Application of Multi-level Grey Evaluation on Geological Tourism Resources’ Economic Values of Geopark: A Case Study of Huashan Geopark in Shaanxi Province

Yang Zhang¹, Xianjie Gong², *
¹School of Economics and Management, Xi'an Aeronautical University, Xi'an 710077, China
²Party and Administration Office, Xi'an Aeronautical University, Xi'an 710077, China

*Corresponding author e-mail: gxjxing@163.com

Abstract. Geo-park gives priority to geographical relic landscapes. It has not only rich geological touristic resources but also extraordinarily high values for economic development. Taking Huashan Geological Park as an example, the thesis systematically analyzes the characteristics of the geological touristic resources in this park. It applies the method of multilevel grey evaluation to establish the evaluation model for the economic values of the touristic resources in the geological park and presents detailed result of the assessment. The result concludes an excellent grade for the comprehensive evaluation of the economic values of Huashan geological touristic resources, reflecting the outstanding natural advantages of the park in geological resources. Moreover, in the single-item evaluations, the scientific evaluation ranks the highest in score, indicating that the geological touristic resources of the park have extraordinary geologically science-popularizing values as a significant condition for the development of scientific tours. It shows that the park is endowed with excellent prospects for economic development.

1. Introduction

As the carrier of the geo-park, the geological touristic resources are the origin for its existence and development. With the rising of the great mass fervor for geological tours, geological touristic resources attract numerous tourists with distinctive natural beauty and extraordinary scientific values. At the same time of enhancing public scientific attainments, the resources also powerfully promote the geo-park to become a hot tourist resort. Moreover, the resources also provide affluent funds for the protection of geological relics, foregrounding the special economic values of geological touristic resources. [1] However, the current researches on geological touristic resources focus on exploitation and utilization. They lack the effective recognition and evaluation of the economic values, as a result of which they are ineffective in directing the geological touristic development of the future geo-parks. Thus, taking Huashan Geological Park as an example, the thesis makes a primary exploration for the above mentioned issue by establishing the evaluation model for the economic values of the geological touristic resources as well as analyzing and discussing the economic values of Huashan Geological Park.
2. General situation of Geopark geological tourism resources

Huashan Geological Park locates in the east part of Guanzhong Plain in Shaanxi Province. At the downstream areas of Weihe River, it situates within Huayin City. The Park is enclosed by Qinling Mountains in the south while adjacent to Weihe River in the north. [2] With a height of 2,154 m and a total area of 54 km², the park lies at the south side of North China Platform of the ancient early period as well as the northeastern side of the orogenic belt of Qinling Mountains. Its tectonic position is quite special with the fracture on the northern foot of Qinling mountain running through the whole park, and there breeds the ancient metamorphic rock assemblages and typical monzonitic granites. The geomorphic division of regions is obvious in the park with complicated and diversified patterns. Except the landform of granites, there also appears various types of geological and geomorphologic landscapes such as landform of water erosion, landform of mountain collapse, triangular facet in front of Qinling Mountain, gorges and springs. Among them, such natural landscapes as Huashan granitic precipices, group of granitic peaks and forest of peaks are the most representative. [3] They are famous for their extraordinary characteristics all over the world. The typical evolutionary history of the geological relics and the special tectonic settings of the earth endow the park with numerous geological touristic resources of high scientific popularity, typicality and appreciative values. The park not only provides the significant information of the construction and evolution of the earth-crust in the northern area of Qingling Mountains but also offers the ideal position for the investigation of geological disasters. [4] It is a rare place for scientific education and sightseeing tourism in northern Qinling Mountains.

3. Evaluation and analysis

3.1. Constructing evaluation index system

Most of the evaluation indexes for the economic values of geological touristic resources are subjective with complex and multilevel characteristics, and usually the conclusions are reached on the basis of the assessors’ professional backgrounds, cognitional preferences, personal capacities and experience; so the deviation of the evaluations can’t be avoided to be caused by the personal factors, which can be regarded as the gray property in the evaluation. Different from common mathematical statistics, the gray multilevel evaluation needs neither large number of samples nor any certain kind of distribution that should be obeyed in the arrangement of data. The establishment of the model can be realized under the condition of less samples and data. Therefore, it is proper to use multilevel gray evaluation to practice the mono-case appraisement of the resources of geological relics. According to the principles of gray evaluation method for the sample capacity of the data, the method of expert evaluation is applied to ascertain the sample matrix of the evaluation. The author respectively invites five experts who are familiar with the situation of Huashan Geological Park to score the economic values of the geological touristic values according to the established scoring standards. The evaluation matrix of No. K expert’s evaluation on the economic values of the No. S geological touristic resources is defined as D(s). According to the principles of gray evaluation method for the sample capacity of the data, the method of expert evaluation is applied to ascertain the sample matrix of the evaluation. The steps of the evaluation are as followed: First, the quantitative evaluation index system for the economic values of the geological touristic resources is defined. Second, the evaluation standards are defined and the relevant experts are invited to give the scores of evaluation. Third, the gray classification of the evaluation are defined. Fourth, the gray evaluation coefficients and weight vectors are calculated. Last, the final evaluation result of the evaluated objects are reached. In the following parts, the evaluation of the economic values of the geological touristic resources in Huashan geological park are taken as the example to introduce the evaluation methods for the economic values of the geological touristic resources in geological parks.
Table 1. The evaluation indices and weights of geological tourism resources’ economic values

