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Landscape pattern and ecotourism carrying capacity of Pan'an Lake wetland park in Xuzhou City, China

Xuehong Tan[a,*], Yunle Peng[b], Shengli Liu[b], Pin Liu[a]

[a]*School of Environmental Engineering, Xuzhou Institute of Technology, Xuzhou 221008, China, email: snowman100@126.com (X. Tan)*
[b]*School of Arts, Xuzhou Institute of Technology, Xuzhou 221008, China*

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ABSTRACT

In this paper, the landscape pattern and ecotourism carrying capacity of Pan'an Lake Wetland Park in Xuzhou city were analyzed by means of geographic information system technology, field investigation, questionnaire survey, and other methods. The results showed that: (1) In the classification of first-level landscape elements, water patches accounted for 63.879% of the total area and had a high degree of aggregation; the number of green space patches was the largest and the average patch density was the largest; the construction land area was the smallest, the aggregation degree was the lowest; Shannon diversity index (SHDI) was 0.872, Shannon evenness index (SHEI) was 0.794. (2) In the classification of second-level landscape elements, the area of water surface was 2.256 times of wetland, the area of multi-layer green space was 2.19 times of grassland. The area of building was the largest in construction land. The shape index (LSI) of road was the largest. The SHDI was 1.538, and the SHEI was 0.791. (3) The ecotourism carrying capacity of Pan'an Lake Wetland Park was 23,226–35,240 persons/day, 8,477.49–12,862.6 thousand persons/year, watching-birds capacity was the limiting factor of ecological capacity, while catering facilities were the limiting factor of facility capacity. (4) Landscape pattern has a certain impact on the carrying capacity of ecotourism. The higher evenness index increased the possibility of tourists' diversion in different scenic spots in peak season and the bird watching capacity should be improved by increasing the LSI of the roads in Pan'an Lake Wetland Park. Ecotourism carrying capacity may be increased by increasing construction land area, but the ecological effect of wetland park may be reduced.

Keywords: Landscape pattern, Ecotourism, Pan'an Lake, Wetland park

1. Introduction

Urban park wetlands were an important ecological infrastructure for sustainable urban development [1]. They were available for people to appreciate, tour, carry out science education, and scientific study [2]. However, with the number increase of urban wetland parks, the contradiction between protection and rational utilization had become increasingly prominent, some wetland parks were over-used for tourism in pursuit of economic benefits, so the healthy and sustainable development of urban wetland parks had been restricted [3–5].

Landscape pattern was a heterogeneous region composed of interacting ecosystem space mosaics and it was the final result of various natural and human factors acting on different spatial and temporal scales [6,7]. Landscape patterns deeply affected and determined various ecological processes and functions [8–10]. The ecotourism carrying capacity was not only limited to not destroying the ecological environment of a tourist destination but also emphasized the protection and improvement of the local ecological environment [11–15]. As a relatively fragile ecosystem, wetland park could not only obtain a certain economic benefit but also met people's growing needs for recreation and popular

* Corresponding author.

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science propaganda by developing eco-tourism without damaging its natural benign succession [16].

The urban wetland park, as a special landscape in the city, the research on the landscape pattern had always been in the aspect of the description of landscape characteristics, and the connection between landscape pattern and landscape function was still in the exploratory stage [17]. The landscape pattern was closely related to the landscape function, especially for urban wetland parks with heavy artificial traces, the landscape pattern was the dominant factor restricting its function [17–20]. As for the ecotourism carrying capacity of urban wetland parks, different scholars had discussed and analyzed the ecological capacity, spatial capacity, facility capacity, management capacity, and psychological capacity, respectively [21–28]. As an important function of urban wetland parks, ecotourism had a certain relationship with the landscape pattern of wetland parks. In this paper, taking Pan'an Lake Wetland Park in Jiawang district of Xuzhou city as an example, the relationship between landscape pattern and ecotourism carrying capacity was attempted to explore on the basis of the analysis of landscape pattern and ecotourism carrying capacity [29–33]. This study could provide an important reference for the transformation and management of wetland parks, wetland ecological protection, and rational utilization. At the same time, this study could also provide a theoretical basis for the planning and design of other urban wetland parks.

