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# Evaluation of tourism ecological environmental carrying capacity of southwest

**Qiong Sun**
**Tourism Institute of Beijing Union University, Beijing, 10010, (CHINA)**
**E-mail: sqqkkw@163.com**

## ABSTRACT

It is well-known that the sustainable development of tourism derives from ecological environment. Southwest is the one of the most enriched area of China's tourism resources. Tourism economy has become the growth point of economic development in southwest area. Achievement of harmonious development between tourism and ecological environment is an important topic of promoting economic growth of southwest area that need to be deep thought. Research holds that tourism and has a complementary with ecological environment. Proper tourist activity can promote the development of ecological environment. However, too many activities are bound to affect the sustainable development of environment[1]. This paper aims to evaluate the tourism ecological environmental carrying capacity in southwest area and found that tourism carrying capacity shows in different are of southwest shows complete different situation, which worries people a lot. Therefore, we must solve the existing problem to achieve sustainable development of regional tourism economy.

## KEYWORDS

Tourism; Ecological environment; Environmental carrying capacity; Southwest area.

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## INTRODUCTION

Tourism in southwest started late but the development is quite rapid. Distribution of tourism development in southwest area shows malconformation. When tourism in traditional tourist cities and attractions of southwest develop rapidly, tourism development of other areas are in trough area due to the limitation of many reasons[2].

Yunnan is just in the trough area. Although Yunnan is a big tourism province and tourism economy strong province, there is abundant and highly developed tourism resources. However, tourism economy development of Yunnan is typical resource-oriented pattern and its improvement of economic benefit is mainly relied on the overdevelopment of current and potential resources. In the perspective of comprehensive pressure system, ten thousands Yuan GDP tailpipe emission, ten thousands Yuan GDP comprehensive energy consumption and waste amount produced by unit tourism income shows downtrend but are still higher than standard value. The ratio of growth rate of tourism person-time and tourists is relative to standard value. It illustrates that the ecological environment of tourism have large pressure and low quality of ecological environment and tourism consumption pattern is in the low end. In the perspective of current carrying system, pert capita GDP, emission achieved rate of industrial wastewater, Engel coefficient of urban resident, rural per capita net income and proportion of tourism income account for GDP show upward trend but are still lower than standard value. It illustrates that regional tourism demand is not enough and the tourism economic benefit comes from outside the province to great extent. In addition, the self-development ability of tourism is insufficient[3]. In the perspective of development support system, the development of relative industry support tourism industry is relatively lagged behind. It becomes bottleneck that limits the ecological environmental carrying capacity of Yunnan tourism.

## CONCEPTION OF TOURISM ECOLOGICAL ENVIRONMENTAL CARRYING CAPACITY

So far, research on tourism ecological environmental carrying capacity is more and more abundant. Many scholars make deep study on tourism environmental carrying capacity in the aspects of ecology, space, society and economy. Although their perspectives and research methods are different, they all regard ecological environmental carrying capacity as one of the most important criteria[4]. Scholars are skeptical on the various calculation results because of the imperfect measure model. The reason is that although people have master the effective evaluation method on space carrying capacity, society carrying capacity and economy carrying capacity, evaluation on ecological environmental carrying capacity has not established a convenient, effective and operable calculation model because of the complexity of ecological environment. It leads the overall use of tourism carrying capacity to encounter obstacle[5].

## EVALUATION SYSTEM CONSTRUCTION OF TOURISM ECOLOGICAL ENVIRONMENT CARRYING CAPACITY OF SOUTHWEST

### Index selection and system construction

Evaluation system of tourism environmental carrying capacity is constructed. It is composed of tourism resource environment, tourism ecological environment, tourism economic environment and tourism society environment in southwest area, as shown in TABLE 1. The tourism ecological environmental carrying capacity of southwest area represents the quality and situation of tourism

ecological environment of southwest area. The index of tourism economic environmental carrying capacity mainly reflects the economic support capacity to the development of southwest tourism[6].

