Exploring the sustainable development for tourism destination by applying an ecological footprint

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ABSTRACT

Subsequent to the rapid growth of ecotourism, problems of the impacts on the environment in the touring process appear, such as traffic jams and over-exploitation of natural resources. It is therefore essential to ask how the tourism industry can develop under the principle of sustainable operation, which involves assisting the protection of the ecosystem and carrying out such important environmental protection tasks as biodiversity and climate control. This research first measures the environment impacts of Yangmingshan National Park, a recreational area in Taiwan. The average ecological footprint per person is 4.180 hm^2, the ecological carrying capacity is 1.803 hm^2, and the ecological possession ratio) is 2.318. Then, through average ecological possession ratio comparisons and the golden section search technique, we determine that the ecological quality of the Park is worse than its peers and that its ecological utilization is inappropriate. This means that, if the scale of tourism is expanded, the pressure of Yangmingshan National Park on its natural ecological system will be greater than its ecological capacity, endangering the ecosystem. Further development of this recreational area therefore goes against sustainability. The governing agency of the recreational area needs to fully understand the adverse impact of recreational expansion on sustainable development and take the necessary measures to stop or alleviate deterioration of the ecological environment.

1. Introduction

According to the WTO (2000), “tourism” has become the prime resource of earning foreign exchange in many countries. In recent years, Taiwan has made active efforts to promote such international events as the *Challenge 2008 National Development Plan -- Doubling Tourist Arrivals Plan,* the *World Games 2009 in Kaohsiung,* the *21st Summer Deaflympics Taipei 2009*, and the *2010 Taipei International Flora Exposition*. As a result, the number of tourists to Taiwan and the amount of tourism revenue in foreign currencies have also been increasing. The number of inbound tourists has risen from 2.98 million in 2002 to 4.40 million in 2009. The amount of tourism revenue in foreign currencies has

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increased from US$4.59 billion in 2002 to US$6.82 billion in 2009. According to a report of the World Economic Forum (WEF 2009), Taiwan's worldwide tourism and travel competitiveness rose to 43rd in 2008 from 52nd in 2007.

Since Yellowstone National Park -- the first national park in the world -- was established in the United States in 1872, countries across the world have followed suit, establishing one national park after another. It has been widely accepted that national parks are the most important resources for the development of a country's tourist and leisure industry (Buckley, 2000; Cho, 1998; Uysal *et al.,* 1994). However, as the tourist industry flourishes, those activities have also created environmental impact issues, such as traffic congestion, over-exploitation of natural resources, and the adverse effects of inappropriate tourist behaviors on human, natural, and culture heritages. In addition, these activities create a considerable amount of pollution (Wu, 2003). Under the idea of sustainable development of tourism resources and the lessening of recreation-incurred impacts, the question arises: How to ensure that Taiwanese tourism is developed under the principle of sustainable operation in such a way that it is beneficial to ecological conservation with biological diversity and climate change.

With the trend toward sustainable development, tools and standards are being developed around the world for sustainability assessment so as to truthfully and sensibly reflect the current ecological environment, analyze the depletion status of resources, and explore the interrelationships among different environmental impacts (Chen *et al.,* 2009). In view of the fact that traditional economics measures natural resources in monetary value and fails to take into account the biological aspect of the issue, this study attempts to adopt the ecologic economic model of the ecological footprint to evaluate the sustainability of a national park in Taiwan.

According to the literature on the ecological footprint of tourism, Hunter (2002) was the first to put forward the concept of tourist ecological footprint, its categorization, and its application to the sustainable development of tourism. Wackernagel and Yount (2000) were the first to conduct a preliminary study on the ecological footprint of the international tourist industry, reaching the conclusion that tourism accounts for 10% of the total global ecological footprint. Johnson (2003) analyzed and compared the tourist consumption of biological resources in Lake Ontario. Bagliani *et al.* (2004) calculated the ecological footprint of Venice, Italy, presenting findings that suggest that tourism is an important contributor to the expansion of a city's ecological footprint. Chambers *et al.* (2005) calculated the ecological footprint of tourism in the western regions of England. Patterson *et al.* (2008) studied the gap between the tourist ecological footprint and biodiversity in Siena, which then served as the target for improvement in environmental management.

