Dialectical Relationship between the World Natural Heritage Protection and Tourism Development-Based on the Evaluation of Tourism Ecological Footprint

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Abstract. In order to explore the dialectical relationship between the world natural heritage sites protection and tourism development, this paper takes Wulong karst world natural heritage site as an example and uses tourism ecological footprint model to evaluate the impact of tourism development on heritage protection. As a result, tourism development can indeed impact on heritage protection, but also endows heritage protection with more realistic possibilities. World natural heritage protection and tourism development are not opposites to each other. By limiting tourism speed development and enhancing ecological compensation, the protection of world heritage sites and tourism development may be unified in the long run. To be specific, the sustainable development of world natural heritage can be realized by limiting the degree of tourism development, limiting the number of tourists, guiding tourists to transform consumption, reducing the ecological footprint of tourism, transferring tourism ecological footprint, and improving the ecological carrying capacity.

Introduction

Known as a "smokeless industry" and a "sunrise industry", tourism has gradually developed into one of the world's largest and most powerful industries. While the rapid development of tourism drives the economy, it also brings a lot of negative effects, such as a series of problems caused by the blind and excessive development of tourism resources, extensive management of tourism scenic spots, and idle tourism infrastructure, etc. The world natural heritage has the comprehensive value of tourism value, scientific value, artistic value and so on. Natural heritage protection is the inevitable requirement of preserving the earth's landform and biodiversity, but the work of heritage protection faces challenges from politics, economy, environment, social culture and other aspects. The development of heritage resources must be carried out on the premise of not damaging the authenticity and integrity of heritage resources. However, the predatory exploitation of heritage resources in world heritage sites makes the world heritage sites face unprecedented high consumption and pressure. It is urgent to explore a sustainable development path to effectively protect the world's natural heritage. At present, the world natural heritage sites are generally developed and protected by tourism. But what is the impact of tourism development on heritage sites? Whether it is an effective way remains to be further explored. This paper takes Wulong karst world natural heritage site as an example, evaluates the sustainability of its tourism development and the effectiveness of its protection with the tourism ecological footprint model, then puts forward strategies for the protection of world natural heritage site and the sustainable development of tourism.

Theoretical Basis and Calculation Model

The tourism ecological footprint originates from the concept of ecological footprint and analysis of ecological footprint (EFA).Ecological footprint can be seen as “the footprint left on the earth by a giant foot on a city and factory created by human beings” [1], and then gradually developed into
ecological footprint analyses (EFA)[2] and ecological footprint model[3]. As to tourism research, Wackernagel (2000) was the first to make a preliminary analysis on the ecological footprint of international tourism, and Yount (2000) proposed that the ecological footprint of tourism accounted for 10% of the global ecological footprint[4]. Colin Hunter (2002) firstly proposed the concept and classification of tourists' ecological footprint and the application of this method in the sustainable development of tourism, and calculated the ecological footprint of tourists and individual tourism products throughout the life cycle of tourism products[5]. In short, tourism ecological footprint is the bioproductive land area needed by a region to support the consumption of various resources and the absorption of wastes related to tourism activities. In the area of tourism activities usually includes tourists and local residents, only tourists tourism activities of the biological productive land area can be called "tourism ecological footprint", which corresponds to the survival and development of biological productive land area known as the "regional local ecological footprint", local ecological footprint of tourism ecological footprint with area "superposition" effect to influence the sustainable development of regional tourism.

