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Mapping and Assessing the Supply and Demand of Rural Recreation Services in National Parks: A Case Study of Qianjiangyuan, Zhejiang, China

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Abstract: National parks not only protect natural resources but also provide a variety of cultural ecosystem services, with their rural areas serving as important locations for providing rural recreation services (RRS). Spatial quantification of RRS supply and demand will contribute to ensuring the protection and promotion of human well-being in national parks. In this study, we proposed an integrated framework to map and assess the spatial distribution of RRS supply and demand in Changhong Township, located within Qianjiangyuan National Park. We used a combination of spatial analysis and the MaxEnt model as tools, which played a positive role in saving time when modeling areas providing cultural ecosystem services. Based on the findings, the study area was divided into different zones to propose spatial planning measures. The results showed that (1) the MaxEnt model was robust in mapping RRS supply. RRS supply and demand distribution had high spatial heterogeneity. (2) The proportion of areas where RRS supply exceeded demand was 72.58%, primarily distributed in areas with a high level of naturalness at the periphery of the study area. (3) This study divided Changhong Township into four types of zones: developed recreation service area, potential recreation service area, recreation service demand area, and marginal recreation service area. We proposed suggestions for the scientific utilization and management of RRS in each zone. Overall, our findings provide a scientific basis for planning rural recreation spaces within national parks, promoting the comprehensive utilization of rural cultural ecosystem services.

Keywords: rural recreation services; supply and demand; MaxEnt; national parks; spatial planning

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1. Introduction

Ecosystem services (ES) refer to the benefits derived from ecosystems that are utilized by humans, which have gained recognition as an effective instrument for decision-making in addressing a variety of ecological and social challenges [1]. The Millennium Ecosystem Assessment categorized ecosystem services into four types, with cultural ecosystem services (CES) being one of the important categories, defined as the non-material benefits that humans derive from ecosystems, including spiritual fulfillment, reflection, aesthetic experience, recreation, and cognitive development [2]. CES can promote human well-being and encourage environmental action [3–5], linking society, ecology, and landscape [6]. Moreover, as a significant category of CES, recreation and ecotourism are characterized by a variety of leisure and recreational opportunities and experiences that individuals obtain from natural environments [7,8], which have become one of the most widely studied areas within CES [9]. Recreational activities in forest ecosystems cause the destruction of

forest litter and soils, potentially leading to landscape changes [10]. Ecotourism enables conservation and economic development, but it could also lead to forest loss because it stimulates economic development [11]. While preserving the ecological and cultural characteristics of the protected areas, the national parks simultaneously provide the public with opportunities for recreation and ecological tourism [12]. However, the ecology of national parks is sensitive. The increasing demand for recreational activities exerts significant pressure on ecosystems. Given the significance of CES in promoting human well-being and environmental conservation, their incorporation into national park management is crucial.

The increasing recreational use and development in national parks pose challenges to the conservation of natural ecosystems, directly affecting the effectiveness of ecosystem conservation in national parks and the achievement of conservation goals. Employing the CES method in recreation planning and management can reduce the negative impacts of recreational activities while increasing the benefits of regional tourism [13,14]. Furthermore, people can experience CES in national parks firsthand, which will improve their knowledge of ecosystems and encourage their preservation [15]. However, current research on CES remains relatively underexplored, impeding the achievement of management objectives. Therefore, it is important to incorporate CES into the decision-making and planning of tourism destinations.

Currently, a great deal of research focuses on how to quantify and assess CES. Some scholars have adopted the perspective of monetary evaluation methods to study and explore the economic value of CES [16,17]. However, a singular emphasis on monetization evaluation overlooks the complex interplay between humans and nature [18] and fails to reflect the spatial characteristics of CES. Consequently, CES transitions from a singular economic value assessment to a non-monetary social value assessment. CES mapping is an important tool for incorporating ecosystem service methods into spatial management. However, compared to other physical services of ecosystems, CES are considered subjective and challenging to quantify and map [6]. Common methods and data for CES mapping and assessment include community engagement or survey-based methods [8,19–21], representative indicators [22,23], and social media data [19,24–30]. The InVEST model, the SolVES model, and the MaxEnt model [29,31,32] are useful tools for evaluating CES. While quantifying and mapping ES values are necessary, research in this area is significantly less extensive than that on regulating and supplying services [33,34]. Nevertheless, it is difficult to distinguish between different CES categories, which frequently results in double counting. There is a need for further study on recreation as a distinct product because the majority of current studies have mapped and evaluated recreation as a component of CES [9,35]. Therefore, this study examined recreation services as a distinct component of CES, aiding policymakers in identifying sustainable solutions in the national park.

