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Study on the Economic Carrying Capacity and Peak Diversion of Plateau Mountainous Tourism Destinations: A Case Study of Siguniang Mountain Town

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Abstract: Mountain tourism has become an important component of global tourism, and with the surge in tourism demand, mountainous tourism destinations are facing enormous challenges. Siguniang Mountain is a world-renowned outdoor mountainous tourist attraction, but there are often difficult tourist turnover and traffic congestion events during peak hours. Based on existing research on tourism carrying capacity both domestically and internationally, this study selects a suitable econometric model for measuring the tourism economic carrying capacity of Siguniang Mountain Town. It is calculated that the tourism economic carrying capacity of the study area during peak tourism hours is 11785 overnight tourists per day and 3813 non overnight tourists per day. Based on the current situation of the study area and peripheral service facilities, measures are proposed to divert tourists during peak periods.

1. Introduction

Mountain areas account for 30% of the global land area and one third of China's land area. Mountain tourism is also an important part of natural heritage tourism, so it is of great practical significance to study the carrying capacity of mountain tourism. Tourism carrying capacity is an important influencing factor restricting the sustainable development of tourism, among which, tourism economic carrying capacity mainly refers to the carrying capacity of the destination in the tourism facilities, including the carrying capacity of accommodation facilities, transportation facilities, catering facilities, water supply, power supply, gas supply and drainage capacity. The Siguniang Mountain Scenic Spot in Xiaojin County is a national 5A level scenic spot, and has a certain popularity among the mountain scenic spots at home and abroad. However, due to the influence of the domestic vacation system, the number of tourists during the small holiday showed a blowout outbreak, far exceeding the tourism carrying capacity of Sigunangshan Town in Xiaojin County, leading to traffic congestion, slow tourists, the decline of tourism service quality and other problems. The ecological environment is also facing a major test. At present, the lack of plateau mountain type tourism destination at home and abroad economic bearing capacity of the research,

and the development of tourism is to increase employment, farmers to get rich and promote the development of fair and sustainable important driving force, around the problem of four girls mountain town of tourism economic bearing capacity, has important practical significance.

2. Study review

2.1. Research on the development of mountain tourism

Mountain tourism originated in European and American countries, is the mountain natural environment as the main body, according to the tourism market demand for sightseeing, hiking, skiing, rock climbing and other tourism activities. Mountain tourism resources are an important part of the world's natural tourism resources, and they are highly related to natural heritage tourism. Mountain tourism that started early abroad and developed more mature is mainly in the central European Alps, Mount Fuji in Japan, and Yellowstone Park in the United States. The more famous mountain tourist destinations in China include Jiuzhaigou Valley, Huanglong Mountain, Huangshan Mountain, Zhangjiajie Mountain, Guilin landscape, Emei Mountain, Siguniang Mountain and so on. The practice and development of global mountain tourism is mainly outdoor sports, and the products are gradually developed into sightseeing vacation, popular science and so on. At present, there are many related studies on mountain tourism development, sustainable development of tourism, tourism environmental evaluation, environmental capacity and carrying capacity at home and abroad[1], Foreign countries focus on mountain tourism methods, such as mountain adventure tourism, mountain ecological tourism, mountain sports tourism, etc[2-4]. China focuses on mountain tourism resources, outdoor sports, tourism safety and high-quality development.