**Data source and index explanation**

Relative data of 2006 to 2010 in Yunnan is selected according to the availability, objectivity and typicality of data. And the relative tourism index data come from Brief Guide of Yunnan Tourism Statistics (2007 to 2010). Social economic index data such as student enrollment of ordinary university, employee proportion of service sector and Engel coefficient come from Shandong Statistics Yearbook (2007~2011) and Chinese City Statistics Yearbook (2007 to 2011). Specific meaning and composition of indexes are as follows. Tourism resource scale index reflects the overall occurrence condition of developable tourism resource. The amount of national scenic spot over A level is assigned. Tourism resource taste index reflects the aesthetic value, historical value, scientific value and rarity of tourism resource. And amount of national scenic spot over 4 A level is assigned. Tourism combination degree $\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}}\Big/\bar{x}$. Where $x_i$ is proportion of various tourism resource accounting for tourism resource of southwest area, $\bar{x}$ is expressed as the average value of proportion of various tourism resource accounting for total amount of tourism resources in peninsula blue economic zone, n is total amount of tourism resource. The smaller combination index is, the more coordinate resource matching is. Popularity index of tourism resources is represented by tourism city popularity. Tourism city is the important carrier of tourism industry development of Yunnan. The higher the popularity is, the stronger people's recognition of tourism resources is, the stronger the agglomeration tendency of tourism flowing into the city and the larger tourist scale and activity scale are. Here three Chinese network search engine (Baidu, Google and Yahoo) are applied to search by key words "year + ** city+ tourism". The popularity is calculated through the average value of webpage number searched in three websites. Tourist density = total number of tourists / total population of local residents. Tourist density reflects the psychological enduring capacity of tourists. The increase of tourist density will decrease the psychological enduring capacity of tourists[7].

**Confirmation of evaluation index weight**

Analytic hierarchy process is a kind of multi-objective decision analysis method combining qualitative and quantitative analysis. It makes numerical quantization on the experience-based judgment. This method can eliminate the effect of subjective factor. This paper made assignment marking on subsystem layer and concrete index layer by expert scoring method. It made pairwise comparison of expert scoring combining with analysis of influence factor of tourism environmental carrying capacity by analytic hierarchy process. And it constructed comparative judgment matrix and made consistency check to confirm the rationality of expert scoring[8].

First, pairwise comparison judgment matrix of subsystem layer $A=(a_{ij})_{4\times4}$ was constructed. Make vector normalization on each column of matrix $A=(a_{ij})_{4\times4}$ by harmonization method and obtain:

$$\breve{W}=a_{ij}\Big/\sum_{i=1}^{4}a_{ij},(j=1,2,...,n\_)$$

$$A(\breve{W}_{ij})_{4\times4}=\begin{bmatrix}0.2611 & 0.2400 & 0.2790 & 0.1818\\ 0.0862 & 0.0800 & 0.0698 & 0.1818\\ 0.5222 & 0.6400 & 0.5580 & 0.5455\\ 0.1305 & 0.0400 & 0.0932 & 0.0909\end{bmatrix},$$