Based on the above research motives, this study applies the concept of Ecological Footprint (EF) to the exploration of environmental load and land resource requirements, with adjustments for computing local land resource demands. It estimates the Ecological Footprint and Ecological Capacity (EC) of Yangmingshan National Park as a reference for the responsible agency to maintain a balance between ecological preservation and tourism development.

2. Ecological Footprint Theory

The implications of ecological footprint

The ecological footprint model proposed by the Canadian ecological economist William Rees (1992) was gradually improved and completed by relevant research (Wackernagel and Rees, 1996;

Wackernagel *et al.,* 2004a, 2004b). EF uses corresponding biological productive land to estimate the resource consumption and waste absorption area of a specific population or economy. Wackernagel and Rees (1996) believe that the size of ecological footprints is in direct proportion to the environmental impact, in other words, the larger the ecological footprint, the larger the environmental impact. They further reasoned that the size of the ecological footprints is inversely proportional to biological productive land per person: the larger the ecological footprint, the smaller the biological productive land per person. The calculation of ecological footprints can measure the different types of biological productive land and water a specific population requires to support its energy and resource consumption and to absorb the waste it produces. If countries, regions and cities can monitor load capacity and ecological footprint each year and announce GDP at the same time, they will be able to understand economic trends and ecological changes, implementing nature conservation and sustainable development concepts into the society's overall operation and feedback mechanisms, and further provide a judgment standard and action direction for the future of mankind.

Having advantages such as an easy and comprehensive approach, lively expression and comparable outcomes, the ecological footprint can be adopted as an assessment indicator of sustainable environmental development. At present, directions in ecological footprint research mainly consist of balance factors, rational adjustment of output factors (Erb 2004; Venetoulis and Talberth 2008), the increase of syndrome count accounts (Jenerette and Larsen 2006), computation of greenhouse emissions (Lenzen *et al.,* 2007; McGregor *et al.,* 2008), calculation of the ecological footprint of environmental pollution (Bai *et al.,* 2008; Song *et al.,* 2005), the time sequence footprint model (van Vuuren and Bouwman, 2005; Wackernagel *et.al.,* 2004a, 2004b; Yue *et al.,* 2006), the footprint model combined with the context model (Senbel *et al.,* 2003; van Vuuren and Bouwman., 2005), the input-output footprint model (Bicknell *et al.,* 1998; McGregor *et al.,* 2008 ; Moran *et al.,* 2008; Sánchez-Chóliz *et al.,* 2006), the life cycle footprint model (Monfreda *et al.,* 2004), the footprint model combining energy analysis (Chen and Chen, 2007; Zhao *et al.,* 2005;) and the land interference footprint model (Lenzen *et al.,* 2007; Lenzen and Murray, 2001). The above models have promoted and developed the theories and calculation methods of ecological footprint at different levels. However, the accuracy and completeness of the computation of ecological footprints still need further improvement. Since much literature (Chen and Chen, 2007; Cuadra and Bjrklund, 2007; Gu *et al.,* 2007; Li *et al.,* 2008; Nguyen and Yamamoto, 2007; Turner *et al.,* 2007; Wiedmann *et al.,* 2007; Wiedmann and Manfred, 2007; Zhang and Zhang, 2007) has explored the theoretical hypotheses, basic concepts, calculating methods, empirical applications and deficiency improvements of ecological footprint model; this paper need not go further on these topics here..

