Analysis on Ecological Footprint of Agricultural Heritage Sites under Tourism Utilization: A Case Study of Nanfeng County

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Abstract: Tourism is an important way to achieve dynamic protection and adaptive management for agricultural heritage sites. The balanced relationship between tourism development and protection of agricultural heritage sites is the key to the sustainable development of its tourism industry. This paper uses Ecological Footprint Model (EF) to evaluate the ecological state of a specific agricultural heritage site, namely Nanfeng County in Jiangxi Province, China. The result indicates that Nanfeng County showed a safe ecological state under tourism utilization in 2015. It inspires how to realize sustainable tourism of agricultural heritage sites: 1) ecological environment is the guarantee of sustainable tourism development; 2) develop tourism adaptively based on actual resource characteristic; 3) social economy and tourism development should promote mutually. This study provides a scientific case for ecology security evaluation and sustainable tourism development of Nanfeng County.

1. Introduction

Agricultural culture is the most vital and essential cultural heritage in the process of human civilization [1]. In the past few decades, people have paid great attention to agricultural production capacity, specialization level and global market, while have ignored the relevant externalities and adaptability management strategies, and the research, protection and development of diverse and unique traditional agriculture systems [2]. In 2002, the United Nations Food and Agriculture Organization (UNFAO), with the union of relevant international organizations and countries, launched Globally-important Ingenious Agricultural Heritage Systems (GIAHS) Project, to establish a globally important agricultural heritage and its associated landscape, biodiversity, knowledge and cultural protection systems, and to be recognized and protected worldwide as the basis for sustainable management. In 2006, the first batch of
GIAHS protection pilots was established. China, one of the earliest countries in the world for agricultural development, owns rich agricultural heritage which faces severe challenges with the development of the economy and application of modern technology [3]. Under this background, the excavation and protection of National Important Agricultural Heritage Sites in China (China-NIAHS) launched to protect China's important agricultural heritage dynamically and promote the sustainable economic and social development of heritage sites. By the end of 2018, China had announced four batches of ninety-one major NIAHS.

Focusing on the dynamic protection of agricultural heritage and its sustainable economic and social development, scholars have carried out related research work. Its research work and exploration of protection practice shows the characteristic of multidisciplinary cooperation, the combination of theoretical research and practical exploration, along with the coordination of protection and development [4]. With the implementation of agricultural heritage projects, the historical culture, system structure, mechanism of action, functional value and landscape characteristics of various agricultural heritages have been fully explored and revealed, laying a theoretical foundation for protection and development practice. Min et al pointed out that, agricultural heritage faces threats such as reduced comparative benefits, massive outflow of working-age labor, the impact of modern concepts, and insufficient understanding of multiple values [5]. Zhang et al systematically explained the reasons, objects, implementers and measures of its protection [6]. The protection of agricultural cultural heritage should follow the requirement of dynamic protection, adaptive management and sustainable development [7]. And the scientific and rational management mechanism is the key to dynamic protection and sustainable development. The introduction of ecological museums, multi-participation, alternative industrial, ecological compensation and laws and policies provide good references for the protection and development of agricultural heritage [8,9].

In the context of tourism, agricultural heritage is regarded as tourism resource [10]. To promote the sustainable development of the economic and social of heritage sites, the research of how to develop tourism industry is conducted, which is considered as an alternative industry. Sun et al. explored the relationship between the tourism development and social economy of agricultural heritage sites, and the case study of Qingtian County, Zhengjiang Province showed they mutually developed in the interaction [11]. Thus, tourism exploration got more and more attention as an effective means of adaptive management of agricultural heritage [12], and the contents of tourism resources evaluation and development, production design and marketing, tourism perception and the impact of tourism development in agricultural heritage sites were mainly discussed in related research [13]. Although these studies have important implication for the economic and social development of agricultural heritage sites, they ignore the sustainability of tourism to promote the economic and social development of agricultural heritage sites, namely sustainable development of tourism in agricultural heritage sites. Excessive tourism development causes severe ecological pressure on agricultural heritage sites and threats on the protection of agricultural heritage [14]. How to balance the relationship between tourism development and agricultural heritage protection has become an urgent scientific problem.