**TABLE 1 : Evaluation index and weight of tourism environmental carrying capacity in southwest**

| Subsystem layer | Concrete index layer | Unit | Weight | Low grade | Medium grade | High grade |
|---|---|---|---|---|---|---|
| C1 Carrying capacity index of tourism resources environment in southwest (0.2405) | C11 Tourism resources scale (natural endowment) | One | 0.146 7 | 10 | 30 | 50 |
| | C12 Taste of tourism resources | One | 0.239 8 | 6 | 12 | 20 |
| | C13 Combination degree of tourist resources | — | 0.104 3 | 2 | 1.5 | 1 |
| | C14 Popularity of tourism resources | — | 0.426 2 | 1000 000 | 2000 000 | 3000 000 |
| | C15 Travel fitness of scenery | — | 0.052 2 | 40 | 60 | 100 |
| | C16 Sightseeing index of land | — | 0.030 8 | 2 | 4 | 5 |
| C2 Carrying capacity index of tourism ecological environment in southwest (0.1044) | C21 Disposal of domestic rubbish | Ten thousand t | 0.074 8 | 40 | 60 | 100 |
| | C22 Waste water discharge | Ten thousand t | 0.044 2 | 18000 | 12 000 | 6000 |
| | C23 Waste gas discharge | Hundred million $m^3$ | 0.044 2 | 4000 | 2 500 | 1500 |
| | C24 Green coverage ratio of built up area | % | 0.407 2 | 30 | 45 | 60 |
| | C25 Governance investment of industrial waste gas and water | Million Yuan | 0.207 3 | 50000 | 1000 000 | 1500 000 |
| | C26 Environmental quality of tourist resort in southwest | — | 0.222 3 | 2 | 4 | 5 |
| C3 Carrying capacity index of tourism economic environment in southwest(0.5664) | C31 Water withdrawal of million yuan GDP | $m^3$ / million yuan | 0.047 1 | 150 | 100 | 50 |
| | C32 Power consumption of million yuan GDP | Ten million hours / ten thousand yuan | 0.047 1 | 2000 | 1500 | 1000 |
| | C33 Per capita GDP | Yuan | 0.384 3 | 40 000 | 80000 | 1200000 |
| | C34 Proportion of service sector | % | 0.108 3 | 30 | 50 | 65 |
| | C35 Total income of tourism | Hundred million Yuan | 0.200 2 | 300 | 600 | 1000 |
| | C36 Hotel number over four stars | One | 0.213 0 | 20 | 40 | 80 |
| C4 Carrying capacity index of tourism social environment in southwest(0.0887) | C41 Disposable income of local resident | One | 0.084 9 | 10000 | 20000 | 30000 |
| | C42 Traffic turnover | Millions people/ km | 0.283 0 | 8000 | 15000 | 20000 |
| | C43 Students enrollment of ordinary university | Ten thousand people | 0.038 0 | 50000 | 100000 | 150000 |
| | C44 Tourist density | — | 0.415 7 | 8 | 6 | 3 |
| | C45 Engel coefficient | — | 0.059 4 | 45 | 30 | 15 |
| | C46 Employee proportion of service sector | % | 0.119 0 | 20 | 45 | 70 |

Second, element $\breve{W}_{ij}$ in $A(\breve{W}_{ij})_{4\times4}$ was made summation: $\breve{W}=\sum_{j=1}^{4}\breve{W}_{ij}$. Calculate and obtain $\breve{W}=\begin{bmatrix}0.9619\\0.4177\\2.2657\\0.3546\end{bmatrix}$. Then vector normalized this matrix and obtain approximate value of feature factor. Calculate and obtain $\overline{W}=\begin{bmatrix}0.2405\\0.1044\\0.5664\\0.0887\end{bmatrix}$. Third, the most characteristic root of judgment matrix was calculated by $\lambda_{\max}=\frac{1}{n}\sum_{i=1}^{4}\frac{(A\breve{W})_i}{W_i}$ and obtain: $\lambda_{\max}=4.1572$. At last, make consistency check on judgment matrix. Coincidence indicator $CI=\frac{\lambda_{\max}-n}{n-1}=0.0524$; consistency ratio $CR=\frac{CI}{RI}=0.0546$. CI and CR value are all less than 0.1. From that we can know judgment matrix have satisfactory consistency and the value of judgment matrix is reasonable. Thus index weight of subsystem was obtained.