2. Study area overview

Xuzhou, known as "the capital of Huaihai," is the central city of Huaihai economic zone, and located in the northwest of Jiangsu Province, between 116°22′–118°40′E, 33°43′–34°58′ N. The climate is affected by southeast monsoon, so belongs to the warm temperate monsoon climate. Average annual precipitation is 800–930 mm in Xuzhou area. The main terrain is plains. There were 58 rivers, 16 reservoirs, 3 lakes, and 20 coal mining subsidence areas in Xuzhou city [34].

Pan'an Lake Wetland Park was located in Jiawang district Xuzhou city, and it was originally a coal mining subsidence area. In 2010, Pan'an Lake Wetland Park was constructed through the combination of lakes, wetlands, and islands on the basis of ecological restoration, a "China's most beautiful rural wetland" was formed with rich spatial landscape and diverse species. Pan'an Lake Wetland Park was named National Wetland Park in 2014 [35].

3. Research methods

3.1. Data acquisition

On the basis of the Google Earth aerial image of Pan'an Lake Wetland Park of 2016, geometric correction was carried out with topographic map and field investigation. The vector data interpretation was completed in ArcGIS, and the classification data of landscape elements were obtained. The water environment data were tested by Jiangsu Tongbiao Environmental Protection Technology Development Co., Ltd. The weight of each component of ecotourism carrying capacity was determined by the expert scoring method. In order to gain the date of the satisfaction of tourists to the landscape, environment and facilities of the wetland park and the information of tourists travel and tour modes, 500 questionnaires were distributed in Pan'an Lake Wetland Park from May to October 2017, and 500 questionnaires were returned, of which 491 were valid questionnaires, with an effective rate of 98.2%. Some other data were provided by Pan'an Lake Wetland Park management office.

3.2. Landscape pattern analysis method

Landscape classification was the premise of landscape pattern analysis. According to the principles of wetland classification and landscape ecology in the Wetland Convention, a secondary classification system (Table 1) was established on the basis of the functional characteristics, landscape elements, and research purposes in this paper.

The landscape indexes refer to the quantitative indicator that can highly enrich the landscape pattern information and reflect some aspects of structural composition and spatial configuration [36]. Some indexes describing patch

Table 1
Landscape classification system of the wetland park

Top Category	Sub-category	Landscape characteristics
Water	Water surface	The area of water beyond which aquatic plants were grown, mainly for viewing and entertainment
	Wetland	Areas where aquatic plants were planted near or on the surface of water and islands submerged during flood periods in lakes. Aquatic plants were dominant and some wet plants were present
Green space	Multi-layer green space	Green grass with two or more layers
	Grassland	Greenland with only turf or ground cover
Construction land	Building	Including residential buildings, pavilions, corridors, watching-birds towers, and other tourist service facilities
	Rigid pavement	Pavement for visitors to stay or play
	Road	Landscape roads at all levels in the wetland park, including walking trails, Tingbu, wooden plank roads, etc.

characteristics: class patch type area (CA), proportion of class patches in total landscape area (PLAND), number of class patches (NP), class patch density (PD), mean class patch area (MPS), maximum patch index (LPI), shape index (LSI), average class patch fractal dimension (MPFD), aggregation index (AI). Some indexes describing the overall landscape level: Shannon diversity index (SHDI), Shannon evenness index (SHEI), AI, and Contagion index (CONTAG). All landscape indices were calculated by FRAGSTATS 4.2 software.

