Ecological footprint study on tourism itinerary products in Shangri-La, Yunnan Province, China

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Abstract: The eco-footprint analysis of tourism is one of the most up-to-date and effective methods used to analyze the environmental effects of tourism. This study constructs a model to calculate the ecological footprint (EF) of tourism itinerary products by using a component approach, rudimentarily exploring the calculation methods for EF which target necklace-like tourism itinerary products and base tourist trips. By applying the model to calculate and analyze an "8-day tour of Shangri-La", a typical tourism itinerary product, results of this study suggest that: (a) Tourism is a kind of life style with tremendous ecological consumption, that is, per capita EF that tourists produce in the course of travel is more than the one that local people produce in their daily life in tourist source areas, and it also exceeds the per capita EF that local people produce in their daily life in tourist destination; (b) According to the component approach, EF of tourism itinerary products is broken down into 7 components, among which “Transport”, “Food”, “Waste” and “Accommodation” play important roles; (c) There exist significant differences in ecological efficiency between different departments of tourism; the travel and entertainment sectors maintain a relatively high ecological efficiency, while the food and lodging departments have relatively low ecological efficiency.

Key Words: touristic ecological footprint (TEF); itinerary product; ecological consumption (EC); component; Shangri-La

The impact of human activities on the environment, to a large extent, depends on the quantity and quality of natural resources consumed by humans. The quantitative measurement of the environmental impact resulting from natural resource consumption has been one of the difficulties and focuses in ecology study. There exist some mature approaches to measure environmental impacts, such as environmental bearing capacity (EBC)[1], environmental impact assessment (EIA)[2] and so on; however, these methods mainly focus on microcosmic and direct effects caused by human beings, and rarely pay attention to macrocosmic and indirect effects caused by resource consumption. Ecological footprint analysis (EFA)[3,4] offers possibilities to solve the problem more precisely.

TEF[5–7], which is the EF analysis applied in tourism study, means, within a certain time and space, the ecologically productive land area needed for the resource consumption and waste absorption related to tourism activities, that is, to export ecological consumption within the area. Since Wackernagel and Hunter proposed the concept of TEF[5,6], Cole, et al.[8], Zhang, et al.[9] and Gösslin, et al.[10] carried out empirical studies on Manali village in India, Huangshan city in China and Seychelles, respectively. Most of the studies above were focused on regional analyses about specific tourist destinations which were only spot-like areas, and failed to give a clearer picture of ecological consumption produced in the entire process of tourism activities, especially sightseeing activities, where tourists often move from one place to another. The traffic routes link every tourist destination to form a necklace-like spatial form. Tourism is a dynamic process; the tourists have different consumption behaviors and activities, and the ecological consumption varies greatly as a result. Instead of being concerned with the tourist groups with the same behavioral characteristics, EF of tourist destinations analyzes the regions where all kinds of tourists get together, so is difficult to fully reflect the differences in ecological needs and resource consumption between different groups of tourists. In tourism, the tourism products which link the necklace-like
travel processes are tourism itinerary products, also known as the package tourism products\cite{11,12}. Until now, there have been few studies reporting any calculation methods of EF of tourism itinerary products and its characteristics. Therefore, we are trying to construct a calculation model through the characteristics and actual situations, and apply it to calculate and analyze the EF of a ‘Shangri-La eco-cultural tour’, which is a typical tourism itinerary product with a view of providing new perspectives and methods for EF study and promoting the application of EF and the study on tourism’s environmental impact.

1 Methods

The current calculation method of TEF is based on tourist destinations, which is too complex and difficult to operate and to be suitable for tourism itinerary products. A new method is needed to calculate TEF in accordance with the characteristics of itinerary products and the existing results of related research.

1.1 TEF calculation method of destinations

In reference to the approach of data collection and calculation, there are two approaches in current EF research: compound (top-down) and component (bottom-up) approaches\cite{4}. The former is based on regional or national statistics in a top-bottom way, in which the total amount of regional consumption can be converted into per capita consumption, then combined with the population data and then converted into EF. The latter is based on daily human consumption in a bottom-up way, in which the data of per capita consumption can be acquired by questionnaires and statistics. Energy, transport, food and waste are main parts which are still finally converted into per capita EF\cite{11}.

