Research on Sustainable Development Based on the Algorithm of Tourism Carrying Capacity -- Take Yaowa Village as an Example

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Abstract: Yaowa village has a history of nearly 100 years and has been developing its tourism industry since 2011. In this paper, we made an analysis of the village on its tourism capacity, including ecological carrying capacity, spatial carrying capacity, facility carrying capacity and psychological carrying capacity. In the calculation of spatial carrying capacity, ecological carrying capacity (0. 7 million people) > psychological carrying capacity (0.2 million people) > spatial carrying capacity (0.25 million people) > facility carrying capacity (0.153 million people). Through the study of tourism carrying capacity, it is concluded that facility carrying capacity is an important factor limiting the local tourism. This research can provide countermeasures to promote the development of local rural economy and sustainable development, and provides theoretical support for the sustainable development of local tourism.

Keywords: Tourism carrying capacity; rural economy; sustainable development; rural tourism

1 Introduction

Tourism is one of the fastest growing and most economically productive industry sectors in the world today. As a component of the tourism industry, rural tourism has a better role in promoting the development of rural economy. According to the survey data of the Ministry of Culture and Tourism, in 2019, the number of rural tourists in China reached 3.09 billion people, achieving tourism revenue of 1.81 trillion yuan, becoming an important focus point for rural economic development and the implementation of rural revitalization. However, while tourism brings in a lot of economic income, it also brings environmental damage to the countryside that should not be underestimated. The influx of tourists has also caused problems such as landscape destruction, natural vegetation damage, water pollution and over-commercialization of traditional culture. This will lead to a decrease in the satisfaction of local residents and tourists, and the loss of the visitor market. It seriously affects the sustainable development of rural tourism. The development of rural tourism depends on the local tourism environment, and there is a limit to the carrying capacity of the tourism environment. In order to ensure the sustainable development of the local rural tourism economy, it is necessary to study the factors affecting the carrying capacity of the tourism environment.

Ying Li proposed that sustainable natural resources require sustainable tourism development strategies [1]. and Peng Tao suggested that a city's sustainable development should be achieved

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through the harmonious development of the city's resource and environmental carrying capacity and economic growth, which is an important way to achieve sustainable development in China [2]. Tourism carrying capacity is the intensity of tourism activities that a tourism destination can carry, and is also an important indicator of local sustainable development [3]. Therefore, the study of the tourism carrying capacity of Yaowa Village can provide a basis for the development of local rural tourism, help to protect local natural resources, preserve local cultural heritage, coordinate the relationship between local villagers, tourists and tourism service providers, and promote the sustainable development of the village.

2 Overview of Yaowa Village and Data Sources

2.1 Overview of Yaowa Village

The village is located in the deep mountainous area in the western part of Luoning County, Luoyang City, Henan Province, along the southwest of Guxian Town, along the coast of Guxian Reservoir. The site is located in the ridge plateau area, near the Guxian reservoir, the reservoir area is 34 km long, the widest point is about 1,500 m, beautiful scenery, for the national water conservancy project. It has a total area of 25 square kilometers, with a forest coverage rate of 70%, arable land of 525 acres, and 2,500 acres of woodland and barren hills.

Since the implementation of tourism development in 2011, Yaowa Village has been awarded as a model township for national greening in 2016 due to its high natural vegetation coverage; a garden township by Luoyang Municipal Government in the same year; an advanced township for forestry ecological construction in 2017; a model village for tourism poverty alleviation by Luoyang Municipal Government in 2020; and a key village for the third batch of national rural tourism in 2021.

2.2 Data sources

In recent years, with the boom of rural tourism, the local government has supported the development of rural tourism in order to drive the development of agricultural economy. Yaowa Village is increasingly visited by tourists. According to the statistics of Luoning County Tourism Bureau, the number of tourists in Yaowa Village has been increasing year by year in the past 5 years. The number of tourists in 2016, 2017, 2018, 2019 and 2020 are 22083, 33115, 37688, 47733 and 48322 respectively; the number of tourists is increasing year by year, and the growth rate of tourism continues to grow positively. The village has 10 farm houses and 1 boutique B&B, with 120 beds. The analysis of the carrying capacity of tourism environment can effectively predict the actual tourism reception capacity of Yaowa village and provide relevant data support for the sustainable development of local tourism.