| Target layer                  | Criterion layer                | Weight | Index layer                        | Weight |
|------------------------------|--------------------------------|--------|------------------------------------|--------|
| Geological tourism resources’ economic values (A) | Popular science value (B₁) | 0.38   | Popular Scientific Exhibition Value (C₁) | 0.174 |
|                              | Popular science training Value (C₂) |        |                                    | 0.224 |
|                              | Ornamental value (B₂)           | 0.37   | Elegance (C₃)                      | 0.16   |
|                              | Peculiar (C₄)                  |        |                                    | 0.125  |
|                              | Landscape integrity (C₅)        |        |                                    | 0.076  |
|                              | Added value (B₃)                | 0.25   | Environmental comfort (C₆)          | 0.1    |
|                              | Visiting accessibility (C₇)      |        |                                    | 0.085  |
|                              | Security (C₈)                  |        |                                    | 0.065  |

3.2. Determination of the evaluation of grey type

Suppose g=4, there are 4 evaluation grey class, namely e=1, 2, 3, 4. Its various corresponding grey numbers and whitening weight functions are as follows: First Grey class "Excellent" (e=1), gray number one ∈ [4,∞], and the whitening weight function is f₁; the second grey class is "Good" (e=2), the grey number two ∈ [0,3,6], and its whitening weight function is f₂; the third grey class "Medium" (e=3), the grey number three ∈ [0,2,4], the whitening weight function is f₃; and the fourth grey class "Difference" (e=4), the grey number δ = 0.61 four ∈ [0,1,2], and its whitening weight function is f₄.

3.3. Calculation of grey evaluation coefficient

For evaluation index C₁ (Popular Scientific Exhibition Value), the 1st evaluation of the economic value of Huashan geological tourism resources that belong to the NO.e grey evaluation coefficient of the grey category is (1)

\[
x_{i1}^{(1)} = \sum_{i} x_{i1} = x_{i1}^{(1)} + x_{i1}^{(2)} + x_{i1}^{(3)} + x_{i1}^{(4)} = 7.97
\]

Similarly, when e=2, \(x_{i2}^{(2)} = 2.97\); when e=3, \(x_{i3}^{(3)} = 0\); when e=4, \(x_{i4}^{(4)} = 0\). Therefore, for the evaluation index C₁, the economic value of Huashan geological tourism resource belongs to the total grey evaluation coefficient of each grey category index\( \mathbf{x}^{(1)}_i \):

\[
x^{(1)}_i = \sum_{e=1}^4 x^{(e)}_i = x^{(1)}_i + x^{(2)}_i + x^{(3)}_i + x^{(4)}_i = 7.97
\]

3.4. The calculation of grey evaluation weight vector

As for the evaluation index C₁, evaluation of the economic value proposition of the geological tourism resources of Huashan by all reviewers the grey evaluation weight vector of grey class is labeled as \(r^{(1)}_e\).

\[
\text{when } E=1, \quad r^{(1)}_1 = \frac{x^{(1)}_i}{x^{(1)}_i} = \frac{5}{7.97} = 0.626; \text{ similarly, } r^{(2)}_2 = \frac{x^{(2)}_i}{x^{(2)}_i} = \frac{2.98}{7.97} = 0.374, \quad r^{(3)}_3 = \frac{x^{(3)}_i}{x^{(3)}_i} = \frac{0}{7.97} = 0, \quad r^{(4)}_4 = \frac{x^{(4)}_i}{x^{(4)}_i} = \frac{0}{7.97} = 0.
\]

Therefore the evaluation index C₁ of the economic value of the geological tourism resources of Huashan for grey evaluation weight vectors \(r^{(m)}_e\) of each grey category:

\[
r^{(1)}_i = (r^{(1)}_1, r^{(2)}_2, r^{(3)}_3, r^{(4)}_4) = (0.626, 0.374, 0, 0).
\]
Similarly, we can calculate for other items. Evaluation index of economic value of geological tourism resources in Huashan are B1, B2, B3. For each evaluation grey evaluation, the weight matrix ($R_b^{(1)}, R_b^{(2)}, R_b^{(3)}$) are:

$$R_b^{(1)} = \begin{bmatrix} 0.626 & 0.374 & 0 & 0 \\ 0.533 & 0.411 & 0.056 & 0 \end{bmatrix}$$

$$R_b^{(2)} = \begin{bmatrix} 0.374 & 0.437 & 0.188 & 0 \\ 0.303 & 0.404 & 0.292 & 0 \end{bmatrix}$$

$$R_b^{(3)} = \begin{bmatrix} 0.474 & 0.421 & 0.105 & 0 \\ 0.354 & 0.441 & 0.205 & 0 \end{bmatrix}$$

3.5. Comprehensive evaluation of evaluation indicators at all levels

(1) Comprehensive evaluation of criteria layer (B1, B2, B3)