2.2. Research on tourism carrying capacity

Tourism carrying capacity is also known as tourism capacity. There are rich research achievements at home and abroad. As early as the 19th century, people began to complain about the excessive number of tourists in tourist areas, which affected the travel and life of local residents[5]. American scholars Darling et al. have pointed out the environmental impact caused by the overuse of national parks[6]. Subsequently, some tourism studies began to explore the concept of carrying capacity, and then some tourism researchers re-explored the concept and connotation of carrying capacity. Barker et al. explain the connection between bearing capacity and impact in the development work on the impact of tourism development[7], The meaning of overdevelopment and exceeding the destination carrying capacity is the basis of the life cycle of the tourist area[8].In recent years, foreign scholars have paid wide attention to the environmental carrying capacity and sustainable development of various types of tourist places. Such as Indonesia Sangkuirang Mangkalihat karst area of the geological tourism hazards and carrying capacity[9]. Paskova Built an integrated model of embedded tourist management to solve the problem of local tourism carrying capacity[10]. There are also many comprehensive studies by domestic scholars on the carrying capacity of tourism. For example, Wei Ningning and others evaluated the comprehensive tourism carrying capacity of Wanping Beach based on the evaluation framework of tourism carrying capacity[11]. Song Yuxin et al. studied the tourism carrying capacity of Qingtian, Zhejiang province[12]. Subsequently, it is gradually subdivided into tourism environmental carrying capacity, tourism social psychological carrying capacity, tourism space carrying capacity and other aspects. Zhang Bo studied the psychosocial carrying capacity of local residents in Asakusa Temple in Japan[13]. Similarly, Yang Runtian et al. studied the social psychological carrying capacity of residents in ski tourist areas based on fuzzy level analysis[14]. Liu Shidong et al. studied the tourism environmental carrying capacity of island-type tourist areas[15]. Huang Hong put forward the research countermeasures of tourist diversion in the peak period of

Shilin scenic spot[16]. Yang Xiuping evaluated the carrying capacity of urban tourism environment and put forward the countermeasures to promote regional linkage and reasonable planning of tourism areas[17]. Among them, the research on tourism environment carrying capacity is relatively more thorough and mature, including the concept of tourism environment carrying capacity, index system, measurement model and application research.

At present, there is a lack of special research on tourism economic carrying capacity in relevant studies at home and abroad. Most of the studies on tourism carrying capacity are related to tourism destination management, tourist management and sustainable development of tourism, and the research methods are mostly quantitative studies. Among them, the research on tourism environment carrying capacity and tourist peak diversion tend to be mature, which can provide applicable economic carrying capacity evaluation model and decision-making reference for this study in terms of research methods and paths.

3. Evaluation model of tourism economic carrying capacity

Tourism bearing capacity can be subdivided into tourism social psychological bearing capacity, tourism natural environment bearing capacity, ecological environment bearing capacity of tourism, tourism economic bearing capacity, etc., the existing mainstream research method is econometric model research and build index system of two kinds, including natural, ecological environment bearing capacity and tourism economic bearing capacity to use the measurement model for quantitative research. At present, some scholars have proposed that the tourism carrying capacity is actually a problem of maximizing the economic benefits caused by tourists' use of the existing resources of the tourist destination, which can be calculated by linear planning[18-19]. Linear planning model is a branch of planning, which can calculate the optimal variable value according to the objective function and maximize the benefit allocation of existing resources. Generally, the formula of the planning model of linear planning is[20]:

$$\begin{cases} maxz = cx \\ Ax \le d \\ x \ge 0 \end{cases} \tag{1}$$

In Equation (1), z is the explained variable of the variable value x, c is the objective function, A is the constraint coefficient of x, and d is the output objective function.

The economic carrying capacity of tourism is based on the peak season of tourism is a dynamic process. The reception capacity of accommodation, catering, transportation and other facilities is uncertain, that is, the constraint conditions and target function are fuzzy. In this regard, fuzzy linear programming needs to be adopted. Considering the uncertainty of the model parameters, it is more reasonable to use the fuzzy interval, usually solved by triangular fuzzy number, let μ_a is the fuzzy set R on the real number set $\mu_a \in F(R)$if$\exists x \in R$ makes the $\mu_a(x)=1$, and $\forall\lambda \in [0,1]$, truncated $\mu_a(\lambda)$ is the closed interval, and then it is called the μ_a is fuzzy number[21]. That is$\tilde{a} = tr(a_s,a_m,a_u)$ is a triangular blur number, whose membership function is:

$$\mu_a(x)=\begin{cases} 0, x<a_s \\ \dfrac{x-a_s}{a_m-a_s}, a_s \le x \le a_m \\ \dfrac{a_u-x}{a_u-a_m}, a_m \le x \le a_u \\ 0, x<a_s \text{ or } x>a_u \end{cases} \tag{2}$$

