Analysis and Evaluation of carrying Capacity of Dianchi Laoyu River Wetland Park

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Abstract: Dianchi Laoyu river wetland park carrying capacity was analyzed and evaluated by the classification of wetlands tourism environmental carrying capacity and calculation model for the purpose of realize the sustainable development of the ecological environment and tourism industry of the Dianchi Laoyu river wetland park. The result shows that the minimum capacity of wetland park is 6975 people per day (2.546 million people per year). The minimum capacity is water environment capacity. The main factor of limiting carrying capacity of the wetland is the ecological environment carrying capacity. According to this limitation factor, the optimal strategy for the sustainable development of wetland park's ecology and tourism is provided.

1. Introduction

The origin of the concept of carrying capacity can be traced back to Malthus's theory of population growth. In 1838, Pierre F. Verhulst expressed Malthus's population growth theory in mathematical form, that is, the logistic equation of population growth. He used the "capacity" index to reflect the limiting effect of resources, environmental constraints on population growth and the origin of modern carrying capacity researches[1]. Wetland is a unique ecosystem formed by the interaction of water and land. It plays an important role in maintaining biodiversity and rare species resources, flood storage and drought prevention, degrading pollution, regulating climate and controlling soil erosion. The wetland is called the kidney of the earth and is a precious natural resource for human beings[2].

The Dianchi Laoyu river wetland park was taken as the research object in this paper. We analyzes and evaluates the wetland tourism environmental carrying capacity. Laoyu river wetland park is a typical wetland park around the Dianchi lake. At the same time, Laoyu river wetland park have important meaning to Dianchi lake which can further purification water into Dianchi lake. The analysis of its carrying capacity can improve the Dianchi lake ecological environment. The carrying capacity assessment is carried out to provide management decisions for managers and achieve the goals of scientific management, So as to realize the sustainable development of ecological environment and sustainable development of tourism.
2. Materials and methods

2.1 The wetland situation

Dianchi Laoyu river wetland park, located in Dayu village, is adjacent to Huanhu East Road. It is the closest wetland park to Kunming in Yunnan Province with the most transportation advantages and location advantages. It is based on the relative integrity of wetland ecosystem and the feasibility of park management. The planning scope from the Dujia Village to the bottom of the south side of Xiaowan. The river section ward into KunYu highway on the west side and the intersection near Laoyu river and Liangwang river. The planning coastline is 9.17 km and the river channel is 3.80 km, as shown in figure 1. The main water source is the seasonal river water and domestic sewage in the south of Chenggong new district. The Laoyu river wetland park has received 2 million visitors since its opening to the public in May 2015.

2.2 Experimental materials and data

2.2.1 Equipment

The equipment is portable flow meter, water sampling bottle, tape measure and standard measuring rod.

2.2.2 Data

After investigation and data inquiring, the basic situation of the Laoyu river wetland is shown in Figure 2.
In input, outlet 1 and outlet 2 points are set the sampling points respectively in Laoyu river research area. We sample and analyze total nitrogen and total phosphorus content at water inlet and outlet points during dry and rainy periods. The results are shown in Figure 3.

At the time of taking the water sample, the edge 1/2 and the middle water flow velocity at the outlet (1, 2, 3, 4, 5) of the sluice gate and the left and right homogenization pond are simultaneously tested. The results are shown in Figure 4.

The wetland tour area is about 42 ha in total and the average water depth is 24 cm. Tourists can park 1.5 hours on average. There are 895 parking spaces in there. In 2016, the average daily tourists are 4,100 and the annual tourists are 1.5 million. The scenic area is open from 7:30 to 20:30 every day for 13 hours and is opened all year round. In this paper the tourism environment carrying capacity (TEBC) is evaluated. TEBC mainly includes ecological environment carrying capacity (EECC), resource space carrying capacity (RECC), social psychology carrying capacity (PECC), tourism economy carrying capacity (TECC) \[^{[4-10]}\].

\[
TEBC = \min( EECC, RECC, PECC, TECC )
\]  
(1)

3. Result analysis

3.1 Ecological environmental capacity (EECC)

EECC includes water environmental carrying capacity, air environmental carrying capacity and solid waste carrying capacity. In this paper we just need to consider the water environmental carrying capacity because Kunming’s average annual air quality is excellent and the solid waste is not treated
by wetlands.  

\[ \text{Water retention time (HRT)} = \frac{\text{water storage}}{\text{outflow of wetland}} \quad (2) \]

The area of Laoyu river wetland is 298.10ha and the average depth is 24cm. The HRT can be calculated as 7.67d according to formula 2. The water consumption of tourists is 50 L for one person and per day according to The Design Code of Scenic and Historic Interest Areas. At present, the main pollutants are nitrogen and phosphorus in urine. The content of ammonia nitrogen in fresh urine is 1000mg/L and phosphorus is 500mg/L[8]. The average daily urine output per person was 1.5L.