Tourism Ecological Footprint Model [6]

The tourism ecological footprint model is the specific application of the ecological footprint model in tourism research. According to the characteristics of tourism consumption, tourism ecological footprint model includes seven parts: tourism food, tourism accommodation, tourism transport, visiting, tourism shopping, tourism entertainment and tourism solid waste, which is shown in equation 1:

\[
TEF = TEF_{food} + TEF_{accommodation} + TEF_{transport} + TEF_{visiting} + TEF_{shopping} + TEF_{entertainment} + TEF_{waste} \quad (1)
\]

The tourism food ecological footprint (\(TEF_{food}\)) is mainly composed of three parts. Second, the area of fossil energy converted from energy consumption to provide catering services for tourists; third, tourists' consumption of various kinds of food is transformed into ecological productive land area. According to the actual situation of tourism catering consumption and composition, which is shown in equation 2. The tourism accommodation ecological footprint (\(TEF_{accommodation}\)) is mainly determined by the area of construction land occupied by high-end, medium and low-end hotels, guesthouses, farmhouses and other tourism accommodation facilities that provide accommodation for tourists, and the area of fossil energy land converted by energy consumption of hotels and guesthouses that provide services for tourists, including energy consumption of air conditioning, lighting and washing. According to the difference in the built-up area requirements of different grades and types of accommodation facilities and the energy consumption of providing corresponding services, which is shown in equation 3. The tourism transport ecological footprint (\(TEF_{transport}\)) mainly consists of two parts: the construction land area of tourism transport facilities and the fossil energy area transformed from transportation energy consumption related to tourism activities. The calculation formula is shown in equation 4. Tourism visiting ecological footprint (\(TEF_{visiting}\)) mainly consists of scenic sightseeing facilities construction land area (including tourist trails, roads, viewing space, etc.) and transformation in the scenic area energy consumption of fossil energy land area (including sightseeing car, etc., when they take a sightseeing activities less energy consumption, negligible), which is shown in equation 5; Tourism shopping ecological footprint (\(TEF_{shopping}\)) is composed of three parts: first, the construction land occupied by the production and sales of tourism commodity facilities (including tourism shopping malls, supermarkets, etc.); Second, the ecological productive land area corresponding to tourism commodity consumption; The area of fossil energy transformed from energy consumption in the production, transportation and sales of tourist commodities is shown in equation 6. Tourism entertainment ecological footprint (\(TEF_{entertainment}\)) mainly consists of facilities of construction land occupied area (not including is attached to the indoor recreational facilities in lodging and dining facilities, such as gym, chess and card room, etc.) and offers visitors leisure entertainment is converted to energy consumption of the fossil energy land area (less consumption, negligible) of two parts, which is shown in equation 7; The tourism solid waste ecological footprint (\(TEF_{waste}\)) is shown in
equation 8, composed of the ecological productive land area occupied by solid waste landfill and the forest land area needed to absorb solid waste and produce waste gas through bacterial action.

\[ TEF_{\text{food}} = \left[ \sum S_i + \Sigma (N \times D \times Ci / Pi) + \Sigma (N \times D \times ei / ri) \right] \times Fe \]  

(2)

\[ TEF_{\text{accommodation}} = \left[ \Sigma (Si \times Ni) + \Sigma (365 \times Ni \times Ki \times ei / ri) \right] \times Fe \]  

(3)

\[ TEF_{\text{transport}} = \left[ \Sigma (Si \times Ki) + \Sigma (Ni \times Di \times ei / r) \right] \times Fe \]  

(4)

\[ TEF_{\text{visiting}} = Si \times Fe \]  

(5)

\[ TEF_{\text{shopping}} = \left[ \sum Si + \sum \left( \frac{Ri}{Pi} / gi \right) \right] \times Fe \]  

(6)

\[ TEF_{\text{entertainment}} = \sum Si \times Fe \]  

(7)

\[ TEF_{\text{waste}} = \left[ \left( Q \times q^{DOC} \right) / Pa \right] \times W + \Sigma S_j \times Fe \]  

(8)