Research studies by Wachernagel and Yount (2000) showed that the tourism industry accounts for 10% of the world's total ecological footprint. Hunter (2002) was the first to put forward the concept of the tourist ecological footprint, its categorization, and its application to the sustainable development of tourism. Gössling *et al.* (2002) then constructed an ecological footprint calculation modal for tourist destinations, using Seychelles, Africa, as its example. A study by the World Wildlife Fund for Nature (WWF, 2002) shows that one same vacation product generates three times the per capita ecological footprint in Cyprus as it does in Majorca; therefore, Majorca is obviously a better choice than Cyprus for a vacation. Cole and Sinclair (2002) conducted an analysis of the ecological footprint of tourists in the Indian Himalayas and discussed in their paper strategies for sustainable development in the future; these included waste processing, reducing fossil fuel consumption, developing ecotourism and instilling environmental awareness among tourists. Johnson (2003) analyzed and compared the tourist consumption of biological resources in Lake Ontario.

It can be inferred from the above literature review that the global ecological environment is in dire straits. At present, the pressure that human beings put on the ecological system largely exceeds the carrying capacity of the latter. Unless we take active measures, the gap between the human demand for resources and the carrying capacity of the ecological environment will continue to increase as a result of social economic development and population growth.

The ecological footprint modal and method

According to Wackernagel and Yount(1998), in the calculation of the ecological footprint, resource and energy consumption items are converted into the area of six types of biologically productive land, which are: cropland, grazing land, forest land, construction land, fossil energy resource land and marine area. Adding up the areas of all six types of land yields the per capita biologically productive land area available to human beings on the globe, which is 2 hectares. As biological productivity varies with land types, the areas for the six different types of land must be converted into equivalent areas that reflect the same productivity before they are summed together. The coefficients employed in such conversions are called equivalent factors. The value of the equivalent factor for biologically productive land type *k* (represented as r_k) is equal to the ratio between the world average yield capacity of this particular type of land (represented as $\overline{Y_k}$) and the world average yield capacity of all lands (represented as $\overline{Y_k}$), as is shown in Formula(1).

$$\gamma_k = \frac{\overline{Y_k}}{\overline{\overline{Y}}} \quad k=1, 2,\ldots, 6 \tag{1}$$

As resource endowments differ across countries and regions, biological productivity varies not only across land types, but also across regions within the same land types. Therefore, to enable regional data to be compared and aggregated, we need to convert the area of each type of land concerned in the study to an equivalent area that reflects the world average bio-capacity of this type of land. The coefficient employed in such conversion is the "yield factor." The yield factor of land type *k* in a particular region (represented as λ_k) is the ratio between the average yield capacity of this type of land from this same region (represented by $\overline{y_k}$) and the average yield capacity of this type of land across the world (represented as $\overline{Y_k}$), as is shown in Formula (2).

$$\lambda_k = \frac{\overline{y_k}}{\overline{\overline{Y_k}}} \quad K=1,2,\ldots,6 \tag{2}$$

The physical area of land type *k* in a specified region multiplied by λ_k gives the equivalent area of this type of land at the world average productivity. This figure multiplied by γ_k gives the equivalent area of land at the world average productivity. Such equivalent area of land is globally comparable. It is expressed in units of global hectares (gha). Furthermore, reports by WCED point out that at least 12% of the biocapacity should be reserved for the protection of biodiversity, that is, 0.3 out of the 2 hectares of biologically productive land should be reserved for the protection of biodiversity and only 1.7 hectares is available for human consumption. Therefore, 1.7 hectares is the ecological benchmark against which ecological footprints are compared.

The steps of and elements in calculating ecological footprints are as follows:

1.Categorize consumption into consumption items and work out the resource consumptions of key consumption items. First of all, the total consumption of consumption item i in a specified region is C_i

$$C_i = P_i + I_i - E_i \quad (3)$$

Wherein:

P_i : the annual production corresponding to consumption type i

I_i : the annual import corresponding to consumption type i

E_i : the annual export corresponding to consumption type i

2. Convert the consumptions of key consumption items into land areas (A_k). Using annual average bio-capacity data, convert the above resource occupation, in terms of both biological capacity and waste absorption capacity, into areas of the six major types of biologically productive land/water systems. To calculate the areas divide the average annual per capita consumption of each consumption item obtained through the above calculations by the corresponding average annual yield.