3.3. Ecotourism carrying capacity assessment method

At present, the two methods of ecotourism carrying capacity assessment were the law of minimum factor and the weighted synthesis of each component [37]. The author had calculated the ecotourism carrying capacity of three wetland parks in Xuzhou city by using the weight method that was still used to calculate the carrying capacity of ecotourism of Pan'an Lake Wetland Park in this paper. However, Pan'an Lake was located in the middle of Xuzhou city and Jiawang central district, 15 km away from Jiawang central district and 20 km away from Xuzhou main city, it was necessary to consider the capacity of catering facilities. Therefore, some changes were made in the calculation method of facility capacity on the basis of that article [34]. The specific methods were briefly summarized as follows:

Comprehensive ecotourism carrying capacity

$$C = k_1C(e) + k_2C(s) + k_3C(f) + k_4C(m) \tag{1}$$

In Eq. (1), C was the comprehensive ecotourism carrying capacity, $C(e)$, $C(s)$, $C(f)$, $C(m)$ was, respectively, ecological capacity, spatial capacity, facility capacity, and psychological capacity, k_1, k_2, k_3, and k_4 was the weight of each component, and $k_1 + k_2 + k_3 + k_4 = 1$.

Ecological capacity

$$C(e) = \min\{C_w, C_p, C_b\} \tag{2}$$

In Eq. (2), C_w, C_p, and C_b was, respectively, water ecological capacity, plant ecological capacity, and watching-birds ecological capacity.

$$C_w = \min\left\{\frac{\text{COD}}{c}, \frac{\text{TN}}{n}, \frac{\text{TP}}{p}\right\} \tag{3}$$

In Eq. (3), COD, TN, TP was, respectively, purification quantity of chemical oxygen demand, total nitrogen, and total phosphorus for water pollutants in Pan'an Lake wetland park, c, n, p was, respectively, the production of COD, TN, TP per capita every day.

$$C_p = \frac{O_t + O_g}{o} \tag{4}$$

In Eq. (4), O_t, O_g was, respectively, net oxygen release every day of the multi-layer green space, grassland. o was the per capita oxygen consumption of tourists every day.

$$C_b = \left(\frac{L}{l} + \frac{S}{s}\right) \times R \tag{5}$$

In Eq. (5), L was the length of the tour line at a reasonable distance for the human away birds. l was a reasonable tour route length per capita. S was the area for watching-birds. s was a reasonable area per capita for watching-birds. R was average daily turnover rate of tourists.

Spatial capacity and psychological capacity

$$C(s) = \frac{A_l}{a_l} \times R_l + \frac{A_w}{a_w} \times R_w \tag{6}$$

$$C(m) = \frac{A_l}{m_l} \times R_l + \frac{A_w}{m_w} \times R_w \tag{7}$$

In Eqs. (6) and (7), A_l, a_l, m_l was, respectively, the tour area of accessible land, the reasonable tour area per capita every day and the satisfied tour area per capita every day on land. A_w, a_w, m_w was, respectively, the area of accessible water, the reasonable tour area per capita every day and the satisfied tour area per capita every day on water. R_l, R_w was, respectively, turnover rate of tourists on land every day, turnover rate of tourists on water every day.

Facility capacity

$$C(f) = \min\{C_p, C_t, C_r\} \tag{8}$$

$$C_p = \frac{(D_p \times d_p \times R_p)}{V_p} \tag{9}$$

$$C_t = \frac{(D_b \times d_b \times R_b)}{V_b} + \frac{(D_c \times d_c \times R_c)}{V_c} \tag{10}$$

$$C_r = \frac{(D_r \times R_r)}{V_r} \tag{11}$$

In Eqs. (8)–(11), C_p was the parking capacity, C_t was the capacity of tour facilities, C_r was the capacity of catering facilities. D_p, d_p, R_p, V_p was, respectively, the number of parking spaces, the number of people per car, the average daily turnover rate of parking spaces, and the proportion of tourists driving to the park accounted for the total number of tourists. D_b, d_p, R_b, V_b was, respectively, the number of cruise boats, the number of people per boat, the average daily turnover rate of cruise boats, and the proportion of tourists on boats to the total number of tourists. D_c, d_c, R_c, V_c was, respectively, the number of sightseeing buses and bikes, the number of people per sightseeing bus and bike, the average daily turnover rate of sightseeing buses and bikes, the ratio of tourists on sightseeing buses and bikes to total tourists. D_r, R_r, V_r was, respectively, the number of meals, the number of visitors per seat per day, and the proportion of visitors who choose to eat at the restaurants in the wetland park.