The concrete index layer of every subsystem was constructed pairwise comparison judgment matrix by the above method. Calculate and obtain feature vector:

$$\overline{W_1}=\begin{bmatrix}0.1467\\0.2398\\0.1043\\0.4262\\0.0522\\0.0308\end{bmatrix},\overline{W_2}=\begin{bmatrix}0.0748\\0.0442\\0.0442\\0.4072\\0.2073\\0.2223\end{bmatrix},\overline{W_3}=\begin{bmatrix}0.0471\\0.0471\\0.3843\\0.1083\\0.2002\\0.2130\end{bmatrix},\overline{W_4}=\begin{bmatrix}0.0849\\0.2830\\0.0380\\0.4157\\0.0594\\0.1190\end{bmatrix}.$$

The maximum eigenvalue $\lambda_{\max1}=7.4090,\lambda_{\max2}=6.1592,\lambda_{\max3}=6.1629,\lambda_{\max4}=6.2604$ was made consistency check in the meantime. And the inspection result is

$$CI_1=0.0682<0.1,CR_1=0.0516<0.1$$
$$CI_2=0.0265<0.1,CR_2=0.0214<0.1$$
$$CI_3=0.0326<0.1,CR_3=0.0263<0.1$$
$$CI_4=0.0521<0.1,CR_4=0.0420<0.1.$$

It can be seen that judgment matrix have relative consistency. Through consistency check, we obtained the weighted value of 46 indexes in the concrete index layer as shown in TABLE 1.

# MEASURE AND RESULT OF TOURISM ENVIRONMENTAL CARRYING CAPACITY IN SOUTHWEST

## Measure method

In the research process of tourism ecological environmental carrying capacity, analytic hierarchy process was adopted and yaahp software was regarded as auxiliary means to confirm the weight of various indexes[8]. The confirmation of standard value first adopts national and industrial standard and second refer to national relative project (for example "the 12th Five-Year Plan") and relative data of province whose tourism situation close to southwest (for example Shandong). For the standard value that can not be obtained, questionnaire and expert consultation can be adopted[9]. Index weight and standard value is shown in TABLE 1.

Sustainable carrying capacity of tourism ecological environment β was calculated by vector norm method. Its construction method is $\beta = \frac{STECQ}{PTECQ \times \cos\theta}$. Where STECQ is the carrying capacity of standard tourism environment, which refers to an ideal state of subsystem in tourism environmental system within some specific area in some period in the condition of sustainable development. It is confirmed through industrial standard or national standard. $STECQ = \sqrt{\sum_{i=1}^{n} (w_i x_{ir})^2}$. Where $w_i$ is weight of index i and $x_{ir}$ is standard value of no. ir index[10].

PTECQ is the actual tourism environmental carrying capacity. It reflects actual enduring tourism economic activity intensity. PTECQ ×cos θis the projection of actual tourism environmental carrying capacity on standard tourism environmental carrying capacity vector quantity. Where the calculation formula of cos θ is $\cos\theta = \frac{\sum_{i=1}^{n} x_i x_{ir}}{\sqrt{\sum_{i=1}^{n} x_i^{\,2} \times \sum_{i=1}^{n} x_{ir}^{\,2}}}$. When β>1, it illustrates that standard tourism environmental carrying capacity is larger than actual tourism environmental carrying capacity and tourism environment shows a state of sustainable carrying. When β=1, it illustrates that tourism environment show critical state of sustainable carrying. When β<1, it illustrates that standard tourism carrying capacity is less than actual tourism environmental carrying capacity and tourism environment shows a state of unsustainable carrying. Tourism environmental carrying situation and development tendency in different period and area can be confirmed based on the change of βvalue. Thus proper control strategy can be adopted[11].

Present value and standard value of the relative index of tourism ecological environmental carrying capacity evaluation all adopt centralized dimensionless method for standardized treatment[12].