The average pollutant discharge is 93.75mg if the tourists in the park is 1.5 hours. Since the average visiting time of tourists in the park is 1.5 hours. So the average pollutant discharge is 93.75mg. The relative pollutant concentration in the rainy period that TN is 0.0065 mg/L and TP is 0.195 mg/L. In dry period that TN is 0.187 mg/L and TP is 3.945 mg/L. Therefore the water environment capacity of each data can be calculated. The water environment carrying capacity can be obtained finally according to the data.

Table 1. Water environmental capacity of Laoyu river wetland during dry and rainy water periods

| Period  | Water environmental capacity of TN /Kg | Water environmental capacity of TP /Kg | Bearing capacity of TN /person • day\(^{-1}\) | Bearing capacity of TP /person • day\(^{-1}\) |
|---------|---------------------------------------|---------------------------------------|-----------------------------------|---------------------------------|
| Dry     | 10.46                                 | 313.86                                | 6975                              | 6695672                        |
| Rainy   | 300.98                                | 6349.62                               | 64209                             | 135458601                      |

3.2 Resource Space Bearing Capacity

\[ \text{RECC} = \frac{ST}{st} \quad (3) \]

As the effective tourist area of the Laoyu river wetland is 42 ha and the scenic area is open for 13 hours every day. The average tourist visiting time is 1.5 hours according to the average parking time of tourists. The reasonable area occupied by each tourist during good induction is 50m2. So it's calculated that the capacity of the resource space is 72,800 people per day.

3.3 Society Mentality Bearing Capacity

Society Mentality Bearing Capacity including the psychological carrying capacity of residents and tourists. There are almost no people living around the wetland park of laoyuhe river, so it is only necessary to calculate the psychological carrying capacity of tourists.

\[ Q(s) = \frac{SKT}{st} \quad (4) \]

K is the utilization rate of the park and the experience value is 1/10. The social psychological carrying capacity was calculated at 7,280 per day.

3.4 Tourism economy capacity

According to formula 1, in the wetland parking area is the main consideration in the facilities because most of them are one-day tourists and have a short time to visit. In the wetland park the main supply for the supply of Parking spaces. There are 895 parking Spaces in the wetland park. If parking 1.5 hours on average and the scenic spot open time for 13 hours, It will stop about 7756 times a day. So the capacity of the tourist economy is 7,756 per day.

3.5 statistical result
Table 2. Tourism Environment Carrying Capacity

| Period   | Daily tourism environment capacity /person·day⁻¹ | The annual tourist bring capacity /million person·year⁻¹ |
|----------|-----------------------------------------------|-------------------------------------------------------|
| WECC     | 6975                                          | 254.6 million                                        |
| RECC     | 72800                                         | 265.7 million                                        |
| PECC     | 7280                                          | 265.7 million                                        |
| TECC     | 7756                                          | 283.1 million                                        |

Tourist environmental capacity $TEBC = \min(WECC, RECC, PECC, TECC)$. Therefore, the minimum value is 6,975 person-day capacity of the wetland park's tourist environment.

4. Discussion and Conclusion

Laoyu river wetland park has been upgraded with ecological and landscape functions. It has great importance to protect and improve the ecological environment of Dianchi lake. According to the above calculation, the minimum capacity of the wetland park is 6,975 people/day (2,546,000 people/year) and the minimum capacity is water environment capacity. The main factor which limits the carrying capacity of the wetland is the ecological environment carrying capacity.

According to statistics, the average daily passenger volume in 2016 is 4,100 with an average annual passenger volume of 1.5 million which is still within the capacity range. However, the carrying capacity should be taken as the index of development and management in order to protect the wetland well. The environmental carrying capacity should be calculated periodically to achieve tourism development and sustainable development of the ecological environment.

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