4. Result analysis

4.1. Landscape pattern analysis

4.1.1. Analysis of landscape patch characteristics

The total area of Pan'an Lake Wetland Park was 749.6645 hm^2, and the area of water patches accounted for the largest proportion (63.879%), with a total of 478.876 hm^2, so water patch was the main patch type of the landscape. MPS, LPI, and AI of the water patches were also the largest, which indicated that the water patches had a controlling effect on the overall landscape and formed the landscape matrix of the wetland park. The LSI and MPFD of water patches were the smallest because Pan'an Lake was an artificial lake on the basis of coal subsidence and had a large area, so the average shape of water patches was relatively regular compared with the small and scattered construction land and green space.

There were 191.908 hm^2 green space, accounting for 25.599% of the total area, with the largest number of patches (297), and the average PD were 39.618, far larger than water and construction land. The MPS of green space was the smallest, indicating that although the green space was an important component of the overall landscape, the fragmented degree was the largest. Although the LSI of green space was slightly smaller than that of construction land, the MPFD of green space was slightly larger than that of construction land, which was mainly due to the large number and the large size difference of green space patches.

The construction land occupied the smallest area, which was 10.522% of the total landscape. The NP, mean PD, and AI of the construction land were all the smallest because the construction land patches were dispersed to all parts of the wetland park. In addition to a large building complex, a concentrated area of catering and service facilities, the rest of the construction land patches were roads, hard pavement and small structures scattered throughout the wetland park. It could be seen from the top category (Table 2 and Fig. 1) that the planning and construction of Pan'an Lake Wetland Park adhered to the rational utilization of ecological protection and other functions such as leisure and entertainment.

From Table 3, it could be seen that the area of water surface patches was much larger than that of wetlands, but the number of water surface patches was only 39, while the number of wetland patches was 151. The MPS, LSI, and AI of the water surface were the largest, which indicated that the water surface was the landscape element with the best connectivity and controlling effect. Wetland patch was the second largest patch type after the water surface. Wetlands were mainly distributed around the water surface and scattered islands in the interior. Wetland patches played an important role in the protection of wetland landscape in the whole wetland park.

Table 2
Patch landscape pattern index of top category

Landscape types	CA (hm^2)	PLAND (%)	NP	PD (/100hm^2)	MPS (hm^2)	LPI (%)	LSI	MPFD	AI
Water	478.876	63.879	49	6.536	9.773	42.910	9.103	1.129	99.629
Construction land	78.880	10.522	42	5.603	1.878	5.551	34.855	1.164	96.182
Green space	191.908	25.599	297	39.618	0.6462	2.876	32.326	1.167	97.737

CA, class patch type area; PLAND, the proportion of class patches in total landscape area; NP, the number of class patches; PD, class patch density; MPS, mean class patch area; LPI, maximum patch index; LSI, shape index; MPFD, average class patch fractal dimension; AI, aggregation index.

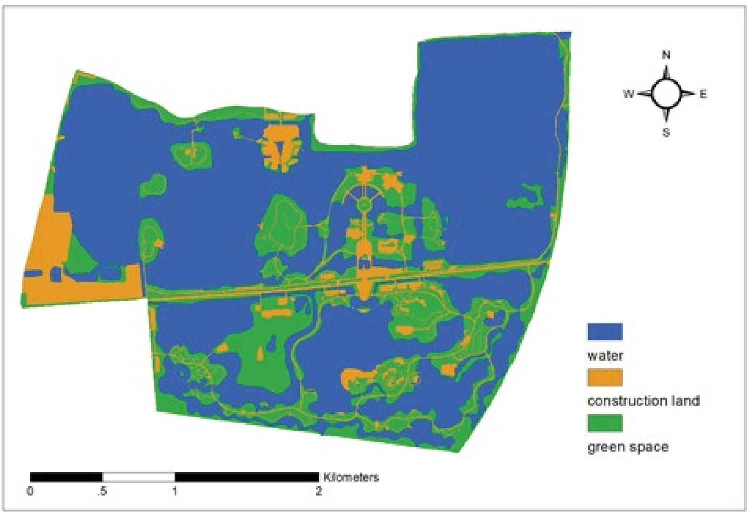

Fig. 1. Map of top-category landscape elements.