According to the compound approach, the calculation and analysis of EF of a tourist destination are made by dividing and calculating per capita consumption and construction occupation during the tour, which will be finally converted into productive land\cite{7–10}. So the division of consumption (identification of components) and the access of data is an important step for TEF.

1.2 Calculation approach to EF of tourism itinerary

1.2.1 Selection of approach

Most itinerary products consist of cross-regional tourism activities, involving a number of tourism destinations and the processes of arrangements. For itinerary products, the compound approach has some limitations. However, the component approach, which is based on items of consumption and needs to survey ecological consumption during the tour in a bottom-up way, can reduce the impacts on environment brought by tourist movement and changes in regions.

1.2.2 Identification of components

Tourism itinerary products are one of the fastest growing sectors in the tourism market, where sightseeing is clearly the main purpose, team activities are the basis, main activities are pre-arranged, arrangements and services are provided by travel agents, and the price is comparably cheaper. The EF of tourism itinerary products, used to analyze ecological demands during the course of travel, including all kinds of resource consumption and waste products, is denoted by productive land occupation area. The major consumption of resources is land occupation and energy use. All kinds of wastes in the tour are taken into account, such as waste water and solid waste. The EF of waste water mainly comes from energy consumption for depuration, which has been included in other components (accommodation, transports, etc.) and is ignored in this study.

According to the component approach, items selected should include all consumption and waste as the result of tourism activities. Therefore, the EF of itinerary products is made up of seven major components: food & fibre, accommodation, transport, sightseeing, purchase, entertainment and waste (Fig. 1).

1.2.3 Calculation of components

According to the characteristics of the itinerary products and related research, to analyze the components of tourism activities, a suitable approach is selected for each of the various components.

(1) Calculation of food & fibre component ($\text{TEF}_f$)

Food, clothing and daily necessities are included in the Food & fibre component. In reference to some research outside China, the daily consumption of food & fibre by tourists in a destination are replaced by the per capita needs of the resource country (place)\cite{10}. As a result, the total per capita $\text{TEF}_f$ is equal to the daily EF in residence multiplied by the number of days at a destination

$$\text{TEF}_f = n \times e_{f}$$  \hspace{1cm} (1)

In Eq. (1): $n$ is the duration of the tour (days) and $e_{f}$ is the

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**Fig. 1** Touristic ecological footprint components of itinerary products
EF of daily consumption in the tourists’ residence. The methods and relevant data of per capita EF of daily consumption in urban and rural areas of many countries were provided in researches[14–16].

(2) Calculation of accommodation component \((TEF_a)\)

Food & fibre component mentioned above contains a part of the accommodation component. But there is a great gap in ecological consumption between “accommodation” in hotels and “living” in the tourists’ residence. The average daily amount of water consumption, energy use, and solid waste is far more than that for the local people in tourists’ destinations. For example, the amount of water and electricity demand is 6–9 times the local residents’ use[17]. So this needs to be considered accordingly. The EF of this component is equal to daily EF multiplied by the number of days staying at hotels

\[
TEF_a = \sum_{i=1}^{n} a_i \times ef_{a_i}
\]  

In Eq. (2): \(a_i\) is the duration (days) in \(i\) star hotels; \(ef_{a_i}\) is the per capita daily EF in hotels. According to Gössling et al.[10], the EF of a five-star hotel is 0.0029669 hm\(^2\)/per bed per night, a three- or four-star hotel is 0.0011418 hm\(^2\)/per bed per night, and a one- or two-star hotel is 0.0005958 hm\(^2\) and a guesthouse is 0.000429 hm\(^2\)/per bed per night.

(3) Calculation of transport component \((TEF_t)\)

Transport is the premise for tourism, including per capita land occupation area for energy use by various vehicles, all roads (between and within destinations or scenic areas) and infrastructure (airports, railway stations, parks, etc.). Under this idea, per capita EF has been worked out in distance by all types of vehicles in related research[18]. If the mileage (kilometers) and the type of vehicles are identified, and also the EF per capita per km is acquired, the \(TEF_t\) is available—as Eq. (3) shows:

\[
TEF_t = \sum_{i=1}^{n} t_i \times ef_{t_i}
\]

In Eq. (3): \(TEF_t\) contains all EF generated by various vehicles (planes, trains, automobiles, etc.); \(t_i\) is the distance by type \(i\) vehicles; \(ef_{t_i}\) is the per capita per kilometer EF by type \(i\) vehicles. According to related research[18], the EFs of major vehicles are as follows: \(2.93 \times 10^{-3}\) hm\(^2\)/(km-per) for long-distance aircraft, \(4.72 \times 10^{-3}\) hm\(^2\)/(km-per) short-haul aircraft, \(1.70 \times 10^{-3}\) hm\(^2\)/(km-per) for coach, \(3.34 \times 10^{-3}\) hm\(^2\)/(km-per) for short-haul bus, \(1.74 \times 10^{-3}\) hm\(^2\)/(km-per) for train and \(8.08 \times 10^{-4}\) hm\(^2\)/(km-per) for taxi.

