan WH Administration, related local communities and enterprises in recent years (Table 6).

Fanjingshan has performed well in various conservation measures and management foundations since it was inscribed on the World Heritage List in 2018, but there are still some concerns. Table 3 shows that the scores from C5 (tourism development) and C3 (community participation) are relatively low. The average score for tourism development is 3.8 , and the average score for community participation is 3.9 . This reveals that the effectiveness of the current protection and management of Fanjingshan WH Site is threatened by tourism development and community communications. First of all, the pressure from tourism development is remarkable for Fanjingshan. The number of tourists has been rising steadily, which may affect the daily activities of some animals in Fanjingshan. Now the Fanjingshan WH Administration has responded to the threat. Fanjingshan

Table 5 Fanjingshan WH ME assessment score

Dimension	Index	Weight coefficient	Average score	Weighted score
Management foundation	A1 World heritage value identification	0.040	4.3875	0.176
	A2 boundary delineation	0.042	4.525	0.190
	A3 Protection management target recognition	0.039	4.25	0.166
	A4 Fundamentals of law	0.039	4.375	0.171
	A5 Working system	0.041	4.2875	0.176
	A6 Manning level	0.039	4.225	0.165
	A7 Financial management	0.040	4.4	0.176
	A8 Infrastructure	0.043	4.1875	0.180
Management measures	B1 Resources investigation	0.061	4.225	0.258
	B2 Scientific research	0.061	4.225	0.258
	B3 Publicity and education	0.059	4.1	0.242
	B5 Tourism management	0.060	4.2	0.252
	B6 Community management	0.060	4.3125	0.259
	B7 Cross-regional collaborative management	0.059	4.05	0.239
	B8 Formulation and implementation of planning	0.060	4.0375	0.242
	B9 Monitoring and assessment	0.059	4.35	0.257
	Management performance	C1 Integrity of World Natural Heritage	0.040	4.45
C2 Community welfare		0.039	4.15	0.162
C3 Community participation		0.043	3.9	0.168
C4 Conflict reduction level		0.036	4.05	0.146
C5 Tourism development		0.040	3.8125	0.153
Total				4.210

currently limits the number of visitors to the site to less than 8000 visitors per day. Besides, to ensure that tourists traveling activities are mainly concentrated in relatively small areas, the public tour area only accounts for 2.1% of the whole property. At the same time, protected areas of major biodiversity and habitats of plants and animals are off-limits to visitors [32]. Although the control of tourism management measures is quite strict, the potential threats brought by tourism will still exist. Therefore, all kinds of tourism activities carried out on the property should be monitored and assessed to ensure the safety of animal and plant habitats in Fanjingshan and protect the biodiversity.

Community participation in the protection, supervision and daily investigation of world heritage property plays an important role in protecting sustainable development and good interaction between the property and residents [33, 35]. We have to admit that the attitude of community residents is important for the sustainability of tourism development because the community is closely related to the property. Meanwhile, community residents make their living on local environmental resources [36]. Communities have two sides to heritage conservation and development. If heritage protection can guarantee the benefit of the community, the community will show

positive feedback to heritage management. Otherwise, heritage management work will be negatively affected [33]. At present, community participation in the Fanjingshan WH site still has a long way to go. The effectiveness of heritage management depends on the participation of the community to some extent. Allowing their residents to benefit from heritage protection is the most direct way for communities to participate in heritage management work, by which their recognition of the heritage value can be strengthened [34]. In August 2020, Fanjingshan WH Site carried out a pilot program of joint community management with the heads of villages and towns, supervising the natural resources under their jurisdiction and banning improper behaviors such as illegal cutting and illegal hunting. This measure can help the community to solve existing problems in time and promote the protection of biodiversity in Fanjingshan and the harmonious development of man and nature. Although the goal of the policy is positive, it lacks a corresponding incentive mechanism. It is necessary to stimulate the inner motivation of the community to participate in the protection, promote the community's understanding of heritage protection and management, and then improve the relationship between the community and the heritage management staff.