In equations 1 to 8, Si respectively represents the construction land area of type I catering, accommodation, transportation, sightseeing, shopping, leisure and entertainment facilities; N represents the number of tourists; D represents the average number of days of travel for tourists; Ci represents the per capita daily consumption of food type I for tourists; Pi represents the average annual productivity of ecologically productive land corresponding to food type I; Ri represents the average calorific value per unit of fossil fuel productive land area of type I energy; Ei respectively represents the daily energy consumption corresponding to type I catering facilities, transportation means and accommodation facilities; Fe (e=1,2,3,4,5,6) represents the equilibrium factor of six types of ecological productive land. Ni represents the number of beds in category I accommodation facilities; Ni= Ni (1+ti)/2, where ti is the room double opening rate of type I accommodation facilities; Ki represents the average annual room occupancy rate of type I accommodation facilities; R represents the average calorific value per unit of ecological productive land area of fossil fuels in the world; Ki represents the tourist utilization rate of type I traffic facilities; Nj represents the number of tourists of the JTH mode of transportation; Dj represents the average travel distance of tourists of type j vehicle; Ri refers to the consumption expenditure of tourists for the i-type tourist commodities. Pi represents the local average selling price of the ith tourist commodity; Gi represents the average annual productivity of the local bio-productive land corresponding to unit I of tourist commodities; Pa represents the amount of CO₂ that can be absorbed per hectare of woodland on average (the global average of 5.2tCO₂ per hectare of woodland per year [7]); Q stands for waste production; Q^{DOC} refers to the proportion of organic carbon per unit of waste. W is the CO₂ equivalent coefficient of organic carbon (about 30% organic carbon is contained in 1 ton of waste in China [8] W is 2.89). Sj represents the area of farmland occupied by landfill.

**Tourism Ecological Carrying Capacity Calculation Model**

\[ TEC = N \cdot tec = N \sum_{i=1}^{6} (a_j \cdot r_j / y_j) \]  

(9)

Tourism ecological carrying capacity calculation model is shown in equation 9. TEC represents the total tourism ecological carrying capacity; N is the population; Tec stands for per capita ecological carrying capacity; Aj represents per capita ecological land area; Rj is the equilibrium factor; Yj is the yield factor.
Tourism Ecological Surplus or Ecological Deficit Calculation Model

\[ TES/TED = TEC - TEF \] (10)

Tourism ecological surplus or ecological deficit calculation model is shown in equation 10. TES stands for tourism ecological surplus; TED is the tourism ecological deficit; TEC represents the total ecological capacity of tourism; TEF stands for tourism ecological footprint. Tourism ecological footprint and tourism ecological carrying capacity are compared. When TEF < TEC, it is ecological surplus (TES). It reflects that the tourism ecological footprint of a place is less than the carrying capacity of the tourism ecological, resulting in the tourism ecological surplus, indicating that the ecological capacity of the place is enough to support its human load, and its tourism development mode is in a relatively sustainable state. When TEF > TEC, it is ecological deficit (ED). It reflects that the tourism ecological footprint of a place is larger than the tourism ecological carrying capacity, resulting in the tourism ecological deficit, indicating that the human load exceeds the ecological capacity, and the tourism development mode is in an unsustainable state.

Evaluation of Sustainable Development of Tourism in Wulong Karst World Natural Heritage Site

Overview of Tourism Development

In 2007, Wulong karst, Shilin karst in Yunnan and Libo karst in Guizhou were included in the world natural heritage list as "south China karst". Wulong karst system is mainly composed of Furong cave karst, Tiansheng sanqiao karst and Houping tiankeng karst, with a total area of 380 square kilometers. In 2007, Wulong was listed as a world natural heritage site as part of "south China karst", marking the official start of Wulong's real heritage tourism. The number of tourists increased from 1,642,600 in 2007 to 1,610,600 in 2012, with a growth rate of 880.3%. The total revenue of tourism increased from 166.55 million yuan in 2007 to 8100.74 million yuan in 2012, an increase of nearly 50 times.