(4) Calculation of sightseeing (visiting) components \((TEF_v)\)

“Sightseeing (visiting)” is the main purpose of tourism activities, whose EF mainly refers to construction occupation of scenic sites and energy use for supporting the area. Roads for vehicles, walking paths and viewing facilities are the main parts of construction occupation. Because the roads for vehicles have been calculated in the transport component \((TEF_t)\), more attention is paid to the land occupation of the latter two elements. For tourism products of sightseeing, which include museums, historical buildings, forest parks and other sites, energy consumption is mostly concentrated in the reception facilities, such as visitor centers. Electricity is the main part of energy consumption, used for exterior decoration, simulation displays, human computer interaction (HCI) and thermoregulation.

\[
TEF_v = \sum ef_{v_i} + \sum ef_{p_i}
\]

In Eq. (4): \(ef_{v_i}\) is the construction occupation of type \(i\) scenic areas, which is available by survey; \(ef_{p_i}\) is the EF of the energy consumption in type \(i\) scenic areas. According to Susanne et al.[18], the average energy consumption by visiting museums is 10 MJ/per capita and the one by visiting the visitor center is 29 MJ/per capita. All the energy consumed can be converted into energy land occupation.

(5) Calculation of purchase components \((TEF_p)\)

This part mainly contains EF from the tourist commodities that tourists purchase and the shops that tourists go. Tourist commodities mainly include native products, jewelry, souvenirs, handicrafts, travel necessities, plant and animal products, and special goods, which are generally brought back from a destination to the residence as gifts or souvenirs and thus consume little resources during the journey. The variations of these commodities are focused on spatial transfer following the tourists’ transportation, from which EF generated is related to trade adjustment. The purchase component \((TEF_p)\) in this study only takes into account the ecological consumption of tourism activities as research objects while the transfer of commodities is neglected. So the EF of shops is the key part in the component in this study, including construction occupation and energy use.

\[
TEF_p = \sum ef_{p_{v_i}} + \sum ef_{p_{p_i}}
\]

In Eq. (5): \(ef_{p_{v_i}}\) is per capita EF of energy in the “\(v\)” shop, \(ef_{p_{p_i}}\) is per capita construction occupation of the “\(p\)” shop which can be obtained through survey. The EF of energy can be converted from per capita energy consumption of tourist shopping spots, which is usually 10 MJ/per capita[18].

(6) Calculation of entertainment components \((TEF_e)\)

Entertainment is an important part of tourism, including dance performance and other participant activities. However, the construction occupation and energy consumption vary widely among different types of entertainment. The watching-based projects, such as open-air dance performances, generate very little EF in both items, while experience-based projects need more resource and energy. For example, golfing occupies larger land, and boats and skiing by helicopters consume far more energy. Nowadays, the entertainment arranged in tourism itinerary products is mainly sporadic watching-based performances.
In Eq. (6): $e_i$ is the time of enjoying the “$i$” type of entertainment, $e_{fei}$ is per capita EF of energy use for the “$i$” activity, and $e_{fai}$ is per capita EF of construction occupation for the “$i$” entertainment. Watching-based entertainment belongs to the low energy consumption activities, in which per capita energy consumption is 9 MJ\([18]\).

(7) Calculation of waste components ($TEF_w$)

There is a certain amount of waste generated from every component in the journey mentioned above, such as food & fibre, accommodation and transport components, in which solid waste is the main part. However, a lot of attention has been paid to the resources consumed in the six basic elements\([9,10]\). EF of waste is mainly generated from garbage storage and transportation. The former comes from fields occupied by storage and garbage gas emissions (CO$_2$ and CH$_4$)\([19]\). The garbage generated during the journey can generally be divided into three parts: kitchen garbage from food and accommodation, papers and other daily organic waste, and inorganic garbage in parks like the plastic and metal packages discarded during the entertainment activities and the visit in general.

