Exploring the Distribution of Forest Recreation Resources in Sichuan Province Based on GIS Spatial Statistics

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Abstract. Sichuan Province has excellent basic conditions for forest recreation. Sichuan Province is divided into six regions, namely, Chengdu Plain, Qinba Mountain, Panxi, Southeast Sichuan, West Sichuan and East Sichuan. According to the existing data and the needs of forest recreation evaluation in Sichuan Province, the aggregation index, superiority index and scale index are selected to calculate the regional development potential and are used as evaluation indices for evaluation. GIS and spatial statistics are used to analyze the distribution and pattern of recreation resources in Sichuan Province, and to provide reference and support for the future planning direction and strategic layout of forest recreation in Sichuan Province.

1. Foreword
With the deepening of the national forest recreation concept and practice, the forest recreation industry in Sichuan Province has also developed to a certain extent and become a new growth point for the economic and social development of Sichuan Province. With the deepening of the research on forest recreation industry, the theory of forest recreation industry has been gradually improved. By analyzing the distribution and pattern of recreation resources in Sichuan Province through GIS and spatial statistics, it is important to deepen the reform of forest recreation industry and to build a national forest recreation destination and a large forest recreation industry province.

2. Forest recreation industry in Sichuan Province and its characteristics
2.1 Sichuan forest recreation industry
In 2014, Sichuan took the lead in putting forward the concept of "forest recreation" in the country, taking the development of forest recreation industry as a new initiative to transform forestry, upgrade ecological economy and boost economic development and poverty alleviation; on October , 2021, the annual conference of China Forestry Association 2021 Forest Recreation was held in Hongya, Sichuan. As a new industry in forestry and grass industry, forest recreation is ushering in a golden period of accelerated development. Riding on the momentum to make the forest recreation industry bigger and stronger is the best mode for all people to share the fruits of ecological construction and promote the construction of a healthy China, and it is also the most ideal and realistic way to practice the "two mountains” concept. The forest recreation industry is emerging and promising, and the advantages of developing forest recreation are obvious, but the laws of the initial stage of industrial development still need to be actively explored.

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2.2 Characteristics of the forest recreation industry in Sichuan

2.2.1 Rich forest resources. Sichuan has an area of 292 million mu of forest, with a forest coverage rate of 40.03% (Figure 1). According to the industrial data of the Sichuan subplatform of the National Forestry and Grassland Scientific Data Center, more than 500 nature reserves, scenic spots, forest parks, wetland parks and geological parks have been built. According to the 2018 Sichuan forest recreation base list of the Sichuan subplatform industry data of the National Forestry and Grassland Science Data Center, 375 forest recreation bases have been established in Sichuan Province.

![Distribution map of forest resources](image)

Figure 1 Distribution map of forest resources

2.2.2 Broad market demand. Market demand is the key to the development of forest recreation industry. Sichuan Province has 21 states and cities with a population of 83.675 million, the total resident population ranks fifth in China. The huge population base and consumption capacity provide huge development space and market potential for the development of forest recreation industry.

2.2.3 Profound ethnic culture. There are 18 cities in Sichuan Province where ethnic minorities live in scattered areas, and the ethnic areas are vast, covering an area of 302,100 square kilometers, accounting for 60.14% of the total area of the province. There are 55 ethnic minorities and 4.998 million people. Sichuan is the only Qiang settlement in China, the largest Yi settlement, the western Hakka province and the second largest Tibetan area in China. Therefore, in terms of recreation and medical care, Sichuan not only has a long history of traditional Chinese medicine, but also Qiang medicine, Tibetan medicine and Yi medicine as unique support for the development of recreation and medical care industry in Sichuan.

3. Spatial statistical analysis of forest recreation resources in Sichuan Province

3.1 Spatial division

According to the instructions of the Sichuan Provincial Party Committee document No. 1 in 2017, it is required to build a forest recreation cluster around Chengdu Plain, Qinba Mountain area, Panxi area, and Wumeng Mountain area. Therefore, the areas mentioned in the document are divided into 3 regions, and the Wumeng Mountain Region covers the areas of Liangshan, Leshan, Yibin and Luzhou, among which the difficult areas are dominated by Liangshan, so the whole of them are classified into the Panxi Region, and the remaining areas are divided into 3 regions according to the criteria of geographical location, cultural scenery and similarity of the areas covered by industrial radiation. Therefore, Sichuan province is divided into 6 areas, namely, Chengdu Plain Ring Area, Qinba Mountain Area, Panxi Area, Southeast Sichuan Area, West Sichuan Area, and East Sichuan Area (Figure 2), so as to conduct GIS spatial analysis on them.
3.2 Data collection

Based on forest resources, Sichuan Province combines the green economy of special agriculture and forestry, combines ecological tourism, poverty alleviation, medical care, pension, education and culture in Sichuan, and makes full use of natural landscape, forest environment, folk customs and highland special agriculture in Sichuan, etc. This study takes the existing nature reserves, national parks and wetland parks as carriers to build and improve forest recreation bases and gradually form forest recreation industry clusters [3].