Table 6 Assessment score analysis

Measurement index	Assessment performance	Reasons and measures
World heritage value identification	Excellent	Related experts and departments have investigated the site from its natural characteristics, geological development, ecosystem, habitats and aesthetic landscape. Finally, the principal values of Fanjingshan are determined to be “the unique isolated ecosystem with high endemic characteristics surrounded by the karst ocean, the largest continuous distribution area of the primary beech forest in the global subtropical region, the global wild population of Guizhou Snub-nosed Monkey, the only habitat of Fanjingshan Fir, unique bryophytes and gymnosperms”
Boundary delineation	Excellent	According to the declaration and management of the World Natural Heritage, the scope of Fanjingshan heritage site and buffer zone has been determined, and special wildlife protection area, wildlife protection control area, important landscape protection area and general buffer zone have been formed in the continuous protection and coordinated development. The protection value and the protection target are identified for different areas. The Boundary demarcation and calibration project of Fanjingshan WH Site has been implemented, and 340 marking points (28 boundary tablets, 312 boundary stakes) have been completed in the heritage site, and 1060 marking points have been completed in the buffer zone
Fundamentals of law	Excellent	At present, there are such important laws and regulations and related plans as the <i>Regulations on the Protection of Fanjingshan of Tongren City</i> , the <i>Declaration and Management Measures for the World Natural Heritage, Natural and Cultural Dual Heritage (Trial)</i> , the <i>Protection Plan for Guizhou Snub-nosed Monkey (2015–2025)</i> , and the <i>Protection and Management Plan for Fanjingshan World Natural Heritage Site (2016–2035)</i>
Financial management	Excellent	The Fanjingshan WH Site is in good financial condition. From 2019 to 2020, the funds for the protection and management of the Fanjingshan WH Site come from provincial financial funds, which is used for the conservation and management project of the Fanjingshan WH Site, ecological protection and other aspects. And the source of funds is stable and sufficient
Community management	Excellent	Manage the residents in different areas according to the management objectives of the controlled areas. For example, reduce the population in the heritage site as far as possible and carry out ecological relocation work. In the buffer zone, residents can develop appropriate tourism
Monitoring and assessment	Excellent	Monitoring stations and wildlife rescue centres have been set up. The administration works with universities in Guizhou to monitor the environment, heritage values, natural disasters and tourist activities. The monitoring means is a combination of manual monitoring and equipment monitoring. The monitoring time is mainly long-term monitoring, and the monitoring results are evaluated and fed back in time
Integrity of World Natural Heritage	Excellent	According to the objectives of conservation management, there are abundant management measures such as resource surveys, scientific research, publicity and education, tourism management, community management, cross-county cooperative management, planning formulation and implementation, and monitoring and evaluation. The management basis is relatively perfect so that the habitat of animals and plants in the heritage site is maintained in a good state. Therefore, the outstanding universal values and integrity of Fanjingshan WH Site are well protected, and potential threats from tourism development and community participation are well controlled

Discussion

According to the research results of index weights in Fig. 2, B7 (cross-regional coordinated management) and C4 (conflict reduction level) have a certain weight in the ME evaluation of natural WH, which indicates that these two factors must not be ignored in the ME evaluation of natural WH, unless the heritage site does not involve cross-regional management. Most world natural heritage sites are nominated to meet the requirements of integrity, so it is common for them to be cross-regional or transnational [37]. Protected areas that transcend administrative boundaries within a country or beyond national boundaries often have high ecological connectivity [38]. Such areas divided by administrative boundaries are prone to management difficulties that threaten the biodiversity of protected

areas [39–41]. For example, the large cross-border landscape ‘Heart of Borneo’ across Brunei, Indonesia, and Malaysia have been damaged because of poor governance, lack of cross-border cooperation, and infrastructure development along the international borders between the three countries [42]. Due to the lack of coordinated management and co-management measures, some disputes, like conflicts on resource ownership, often occur [43, 44]. Therefore, cross-regional coordinated management is necessary. On the one hand, coordinated management can reduce regional conflicts; on the other hand, it can protect cross-regional habitats for animals and plants from threats. Previous studies on management effectiveness assessment mainly focus on biological resources and management systems in protected areas [45–47], without concerning the restriction of administrative boundaries

on protected areas. In view of this, B7 and C4, the two indexes evaluated in this paper, are targeted to enrich the content of management effectiveness evaluation for World natural heritage management and other types of heritage sites.