$$A_k = \sum_{i=1}^{n} A_{ki} = \sum_{i=1}^{n} \frac{C_{ki}}{Y_{ki}} \quad i=1,2,3\ldots6 \quad (4)$$

where

N : the number of human consumption items that are provided for by land type k in the region

A_{ki} : the area required of land type k for consumption item i (hm^2)

$C_{k\ i}$: the annual consumption of consumption item i that is provided for by land type k ($t \bullet a^{-1}$)

Y_{ki} : the world average yield capacity for consumption type i provided for by land type k ($t \bullet hm^{-2} \bullet a^{-1}$)

3. Calculate the ecological footprint. Y_{ki} is the world average yield capacity of land type k for consumption item i. A_{ki} is the area of land type k at the world average yield capacity. Hence, we convert the values of A_k into areas of land at the world average yield capacity using the equivalent factors and add them up to obtain the ecological footprint (EF) of the region being studied.

$$EF = \sum_{K=1}^{6} A_K \gamma_K \quad (5)$$

Wherein:

r_k : the equivalent factor of biologically productive land type k

EF divided by the population of the region gives the per capita ecological footprint of the region.

4.Calculate the ecological carrying capacity. The total area of biologically productive land possessed by a particular population or region is called the ecological carrying capacity (or Bio-capacity). To provide uniform measurement standards for both ecological carrying capacities and ecological footprints and enable global comparison of data, it is necessary to convert the actual physical areas of the various land types in the studied region into equivalent areas that are expressed in units of global hectares. Multiply the physical areas of the six land types in the studied region (expressed as $S_k(k=1,2,\ldots,6)$) by their corresponding equivalent factors (expressed as r_k) and yield factors (expressed as λk) respectively. Add up the products and we have the ecological carrying capacity area of the region based on the world average yield capacity. See Formula (6). *EC* divided by the population of the region gives the per capita ecological carrying capacity area in that region. Ecological carrying capacity areas are expressed in units of global hectares.

$$EC = \sum_{K=1}^{6} S_K \gamma_K \lambda_K = \sum_{K=1}^{6} S_k \cdot \frac{\overline{Y_k}}{\overline{Y}} \cdot \frac{y_k}{\overline{Y_k}} \quad (6)$$

5. Calculate the ecological remainder, ecological deficit and ecological occupancy rate. An ecological deficit (ED) occurs if the ecological carrying capacity is smaller than the ecological footprint (as is shown in Formula 7), an indication that the ecological load of the country in question exceeds its biological capacity and that the development in the country is in a relatively unsustainable mode. If the ecological carrying capacity is larger than the ecological footprint (as is

shown in Formula (8)), then there is an ecological remainder (ER) meaning that the country has adequate biocapacity to sustain the ecological load and that its development is in a relatively sustainable mode.

$$ED=EF-EC(EF \geqq EC) \tag{7}$$

$$ER=EC-EF(EF \leqq EC) \tag{8}$$

In the course of this study, the concept of an ecological possession ratio (EPR) is proposed, which serves as the parameter for gauging the relationship between the EF and the EC (formula 9). Through the calculation of the EPR, we can determine whether a regional environment is in a load-worthy or overloaded state.