The patch area of multi-layer green space was 2.19 times that of grassland. The NP and PD of multi-layer green space were the largest, and the LSI was second only to road. There were also a large number of grassland patches (195). The MPFD and AI of grassland patches were both slightly larger than that of multi-layer green space because the number of grassland patches was much smaller than that of multi-layer green space. As we all know, the ecological effect of multi-layer green space is obviously better than that of grassland. As could be seen from Fig. 2, the multi-layer green space and grassland were distributed in all parts of the wetland park. The edge line of multi-layer green space and grassland were mainly treated with the curve of natural flow. Considering the ecotourism service function and landscape heterogeneity provided by wetland park, a certain amount of grassland was provided.

Construction land was divided into road, hard pavement and building in the Sub-category. From Table 3 and Fig. 2, it could be seen that the LSI of construction land patches was mainly contributed by winding roads, but the road AI was the lowest (90.802), which distributed throughout wetland parks and played a connecting role. In the construction land, the building area was the largest and the AI was the highest (99.191). The hard pavement area was the smallest and the MPS and the LPI were the smallest, but the number of hard pavement patches was higher than that of roads and buildings. The hard pavement in Pan'an Lake Wetland Park was distributed all over the park in small area to provide visitors with a space for rest and entertainment.

4.1.2. Analysis of overall landscape pattern

There were 388 patches in the top category and 948 patches in the sub-category, which were mainly caused by the separation of hard pavement from roads and buildings, the division between grassland and multi-layer green space, and the separation of wetlands from waters. The MPS of patches in top category was 1.932 and 0.791 hm^2 in sub-category. It could be seen that subdivision of landscape types increased the landscape LSI and SHDI greatly, slightly reduced the SHEI, and the AI, improved the CONTAG (Table 4).

4.2. Ecotourism carrying capacity analysis

4.2.1. Ecological Capacity

Based on the investigation of the environment of Pan'an Lake Wetland Park and its surroundings, the ecological capacity of water, plants, and watching-birds that had a great impact on tourist activities was estimated in this paper. On the premise that the water environment quality did not change significantly, the ecological capacity of COD, TN, and TP were estimated based on the standard of category IV water (recreational water without direct contact with the human body) stipulated in "Surface Water Environmental Quality Standard" [38]. According to Eq. (3), the water ecological capacity of Pan'an Lake Wetland Park was calculated to be 1,022,727 persons/day (Table 5), which was mainly controlled by TN.

In this paper, vegetation types were divided into two vegetation types: multi-layer green space and grassland. According to the literatures [39–41], the daily average oxygen consumption of one person was 750 g/d, and the oxygen production of multi-layer green space and grassland was 75 and 30 g/d. According to Eq. (4), the vegetation ecological capacity of Pan'an Lake Wetland Park was calculated to be 155,776 persons/day (Table 5). Oxygen production of multi-layer green space was far greater than that of grassland. Under certain conditions of green space area, increasing the area of multi-layer green space was the best choice to increase the ecological capacity of vegetation.

There were 40 species of wild birds under national three-level protection or provincial key protection, and more than 100 species of wild resident birds on the bird islands, with a total of more than 200 bird species. In order to ensure a safe distance for birds, sufficient distance should be left between the watching-birds area, tourist roads, and birds activity area. Studies had shown that tourists and waterfowls approaching the distance of 100–200 m could