Ecological Footprint Model (EF) is a method to measure regional sustainability. It provides a new research perspective for sustainable development of tourism in agricultural heritage sites. EF was proposed by William Ree and perfected by his students [15]. It refers to the resources consumed by the population in a certain area, and the area of ecologically productive land needed to absorb the waste generated by human being and the total amount of water resources. EF helps to quantitatively assess regional sustainability level from the perspective of ecological supply and demand. This paper uses it to measure the ecological status, and discuss the sustainable development of tourism in agricultural heritage site, in order to enrich the tourism research of agricultural heritage sites, and provide scientific references for the sustainable development of agricultural heritage sites.
2. Methods and Materials

2.1 Methods

2.1.1 Ecological Capacity (EC) Calculation. EC refers to self-sustainability and self-regulation capacity of an ecosystem, supply capacity of resource and environment subsystem, maintainable social and economic intensity, and the number of people with a certain standard of living. It is an important basis to judge the coordination between resource development intensity and environmental carrying capacity [16]. Eq. (1) is the equation for calculating EC:

$$ EC = \sum (A_i \ast r_i \ast y_i) $$

Where EC denotes the total regional EC, $A_i$ is the area of land $i$, $r_i$ refers to the equivalence factor and $y_i$ refers to the productivity coefficient of land $i$.

2.1.2 EF Calculation. The calculation of EF is based on the local residents’ consumption of various resources, as shown in Eq. (2).

$$ EF = N \ast ef = N \ast \sum (r_i \ast e_i) $$

In Eq. (2), EF refers to the regional total EF, N stands for the population and ef pertains to per capita EF, $c_i$ and $p_i$ represents the per capita consumption and average productive capacity of the resource $i$. And more, waste treatment can also lead to EF due to the production of CO$_2$ and solid waste. Eq. (3) is the equation for calculating the EF of waste treatment [17]:

$$ EF_{\text{waste}} = Q \ast q_{\text{DOC}} \ast Pa^{-1} \ast W + S $$

where $EF_{\text{waste}}$ represents the EF of waste treatment, $Q$ means the amount of garbage, $q_{\text{DOC}}$ refers to the proportion of organic carbon in garbage, $Pa$ denotes the amount of CO$_2$ absorbed by forest land, $W$ is the CO$_2$ equivalent coefficient of organic carbon, $S$ stands for the land required for landfill.

2.1.3 Ecological Pressure Index (EPI) Calculation. The difference between EC and EF denotes the quantitative relation between social resource consumption and available natural resources. If EC>EF, then the region is ecological surplus (ES). Otherwise, it is ecological deficit (ED). Ecological Pressure (ES) reflects the degree of pressure on the regional ecological environment and EPI represents the ratio of EF to EC, a larger value means a higher pressure on the regional environment.

2.2 Study Area and Datasets

2.2.1 Study Area. This study takes Nanfeng County as an example of empirical research. Nanfeng County is located in the south of Fuzhou City, Jiangxi Province, China, with a total area of more than 1900 km$^2$. The climate in Nanfeng County is mild and humid, and its citrus cultivation has a so long history that earns the reputation of “millennial tangerine”. Due to the characteristics of golden color, thin skin, less pit, tender flesh, fragrant smell and rich nutrition, local tangerine is the imperial tribute of past dynasties. With the gradual expansion of the tangerine planting range, the tangerine is distributed from riverbank sand to hilly and mountainous areas. The tangerine cultivation system covers the whole territory of the county, with a cultivation area of 700 thousand acres. Tangerine not only provides the livelihood guarantee for the local people, but also becomes the spiritual sustenance they admire now. In June 2017, after being appraised by the China Expert Committee on Important Agricultural Cultural Heritage of the Ministry of Agriculture, the tangerine cultivation system in Nanfeng County was rated as a China-NIAHS.

Under the background of tourism, tangerine has become the biggest feature of tourism development in Nanfeng County and the most important natural landscape for tourism, such as 700 thousand acres of tangerine. And the tangerine culture is also manifested in various tourism activities, such as the
International Tangerine Festival. The tangerine has become the basis for the establishment of Nanfeng's global tourism brand. In 2017, Nanfeng County's tourism revenue reached 3.16 billion yuan, and the number of tourists reached 3.92 million. Nanfeng County has become a typical agricultural heritage site under tourism utilization.