Tourism Ecological Footprint Calculation Results

Data Source and Processing

There are four types of data needed for the calculation of tourism ecological footprint in Wulong karst world natural heritage site. It includes tourism reception, daily consumption of tourists, average productivity level of six types of ecological productive land, etc. This part of data mainly comes from China statistical yearbook, Chongqing statistical yearbook, Wulong statistical yearbook and related websites. Second, survey data. Including tourism ecological footprint model involves all kinds of food and beverage, transportation, accommodations, sightseeing, shopping, entertainment, and solid waste utilization of all kinds of tourist facilities, tourist consumption patterns, tourists travel days on average, respondents are Wulong karst within the scope of the world natural heritage site visitors, Wulong county tourism bureau and tourism enterprise practitioners; Standard data. It includes six types of ecological productive land corresponding to equilibrium factor, yield factor, energy consumption per unit average distance of different means of transport, average calorific value per unit of land area of fossil fuel production in the world and conversion coefficient, etc. Relevant data are derived from existing research reports and related research literature. Fourth, data processing. Due to the high degree of data synthesis and complexity required by the calculation of the tourism ecological footprint model, many data cannot be directly obtained through the statistical yearbook or related websites, and it is difficult to obtain the exact value from the actual survey. Therefore, it is necessary to carry out relevant calculation or standardized processing on the basis of acquired data to meet the needs of data model calculation.

Input these collected datas into tourism ecological footprint model, and the results were sorted out to draw the change trend chart of the tourism ecological footprint (total and per capita) of Wulong world natural heritage site (as shown in figure 1-1) and the change trend chart of the
composition of the tourism ecological footprint (as shown in figure 1-2).

![Total tourism ecological footprint](image1)

**Figure 1-1.** Tourism ecological footprint of Wulong world natural heritage site.

![Composition of tourism ecological footprint](image2)

**Figure 1-2.** Composition of tourism ecological footprint of Wulong world natural heritage site.

It can be concluded that:

1. The total tourism ecological footprint of Wulong world natural heritage site shows a rapid growth trend. With the large increase of tourist reception in the scenic area of the heritage site, a number of tourist reception and service facilities have been built to meet the tourist reception needs. With the increase of the number of days and consumption of tourists in the heritage site, the ecological footprint of tourists increases rapidly. It can be concluded that the ecological footprint of tourists increases with the increase of the number of tourists.

2. The per capita ecological footprint of tourists in Wulong world natural heritage site shows an overall growth trend. The main reason is that tourists tend to choose comfortable and convenient (relatively speaking, the unit ecological footprint is usually high) travel mode and consumption behavior mode. Compared with the growth of the total tourism ecological footprint, the growth rate of the per capita ecological footprint of tourists in Wulong world natural heritage site is relatively small and relatively flat.

3. The ecological footprint of tourism catering and transportation occupies the majority of the ecological footprint of tourism. Among them, the tourism catering ecological footprint occupies the largest proportion, followed by the tourism transportation ecological footprint, and then the tourism garbage ecological footprint occupies a larger proportion and presents a trend of increasing year by year, while the other four categories account for a smaller proportion. Therefore, the tourism ecological footprint of Wulong world natural heritage site is mainly composed of tourism catering ecological footprint, tourism transportation ecological footprint and tourism garbage ecological footprint.
Tourism Ecological Carrying Capacity and Surplus of Wulong Karst World Natural Heritage Site

Wulong karst world natural heritage site belongs to Wulong county, and its average forest coverage rate is as high as 47%. The research scope is the core area and buffer zone of the world natural heritage site, and the forest coverage rate is higher, which means the ecological productive land within the scope of this study can be regarded as all forest land. The yield factor is the average of China's yield factor. The following is the calculation of tourism ecological carrying capacity and per capita tourism ecological carrying capacity of Wulong world natural heritage site, as shown in figure 1-3.