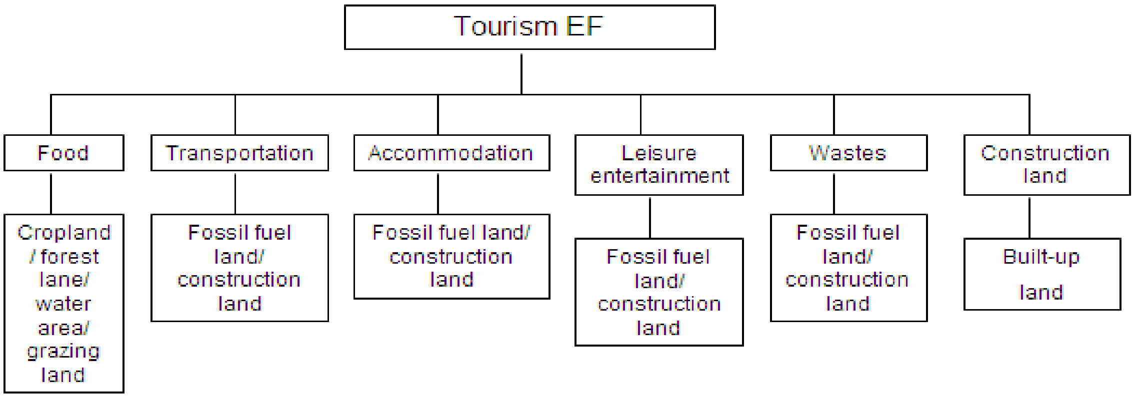
$$EPR=(EF/EC) \tag{9}$$

3. Research Mothods

Research framework

Based on the literature review above, we construct a calculation model by consumption categories as shown in Figure 1. The model has six parts: Food, transportation, accommodation, leisure entertainment, wastes, and construction land. Various resource or energy consumption items are converted into biologically productive land areas. There are six basic types of biologically productive land: Cropland, grazing land, forestland, construction land, fossil energy resource land, and water (marine) area.

Figure 1: The framework of tourism EF



Based on the characteristics of tourist activities, EF analysis of recreational areas differs from ordinary national/regional EF analysis. It requires that the tourists' transportation footprint, daily expenditure, tourism area development land use and waste disposal treatment be calculated separately in order to compute the tourist-generated EF more reasonably. The following is an introduction to the factors:

1. *Estimate of number of tourists.* The EF is computed over a year while the population of a recreational area consists of short-term visitors and permanent residents (workers and locals). In accordance with the time spans tourists stay in different recreational areas may vary, therefore, in calculating the recreational area population EF we need to estimate the number of tourists in the recreational area, which at present is calculated in terms of person-trips.

2. *Recreational transportation fossil energy land calculation*. Differences in the points of origin of recreational area tourists result in significant discrepancies in transportation energy consumption. Therefore, in tourist transportation fossil energy land calculations, we should first investigate the tourists' points of origin and transportation means, and -- according to differences in makeup of the tourists' points of origin and in transportation consumption of fossil energy -- calculate transportation energy consumptions respectively and convert them into estimated fossil energy land areas.

3. *Equivalence factor adjustment.* According to the six land categories in EF analysis, the EF computation for national parks is different from regular national or regional EF calculations. For instance, examination of national park architectural land reveals that most of the built-up sites in recreational areas come from forest lands, pastures or wastelands.

This study proposes to verify the equivalence factor that is appropriate for the characteristics of recreational areas according to the nature and makeup of the land resources of recreational areas.

4. Empirical Analysis

Ecological footprint productivity land change analysis

This study analyzes changes in the six EF productivity land categories of Yangmingshan National Park in 2007 as follows:

Fossil energy land

Fossil energy land refers to the forest land area required for absorbing greenhouse gas CO_2 emitted from burning of fossil energy. According to global average CO_2 absorption by forest lands, the greenhouse gas emitted from fuels, of which the energy absorbed per hectare of forest land is 55GJ, is adopted for calculation. In the total EF of recreational area population, the fossil energy land mainly comprises transportation energy consumption; tourists' food and board; tourist activity within the recreational area; fuels, coals and electricity consumed in different manners; and total fossil energy EF of permanent residents of the recreational area.

Recreational Area Population Count. Yangmingshan National Park is mainly for short-term recreation, and tourists mostly stay for only one day, while past EF analysis was conducted on annual basis. For effective utilization of past EF research data and horizontal comparison with EF levels of other nations/regions, this study adopts the annual number of tourists of the recreational area for EF computation as shown in Table 1.