All resource data obtained in this study were obtained from the Sichuan subplatform of the National Forestry and Grassland Science Data Center. Through data collection, a total of 322 forest recreation tourism resource monoliths were collected in 21 cities (states) in Sichuan Province, including 92 forest parks, 166 nature reserves, and 64 wetland parks. In view of the different development potentials of the single resources with different quality, the different single resources are graded. National forest parks are excellent grade, with 38 parks in total; provincial and city-county forest parks are general grade, with 54 parks in total. Wetland parks at the national level are of excellent grade, with 29 in total; wetland parks at the provincial and city and county levels are of general grade, with 35 in total. There are 31 national-level nature reserves at the excellent level and 135 provincial-level and city and county-level nature reserves at the general level. We also used GIS to construct a database of forest recreation resources attributes in Sichuan Province and draw a distribution map of forest recreation resources (Figure 3).
According to the existing data and the needs of forest recreation assessment in Sichuan Province, the aggregation index, superiority index and scale index are selected to calculate the regional development potential and used as the evaluation index for evaluation.

3.2.1 Aggregation index. Aggregation index is used to reflect the degree of aggregation of individual spatial distribution of recreation resources in a certain region, and is an important index to measure the size of the shielding effect produced by the spatial vertical arrangement of tourism resources in the region. If the aggregation index is less than 1, it is clustering; if the aggregation index is greater than 1, the pattern tends to be discrete \[^4\]. The formula is:

$$ R_i = \frac{r_i}{r_e} = 2r_i\sqrt{D} $$

where: \( r_i \) is the average of the distance between the nearest neighboring points, \( r_e \) is the theoretical nearest neighbor distance, and \( D \) is the point density. And \( r_e \) can be calculated by using Eq.

$$ r_e = 2\sqrt{\frac{n/A}{2\sqrt{D}}} $$

\( A \) is the area of the region and \( n \) is the number of points.

3.2.2 Superiority index. The superiority index is an indicator of the status of a certain type of recreation resource quality in the resource group. It indicates the degree of dominance of this type of recreation resource type in the forest recreation resource group in the composition of regional tourism resources. When \( S_i \) is larger, it means the superiority of the recreation resource group in the region is larger \[^5\]. The formula is:

$$ S_i = \frac{\sum H_i}{N_i} $$

Where: \( H_i \) represents the number of excellent level recreation resource units; \( N_i \) represents the total number of recreation tourism resource units at the upper level.

3.2.3 Scale index. The scale degree index refers to the density of regional recreation resources individual units. It is used to describe the number of individuals of each recreation resource distributed in unit space, and the larger the index value is, the larger the scale is. The formula is:

$$ D_i = \frac{M_i}{S_i} $$

Where \( M_i \) is the number of individual recreation tourism resources of the recreation tourism resource group of class \( i \); \( S_i \) represents the area of the recreation tourism resource group of class \( i \).

3.2.4 Measure the development potential of recreation tourism resource group. The development potential of recreation tourism resource group is mainly related to the result of the spatial interaction between the own characteristics of recreation resource group and resource monomer. The development potential size directly depends on the size of the recreation tourism resource group, the superiority of the resources and the strength of the gathering degree. It can be expressed by the formula:

$$ P_{ij} = \frac{S_{ij} + D_{ij}}{R_{ij}} $$

Where: \( P_{ij} \) is the development potential of tourism resource group \( j \) in region \( i \); \( R_{ij} \) is the aggregation index of tourism resource group \( j \) in region \( i \); \( S_{ij} \) is the superiority index of tourism resource group \( j \) in region \( i \); \( D_{ij} \) is the scale index of tourism resource group \( j \) in region \( i \).
### Table 1 Index of healthy tourism resource group in each area of Sichuan Province

| Partition         | Forest Park | Wetland Park | Natural Reserve |
|-------------------|-------------|--------------|-----------------|
|                   | Aggregation | Strengths    | Scale           | Aggregation | Strengths    | Scale           | Aggregation | Strengths    | Scale           |
| East Sichuan      | 0.56360     | 0.03261      | 0.00071         | 0.56865      | 0.12500      | 0.00062         | 0.50705     | <0.00001     | 0.00012         |
| Southeast Sichuan | 0.52264     | 0.01087      | 0.00033         | 0.40876      | 0.01563      | 0.00071         | 0.54954     | 0.01807      | 0.00005         |
| West of Pan       | 0.67913     | 0.01087      | 0.00007         | 0.40839      | 0.03125      | 0.00060         | 0.72375     | 0.01205      | 0.00004         |
| Qinba region      | 1.14611     | 0.15217      | 0.00028         | 0.66868      | 0.09375      | 0.00266         | 1.15629     | 0.04217      | 0.00005         |
| Chengdu Plain     | 0.55433     | 0.14130      | 0.00007         | 0.49994      | 0.07813      | 0.00055         | 0.57965     | 0.03614      | 0.00006         |
| West Sichuan      | 0.63518     | 0.06522      | 0.00005         | 0.90382      | 0.10938      | 0.00024         | 1.21690     | 0.07229      | 0.00001         |
| Sichuan Province  | 0.70419     | 0.41304      | 0.00012         | 0.58348      | 0.45314      | 0.00041         | 0.80675     | 0.18072      | 0.00002         |

### 3.3 Analysis results

The development potential of the recreation tourism resource group is formed by the interaction of three indexes: resource aggregation degree, resource superiority degree and resource scale degree. Aggregation index is used to reflect the degree of aggregation of individual spatial distribution of recreation resource groups in a region. The superiority index measures the status of a certain type of recreation resource quality in a resource group. The scale degree index refers to the individual density of regional recreation resources. The development potential of recreation tourism resources is calculated according to the formula, and the results are shown in Table 2.