If the quantity of daily per capita garbage, the EF of unit garbage (kg), the EF of garbage transport as well as that of recycling are available, the total EF generated from garbage can be calculated.

$$TEF_w = \sum_{i=1}^{n} w_i \times e_{fi} + \sum_{i=1}^{n} w_i \times e_{fai} \quad (7)$$

In Eq. (7): $TEF_w$ is the EF of all kinds of garbage storage; $w_i$ is the average daily quantity of the “$i$” garbage per tourist; $e_{fi}$ is the EF from storage of the “$i$” garbage in unit quantity; $e_{fai}$ is the EF from the garbage transportation in unit quality. The EF of different kinds of storage is as follows\([19]\): 3.98 × 10$^{-4}$ hm$^2$/kg for paper and textile, 1.69 × 10$^{-5}$ hm$^2$/kg for park garbage, 1.49 × 10$^{-5}$ hm$^2$/kg for kitchen waste, 3.34 × 10$^{-5}$ hm$^2$/kg for wood products and approximately 2.1 × 10$^{-5}$ hm$^2$/kg for transportation.

(8) Calculation of tourism itinerary products ($TEF$)

In short, the EF of tourism itinerary products is the total value accumulated with the seven fore-mentioned components during the whole journey, as Eq. (8) shows below:

$$TEF = TEF_f + TEF_a + TEF_t + TEF_s + TEF_p + TEF_e + TEF_w \quad (8)$$

2 Empirical study on tourism itinerary products of Shangri-La, Yunnan, China

2.1 Background introduction

The tourism itinerary of Shangri-La, located in the transitional ecotone area from Yunnan-Guizhou Plateau to Qinghai-Tibet Plateau, is located in the core area of the world natural heritage “Three Parallel Rivers”, the communication channel of Han, Tibetan, Naxi and other nationalities, and the multicultural intersection of Bashu, Tibet, Nanzhao Dali and Naxi people. It can also fully reflect the ecological, ethnic and cultural diversity and blending of Yunnan, China. The tourism itinerary is mainly composed of Kunming and three other tourism destinations in northwest of Yunnan Province, namely, Dali, Lijiang and Shangri-La, which are distinct from each other and spatially continuous.

The tourism itinerary was selected as one of the “top 10 eco-tourism itineraries of China” in 1999, the Year of Ecological Tourism, and it continues to be the important golden tour itinerary promoted by the Yunnan Province. Without taking into account the tourist reception of Kunming, the tourism itinerary has received 25% of the tourists within China and 70% of the tourists outside China coming to Yunnan Province.

This itinerary takes an important role in the development of Yunnan’s tourism.

This article chooses the tourism itinerary product of “Shangri-La 8-day tour” as the research object since it represents Yunnan tourism and has been popular to tourists both in China and abroad. The product gathers together the most important attractions of Shangri-La. As far as the traffic is concerned, visitors come by train from Kunming to Dali, and by bus for the rest of the tour. Visitors are accommodated with 3-star hotels and meals for tour groups, including eight dishes and one soup. The journey includes 13–15 scenic spots, 18–20 shopping centers and 2–3 amusement activities. According to a survey by the Urban Survey Organization of Yunnan Province, visitors from East China to Yunnan account for nearly 24.8% of the total visitors from other provinces. In this article, we take visitors from Shanghai as an example since Shanghai is the center of East China, and we can assume they travel by air.

2.2 Data sources

The data and information needed for the study are from three sources: (1) Data about the tourism development status of Yunnan and information about the “Shangri-La tour itinerary” were obtained by referring to the Yunnan Statistical Yearbook and the Year Book of Yunnan Tourism, as well as consulting the local tourism bureau. (2) Structure of the “Shangri-La tour itinerary” product was researched through a process of interviewing. The task group took part in a tour group and investigated the travel agencies with relatively more tourists from July 2004 to November 2005 to obtain related data on the “Shangri-La tour itinerary”, such as information about the components and time allocation of the tour, occupation of the land by scenic areas, scenic spots and shopping places, the types of vehicles and the distance they cover, and daily garbage products per capita by tourists and the various components. The distance by air was gained through GIS and taking into account any detour factors\([20]\). (3) Energy consumption and EF data of specific activities were mainly obtained through...
referring to professional literature and research reports by related international organizations, including footprints of vehicles, daily life consumption per capita and footprints of accommodation, energy consumption of tourist reception and entertainment activities.