Table 1: Total Population of Tourists and Permanent Residents

Year	Annual Tourists	Average Span of Stay (day)	Number of Permanent Residents
2007	3,291,910	1	19,133

Sources:
1. Annual Number of Tourists in 2007 comes from National Park Website (2008).
2. Annual of Permanent Residents in 2007 comes from Taipei City Shilin District Office Website (2008), which includes Taipei City boroughs within the premises of Yangmingshan National Park.

2. *Transportation Energy Consumption*. This comprises energy consumed by various vehicles used to transport tourists into, out of, and within the recreational area. Tourism is a short-term activity. The actual transportation distance between the originating point and the destination, transportation convenience, topographic complexity of the transportation route, and the vehicle employed significantly affect transportation energy consumption. Analysis reveals that the actual transportation distance between the originating point and the destination is the primary factor of transportation energy consumption. This study therefore bases its calculation of transportation energy consumption on the actual transportation

distance between the originating point and the recreational area.

According to statistics of originating points of recreational area tourists and prediction of recreational area feasibility study report, tourist originating points of the recreational area and the transportation distance in 2007 are shown in Table 2. Based on 2 liters of energy consumption per 100 km per person, the average gasoline consumption per person for transportation to and from the recreational area in 2007 is approximately 2 liters.

Table 2: Tourists Distribution Statistics

	North Taiwan	Northwest Taiwan	Middle Taiwan	Southwest Taiwan	South Taiwan	East Taiwan	Other	Average round trip distance (km/person)
Round trip distance (km)	40	280	300	560	720	500	600	106.9km
Tourist proportion in 2007	85%	4%	2%	4%	3%	0.3%	1.7%	

Source:Tourist proportion and round trip distance data are estimated figures based on Liao (2003), *Assessment of Economic Value of Yangmingshan National Park's Tourism Resources*, M. Econ. thesis, China Culture University.

3. Energy consumption of food/accommodation and tourist activities within the recreational area. Energy consumption of food/accommodation, entertainment and recreational facilities within the recreational area is divided into three fuel categories: coal, petroleum and electricity. Energy consumption standards of different recreational facilities developed within the recreational area are different. Energy consumptions of Yangmingshan National Park in 2007 are shown in Table 3.

Table 3:Energy consumption of food/accommodation and tourist activities within the recreational area

Year	Coal	Petroleum	Electricity
2007	78,951 kg	39,476 kg	236,853 kwh

4. Other Fossil Energy Consumption. For energy consumption increase as a result of added sewage treatment and electricity facilities we mainly take into account increased coal, petroleum and electricity consumption.

Architectural land

This land category includes various recreational and supplementary facilities such as tourism service facilities, public roads, trail, parking lots, power supply facilities, water supply/discharge facilities, and garbage and sewage disposal facilities. Table 4 shows conditions of various architectural lands.

Table 4: Recreational Area Architectural Land Change Computation Table

Year	Tourism service facility	Public road	Trail	Park lot	Power supply	Water supply/ discharge facility	Garbage / sewage disposal facility	Architectural lands	Total
2007	52,915	313,191	8,268	3,059	3,307	1,654	165	82,680	465,239

Note: * Unit: m^2

<u>Cultivatable land, pasture land, marine area and forest</u>

Table 5: Areas of the six land Categories

Year	Cultivatable land	Pasture land	Forest	Architectural lands	Marine area	Fossile energy land
2007	45 hm^2	573 hm^2	6725 hm^2	45 hm^2	66 hm^2	181 hm^2

Yangmingshan National Park ecological footprint computation

Ecological footprint computation and ecological capacity computation

EF values of Yangmingshan National Park are shown in Table 6.

Table 6: EF values of Yangmingshan National Park in 2007

Land category	Equivalence factor	Average land per person	Global hectares
Cultivatable land	2.8	0.119	0.333
Pasture land	0.5	0.176	0.088
Forest	1.1	0.176	0.194
Fossil energy land	1.1	1.343	1.477
Architectural land	2.8	0.005	0.014
Marine area	0.2	10.37	2.074
Average tourist EF per person			4.180
Total Tourist EF	4.180×19,133=79,975.94		

Forest land comprises the majority of the recreational area, and other productive lands only account for minor portions. In calculating the EC of architectural land, if we employ the agricultural production coefficient as usual, the resulting value will be greater than the actual condition. This study, therefore, adjusts the architectural land production coefficient employed for architectural land EC computation. According to the proportion of architectural land sources of Yangmingshan National Park (pasture 30%, forest 70%), the architectural land production coefficient (0.69) of Yangmingshan National Park is arrived at to make the computation more reasonable. The EC values for the six land categories are calculated as shown in Table 7.