Analyzing CES supply and demand is essential in the assessment of these services. The ability of an ecosystem to produce a specific service or good within a specified time frame is referred to as ES supply [36], while ES demand refers to the quantity that society desires or needs [37]. Additionally, demand is represented by the ES consumption or preferences and desires for consumption expressed by the population within a specific time frame [38–40]. This study adopted the spatial distribution of beneficiaries of recreation services in national parks to represent the spatial distribution of CES demand from the perspective of beneficiaries. Moreover, mapping and modeling the supply–demand relationship of recreation ES, identifying their spatial distribution patterns, and determining where recreation ES are not being met will help provide insights and understanding of their matching relationship, which will provide a basis for recreation planning and management.

Recreation services are primarily studied in forests [41], green spaces [42], and coastal areas [31] in urban environments and their surroundings. However, to date, few studies

have investigated recreation services in nature reserves, particularly in rural areas. Shi et al. [20] explored the linkage between the supply and demand of CES using Shigou Township in the Loess Plateau as a case study. Zhao et al. [43] integrated the SolVES model with social media comments to develop an approach for assessing the supply and demand linkage of CES in a typical county-level city near Mount Wuyi National Park in China. Zuo and Zhang [44] took the Jiangnan Water Network Rural Areas as a case study and integrated the MaxEnt model to establish a quantitative research and spatial optimization framework for CES in rural areas. National parks protect nature and biodiversity while also providing recreational opportunities [26,45]. Since China's national park system began to expand quickly in 2013, rural areas within national parks have become important sites for recreational use and service provision. Moreover, rural ecosystems furnish the essential resources and ecosystem services necessary for the survival of humans and other animals, serving as the cornerstone for sustainable societal development. The rapid growth in tourist demand for CES within national parks has highlighted a significant imbalance between the CES supply and demand. Some areas of national parks experience the overuse of tourism resources. Furthermore, the contradiction between ecological conservation and tourism development in national parks has also raised concerns that the ecosystems of national parks are under threat [46]. Therefore, this study aimed to develop a framework to assess the RRS in national parks, focusing on analyzing the spatial patterns of their supply and the alignment of these services.

This study aimed to investigate the spatial patterns and relationships of RRS supply and demand through mapping and modeling processes. Moreover, Our comprehension of the relationships between ecosystems and human well-being will be enhanced by analyzing cultural ecosystems from the perspective of supply and demand [37], which is important for achieving sustainable provisioning of cultural ecosystem services and addressing people's cultural needs. Qianjiangyuan National Park is a typical ecological function area in eastern China. Furthermore, Qianjiangyuan National Park includes national nature reserves and forest parks of high landscape and ecological value and is gaining recognition as a popular rural recreation destination due to its rich tourist resources, such as terraced rice fields, rapeseed blossoms, and stargazing. However, the utilization of rural recreational activities has posed a significant threat to the authenticity and integrity of this vital national ecosystem, thereby undermining the potential for harmonious coexistence between humans and the natural environment. In this study, taking the countryside of Qianjiangyuan National Park, which has high ecological and recreational values, as an example, we provided a scientific solution for the integrated scientific utilization of RRS by mapping and evaluating the supply and demand.