2.3 Calculation results

According to the data and Eq. (8), the footprint and its components for the tourists from Shanghai to enjoy an “8-day tour in Shangri-La in Yunnan, China” (the entire journey including both travel there and back) are shown in Table 1. The footprint of “transport” is produced by various vehicles (footprints produced by cableways and cruise ships are converted into kilometers covered by bus with equal price). Eight days were covered when calculating the footprint of “Food and fibre”, but only 5 days for “accommodation” since visitors spent 2 nights on train. The waste produced by visitors during the tour was about 3 kg/day: there was 2 kg of kitchen garbage, and garden and park garbage was included.

2.4 Result analysis

2.4.1 Total ecological footprint analysis

The tourist EF of a visitor from Shanghai who participates in an “8-day tour in Shangri-La” is 0.21009 hm², compared with 0.0256 hm²—the footprint of daily life consumption of a local resident for 8 days in Shanghai. The former is 8.2 times as large as the latter. That is to say, the footprint produced by a visitor from Shanghai in one day is as much as or more than that when at home in Shanghai for eight days. In 1999, EF per capita in Shanghai was 4.7 times as large as that in Yunnan and it would remain 4 times as much if we are to suppose that the EFs of Shanghai and Yunnan continually increase with the same rate. So we can conclude that the ecological consumption in Yunnan for a visitor from Shanghai is 32 times as much as that of a local resident, which means that the ecological consumption of a visitor from Shanghai for an “8-day tour in Shangri-La” is more than that of a resident for half a year. From the fore-mentioned results, it follows that tourism is definitely a strong ecological consumer.

The EF of the whole tourism itinerary product can be divided into two parts in terms of different origins: increased part and transferred part. The former, i.e., the increased part, is mostly produced by supporting tourism activities such as transport and sightseeing, and this is the principal part of tourism itinerary products’ EF, accounting for 87.80% of the total. It’s the net increment of global environmental impact, and is principally brought on by transportation, especially aviation, which makes a great contribution of 67.27% to the total transport EF. The latter, i.e., the transferred part, refers to the resource consumption indispensable to humans, like food; this part of the EF is transferred from one place to another, and occurs with or without tourism, thus contributing little to the whole footprint of the tourism itinerary products, and only accounting for 12.19% of the total.

2.4.2 Component analysis

In this study, the EF of resource consumption adds up to 0.205769 hm², accounting for about 97.981% of the total, and it involves transport, food and fibre, accommodation, purchase, sightseeing, and entertainment. The EF of total waste adds up to 0.00424 hm², accounting for about 2.019% of the total.

(1) “Transport” accounts for a large portion

The footprint of “transport” is 0.1724974 hm² (82.139% of the total), composing the largest part of the EF of the whole itinerary products, and aviation plays the most important role

<table>
<thead>
<tr>
<th>Component type</th>
<th>Ecological footprint (hm²)</th>
<th>Ratio(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and fibre, ( ef_f )</td>
<td>0.02560</td>
<td>12.190</td>
</tr>
<tr>
<td>Accommodation, ( ef_a )</td>
<td>0.005709</td>
<td>2.718</td>
</tr>
<tr>
<td>Transport, ( ef_t )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airplane</td>
<td>0.12406</td>
<td>59.074</td>
</tr>
<tr>
<td>Train</td>
<td>0.01075</td>
<td>5.119</td>
</tr>
<tr>
<td>Coach</td>
<td>0.01224</td>
<td>5.828</td>
</tr>
<tr>
<td>Bus</td>
<td>0.01403</td>
<td>6.681</td>
</tr>
<tr>
<td>Taxi</td>
<td>0.00808</td>
<td>3.847</td>
</tr>
<tr>
<td>Others</td>
<td>0.00334</td>
<td>1.590</td>
</tr>
<tr>
<td>Total</td>
<td>0.17250</td>
<td>82.139</td>
</tr>
<tr>
<td>Sightseeing, ( ef_s )</td>
<td>0.00093</td>
<td>0.443</td>
</tr>
<tr>
<td>Purchase, ( ef_p )</td>
<td>0.00098</td>
<td>0.467</td>
</tr>
<tr>
<td>Entertainment, ( ef_e )</td>
<td>0.00005</td>
<td>0.024</td>
</tr>
<tr>
<td>Total</td>
<td>0.205769</td>
<td>97.981</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wastes</th>
<th>Ecological footprint (hm²)</th>
<th>Ratio(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid wastes, ( ef_w )</td>
<td>0.00424</td>
<td>2.019</td>
</tr>
<tr>
<td>(Total , TEF)</td>
<td>0.210009</td>
<td>100.000</td>
</tr>
</tbody>
</table>
in it, taking up 71.928% of “transport” and 59.073% of the total. It attaches great importance to calculating and analyzing the consumption of fossil fuel energy; air travel is based on a certain amount of aviation fuel consumption, and its high EF can be strong evidence to that. Sightseeing travel itineraries often link several tourism attractions together; tourists constantly change locations and tourism items. In the Shangri-La tour itinerary, the average trip covered by travel buses has exceeded 400 km per day, which is bound to increase the EF of the “transport” component.