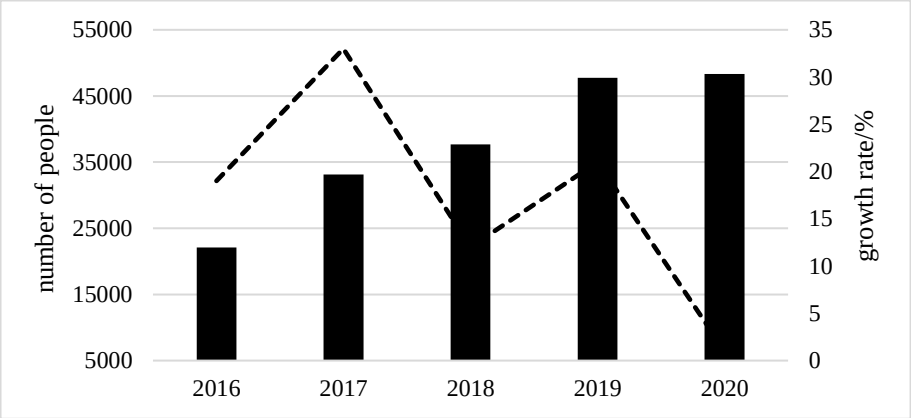

Figure 1 Number of tourists and growth rate of Yaowa Village in the past 5 years

3 Methods and Materials

Factors affecting the tourism carrying capacity include natural resources such as atmosphere, water resources and land resources, as well as social resources such as tourism facilities and equipment and the psychological acceptance of local villagers [4]. In view of the specific situation of Yaowa Village, this paper studies the tourism development of Yaowa Village in terms of ecological carrying capacity, spatial carrying capacity, facility carrying capacity and tourism psychological capacity. In order to ensure the sustainable development of local tourism resources, the smallest component was chosen for all four components of the extraction. According to the Specification for Scenic Area Planning (GB 50298-1999), it is mainly composed of ecological carrying capacity C(e), spatial carrying capacity C(r), facility carrying capacity C(f) and psychosocial capacity C(s), and the size of the extreme value depends on the minimum bottleneck factor among them. Therefore, the capacity of the tourism environment should be taken as the smallest value of the collection component, which can be expressed as:

$$C=\min\{C(e),C(r),C(f),C(s)\}$$

4 Calculation process

4.1 Ecological carrying capacity of tourism

Ecological carrying capacity refers to the amount of tourism activities that can be carried by the natural ecological environment of a tourist place in a certain period of time to maintain a balance, which is related to the natural ecological environment purification power and the pollutants produced by tourists in a certain period of time [5].

Based on the oxygen and exhaust gas produced by photosynthesis of green vegetation, and based on the exhaust gas produced by tourists entering and leaving tourist attractions, it is concluded that 30-40 km² of green space per person is required to maintain a comfortable feeling and to

keep the air fresh [6]. Combining the self-purification capacity of green plants and the number of pollutants produced per capita, the following formula was derived:

$$C(e) = \sum_{i=1}^{n} \frac{SiPi}{Sa} (i1,2,\ldots\ldots n)$$

Where *Si*, *Pi* and *Sa* are the core visitable area, forest cover and green area per capita of the tourism area, respectively. The total area of Yaowa village is 1.2 km², the core area available for touring is about 0.4 km², the forest coverage is 70%, according to the ability of green plants to absorb waste gas and release oxygen, and considering the harmful gas released from industrial production, the forest green area of 30~40 m² per capita is needed to keep the air fresh and maintain the normal ratio of O_2 and CO_2 in the air [7].The green area per capita is taken as The green area per capita is 40 m²/person, and the ecological carrying capacity in Yaowa Village is calculated to be 7,000 person-times/d, and the annual ecological carrying capacity is 2,555,000 person-times.

4.2 Spatial carrying capacity

Spatial carrying capacity refers to the relationship between local tourism spatial carrying capacity and tourable area, where *Si* and *Ai* are the core tourable area, reasonable area capacity per capita, respectively is the passenger turnover rate (tourist turnover rate = scenic spot opening hours/tourist tour hours), and its calculation formula is:

$$\mathrm{C(r)} = \sum_{\mathrm{i}}^{\mathrm{n}} \frac{\mathrm{Si}}{\mathrm{Ai}} \mathrm{R(i1,2,\ldots n)}$$

The reasonable area capacity per capita of Yaowa Village is 400 m²/person, the core area available for tour is 0.4 km², the opening time of the scenic spot is 10 h, the average tour time of tourists is 4 h, and the turnover rate of tourists is 2.5. Spatial carrying capacity of tourism in Yaowa Village is calculated to be 2,500 persons/d, and the annual spatial carrying capacity of tourism is 912,500 persons.

4.3 Facilities carrying capacity

Tourism facilities include tourism infrastructure and tourism service facilities [8]. By 2020, there will be 120 beds in farmhouses in the village, and the maximum number of people who can receive meals is 470. According to the actual situation of Yaowa Village, the capacity of tourism facilities in Yaowa Village C(f) = the daily reception of catering facilities(N) + the daily reception of accommodation facilities(A), and the formula is as follows:

$$\mathrm{C(f)} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{Ni} * \alpha + \mathrm{Ai(i} = 1,2,3\ldots\ldots \mathrm{n)}$$

If the meal time of tourists is set as 1 h, the meal service time is 3h/d, and the turnover rate α is 3; then the daily facility carrying capacity C(f) is calculated: the daily facility carrying capacity of Yaowa Village is 1,530 persons/d, and the annual tourism facility carrying capacity is 558,450 persons.