## Result of measure

Actual value of the above indexes were collected by refer to China statistical yearbook from 2008 to 2011 and the statistical yearbook of Sichuan, Yunnan, Guizhou and Tibet. And the actual value and standard value was standardized treated by centralized dimensionless. The result of tourism ecological environmental carrying capacity of five provinces and cities in southwest from 2007 to 2011 was calculated according to the above formula, as shown in TABLE 2. It can be seen from the calculation result that tourism ecological environmental carrying capacity of five provinces and cities of southwest which are the tourism resources enriched area shows complete different development situation and the overall situation is worrying. First is Sichuan. Its tourism ecological environmental carrying capacity first rise then decrease. Especially in 2008, tourism ecological environmental carrying capacity decrease because of earthquake. It rise in recent years but overall it is still in unsustainable

carrying state. Second is Chongqing. Its tourism ecological environmental carrying capacity at first appears and then decrease and always in unsustainable carrying state. Chongqing is always the important industrial city of China. Extensive rapid development of industry is bound to cause the intensive damage on ecological environment. Third is Yunnan. Its tourism ecological environmental carrying capacity increases constantly but still in unsustainable carrying state. Yunnan is the big tourist province and powerful province of tourism economy. Its tourism resources are abundant and highly developable. However, economic development of Yunnan is typical resource-oriented pattern. The improvement of tourism economic benefits mainly relies on overdevelopment of current and potential resources. Fourth is Guizhou, its tourism ecological environment carrying capacity increases constantly and is always in sustainable carrying state. Relatively speaking, Guizhou is the province with the best tourism ecological environmental carrying capacity in southwest. Last is Tibet. Overall, its tourism ecological environmental carrying capacity still shows unsustainable carrying state while the ecological environmental carrying capacity constantly decline.

**TABLE 2 : Measure result of tourism ecological environmental carrying capacity of five provinces and cities of southwest from 2007 to 2011**

| Province | Year | STECQ | COS θ | PTECQ | β | Carrying capacity state |
|---|---|---|---|---|---|---|
| Sichuan | 2007 | 0.405 | 0.611 | 0.662 | 1.001 | Sustainable carrying |
| | 2009 | 0.405 | 0.878 | 0.583 | 0.791 | Unsustainable carrying |
| | 2011 | 0.405 | 0.541 | 0.847 | 0.884 | Sustainable carrying |
| Chongqing | 2007 | 0.405 | 0.571 | 0.914 | 0.776 | Sustainable carrying |
| | 2009 | 0.405 | 0.687 | 0.66 | 0.893 | Sustainable carrying |
| | 2011 | 0.405 | 0.407 | 1.299 | 0.766 | Sustainable carrying |
| Yunnan | 2007 | 0.405 | 0.577 | 0.941 | 0.746 | Sustainable carrying |
| | 2009 | 0.405 | 0.764 | 0.63 | 0.841 | Sustainable carrying |
| | 2011 | 0.405 | 0.843 | 0.548 | 0.877 | Sustainable carrying |
| Guizhou | 2007 | 0.405 | 0.3 | 1.283 | 1.05 | Sustainable carrying |
| | 2009 | 0.405 | 0.416 | 0.825 | 1.18 | Sustainable carrying |
| | 2011 | 0.405 | 0.435 | 0.756 | 1.23 | Sustainable carrying |
| Tibet | 2007 | 0.405 | 0.235 | 1.339 | 1.287 | Sustainable carrying |
| | 2009 | 0.405 | 0.253 | 1.329 | 1.205 | Sustainable carrying |
| | 2011 | 0.405 | 0.326 | 1.052 | 1.181 | Sustainable carrying |

## RESULT ANALYSIS

As measure of regional tourism sustainable development, tourism environmental carrying capacity always draws attention of academic world. However, quantitative research technique and method of tourism environmental carrying capacity in southwest needs to be deep explored because of the complexity of tourism environmental carrying capacity and the fragility and particularity of tourism environmental system in southwest[13,14]. The research result of this paper shows that it is necessary to integrated develop tourism resources in southwest, improve the tourism product brand in southwest, build good tourism ecological environment, strengthen the comprehensive support capacity of southwest and society environment on tourism development and build and perfect relative mechanism and system to rationally adjust tourism environmental carrying distinction. And we also need to comprehensive promote the overall carrying level of tourism environment and effective excavate the carrying potential

of systems to promote the orderly development of tourism resources and reasonable distribution of tourism industry space in southwest[15].

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