Table 7: The EC values for Yangmingshan National Park

Land Category	Equivalence factor	Average land/person	Equivalence area
Cultivatable land	2.8	0.206	0.342
Pasture land	0.5	0.000	0.000
Forest	1.1	0.001	0.001
CO_2 absorption	1.1	0.000	0.000
Architectural land	2.8	0.001	0.001
Marine area	0.2	1.705	1.705
Total			2.049
	Biodiversity Conservation Area (−12%)		
Average EC per person	1.803		

Tables 6 and 7 show the interrelationships between the provision of ecological services by nature and the human demand on nature through the productive and consumptive activities of residents and tourists. In terms of per capita ecological footprint demand, in 2007 the average per capita ecological footprint demand of Yangmingshan National Park stands at 4.180 hm2, whereas the actual per capita area available is 1.803 hm^2, giving a per capita deficit of 2.377 hm^2.

EF analysis-based recreational area sustainable development assessment

To help determine whether or not the ecological environment of Yangmingshan National Park is in a state of sustainable development, this study is based upon the "National Ecological Footprint" of Wackemagel *et al.* (1997). It compares Yangmingshan National Park with 52 countries in terms of EF, EC and EPR levels as follows:

1. Average Ecological Possession Ratio Comparison. Out of the 52 countries above, 10 typical countries (Peru, New Zealand, Iceland, Brazil, Indonesia, Canada, Australia, Finland, Malaysia, Colombia) of more advanced ecological resources and tourisms are selected for calculation of EPR. The average EPR is 0.415 while that of Yangmingshan National Park is 2.318, or 5.59 times higher than the 10 typical countries. Factors responsible for such a high ecological occupancy rate include: (1) the continued growth of the tourist population leading to increases in energy consumption and in the generation of domestic pollutants; (2) the modification/ expansion of the tourist zones which renders some parts of the forest lands, grazing lands and croplands into construction lands and reduces the size of biologically productive lands that provide for tourist activities so as to give way to tourism facility expansions. In sum, the fast growth of the tourist population is the main reason behind the increased ecological occupancy rate.

2. Ecological Possession Golden Section Search Technique (GSST)

To ensure proper development and utilization of the ecological environment of a recreational area this study employs the 0.618 Method (GSST) to classify the 52 countries in terms of ecological utilization appropriateness. There are 5 levels of appropriateness. In accordance with ecological possession of major countries around the world, the five levels and typical countries are shown in Table 8.

Table 8: Ecological Possession Appropriateness Levels

Ecological possession appropriateness leaves	EPR	Typical country
Especially Appropriate	<0.382	New Zealand, Peru, Iceland
More Appropriate	0.382-0.618	Brazil, Australia, Colombia, Indonesia, Canada
Appropriate	0.618-0.726	Finland, Malaysia, Argentina
Lower Appropriate	0.726-1	Chile, Sweden, Norway, Ireland, Venezuela
Inappropriate	>1	Hong Kong, Singapore, Israel, Belgium

Nations with EPR levels of "especially appropriate" and "more appropriate" have a better ecological environment. The domestic ecological quality of some of the developed countries such as the USA, UK, Germany and France is quite good. Yet as a result of modern life styles their average energy consumption per person is higher than the global average, and their average EF person has also been too high. Countries with the lowest ecological utilization appropriateness such as Hong Kong, Singapore, Israel and Belgium mainly lack productive land resources. The average EPR of nations with very high ecological possession per person is far greater than 1.0, and even approaches infinity. Compared with EPR levels of typical countries of Table 8, the EPR (2.318) of Yangmingshan National Park is too high and is in the range of ecological utilization inappropriateness. That means the expansion of Yangmingshan National Park runs counter to the sustainable development of its ecological environment.