4.4 Psychological carrying capacity

Psychological carrying capacity is a part of tourism capacity system, and the size of tourism psychological capacity is one of the important factors reflecting the harmonious development of local residents and tourists in a region [9]. The psychological capacity of tourism is influenced by point-in-time capacity C(p) and daily capacity C(s). The factors affecting the psychological capacity of tourism are the daily opening hours of scenic spots, replaced by T in the equation; the length of tourist visits, replaced by t in the equation; the area of major scenic spots visited, replaced by A in the equation; and the basic standard space for tourism, replaced byσin the equation, as follows:

$$C(p) = \frac{A}{\sigma} \qquad C(s) = \frac{T}{t}C(p)$$

The daily opening time of the scenic spot of Yaowa Village is 10 h, the visiting time of tourists is 4 h, the core visiting area is 0. 4 km², the basic standard space for tourism is 50 m²per capita according to the "Scenic Spot Planning Code" (GB50298-1999). Then the psychological point-in-time capacity of tourists in Yaowa Village is 800, and the psychological daily capacity of tourists is 2,000. The annual capacity of tourist psychology in the village of Yaowa is 730,000 visitors.

5 Analysis of the carrying capacity of tourism environment and suggestions

5.1Analysis of tourism carrying capacity

In summary, the ecological carrying capacity C(e), spatial carrying capacity C(r), facility carrying capacity C(f) and psychosocial capacity C(s) of the tourism environment capacity of Yaowa Village can be derived as shown in the table 1 below.

Table 1 Tourism carrying capacity in Yaowa Village

	Ecological Carrying Capacity	Spatial Carrying Capacity	Facility Carrying Capacity	Psychological Carrying Capacity	Tourism Carrying Capacity
Daily carrying capacity (million people)	0.7	0.25	0.153	0.2	0.153
Annual carrying capacity (million people)	255.5	91.25	55.845	73.00	55.845

In order to ensure the sustainable development of tourist attractions, the smallest of the four capacity values needs to be selected. The analysis of the four values shows that the value of facility carrying capacity is the smallest value among the four values of tourism environment capacity, and it is one of the important factors to determine the tourism environment capacity of Yaowa Village. The analysis of the four values, combined with the number of tourists in Yaowa Village in the past five years, shows that the number of tourists in Yaowa Village is below the

value of the tourism environment capacity. Therefore, tourism in Yaowa Village can continue to develop.

5.2 Suggestions for Development

The village has beautiful natural scenery, rich natural and cultural landscapes, and a strong local culture that attracts more and more tourists to come and visit [10]. However, due to the late development of infrastructure support is not complete, which limits the speed and scale of local tourism development. By calculating the ecological carrying capacity, environmental capacity, facility carrying capacity, and psychological capacity of the tourism environment of Yaowa Village, we can analyze the current situation and future development direction of Yaowa Village. It can be seen from table1 that tourism

infrastructure is the main factor limiting the development of tourism economy in Yaowa Village. Due to the late development of the village, the village road was only opened in 2016, and in 2017, under the guidance of the government, an investment group invested in the village to build a boutique lodging, which attracted many tourists to stay in that year. However, due to the single tourist attraction in Yaowa Village, the carrying capacity of individual tourist attractions is insufficient.

Based on the problems in the development of rural tourism in Yaowa Village, first, to improve the construction of tourism infrastructure in Yaowa Village, although the actual number of tourists in Yaowa Village is lower than the capacity of the tourism environment, but with the construction of village roads, the number of tourists will continue to increase after the improvement of transportation facilities. At the same time, villagers who are in a position to do so are encouraged to set up special farms, increase the capacity of beds and restaurants, and improve the reception capacity of tourists. Second, the development of a reasonable tourist tour route, the development of the number of tourist activities, decentralized tourist destinations. By combining the surrounding villages, people can choose different styles of tourist destinations according to their preferences. Thirdly, the theme features are obvious, and the integration of culture and tourism is realized. Combining with the cultural resources of Yaowa Village, the special rural cultural tourism is developed to enhance the cultural attributes and added value of tourism products. It not only preserves the local simple rural culture, but also enriches the local tourism industry. Fourth, to improve the production and living conditions of the village, to improve the quality of the living environment of local residents, and thus to enhance the psychological capacity of the villagers for tourism.

6 Conclusions

This paper analyzes the capacity of tourism environment from four aspects, including ecological carrying capacity, spatial carrying capacity, facility carrying capacity and tourism psychological capacity. The daily capacity of tourism facilities is 1,530 persons/d, and the annual capacity of tourism facilities is 558,450 persons; the daily capacity of tourism psychology is 2,000 persons/d, and the annual capacity of tourism psychology is 730,000 persons. It can be seen that the main limiting factor for the development of tourism in Yaowa Village is the capacity of the facilities. In order to promote the sustainable development of Yaowa village, we can promote the development of local tourism economy by increasing tourism infrastructure; increase spatial

carrying capacity by increasing tourism activity content and tourism tour route; and enhance the tourism psychological capacity of villagers by improving the production and living conditions of residents, thus promoting the sustainable development of Yaowa village.

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