To evaluate criteria layer (B1, B2, B3) comprehensive of Huashan, we have got the results:

$$B^{(1)}=A_1 \times R_b^{(1)}=(0.574,0.368,0.032,0)$$

$$B^{(2)}=A_2 \times R_b^{(2)}=(0.312,0.395,0.292,0)$$

$$B^{(3)}=A_3 \times R_b^{(3)}=(0.346,0.411,0.242,0)$$

Though these, it’s clearly for us to get the total grey evaluation weight matrix of the economic value of the geological tourism resources in Huashan ($R^{(1)}$) as follows:

$$R^{(1)} = \begin{bmatrix} B^{(1)} \\ B^{(2)} \\ B^{(3)} \end{bmatrix} = \begin{bmatrix} 0.574 & 0.368 & 0.032 & 0 \\ 0.312 & 0.395 & 0.292 & 0 \\ 0.346 & 0.411 & 0.242 & 0 \end{bmatrix}$$

(2) A comprehensive evaluation of target level index A

To get the economic value of the geological tourism resources in Huashan, we have get a comprehensive evaluation result ($B^{(1)}$):

$$B^{(1)}=A \times R^{(1)}=(0.425,0.388,0.176,0)$$

(3) Calculate the comprehensive evaluation value and sort

Due to the grade-valued vector of the Grey Class $C=(4, 3, 2, 1)$, therefore, the comprehensive evaluation value of the economic value of the Huashan’s geological tourism resources $W$: $W^{t}B^{(1)}C^{T} = 3.232$. The rating is excellent, like Table 2.

**Table 2. Evaluation results of Huashan geological tourism resources’ economic values**

| Name                                | Scale          | Each calculation score | $W(s)$ |
|-------------------------------------|----------------|------------------------|--------|
| Geological tourism resources’ economic values |                |                        |        |
| First gray class                    | 0.575          | 0.311                  | 0.322  | 0.426  | 3.221 |
| Second gray class                   | 0.367          | 0.396                  | 0.423  | 0.389  |
| Third gray class                    | 0.031          | 0.293                  | 0.255  | 0.175  |
| Fourth gray class                   | 0.000          | 0.000                  | 0.000  |        |

4. Conclusion

The economic values of the geological touristic resources in Huashan score as 3.221 and their evaluation grades as excellence. It reflects that the economic values of the overall geological touristic resources of the park are relatively higher with excellent exploitative prospects. With proper operations and managements, the valuable granitic geological touristic resources can be transformed into touristic products of relatively higher scientific and educative values so as to provide better services to the geological scientific tour in the park. The evaluation of economic values of the geological tourism in Huashan Ecological Park scores as the excellence, and the evaluations of the scientific, appreciative and added values grade as better than good. In an overall view, the geological
Touristic resources of the park have been endowed with relatively higher economic values at the current stage, but the gradual optimization should be practiced in the aspects of the construction of the scientific sightseeing system, the enhancement of the accessibility of the park and the endurance of the sustainability of the resources. In future, the application for and construction of the world-class geological park in Huashan can be taken advantage to protect the landscapes of granitic landforms and the numerous valuable geological touristic resources within the park. By constructing service facilities of scientific popularization, system of signs and museums and so on in the geological park, the science-popularizing level of the park can be enhanced in all aspects, so as to deliver the significant knowledge of Huashan to the public and ensure its longtime economic values.

References
[1] Qiao G H, Management S O. A Research on Eco-Tourism Destination Images, Tourist Satisfaction and Destination Loyalty——Taking Geopark Mount Yuntai as an Example [J]. Economic Survey, 2015.
[2] Dong H, Song Y, Chen T, et al. Geoconservation and geotourism in Luochuan Loess National Geopark, China [J]. Quaternary International, 2014, s 334–335(12): 40-51.
[3] Chen L Q, Guo F S. Upper Cretaceous alluvial fan deposits in the Jianglangshan Geopark of Southeast China: implications for bedrock control on Danxia landform evolution [J]. Journal of Mountain Science, 2017, 14(5): 926-935.
[4] Yuan Y, Zeng Y, Yin L I, et al. Study on Forming Condition of Geologic Hazards in Wudang Mountains National Geopark [J]. Resources Environment & Engineering, 2017.
[5] Xia H, Niu D. Grey Comprehensive Evaluation of Biomass Power Generation Project Based on Group Judgement [J]. 2017, 212(1): 012026.
[6] Ma D, Chu J, Liu X, et al. Study on Evaluation of Earthquake Evacuation Capacity in Village Based on Multi-level Grey Evaluation [J]. Systems Engineering Procedia, 2011, 1(1): 85-92.
[7] Liu Y, Zhang D, Yao K. Research on Evaluation Effect of Reservoir Resettlement Post-stage Support Policy Based on Multi-Level Grey Evaluation Method [J]. Water Power, 2016.
[8] Jing Z, Wen P U, Zhao X. Multi-Level Grey Evaluation of the Shangli Ancient Town's Tourism Resources Redevelopment Planning [J]. Ecological Economy, 2011.