In equation (2), a_m as the center value, a_s and a_u the minimum and maximum values, respectively, represent the interval value of the triangular blur number a. Then, the fuzzy linear planning can be expressed as[22]:

$$\begin{cases} max\tilde{z} = \sum_{j=1}^{n} \tilde{c}_j x_j \\ \sum_{j=1}^{n} \tilde{a}_{ij} x_j \le d_i, i = 1,2,\cdots,m \\ x_j \ge 0, j = 1,2,\cdots,n \end{cases} \tag{3}$$

4. Overview of the study area and data description

4.1. General situation of Sigunangshan Town

Sigunangshan Town is the only periphery of Sigunangshan Mountain scenic area, which can fully reflect the economic carrying capacity of Sigunangshan scenic area. Sigunangshan Town belongs to Xiaojin County, Aba Prefecture, Sichuan Province, connected with Wolong of Wenchuan County in the east, Dawei Town of Xiaojin County in the west, Putou Town of Li County in the north, and Baoxing County of Ya'an in the south. The administrative area is 577.69km2. The permanent resident population is more than 3,000 people. Sigunangshan Town is a typical high mountain canyon landform, which is representative in the plateau mountain tourism. High altitude, long and narrow terrain, the overall construction area of the town is small, and the lack of construction land indicators, the tourism economic carrying capacity is weak. The field research of the research group found that the tourists to the Siguniang Mountain scenic area mainly took self-driving travel, and the tour time was about 1.5~2 days. The daily capacity of the scenic spot is 20,000 people, and the Siguniang Mountain scenic spot implements the tour measures of limited, reservation and wrong peak. Combined with the actual situation of the three ditches in the scenic spot and the scenic spot, the scenic spot administration has formulated the maximum carrying capacity of Shuangqiao ditch is 13,000 people / day, Changping ditch is 5000 people / day, and Haizi ditch is 2000 people / day. In addition to tickets for scenic spots and sightseeing bus tickets, the average cost of overnight tourists is about 550 yuan, about 550 yuan for non-overnight tourists, 350 yuan, and 1,100 yuan for transit tourists.

4.2. Data description of tourism economic carrying capacity

4.2.1. Carrying capacity of transportation facilities

The parking lot of Sigunangshan Town is concentrated near the tourist distribution center of Sigunangshan Scenic Spot and Shuangqiaogou Scenic Area. There are 84 parking lots and 3072 parking Spaces for 60% (most of them are in the market town), including 130 large parking Spaces and 2942 small Spaces. The main parking lots are: the total construction area of the parking lot of the park is about 10000 square meters, the total number of parking Spaces is 606, including 348 automatic mechanical parking Spaces and 278 underground parking Spaces; the underground parking lot of the entrance is more than 200 vehicles; the parking lot of the park can accommodate about 1000 vehicles. The number of parking Spaces available to tourists in Sigungongshan Town is about 2567,2437 cars, 130 large parking Spaces, 4 seats / car, and 45 seats / car cars[16] That is, the carrying capacity of the

parking lot in Sigunangshan Town is 2437*4+130*45=15,598 people.

4.2.2. Carrying capacity of accommodation facilities

There are 256 accommodation places, 4520 rooms and 9065 beds. The coefficient of adding beds and playing farmhouses is about 1.3, and the occupancy rate in peak season is 100%, so the carrying capacity of accommodation facilities in Sigunangshan Town is: 9065*1.3=11785 people.

4.2.3. Carrying capacity of catering facilities

There are 106 restaurants in the town, 3974 restaurants, and the turnover rate is about 5 in the peak season, so the carrying capacity of catering facilities in Sigunangshan Town is: 3974*5 = 19,870 people.

4.2.4. Water supply, water supply, gas supply and bearing capacity of communication facilities

Peak water supply season of Sigunangshan Town is 300 cubic / hour, low season is 200 cubic / hour, maximum supply is 350 cubic / hour; slow power supply is 3000 kW / hour, peak season is 9000 kW / hour, and maximum supply is 10000 kW / hour. The whole town is in a centralized supply of natural gas tanks. At present, when the number of tourists reached 20,000, the water supply and communication capacity of the town are basically guaranteed, so the capacity of water supply and power supply and communication facilities in Sigunangshan Town is 20,000 people.