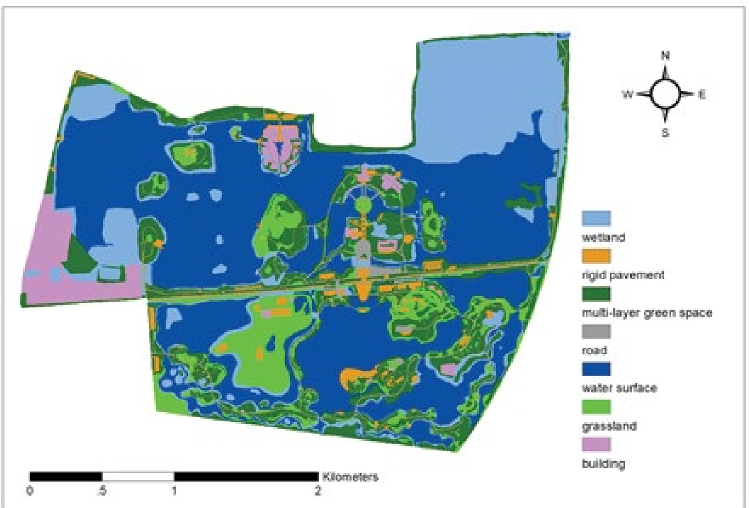

Fig. 2. Map of sub-category landscape elements.

Table 3
Patch landscape pattern index of sub-category

Landscape types		CA (hm^2)	PLAND (%)	NP	PD (/100 hm^2)	MPS (hm^2)	LPI (%)	LSI	MPFD	AI
Water	Wetland	147.065	19.618	151	20.142	0.974	10.349	19.464	1.225	98.476
	Water surface	331.811	44.261	39	5.202	8.508	27.317	9.652	1.160	99.525
Green space	Multi-layer green space	131.688	17.566	366	48.822	0.360	0.671	35.396	1.168	96.999
	Grassland	60.221	8.033	195	26.012	0.309	2.876	22.129	1.189	97.272
Construction land	Road	25.756	3.436	28	3.735	0.920	2.973	47.544	1.437	90.802
	Rigid pavement	19.290	2.573	133	17.741	0.145	0.255	18.590	1.150	95.983
	Building	33.834	4.513	36	4.802	0.939	3.327	5.696	1.084	99.191

Table 4
Overall landscape pattern index

	NP	PD (/100hm^2)	MPS (hm^2)	LSI	SHDI	SHEI	AI	CONTAG
Top category	388	51.757	1.932	18.189	0.872	0.794	98.782	57.225
Sub-category	948	126.457	0.791	25.305	1.538	0.791	98.288	57.777

Table 5
Ecological capacity of Pan'an Lake wetland park

Water ecological capacity (Persons/day)			Vegetation ecological capacity (Persons/day)		Watching-birds ecological capacity (Persons/day)	
COD	TN	TP	Multi-layer green space	Grassland	Route	Platform
2,400,000	1,022,727	2,307,692	131,688	24,088	12,089–24,179	278
1,022,727			155,776		12,367–24,457	

cause waterfowl to fly in surprise [27,28]. On the basis that the standard distance was 5–10 m/person, the reasonable watching-birds area was 200 m^2/person, the daily turnover rate of tourists was 2. Pan'an Lake Wetland Park had watching-birds routes both on land and on water, and some watching-birds platforms. According to Eq. (5), the watching-birds ecological capacity was calculated to be 12,337–24,457 persons/day (Table 5).

The ecological capacity was calculated to be 12,337–24,457 persons/day with the law of the minimum factor method (Table 2). The watching-birds ecological capacity was far less than the ecological capacity of vegetation and water. The watching-birds ecological capacity limited the ecological capacity of wetland parks for ecotourism. It was the key factor in increasing the ecological capacity to improving the capacity of watching-birds.

4.2.2. Spatial capacity and psychological capacity

The spatial capacity and psychological capacity of ecotourism in Pan'an Lake Wetland Park were calculated by area method, and the capacity of water area and land area were considered, respectively. According to the actual situation, the tourist land area was the sum of green space, and construction land, the tourist water area was 40% of the water surface, the daily turnover rate of land tourists was 2, and the daily turnover rate of water tourists was 2.5. According to "the Planning Norms of Scenic Spots" [42]. The land area was 100–200 m^2/person, and the water area was 200–300 m^2/person. According to Eq. (6), the spatial capacity of Wetland Park was calculated (Table 6).