5. Conclusion and Recommendation

Conclusion

Through utilization of EF analysis in the evaluation of the sustainable development of recreational areas, we may reach several conclusions.

First, through comparison with typical nations with better ecological environment and tourism development, and through average EPR comparison and GSST, we have determined that the ecological quality of Yangmingshan National Park, based on 2007 as the standard year, is worse than its peers and that its ecological utilization is inappropriate. Our EF analysis of the impact of Yangmingshan National Park's tourism development shows that the average EF per person of the recreational area is 4.180hm^2, the EC is 1.803hm^2 and the EPR is 2.318. This implies that, following expansion of its tourism scale, the pressure of ecological possession of Yangmingshan National Park on its natural ecological system is over its EC, the ecological system is endangered, and the recreational area development is against its sustainable development.

Secondly, the process of analyzing EF, EC and EPR changes points to the increased number of tourists in the recreational area as the dominant factor that affects EF changes. Expansion of the recreational area results in reduction of productive land in the recreational area and causes its EC to drop slightly, yet the degree to which the EC level declines is far less significant than the rise in EF as a result of increase in tourist number.

Third, the EF of Yangmingshan National Park is greater than its EC, while its EPR has deviated from the scope of sustainable development. These computations indicate that the negative impact on the ecology of increased recreational activities in the recreational area is significant.

Fourth, the governing agency of the recreational area needs to fully understand the adverse impact of recreational expansion on sustainable development and take necessary measures to stop or alleviate deterioration of the ecological environment. For the development of the recreational area to be operationally sustainable, the recreational activity should be in harmony with the natural environment. The pace of development and the number of tourists should be controlled and environmental awareness needs to be intensified. Otherwise, an excessive number of tourists will create such pressure that the very environment on which nature-based tourism is based will be destroyed, and further sustainable development of eco-tourism will be impossible.

Recommendations

Due to the fact that the EF method is ecology-biased, the following situation may occur: The higher the productivity and social/economic development level, the greater the ecological deficit will be; and the lower the living standard, the smaller the ecological deficit will be. To a certain extent this situation ignores the dominance of development. In terms of comprehensively reflecting the sustainable development of different regions, there is a flaw. Evaluation of the pressure of tourism development on the natural environment of the region through the EF method from an ecological perspective often overlooks the economic, social, legal, technical and other fundamental environmental issues that may affect sustainable development. The computational outcome is often too optimistic, since the actual EF value is often greater than the calculated value.

Due to the fact that EF computation is based on the unit of one year, evaluation of the sustainable development of a recreation area via the EF method often neglects the environmental problem triggered by the uneven distribution of tourists over time and space. Influenced by the climate, weekend/holiday and celebrations, the number of tourists fluctuates with the season. The frequency of recreational activities and over-concentration of tourists may result in special changes to the ecological resources of the recreational area (such as concentrated emissions of pollutants, which may cause permanent damage to animals and plants of the recreational area). Yet EF computation fails to demonstrate this possible impact.

Due to the fact that there is a significant difference between the natural ecological condition of nations around the world and simple recreational area, comparison of EF and EPR between a nation/region and a recreational area for determining sustainable development of the recreational area may reach a result that is too optimistic. In future studies, through gradual establishment of an EF/EC databank for typical recreational areas, one can build up a more reasonable standard for assessing the ecological condition of a recreational area and provide a more accurate quantitative evaluation system for sustainable development of recreational areas.

Although the theory of environmental footprints is not perfect, EF analysis has opened up new possibilities for gauging sustainable development of recreational resources. Its analytical results serve as important references for decision-makers of recreational area administrations in recreational resource development and daily management and maintenance; and help them meet people's recreational needs under the premise that sustainable development of recreational resources is ensured.

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