With other elements remaining unchanged, EF of tourism itinerary products increases with the increase of distance. Table 1 indicates that without taking into account the trips between Shanghai and Yunnan and only involving the consumption occurring within Yunnan Province, the EF of the tour is 0.077868 hm², while that of the “transport” component is 0.0403612 hm² (accounting for about 51.832%). When taking into account the trips between Shanghai and Yunnan, the footprint of the “transport” component would increase to 0.1724974 hm² (accounting for about 82.140% of the total). It would be especially true for international travel because of the increasing distance.

(2) “Waste” component can not be ignored
In 2004, the average daily city trash is 0.8 kg/person in China, and only 0.5 kg/person in Yunnan Province. In the course of travel, various tourism activities will, without fail, bring a certain amount of waste, and the waste will be far more than that generated in daily life by local people. The investigation indicates that the average daily trash is 3 kg/person produced by visitors to Yunnan, about 5 times more than that produced by Yunnan local population. The generation, transportation and storage of so much waste will inevitably lead to augmentation of the EF of tourism itinerary products. In this study, the proportion of \( e_{\text{w}} \) is 2.019%, closely following \( e_{\text{f}} \) and \( e_{\text{e}} \) while overrunning \( e_{\text{f_o}}, e_{\text{f_p}}, e_{\text{f_m}} \) and \( e_{\text{e}} \). However, \( e_{\text{f}} \) has been neglected in the past TEF studies.

(3) EF of “sightseeing”, “purchase” and “entertainment” has few impacts
\( e_{\text{f_o}}, e_{\text{f_p}}, e_{\text{f_m}} \) and \( e_{\text{e}} \) account for a very low proportion, only 0.934% in all in this study, which is closely related with the configuration of tourism itinerary products and the characteristics of sightseeing travel.

\( e_{\text{f}} \): The tourism itinerary products generally use existing natural landscape, historical heritage sites, ethnic customs and city view as attractions, and need very little construction. Meanwhile, the scenic spots covered in the itinerary usually have a tremendous amount of visitation, resulting in very little land area per capita. As for natural scenic spots with large territory areas, the landscape function is just one of the many functions of the ecosystem composed by the entire scenic area\(^2\). What really serve for the tourism function are roads and facilities for sightseeing (carriageways have been involved in the “transport” component). Taking Shuodu Lake in Shangri-La as an example, the lake area is 5 km², the ponding area is 15 km², but the walking paths and other facilities are only 2 km², while the average number of visitors reaches one hundred thousand every year, occupying the land area of only 0.2 m² per capita. In terms of the cultural landscape, the area of construction is extremely small, not to mention the area per capita. For instance, the ancient city of Lijiang, which is the largest cultural landscape in the Shangri-La tour itinerary, has an area of 3.8 km², with its one fifth serving as roads and squares for passing and sightseeing. There are about 30 thousand residents, and a number of shops and hostels. Visitors there exceeded 3 million in both 2004 and 2005 with an average area of about 0.152 m² covered by each visitor per day. The scenic area has been shared equally by large numbers of tourists; it still remains small after adding up \( e_{\text{f}} \) of a limited number of tourism destinations.