Table 1: Data description of tourism economic carrying capacity of Sigunangshan Town during peak period

Tourist reception facilities	Indicator instructions	The maximum capacity (person-time)		Overnight visitor utilization rate is /%	Non-overnight visitor utilization rate is /%	Utilization rate of transit tourists is /%
Transportation facilities	The number of parking Spaces available to tourists in Sigunangshan Town, including 2437 small cars and 130 large parking Spaces.	2567 Vehicles. The car is 4 seats / car, 45 seats / car.	15598	100	100	20
Accommodation facilities	All accommodation and reception facilities, such as hotels, guesthouse, homestay, farmhouses, etc.	9065 Zhang. Including peak season plus bed, farmhouse and other coefficient is about 1.3.	11785	100	0	100
Catering facilities	The number of meals for all the open restaurants in Sigunangshan Town.	3974 Of the. The peak season turnover rate is about 5.	19870	100	80	100
Water supply, power supply, gas supply and communication facilities	When the number of tourists reached 20,000, the water supply, power supply and communication capacity in Sigunangshan Town were basically guaranteed.	20000		100	30	100

5. Calculation and analysis of the tourism carrying capacity in the study area

The tourism economic carrying capacity of Sigunangshan Town is mainly the carrying capacity of overnight tourists, non-overnight tourists (same-day visitors) and inbound tourists using accommodation, catering, transportation, water supply, power supply, gas supply and communication facilities at the destination. Including three types of tourists (x_1,x_2,x_3), four constraints (a_1,a_2,a_3,a_4) and the four objective functions (d_1,d_2,d_3,d_4). Then the fuzzy linear planning formula of the tourism economic carrying capacity of Sigunangshan Town is as follows:

$$\begin{cases} max\tilde{z} = \tilde{c}_1 x_1 + \tilde{c}_2 x_2 + \tilde{c}_3 x_3 \\ \tilde{a}_{1,1} x_1 + \tilde{a}_{1,2} x_2 + \tilde{a}_{1,3} x_3 \le \tilde{d}_1 \\ \tilde{a}_{2,1} x_1 + \tilde{a}_{2,2} x_2 + \tilde{a}_{2,3} x_3 \le \tilde{d}_2 \\ \tilde{a}_{3,1} x_1 + \tilde{a}_{3,2} x_2 + \tilde{a}_{3,3} x_3 \le \tilde{d}_3 \\ \tilde{a}_{4,1} x_1 + \tilde{a}_{4,2} x_2 + \tilde{a}_{4,3} x_3 \le \tilde{d}_4 \\ x_1, x_2, x_3 \ge 0 \end{cases} \tag{4}$$

In formula (4): z expressed the maximum revenue brought by the tourist reception facilities during the peak period of Sigunangshan Town;

c_1 for overnight tourists during peak hours (x_1) of the constraint coefficient, c_2 non-overnight tourists during peak hours (x_2) of the constraint coefficient, c_3 for tourists tourist town town town during town mountain town (x_3) the constraint coefficient;

a_1,a_2,a_3,a_4 it respectively indicates the utilization rate of transportation facilities, accommodation facilities, catering facilities, water supply, power supply and gas supply and communication facilities during peak hours, namely x_1,x_2,x_3 constraints;

d_1,d_2,d_3,d_4 they are the target functions of transportation facilities, accommodation facilities, catering facilities, water supply, power supply, gas supply and communication facilities in Sigunangshan Town during peak hours;

Among, $a_{i,j}$ indicates the expenses incurred by the class j visitors using the class i facility, such as $a_{1,2}$ represents the cost of using transportation facilities by non-overnight visitors. According to the data obtained in Table 1, the fuzzy linear planning of the tourism economic carrying capacity of Sigunangshan Town during the peak period is as follows:

$$\begin{cases} max\tilde{z} = 5\tilde{5}0x_1 + 3\tilde{5}0x_2 + 1\tilde{1}00x_3 \\ \tilde{1}x_1 + \tilde{1}x_2 + \tilde{0}.2x_3 \le 15\tilde{5}98 \\ \tilde{1}x_1 + \tilde{1}x_3 \le 11\tilde{7}85 \\ \tilde{1}x_1 + \tilde{0}.8x_2 + \tilde{1}x_3 \le 19\tilde{8}70 \\ \tilde{1}x_1 + \tilde{0}.3x_2 + \tilde{1}x_3 \le 20\tilde{0}00 \\ x_1, x_2, x_3 \ge 0 \end{cases} \tag{5}$$

Using MATLAB software, the solution was obtained once iteration. Three results were calculated according to the fuzzy interval value of the objective function, the constraint coefficient and the output objective function (see Table 2 for details), the output value is 7,277,800 yuan; the output value is 7,816,300 yuan; and the output value is 8,538,500 yuan.