2. Materials and Methods

2.1. Study Area

The Qianjiangyuan National Park (QNP) was established in 2016 and is one of the pilot areas in China, located in Quzhou City, Zhejiang Province, at the junction of Zhejiang, Anhui, and Jiangxi Provinces, with a total area of 252 km^2. The QNP is located in the south-eastern coastal area of China. As shown in Figure 1, the QNP involves four townships in Kaihua County, including 19 administrative villages. The areas covered by the QNP include national nature reserve and national forest park with significant landscape and ecological values. In addition, the QNP features a globally rare and typical middle-subtropical zonal vegetation—specifically, a low-altitude native evergreen broad-leaved forest [47]. Moreover, The QNP has apparent geological and geomorphological features, including gravity slope landforms, granite mountains, various types of faults, river terraces, canyons, and other geological and geomorphological landscapes of scientific demonstration value [48]. The

QNP has a rich cultural heritage and has historically been characterized by mountain farming and forestry as the primary source of livelihood.

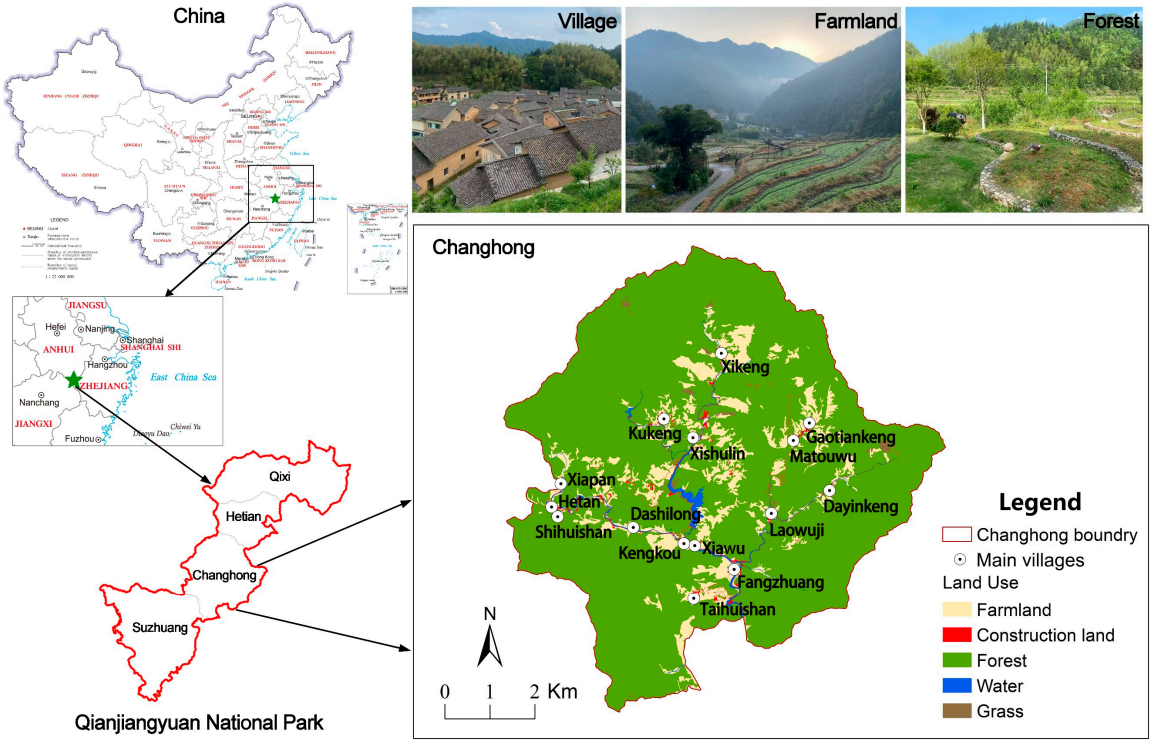

Figure 1. Study area (source: GS(2019)1682).

The QNP has a total of 2979 households and a permanent population of 6158 people, 59.6% of whom are located in Changhong Township. The economy mainly depends on mountain planting, mountain breeding, forestry, and rural tourism. Particularly, Changhong Township is an area within the national park where both population and rural tourism are relatively concentrated. Changhong Township, located in the center of the QNP, is increasingly recognized as a preferred destination for rural recreation, attributed to its rich tourist resources. It is gradually becoming a destination for viewing terraced rice fields, rapeseed blossoms, and stargazing. However, rural recreation in the national park threatens the authenticity and integrity of ecosystems that are important to the country, making it difficult for humans and nature to coexist peacefully. Furthermore, rural tourism is still in its early stages, and the lack of tourism data has created difficulties in the assessment and management of cultural services. With a permanent population of 3672 people, Changhong Township includes four administrative villages: Taoyuan Village, Xiachuan Village, Zhenzikeng Village, and Kukeng Village, as well as 29 natural villages. In this study, villages with a permanent population of more than 100 were selected as the research object.