The psychological capacity of ecotourism was usually lower than the spatial capacity. If the tourists were overcrowded or intensive, it would cause irritability, depression and anxiety, and the satisfaction of tourists would be reduced. Professor Masahiro Mita of Japan showed in his "Sightseeing and Recreation Plan" that the psychological feelings of tourists in different tourist areas were very different. For example, the psychological perception space standard of tourists was 25 m^2/person in zoo, 300 m^2/person in botanical gardens, and 20 m^2/person in the bathing beach. According to the questionnaire survey satisfaction data and reference data, the standard for the psychological capacity of tourists was 200 m^2/person on land and 500 m^2/person on water. The psychological capacity of Pan'an Lake Wetland Park was calculated according to Eq. (7). As could be seen

Table 6
Spatial capacity and psychological capacity of Pan'an Lake wetland park

	Spatial capacity (person/day)	Psychological capacity (person/day)
Land	27,078–54,157	27,078
Water	15,962–23,943	9,577
Total	43,040–78,100	36,655

Table 7
Facility capacity of Pan'an Lake wetland park

Catering facilities capacity (Persons/day)	Parking capacity (Persons/day)	Sightseeing facilities (Persons/day)
11,837–14,918	28,347	34,229

from Table 6, the number of tourists should be appropriately reduced if the psychological satisfaction was to be achieved on the basis of spatial capacity.

4.2.3. Facility capacity

Visitors to Pan'an Lake were mainly one-day or half-day tours, regardless of accommodation.

The parking space, catering, cruise boat, and sightseeing facilities were mainly considered in this study. According to the questionnaire survey, 81% of the tourists came to Pan'an Lake Wetland Park by car. There was 38% by cruise boats, 28% by sightseeing bus, 41% by bicycles in the park, and 74% of the tourists had meals (excluding their own meals) in the wetland park. According to Eqs. (8)–(11), the facility capacity was calculated (Table 7). It could be seen that catering facilities were the limiting factor of facilities capacity in Pan'an Lake Wetland Park. On the basis of considering ecological effects, adding catering facilities in appropriate areas or around wetland park was the basic guarantee of increasing facilities capacity.

4.2.4. Estimation of comprehensive carrying capacity of ecotourism

The weight of each component was determined by the method of expert scoring. The expert members were composed of 20 persons from Xuzhou City Garden Bureau, the managers of the wetland park and teachers of related majors in universities. After on-site inspection and discussion, the experts gave the weights of ecological capacity, spatial capacity, facility capacity, and psychological capacity: 0.35, 0.2, 0.25, and 0.2, respectively. According to Eq. (1), the daily carrying capacity of ecotourism in Pan'an Lake Wetland Park was 23,226–35,240 persons/day, and the annual carrying capacity of ecotourism was 8,477.49–12,862.6 thousand persons/year. According to the statistics of Pan'an Lake management office, the park received 3.4 million visitors in 2016. Since general secretary Xi Jinping visited Pan'an Lake Wetland Park in December 2017, the number of visitors had increased sharply. The number of tourists reached more than six million in 2018. 416,000 tourists were received during the National Day golden week in 2018, seriously exceeding the carrying capacity of ecotourism day.

5. Conclusion and discussion

On the basis of purifying water quality, degrading pollution, regulating local microclimate and mitigating floods, urban wetland parks should also have the functions of tourism, leisure, and recreation. In this paper, the landscape pattern and ecotourism carrying capacity of Pan'an Lake Wetland Park were analyzed to explore how to optimize the landscape layout, balance the relationship between the ecological functions and social services, economic functions of urban wetland park in order to better utilize the wetland park.

5.1. Landscape pattern

The area of water patches in Pan'an Lake Wetland Park was 63.879%. Water patches had a high degree of aggregation and good connectivity, so water was the matrix of the overall landscape. In the water landscape composed of water surface and wetland, the area of water surface patches was much larger than that of wetland, but the number of water surface patches was much smaller than that of wetland patches. Wetland patches played an important role in the ecological environment and species protection of the wetland park.

The number of green space patches was the largest, but the average patch area was the smallest and the fragmentation degree was the largest. The area of multi-layer green space was larger than that of grassland. Although the ecological benefits of multi-layer green space were higher, the existence of grassland landscape was also essential from the aspects of landscape ornamentality, heterogeneity, and functionality.