![Figure 1-3. Tourism ecological carrying capacity of Wulong karst world natural heritage site.](image)

According to the above calculation results and relevant charts, the comprehensive analysis of the change trend of tourism ecological carrying capacity of Wulong world natural heritage site from 2007 to 2012 shows that the tourism ecological carrying capacity of Wulong world natural heritage site basically remains unchanged from 2007 to 2012. Because the core area and buffer zone of the world heritage site are protected strongly, the land use situation has not changed much in recent years. Therefore, this paper assumes that the ecological productive land area within the research scope remains unchanged, and all are forestland. In fact, there will be some changes in the ecological carrying capacity within the research scope, but considering the integrity and subjectivity of the research, the hypothesis in this paper is reasonable. The per capita tourism ecological carrying capacity of WULONG world natural heritage site shows a decreasing trend, and the decreasing range is larger, reaching 82.3%.

Evaluation of Sustainable Development of Tourism

According to the above calculation results, the tourism ecological footprint of Wulong world natural heritage site is compared with the tourism ecological carrying capacity, and the tourism ecological deficit (or surplus) of Wulong world natural heritage site can be obtained. By comparing the per capita ecological footprint of tourists in Wulong world natural heritage site with the per capita ecological carrying capacity of tourists, it can be concluded that the per capita ecological deficit (or surplus) of tourists in Wulong world natural heritage site is sorted into figure 1-4.
The tourism ecological footprint of Wulong world natural heritage site does not exceed the carrying capacity of tourism ecological, which shows as the surplus of tourism ecological. The per capita tourism ecological footprint of Wulong world natural heritage site does not exceed the per capita tourism ecological carrying capacity, which is shown as per capita tourism ecological surplus. Therefore, during the period from 2007 to 2012, the average tourism ecological carrying capacity of Wulong world natural heritage site was 40,421.97 hm², and the average tourism ecological footprint was 18,285.93 hm², with an average ecological surplus of 22,136.04 hm². The average per capita tourism ecological carrying capacity is 0.032861 hm², and the average per capita tourism ecological footprint is 0.009466 hm², with an average ecological surplus of 0.02339 hm². From 2007 to 2012, the tourism ecological surplus and per capita ecological surplus of Wulong world natural heritage site showed a rapid decline trend. Among them, the tourism ecological surplus decreased by 93.75% and per capita ecological surplus decreased by 98.88%. The main reason is that the ecological carrying capacity of the heritage site remains basically unchanged, while the rapid increase of tourist reception and the change of tourists' consumption patterns increase the ecological footprint of tourism by a large margin, resulting in a substantial decrease in the tourism ecological surplus and per capita tourism ecological surplus.

**Sustainable Development Strategy of Wulong Karst World Natural Heritage Site**

**Dialectical Relationship between Conservation and Development of Wulong Karst World Natural Heritage Site**

Since Wulong karst world natural heritage site was successfully applied for the world heritage site, the tourism industry has developed rapidly, but it is accompanied by the rapid increase of the ecological footprint of tourism and the substantial decline of the ecological surplus of tourism. This means that in the period of rapid growth of tourism development in the heritage site, it is easy to cause destructive impact on its ecological environment. But one of the benefits of tourism development is to bring more financial guarantee and social consensus for the protection of natural heritage sites. Thus it can be seen that although unrestricted tourism development can bring impact damage to heritage sites, it also brings the possibility of ecological compensatory recovery. In other words, conservation of natural heritage sites is not in opposition to tourism development. The key to solving the problem lies in limiting the degree of tourism development and increasing the intensity of ecological compensation in natural heritage sites, so as to realize the dual sustainable development of heritage protection and tourism development.
Sustainable Development Strategy for Wulong Karst World Natural Heritage Site

The Wulong karst world natural heritage site can achieve the dual sustainable development of heritage protection and tourism development from the two aspects of limiting the development speed of tourism and increasing the ecological compensation.

Limit Tourism Development Speed

To realize the sustainable strategy of heritage protection, from the perspective of tourism development, measures can be taken to limit the degree of tourism development and limit the number of tourists entering. The details are as follows:

(1) Limit the degree of tourism development. Wulong karst world natural heritage site has the ability of local ecological restoration, and can repair the external ecological damage within a certain carrying capacity. However, if tourism is overdeveloped, the more construction of tourism catering, entertainment and leisure facilities and other man-made damage, the greater the damage to the original ecological environment, then it is difficult to ensure its effective repair. Therefore, the speed and degree of tourism development should be slowed down to reserve effective time for ecological restoration of the heritage sites.