Table 2: Calculation results of fuzzy tourism economic carrying capacity during the tourism peak period of Sigunangshan Town

Metric name vague interval value	objective function			constraint factor				Outputs the objective function				variate-value			Values of interpreted variables
	c_1	c_2	c_3	a_1	a_2	a_3	a_4	d_1	d_2	d_3	d_4	x_1	x_2	x_3	z
lower limit value	500	300	1050	0.9	0.9	0.9	0.9	14500	11000	18000	19500	12222	3889	0	7277800
				0.9	0	0.7	0.2								
				0.1	0.9	0.9	0.9								
central value	550	350	1100	1	1	1	1	15598	11785	19870	20000	11785	3813	0	7816300
				1	0	0.8	0.3								
				0.2	1	1	1								
upper limit value	600	400	1150	1.1	1.1	1.1	1.1	16696	13570	21740	20500	12336	2842	0	8538500
				1.1	0	0.9	0.4								
				0.3	1.1	1.1	1.1								

View Table 2, the optimal combination of tourism economic carrying capacity of Sigunangshan Town during peak period is 11,785 overnight tourists / day, 3,813 non-overnight tourists / day and 0 transit tourists, and the output value is 7,816,300 yuan / day. Among them, the number of overnight tourists and transit tourists is relatively small, which is different from the scenic spot to receive 20,000 people per day. Combined with the current situation of the study area and the analysis results, the main reason is that the capacity of transportation facilities and accommodation reception facilities in Sigunangshan Town is insufficient, consistent with the site situation, and the carrying capacity is 15,598 and 11,785 people respectively. Among them, the transportation facilities are mainly concentrated in the four girls mountain scenic area, parking number accounts for 58.73% of the total, remove the local residents take up 60%, the town for tourists parking space number is about 760, the bearing capacity is weak. According to the daily limit of 200 million tourists in Siguniang Mountain Scenic area, the group distribution ratio is 1:3, and the travel time of self-driving tourists is 1.5~2 days, indicating that the vast majority of tourists will choose to stay overnight, and the accommodation reception gap is large.

6. Countermeasures for diverting diversion during peak tourism

6.1. Scientific construction of transportation system to break the transportation bottleneck of plateau mountain tourism areas

Plateau mountain tourism destinations are usually far away from the consumption center city, and the transportation accessibility is poor. It is of great significance to build a perfect transportation system. During the peak period, the traffic road and the market town leading to Sigunongshan Town are under great pressure. It is necessary to extend and widen the traffic road through scientific planning, increase the parking capacity of the market town, and build a transportation system with strong accessibility, convenient transportation and efficient transportation.

6.1.1. Expand cross-regional transportation channels and improve the transportation network

Analyze the weak links in the internal and external transportation system of plateau mountain tourism destinations, and put forward reasonable solutions. First, to improve the highway grade of the main traffic trunk roads. Dusi mountain rail transit is expected to be open to traffic in 2026, which can relieve the traffic pressure of the small ring road of tourism in western Sichuan to a certain extent. However, according to the demand for self-driving travel, it still needs to improve the highway grade

of the small ring road of tourism in western Sichuan to be upgraded to a first-class highway and improve the traffic efficiency. Second, actively expand the traffic routes of circulation linkage between tourist destinations in Aba Prefecture. Road path (county to gold) is expected to open to traffic in 2024, but the road for the tertiary highway, between across the ditch, the distance is far, suggested to build the county to four girls mountain town highway, forming Chengdu-dujiangyan-wenchuan show-bi tent ditch-four girls mountain town tourism new loop, traffic time and western Sichuan tourism loop is expected to differ half an hour, can radiation wenchuan yingxiu, li county TaoPing-gan fort, bi, tent ditch, ditch tourist destination, realize the scenic spot circulation flow, extend the play time.