2.2. Data Collection

A database was established to map and assess the spatial distribution of RRS supply and demand in the study area (Table 1). The NDVI data are averaged from 2023, while other data are from 2024. We utilized ArcGIS 10.5 software for clipping, spatial analysis, and results display. The coordinate system and cell size were kept consistent across all layers (WGS_1984, 30 × 30 m).

Table 1. Data sources.

Data	Data Sources
The boundary of QNP	Master plan of Qianjiangyuan National Park
The natural landscape resource points and cultural Landscape resource points of Changhong Township	Field research (from 23 April 2024 to 29 April 2024) and the Baidu Pickup Tool (https://api.map.baidu.com/lbsapi/getpoint/index.html, accessed on 5 May 2024)
Normalized difference vegetation index (NDVI)	The Google Earth engine (https://earthengine.google.com/, accessed on 6 May 2024),
Digital elevation model (DEM)	Geospatial Data Cloud (https://www.gscloud.cn, accessed on 5 May 2024).
Land use types of QNP	Master plan of Qianjiangyuan National Park
Roads	Field research (From 23 April 2024 to 29 April 2024)
Permanent residents	The government
Slope	Obtained by analyzing DEM data

2.3. Methods for Mapping Rural Recreation Services

This study examined the relationship between the supply and demand of rural recreation services using the MaxEnt model and the ArcGIS spatial analysis approach (Figure 2). This study was divided into three steps: (1) We assessed the supply of RRS based on natural and socio-geographical data through the MaxEnt model and analyzed the importance and contribution of each environmental variable. (2) We calculated the demand level of CES based on the distribution of rural permanent residents and the exhibition area of the national park. (3) The analysis of the ecological supply–demand ratio and the supply–demand matching patterns of cultural services based on Z-score standardization provided suggestions for developing rural recreational and cultural services.

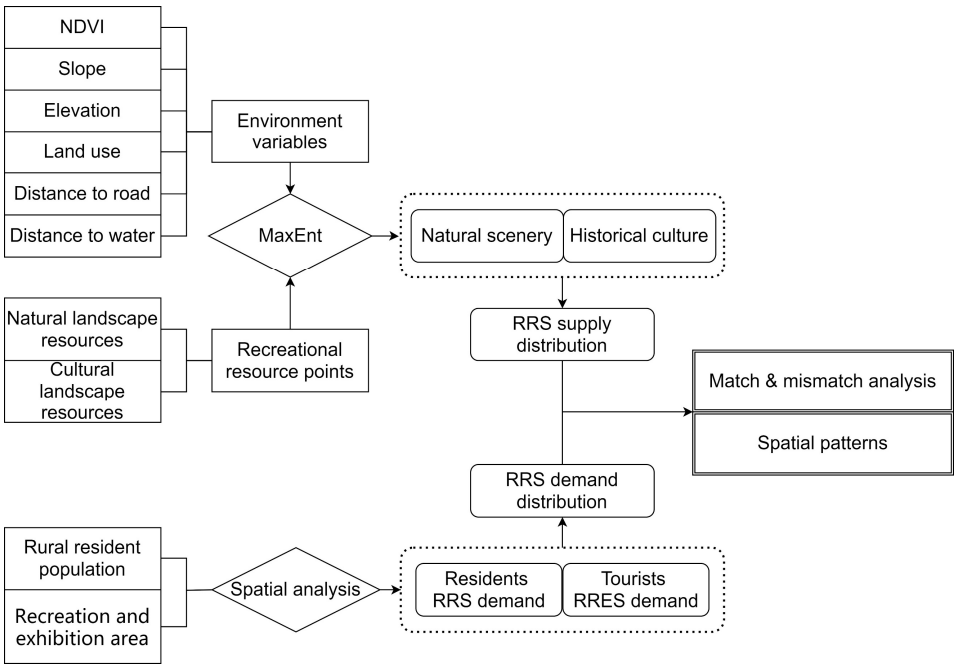

Figure 2. The framework of the research.