In the construction land, the building patches occupied the largest area, the highest degree of aggregation, the number of hard pavement patches was more, but the area was the smallest. Hard pavement was distributed all over the park in a small area and provided visitors with residential space. Most of the roads were naturally smooth curves and distributed everywhere, so the LSI of the road patches was the largest and the degree of aggregation was the lowest.

The landscape pattern of Pan'an Lake Wetland Park was studied by using two-level classification system, which was not only conducive to grasp the landscape condition of wetland park from the commonality, but also conducive to consider the balance between various kinds of landscape elements in planning and design of the wetland park. The subdivision of landscape types increased the diversity index and decreases the evenness index. The author compared the overall landscape pattern of Pan'an Lake Wetland Park with that of Egret Wetland Park in Chengdu city, Xianghu wetland park in Nanchang city and Huaxi wetland park in Guiyang city [43–45]. It could be seen that the diversity index of Pan'an Lake Wetland Park was at a general level, but the evenness index was high, which indicated that the distribution of different landscape types in Pan'an Lake Wetland Park was relatively balanced.

5.2. Ecotourism carrying capacity

The ecological capacity of water was estimated based on the standard of category IV water (recreational water without direct contact with the human body) stipulated in "Surface Water Environmental Quality Standard" (GB 3838–2002), higher requirements about the quality of the water did not been put forward in this study. Watching-birds ecological capacity was the ecological capacity of the wetland park. Protecting birds was an important ecological function of wetland parks. It could not blindly increase watching-birds routes and watching-birds areas in order to improve ecological capacity. It needed scientific planning and implementation. The proportion of people who use the facilities are investigated, so the calculated facility capacity had a higher reference value on the basis of investigated data.

This study showed that the daily carrying capacity of ecotourism in Pan'an Lake Wetland Park was 23,226–35,240 persons/day, and the annual carrying capacity of ecotourism was 8,477.49–12,862.6 thousand persons/year. But we should know that the carrying capacity of ecotourism was a dynamic process, which changes with the change of some factors. Through this study, we could know what factors limited the current ecotourism carrying capacity of Pan'an Lake Wetland Park, and provided a basis for increasing the carrying capacity of ecotourism scientifically.

5.3. Correlation between landscape pattern and ecotourism carrying capacity

The purpose of studying the landscape pattern was to optimize the land layout and maximize the comprehensive value of the landscape. The optimization of land layout needed to understand of the relationship among landscape types, landscape spatial patterns, and functions. The water area of Pan'an Lake Wetland Park was 478.876 hm^2, and the water storage was 15 million m^3, which provided a large amount of solution for the dilution of pollutants. Under certain conditions of green space area, increasing the area of multi-layer green space was the best choice to increase the ecological capacity of vegetation. However, the ecological capacity of water and vegetation was not the limiting factor. The ecological capacity of Pan'an Lake Wetland Park was mainly determined by watching-birds capacity. In order to improve the watching-birds capacity, it was necessary to increase watching-birds routes and watching-birds areas, which would lead to the increase of construction land, and the increase of construction land would weaken the ecological function of the wetland park, and there was a certain contradiction between the two.

Similarly, the increase of facility capacity would not only increase a certain amount of construction land, but also bring certain pollutants which led to increase the load of water environment and reduce the ecological capacity of water, especially the increase of catering facilities would form more concentrated buildings and hard pavement, which would have a certain impact on the ecological flow of the whole landscape. The spatial capacity and psychological capacity were mainly determined by the accessible land area and water area. It was suggested that the accessible water area should be increased to improve the spatial capacity and psychological capacity of the water area. The overall landscape SHEI reached 0.791 in Pan'an Lake Wetland Park, which could improve the conditions for the diversion of different scenic spots in the peak tourist seasons. Road patches with the largest LSI could increase the road length, which was an important factor to improve the watching-birds capacity. Since the SHDI of Pan'an Lake Wetland Park was not very high, the diversity of the landscape should be appropriately increased, which was beneficial to protect different species and provide different tourism experiences.

The relationship between landscape pattern and ecotourism carrying capacity was discussed simply on the basis of the research of Pan'an Lake Wetland Park. The relationship between the two needs to be studied quantitatively in the future.

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