\( e_{\text{s}} \): In tourism itinerary products, entertainment produces very little EF with a proportion of only 0.024% and the reasons are as follows:

1. There are fewer ecologically consuming types of entertainment. There are fewer items of entertainment than necessary in the Shangri-La tour itinerary, not to mention participatory energy-intensive items such as parachute jumping, skiing and motorboating, and there are only sporadic folk song and dance performances, such as the “Three-course Tea” of the Bai nationality in Dali and the Tibetan family visit in Shangri-La. Furthermore, these kinds of entertainment were inserted into the course of travel with little land occupation and energy consumption. Ⅱ. Tourists have little discretionary time of their own. In the Shangri-La tour itinerary, tourists spend too much time on dinner, transport, sightseeing and purchasing, with little time left for entertainment and other activities. Without enough discretionary time, it’s difficult for tourists to enjoy highly ecologically consuming entertainment such as activities in public houses and ballrooms, and leisure sports like swimming and golfing.

2.4.3 Analysis of ecological efficiency
The EF and expenditure are shown in Table 2; the expenditure data are the average of prices in peak seasons and off seasons quoted by local travel agencies in Yunnan. Transport
expenditure is 2040 yuan, accounting for 51.911% of the total, while the EF of “transport” takes up 82.140% (0.17250 hm²) of the whole itinerary EF. It can be seen that the EF of transport shares a relatively high proportion, compared with its relatively low share in expenditure. However, this is exactly the contrary to that of “accommodation”, “sightseeing” and “entertainment”. The proportions of the EF of the last three components mentioned above are 2.717%, 0.469% and 0.024%, respectively, while their specific weights in the total expenditure are 8.016%, 11.120% and 7.888%, respectively. The differences between the consumption expenditure and the EF of the three items virtually suggest the difference in ecological efficiency of different tourism departments[25]. As the ratio of economic value and resource consumption, ecological efficiency is a decoupling indicator reflecting the relation between economic growth and environmental pressure. To certain districts and industries, the greater the ratio the less resource consumption and the greater the economic value is created. EF as resource consumption can more comprehensively reflect the ecological efficiency of a district or an industry. Besides the occupation of land and water, EF also includes waste absorption to better reflect the resource occupation and waste generation in an area or an industry. It can be seen from Table 2 that the ecological efficiency of “food and drink” (8164 yuan/hm²) and “transport” (8164 yuan/hm²) are relatively low, left far behind that of “entertainment” and “scenic area”. Since the EF of the “purchase” component has not been taken into account, it is difficult to discuss its ecological efficiency.

3 Conclusions

(1) Using the component approach to create the computational model of the EF of tourism itinerary products

Previous calculation and analysis of TEF were mainly based on the compound approach, targeting single spot-like tourism destinations. According to the characteristics of tourism activities, this study creates a component approach analysis model targeting necklace-like tourism itinerary products. The EF of tourism itinerary products has been divided into two parts in this model, namely, “resource consumption” and “waste generation”; the former is further fractionized into 6 components: food, transport, accommodation, purchase, sightseeing and entertainment, thereby being more in line with the objective reality of tourism activities and thus being more adaptable. Eq. (8) is derived from ideas discussed above to calculate the EF of tourism itinerary products. It is concise, functionally friendly and suitable for calculating and analyzing the EF of tourism itinerary products based on the sightseeing.

\[ TEF = TEF_f + TEF_a + TEF_t + TEF_s + TEF_p + TEF_e + TEF_w \]

Previous studies have been only concerned with measuring the ecological consumption of certain districts, corporations or certain products, etc. This study starts with a multi-regional tour, calculates and analyzes the ecological demands of various travel behaviors, and develops on TEF research and also on EF research in general.

(2) Travel is a highly ecologically consuming life style

This has been proved by calculations in this study. The TEF produced by a visitor from Shanghai who took part in an “8-day tour in Shangri-La” could be 0.210009 hm² (0.025899 hm²/d), four times that in Shanghai, and 32 times that of a local person in Yunnan. Meanwhile, the results of this study indicate that TEF mostly comes from the increased part (87.80%), while the transferred part makes little contribution to it (12.19%). Transport plays an important role in the increased part, and in especial the EF of aviation accounts for 68.32% of the increased part. Concerning environmental pressure and impact on the tourism destination, increased EF mainly plays an indirect role, but plays a direct role with regards to transferred EF.