(2) Restrict the number of visitors. The study found that the increase of the number of tourists directly leads to the increase of tourism ecological footprint and the reduction of ecological surplus, especially the entry of hedonic tourists, and the excessive ecological consumption directly increases the difficulty of heritage protection. Therefore, on the one hand, the number of tourists should be limited to prevent it from exceeding the limit of tourism ecological carrying capacity; On the other hand, we should persuade tourists to transform consumption, reduce consumption of resources and energy, and reduce the ecological footprint of tourism.

Increase Ecological Compensation

In order to realize the sustainable development of tourism, it is necessary to take measures to reduce tourism ecological footprint or improve the carrying capacity of local tourism ecology. Specifically, it mainly considers the following three aspects:

(1) Reduce tourism ecological footprint. Tourism ecological footprint mainly consists of tourism food ecological footprint, tourism transport ecological footprint and tourism solid waste ecological footprint. Therefore, we should reduce tourism ecological footprint from these three parts. Research has shown that footprint of producing 1t meat is 37 times that of producing 1t grain, and the ecological footprint of producing 1t fish is 6.8 times that of producing 1t grain. Therefore, tourists should be encouraged to reduce unnecessary consumption of fish and meat, and guide them to eat local vegetables and fruits, so as to reduce tourism food ecological footprint; Secondly, the tourist circle should be formed in heritage site to shorten the average travel distance of tourists. Meanwhile, tourists are encouraged to travel green and choose less energy-consuming modes of transportation to reduce tourism ecological footprint. The heritage site should guide tourists, especially overnight tourists, to enjoy a low-carbon and environment-friendly lifestyle and avoid unnecessary waste of consumer goods to reduce the ecological footprint of solid waste in tourism.

(2) Transfer the ecological footprint of tourism. Due to the existence of regional trade among regions, regional trade is accompanied by the transfer and transfer of tourism ecological footprint, which will correspondingly lead to the reduction or increase of regional ecological footprint. Wulong karst heritage site can transfer the transferable part of local tourism ecological footprint to other regions through regional trade, so as to reduce the regional tourism ecological footprint. This kind of method can realize the trade flow of ecological footprint between regions, but it can't reduce the ecological footprint of tourism fundamentally.

(3) Improving the ecological carrying capacity of tourism. Improvement of regional tourism ecological carrying capacity can be realized by changing the proportion of ecological productive land. According to the calculation formula of tourism ecological carrying capacity, the smaller the output factor is, the larger the corresponding ecological carrying capacity will be. Therefore, we should try to improve the proportion of grassland and forest land in ecological productive land, and
reduce the proportion of construction land in ecological productive land, so as to increase the ecological carrying capacity of tourism. The method of returning farmland to forest, afforestation and strict control of construction land can be adopted in the core area and buffer zone of Wulong karst world heritage site.

Conclusion and Discussion

Through the study on the tourism ecological footprint of Wulong karst world natural heritage site, we found that Wulong karst world natural heritage site tourism development does challenge heritage protection, while at the same time, tourism development provides realistic possibility for heritage protection in terms of funds and social consensus. Tourism protection and development are not opposite, they are more likely to be unified in the long run. The key lies in limiting the development speed of tourism and improving the ecological supplement of heritage sites while protecting heritage sites. Although most scholars believe that tourism development is the means to achieve heritage protection, heritage protection is the ultimate goal. However, heritage protection is often regarded as a means of tourism development rather than the ultimate goal in reality. In the development and protection of world heritage sites, include the government, tourism enterprises, local residents, tourists and other stakeholders, how to coordinate the interests of all parties, and ultimately achieve the sustainable development of heritage protection and tourism, still needs further in-depth research.

References