### Table 2 The potential for the development of recreation tourism resource groups in each sub-district of Sichuan Province

| Resource Type | Forest Park | Wetland Park | Natural Reserve |
|---------------|-------------|--------------|-----------------|
| East Sichuan  | 0.05912     | 0.21406      | 0.000024        |
| Southeast Sichuan | 0.02143     | 0.03997      | 0.03297         |
| West of Pan   | 0.01611     | 0.07799      | 0.01670         |
| Qinba region  | 0.13302     | 0.14328      | 0.03651         |
| Chengdu Plain | 0.25503     | 0.15738      | 0.06245         |
| West Sichuan  | 0.10276     | 0.12128      | 0.06941         |
| Sichuan Province | 0.58671     | 0.77733      | 0.22403         |

As can be seen from Table 2, the development potential of forest parks in the recreation tourism resource group in Sichuan Province is higher in the Chengdu Plain Rim, Qinba and West Sichuan regions, with development potentials of 0.25503, 0.13302 and 0.10276 respectively; followed by the East Sichuan region with development potential of 0.05912, and then the Southeast Sichuan and Panxi regions with development potentials of 0.02143 and 0.01611. The wetland parks with higher development potential are in the eastern part of Sichuan, the Chengdu Plain and the Qinba area, with development potential of 0.21406, 0.15738 and 0.14328 respectively; followed by the western part of Sichuan with development potential of 0.12128, and then the western part of Panxi and the southeastern part of Sichuan with development potential of 0.07799 and 0.03997. The development potential of the nature reserve is higher in the western part of Sichuan and the area around Chengdu Plain, with development potential of 0.06941 and 0.05245 respectively; followed by the Qinba, southeastern Sichuan and western Panxi regions, with development potential values of 0.03651, 0.03297 and 0.01670, and again in the eastern part of Sichuan, with development potential of 0.00024.

### 4. Conclusion and Prospect

Taking Sichuan Province as the study area, the spatial distribution of forest parks, wetland parks and nature reserves of recreation resources in Sichuan Province is analyzed through GIS spatial statistics, so as to study the development potential of various recreation resources in Sichuan Province, it can be found that there are many recreation resource points in Sichuan Province and the development potential of forest recreation is large. This data information provides a basis for studying the development of forest recreation in Sichuan Province. According to the spatial distribution points constituted by these data, it is easy to find that: from the perspective of the development of each region
in Sichuan Province, recreation tourism resources in Sichuan Province are mainly distributed in the area around Chengdu Plain, Qinba area and western Sichuan area, and each region has its own resource characteristics.

However, forest recreation in Sichuan Province is still lacking in the corresponding supporting facilities and related personnel training, and the development mode of forest recreation is still very limited, failing to integrate new ideas with local characteristics and not showing ecological resources, ethnic characteristics and other regional characteristics well. Therefore, each place can create its own recreation development path according to the quality and popularity of its recreation resources and other local characteristics, showing ecological resources, ethnic characteristics and other regional characteristics. Finally, the purpose of promoting the development of recreation tourism in Sichuan Province is achieved.

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References
[1] Chen Dingchao, Li Weipeng, Cai Xiaoyu, Jing Nan, Wang Ruifang, Tang Mengdi, Gao Yilin. Analysis of dynamic changes of forest resources and their influencing factors in Sichuan Province[J/OL]. Journal of Earth Environment:1-18[2021-10-31]. http://kns.cnki.net/kcms/detail/61.1482.X.20211025.1352.002.html[In Chinese].
[2] Xiao Zhengli, Jing Shunhua, Liu Hailing, Zhou Yong, Chen Yuping. Determination of population dynamics and spatial density distribution of pine and brown aspen based on GIS spatial statistical trapping method: an example from Yuan'an County, Hubei Province[J]. Forestry Survey and Planning, 2021,46(04):54-60[In Chinese].
[3] Liu Quan. Research on forest park planning based on GIS spatial analysis[D]. Zhongnan University of Forestry Science and Technology, 2020[In Chinese].
[4] Hu Saiqiang, Liu Shuhu, Lin Zhaowu. Analysis of spatial distribution characteristics of traditional villages in Fujian Province based on GIS[J]. Journal of Ningxia University (Natural Science Edition), 2021,42(03):328-333[In Chinese].
[5] Fu Di, Chen Qianli, Cheng Dongyue, Zhang Zhihui. Research on the spatial layout characteristics of public service facilities based on GIS spatial analysis--Urumqi city as an example[J]. Computer and Digital Engineering, 2021,49(08):1604-1608+1655[In Chinese].