2.2.2 Datasets. The data needed in this study includes Nanfeng County’s land use data, year-end resident population, consumption of various resources, average output per unit area of various resources, equilibrium factors, and output factors of various land types. Land use status (2015) is calculated in ArcGIS based on the land use grid data of Nanfeng County. Year-end resident population, consumption and average output per unit area of various resources are obtained through Fuzhou Statistical Yearbook (2016) and the annual report of relevant departments. Among resource consumption, the biological resource account includes 13 kinds of products such as grain, fruits and aquatic products, which can be converted into the EF of cultivated land, forest land and water area. In the energy resource account, because the fossil energy land refers to the forest and grassland used to absorb the greenhouse gases emitted by fossil energy combustion, the EF of liquefied petroleum gas (LPG) is converted by the amount of CO2 absorbed by the forest land and grassland per unit area [18]. The resources consumed by different power generation methods are different, while the power in Nanfeng County is mainly hydropower. Therefore, in the calculation of power EF, the cultivated land submerged by hydropower station storage and power generation is converted. In addition, the waste treatment in Nanfeng County adopts compression landfill, so the land occupation is too less to calculate. The equilibrium factors and yield factors of the EF of each land use type are based on the research results of Liu and Li [19,20] as shown in Table 1.

| Land type          | Equilibrium factor | Yield factor |
|-------------------|--------------------|--------------|
| Arable land       | 1.12               | 1.34         |
| Forest land       | 0.72               | 1.06         |
| Pasture land      | 0.45               | 2.09         |
| Fossil energy land| 0.72               | 0.00         |
| Built-up land     | 1.12               | 1.34         |
| Water area        | 0.35               | 2.09         |

3. Results and Analysis

3.1 EC

The calculation of EC for different land is shown in Table 2. As shown in Table 2, the EC of various types of land is quite different, and the contribution of forest land to the county's EC is most significant, which is 109 869.51 hm2 in total, accounting for 61.99%. Nanfeng County is located in the junction of Wuyi Mountain and Laoshan Mountain, which causes its landform type is mainly low hills, and the subtropical monsoon humid climate has sufficient heat and abundant rainfall, which provides good natural conditions for its forestry development. In terms of natural forests, natural forests in Nanfeng County are effectively protected under the background of national ecological civilization construction and the protection of local authorities. And about the plantation, tangerine cultivation has a so long history that tangerine almost covers the whole county territory, and tangerine has become the major part of the agricultural ecosystem of Nanfeng County.

| Land type     | Area (hm²) | EC (hm²)      | EC per capita (hm²) |
|---------------|------------|---------------|---------------------|
| Arable land   | 41737      | 62638.8896    | 0.20042649          |
| Forest land   | 143959     | 109869.5088   | 0.351550929         |
| Pastureland   | 3405       | 3202.4025     | 0.01024677          |
| Water area    | 2086       | 1525.9090     | 0.004882471         |
| Total         | 191187     | 177 236.7099  | 0.567106658         |
3.2 EF
The EF of biological resources, energy resources and waste disposal are calculated as shown in Table 3 and Table 4. It can be seen from Table 3 that the consumption of biological resources has the most significant EF on cultivated land. Compared with cultivated land, the consumption of biological resources has a very small EF on forest land and water area. Among consumption projects, food consumption has the largest EF, followed by pork, aquatic products, edible oil and vegetables. From Table 4, we can know that energy consumption and waste treatment have the largest EF on forest land, followed by grassland and cultivated land. In consumption projects, LPG has obvious EF on grassland and forest land, and waste treatment has a larger EF on forest land.

### Table 3 EF of biological resources in Nanfeng County

| Land type   | Consumption item         | EF (hm²) | Average EF per capita (hm²) |
|------------|--------------------------|----------|-----------------------------|
| Arable land| Cereal                   | 12 165.731|                                   |
|            | Vegetables               | 1444.8926|                                   |
|            | Cooking oil              | 1619.4693|                                   |
|            | Pork                     | 2241.9474|                                   |
|            | Poultry                  | 598.16324| 0.067075                       |
|            | Eggs                     | 646.55749|                                   |
|            | Milk                     | 128.7815 |                                   |
|            | Beef and mutton          | 12.09793 |                                   |
| Forest land| Melon and fruit          | 189.91968| 0.000438                       |
|            | Aquatic product          | 2035.571 | 0.00228                       |
| Water area | Public service water     | 7.324840764|                                |
|            | Household water          | 10.50955414|                                |
|            | Other water              | 2.643312102|                                |
| Total      | 13 items                 | 21103.60885| 0.070133064                   |

### Table 4 EF of energy resources account and waste treatment

| Consumption item | Land type   | EF (hm²) | Average EF per capita (hm²) |
|------------------|-------------|----------|-----------------------------|
| LPG              | Arable land | 5716.284393| 0.01316914                   |
|                  | Forest land | 6810.542180| 0.00980630                   |
| Electricity      | Pastureland | 247.715241704| 0.00088773188549 |
| Waste treatment  | Water area  | 8384.61538462| 0.01931642                   |

The EF of various types of land are obtained by summarizing the biological resources account, energy resources account and waste treatment EF, as shown in Table 5. It can be seen from Table 5 that the EF of cultivated land in Nanfeng County is the largest, followed by forest land. Cultivated land should provide most of the food consumption, so the EF is large; the EF of forest land is mainly generated by the use of LPG and waste treatment.