(3) EF of the tourism itinerary mostly concentrates in the “transport”, “food”, “solid waste” and “accommodation” components

This has been confirmed by the calculation that the amount of the EF of these four components took up 99.066%. Among these four components, the largest portion belongs to “transport” (82.140%); moreover, the proportion will become even larger with the increase of travel distance. “Food” ranks the second with a proportion of 12.190%, followed by “accom-

<table>
<thead>
<tr>
<th>Item</th>
<th>Ecological footprint (hm²)</th>
<th>Ratio (%)</th>
<th>Expenditure (yuan)</th>
<th>Ratio (%)</th>
<th>eco-efficiency (yuan/hm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; fibre</td>
<td>0.02560</td>
<td>12.190</td>
<td>209</td>
<td>5.318</td>
<td>8164.063</td>
</tr>
<tr>
<td>Accommodation</td>
<td>0.00570</td>
<td>2.717</td>
<td>315</td>
<td>8.016</td>
<td>55212.45</td>
</tr>
<tr>
<td>Transport</td>
<td>0.17250</td>
<td>82.140</td>
<td>2040</td>
<td>51.911</td>
<td>11826.09</td>
</tr>
<tr>
<td>Sightseeing</td>
<td>0.00093</td>
<td>0.442</td>
<td>437</td>
<td>11.120</td>
<td>469892.5</td>
</tr>
<tr>
<td>Purchase</td>
<td>0.00098</td>
<td>0.469</td>
<td>618.8</td>
<td>15.746</td>
<td>6000000</td>
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<tr>
<td>Entertainment</td>
<td>0.00005</td>
<td>0.024</td>
<td>310</td>
<td>7.888</td>
<td>6200000</td>
</tr>
<tr>
<td>Solid waste</td>
<td>0.00424</td>
<td>2.019</td>
<td>0</td>
<td>0.000</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>0.210009</td>
<td>100.000</td>
<td>3929.8</td>
<td>100.000</td>
<td>16056.45</td>
</tr>
</tbody>
</table>

Table 2  Quantitative relationship between the ecological footprint component and the tourist expenditure


modation” (2.717%) and “solid waste” (2.019%); the remaining components (“sightseeing”, “purchase” and “entertainment”) in all enjoy a proportion of less than 1%.

(4) There exist significant discrepancies in ecological efficiency between different departments of tourism

From the calculation it can be seen that the share of “transport” in the total EF is higher than the share of transport expenditure in the total expenses, and the status of “sightseeing”, “entertainment” or “accommodation” is just the opposite. There exists a nonlinear correlation between the proportions of various ecological components and the ratios of corresponding consuming items, and the nonlinear correlation suggests the differences in ecological efficiency of various tourism departments. The study clearly demonstrates that “food” (8164 yuan/hm²) and “transport” (11826 yuan/hm²) have relatively low ecological efficiency compared with “entertainment” (6200000 yuan/hm²) and “scenic area” (469892 yuan/hm²) where the ratio is rather large.

4 Discussion

(1) Simplification of the calculation model

According to the analyses above, the EF of tourism itinerary products is focused on transport, food & fibre, accommodation and waste, which takes up 99.066 % of the total EF, while the other three components are negligible, with an insignificant share in the total EF, and thus very limited impact on the environment. As long as the four important components can be calculated, an approximate result of the tourism itinerary products will be available. Therefore, Eq. (8) can be simplified as follows:

\[
TEF = TEF_f + TEF_a + TEF_t + TEF_w \\
= n \times e_f + \sum_{i=1}^{n} a_i \times e_{f_i} + \sum_{j=1}^{l} t_j \times e_{f_j} + \sum_{w} w_i \times e_{f_w} \\
+ \sum_{w} w_i \times e_{f_w}
\]

(9)

For tourism itinerary products, the EF can be considered as a function of transport modes and distance, hotel grades and duration of stay, the residence of tourists, the duration of journey, and the quantity of garbage produced. That is, farther distance, longer staying time and higher-grade hotels contribute to larger EF.

(2) About the results

In this study, the direct ecological consumption is mainly taken into account for the calculation and analyses concerning scenic spots and hotels. For example, in the hotel industry, ecological resources are needed not only in the operation of hotels, but also in the construction and regular decoration to a certain extent as well, which neither has been fully considered in previous research nor in this study. The calculation results of the accommodation component are bound to decline if this part of ecological consumption can not be taken into account in per bed consumption, which has been reflected in this study to some extent. Therefore, it is certainly worthy of further research.

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