6.1.2. Expand the transportation capacity of market towns and improve the traffic efficiency

Due to the limited terrain of the plateau mountain tourist destination, the construction area of the town is small, and it is difficult for tourists to park. It is necessary to scientifically evaluate the available space and expand the transportation capacity of tourists' passage and parking. When the research group went to Sigunangshan Town for investigation, they found that the parking difficulties of tourists during the peak period. Local management personnel put forward in the town is street space built vertical parking lot, on this train of thought, the study thinks can try to use town idle land reconstruction parking lot, namely the use of golden village idle activity room, main space, long ping ditch village idle green space and delicate second street space built ground or vertical parking lot, can effectively alleviate the town on tourists parking difficulties and tourists parking caused by traffic congestion, also to a certain extent, alleviate local residents because of tourists parking neighborhood contradictions.

6.1.3. Actively guide tourists to travel choices and improve the management of time-space distribution of tourists

Based on the theory of space-time diversion of tourists, the destination tourists can be guided according to their itinerary. In the early stage of tourist travel or on the way to the scenic spot, Sigunangshan Scenic Area WeChat official account and Aba tourism network should add real-time tourist flow and traffic flow information display module, and recommend tour stops and parking spots, and on the display screen along the way, the flag to prompt tourists to use the scenic spot WeChat official account or Aba tourism network. When the tourists arrive at the traffic arteries of the scenic spot, set up electronic screens at important nodes and bayonets to remind self-driving tourists of scenic spots, traffic flow, vacant parking spaces in parking lots and other related information. In site, tourists are guided to actively divert and orderly parking, and after the tour of the scenic spot, again transportation guidance is carried out according to the electronic display information and site command.

6.2. Efficient linkage between county, market town and scenic spot space to relieve the economic bearing pressure

6.2.1. County and town linkage, short-distance rapid diversion

Considering the administrative division, geographical spatial pattern and other factors, priority is given to the county and town linkage, with convenient coordination, close distance and short time. The overloaded tourists will be introduced to Xiaojin County, and the Siguniang Mountain Scenic Spot-Siguniang Mountain Town Scenic Spot and Siguniang Mountain Scenic Spot-Xiaojin County Scenic Spot will be opened. The former can reduce the traffic pressure brought by the turnover of self-driving tourists, while the latter can facilitate the diversion of tourists to Xiaojin County.

6.2.2. Linkage of county bureau, department and town, and multi-department coordination and diversion

Tourism is a linkage industry, and tourists need to rely on scenic spots, transportation, accommodation and catering industries to carry out tourism activities. Tourism peak, the county bureau of town linkage, namely the plateau mountain tourism destination brigade industry administrative departments at all levels, transportation departments, the administrative department of industry and commerce and market regulators, etc., the tourists to tourists travel guide propaganda, the traffic scheduling, accommodation catering industry regulation and tourists in the county shunt work together, to work efficiently.

6.2.3. Bureau and town linkage to improve the tourist reception capacity of destinations

Analyze and judge the carrying capacity elasticity of reception facilities such as accommodation and catering in plateau mountain tourist destinations. Bureau of town linkage, namely the brigade, accommodation and catering industry departments, actively guide and foster four girl mountain town five administrative villages open accommodation, catering reception facilities, and put forward the response season tourism resources redundancy, shortage, expand reception capacity, improve the capacity of destination accommodation, catering reception.

6.2.4. County linkage, large space and long-distance diversion

Integrate the tourism reception resources of the counties (cities) around the plateau mountain destinations, that is, the linkage of the county level, mainly considering the service and reception level and tourist attraction of the county (city). In terms of four girls mountain town, tourism peak, need to rely on the surrounding counties and cities of accommodation reception facilities to relieve the bearing capacity, such as wenchuan county, wolong special administrative region, better choice is open the county to four girl mountain town of high-speed channel, will overload tourist drainage to county, ditch town, the reception facilities level is higher, tourists experience better.

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