The research results of the management effectiveness of Fanjingshan in this paper are basically consistent with the assessment results of the *Fanjingshan 2020 Conservation Outlook Outlook* finished by IUCN. The report shows that the outstanding universal value of Fanjingshan is in good condition. The biggest threat to property is the impact of tourism and the development of related infrastructure. The relationship with the community also worries IUCN [32]. As shown in Table 4, the overall score of the assessment results of management effectiveness is 4.210, which is excellent. However, the average score of community participation and tourism development in management effectiveness is relatively low, indicating that there are still some deficiencies in the two assessment contents. In the study of Ellwanger, AL, it was mentioned that the resource protection of Fanjingshan limited the livelihood of community residents, and some residents were forced to move away for resource protection [48]. Therefore, it is necessary to investigate the willingness of residents and present the method of implementing the relocation process to the public. It is generally believed that understanding local people's attitudes towards the environment and conservation is an important part of developing successful long-term conservation and management strategies [49, 50]. Moreover, initiatives that incorporate local communities into the decision-making process may receive greater community support and compliance with rules. However, if the community believes that restrictions on their livelihoods are unfair or their participation in the decision-making process is limited, it may exacerbate negative perceptions of management [51, 52].

The road around Fanjingshan and the tourist cable car established for the tourism development of Fanjingshan are liable to cause habitat impact, which poses a potential threat to the Guizhou snub-nosed monkeys [23, 53, 54]. However, there is almost no detailed record of the impact of tourism on the habitat of this endangered primate species [23]. To sum up, there are a lot of research topics on Fanjingshan in the future; both the impact of tourism and the elaboration of the process of migration has attracted the attention of the public.

Conclusion

Based on the MEA tool, it is proposed in this paper a set of assessment systems for the management effectiveness of world natural heritage sites. Based on the questionnaire survey data, this assessment system is

empirically tested by exploratory factor analysis. The conclusions are as follows: the management assessment system for the effectiveness of world natural heritage includes 21 assessment indexes in three dimensions: management foundation, management measures, and management performance, which is of great reliability and validity.

The management effectiveness score of Fanjingshan cross-county World Natural Heritage is excellent. The resource investigation and scientific research activities of Fanjingshan have performed well, and the coordinated management measures of Fanjingshan are relatively excellent at present. The Fanjingshan World Heritage Administration is facing some challenges from both the current community participation and the sustainable development of tourism. However, the outstanding universal value of the property has been well protected, and the efforts made by the Authority in recent years to protect and manage the site should not be denied. It is expected that the Fanjingshan Authority will reply to IUCN's concerns (tourism development, relocation) in the future.

Globally, there are few research articles on the management assessment of the effectiveness of world natural heritage sites, and there is not much experience to refer to. Therefore, the results of the research provide referable management effectiveness assessment practices for regions with similar backgrounds to achieve effective world heritage sustainability strategies.

Abbreviations

WH	World Heritage
EOH	Enhancing Our Heritage
ME	Management effectiveness
WCPA	The World Commission on Protected Areas
IUCN	The International Union for Conservation of Nature
RAPPAM	Rapid Assessment and priority of Protected Area Management
METT	Management Effectiveness Tracking Tool

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Conceptualization: XY; methodology: XY; data collection and analysis: XY, DM, MH, JM; writing-original draft: XY, SX; writing-review and editing: XY, DM, SX; supervision: XY, SX; funding acquisition: SX. All authors read and approved the final manuscript.

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Availability of data and materials

Datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

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