### Table 5 EF in Nanfeng County

| Land type   | EF (hm²) | Per capita EF (hm²) |
|------------|----------|---------------------|
| Arable land| 21 240.256671| 0.06796273          |
| Forest land| 10 289.534360| 0.03292356          |
| Pastureland| 3064.743326 | 0.00980630          |
| Water area | 818.843487 | 0.00262006          |
| Total      | 35 413.37784359| 0.11331266         |

3.3 Ecological Status
Combined with Table 2 and Table 5, the ecological environment of Nanfeng County can be obtained by calculation. As shown in Table 6, in 2015, the EC of Nanfeng County is greater than the EF, and the ecological environment presents ES; the EPI is 0.19, referring to the equivalent division standard of the
ecological pressure index of relevant scholars [21,22], the ecological pressure of Nanfeng County is in a very safe degree, and the regional ecology is in a state of sustainable development.

Table 6 Ecological status in Nanfeng County

| Land type   | ES (hm²) | EPI   | Land type   | ES (hm²) | EPI   |
|-------------|----------|-------|-------------|----------|-------|
| Arable land | 41 398.63293 | 0.339090568 | Pastureland | 137.659174 | 0.957013781 |
| Forest land | 99 579.97444 | 0.09365232 | Water area  | 707.065513  | 0.536626684 |

4. Discussion
Based on the above analysis, we know that Nanfeng County’s ecology is safe and shows a state of sustainable development, which provides a good example for the sustainable development of agricultural cultural heritage tourism. Combined with the field investigation, this paper discusses the enlightenment of Nanfeng County on the sustainable development of agricultural cultural heritage tourism from the following aspects:

(1) Ecological environment is the guarantee of sustainable development of tourism. There are numerous cases of unsustainable tourism development caused by the destruction of ecological environment. A good ecological environment is the guarantee of sustainable tourism development. Nanfeng County is a national key ecological functional area, with a forest coverage rate of 76.28%, and the number of days that the annual atmosphere reaches the national level I standard exceeds 300 days. Nanfeng County always adheres to the principle of ecological protection, and good ecological environment has become an important tourist attraction of Nanfeng County.

(2) Adaptive tourism development based on resource characteristics. As a kind of tourism resources, agricultural cultural heritage features in evident characteristics, high vulnerability and sensitivity, wide distribution, strong participation and complex [23]. Based on the characteristics of resources, the adaptive tourism development model is the premise and basis for the sustainable development of tourism in agricultural cultural heritage sites [24]. Nanfeng County develops tourism around the characteristics of "orange", such as Guoli Park, Guanbi Park and other orange garden tourist attractions are built, Datang Fuwa series of orange cultural and creative products are developed, and orange banquet, International Orange Festival and other tourism festivals are hosted.

(3) Mutual promotion of social economy and tourism development. The development of agricultural cultural heritage tourism resources is closely related to the socio-economic culture of the heritage site [11]. The mutual promotion of socio-economic and tourism development is the key to the sustainable development of tourism. Citrus planting is supporting industry in Nanfeng County. Its good economic benefits make citrus planting continue all the time and prevent the outflow of working age. The characteristics of short working time and low intensity meet the labor demand of tourism development, improve the income of orange farmers and promote the development of tourism economy. Social economy and Tourism economy develop together in the interaction.

In recent years, the tourism development of Nanfeng County shows a rapid growth trend: in 2013, the number of tourists in Nanfeng County was 1.55 million, and by 2017, it increased to 3.92 million. The rapid growth of tourists reflects the success of tourism development in agricultural cultural heritage sites, however it also rings the alarm of ecological environment overload.

5. Conclusion
This paper used EF Model to measure the ecology statue of Nanfeng County, a typical agricultural heritage site under tourism utilization, and reached the conclusion that Nanfeng County showed a safe ecological state in 2015. The relationship between development and protection is the key to achieve dynamic protection and adaptive management for agricultural heritage sites. The case of Nanfeng County enlightened the sustainable development of agricultural cultural heritage under tourism utilization. This paper provides a scientific support for ecological security assessment and the sustainable development of agricultural cultural heritage sites under tourism utilization.
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