2.3.1. RRS Supply

Rural recreation in Changhong Township is still at a relatively early stage, and rural recreation services are not only oriented toward tourists experiencing the recreation service value of the national park but also toward the daily recreation value of rural residents. In this study, rural recreation services are categorized into natural scenery and historical

culture based on the specific circumstances of the QNP. The geology, water bodies, and vegetation landscape of Changhong Township provide natural scenery services. Tombstones, memorials, historical buildings, and star bases provide historical cultural services. These elements can reflect the characteristics of natural, social, and cultural resources in the local countryside, collectively offering a rich array of rural recreation and cultural services for residents and tourists in Changhong Township.

MaxEnt was applied to model the potential distribution of CES in this study. This model not only enables the visual analysis of the spatial distribution suitability of multi-scale CES but also captures how spatial suitability responds to various environmental factors. Moreover, even with the mall sample sizes, MaxEnt also performs well [49]. Based on field research and local information, we picked 48 resource points in Changhong Township from the Baidu Pickup Tool. In this research, we used MaxEnt 3.4.4 to evaluate the supply of RRS and analyzed the significance and contribution of each environmental variable. This model was grounded in the maximum entropy theory and the ecological niche model, which infers the probability distribution of unknown information from known incomplete data [50]. The entropy in the MaxEnt procedure is computed as follows [51]:

$$H(P) = -\sum_{x \in X} P(x) \ln P(x) \quad (1)$$

where the probability distribution of the unknown region, denoted as x, is represented by $P(x)$, and the finite set of x in the study region is referred to as X.

MaxEnt plots a Receiver Operating Characteristic (ROC) curve in each simulation. The efficiency of the simulation can be evaluated by analyzing the Area Under the Curve (AUC), which acts as an indicator for evaluating the accuracy of the simulation [29]. The AUC value can characterize the quality of the simulation: values between 0.70 and 0.90 indicate that the model is accurate, while values above 0.90 suggest that the model is highly accurate [52].

Six environmental data were selected for this study, including four environmental data (NDVI, slope, elevation, and land use) and two spatial distance elements (distance to road and distance to water) [53]. The spatial distance elements were obtained by Euclidean distance analysis in GIS, and their spatial resolution and coordinates were standardized with those of the natural environment. The six environmental variable layers were converted to ASCII format.

In this study, we saved the geographic coordinates of the categorized CES supply points as a CSV table. Then, the point data were input into the MaxEnt model for prediction and a layer of environmental variables. We selected the output format as logistic and set the random test percentage to 25% [54], which can produce good performance for the modeling. To further reduce the uncertainty of the MaxEnt model, we set the number of replicates to 10, and the final result was determined by averaging the 10 replicates [50]. Finally, we generated the CES potential supply map.

2.3.2. RRS Demand

In this research, we used the spatial distribution of the beneficiaries to represent the spatial pattern of CES demand levels from the perspective of RRS beneficiaries, including tourists and permanent residents in the villages of Qianjiangyuan National Park. Data on permanent residents in the villages were obtained from the government. The population density distribution map was created using the kernel density tool in GIS and then normalized using the following formula:

$$RD_{norm} = \frac{RD - RD_{min}}{RD_{max} - RD_{min}} \quad (2)$$

where RD_{norm} is the normalized resident density, RD_{max} is the maximum value of RD, and RD_{min} is the minimum value of RD.

Yu et al. [47] divided the QNP into four areas, including the core protection area, ecological conservation area, recreation and exhibition area, and traditional utilization area. Local tourism in Changhong Township was relatively underdeveloped, and no statistics were available on the annual number of tourists. Due to the lack of detailed tourism data on visitor numbers and consumption at the village level, management authorities are unable to accurately predict market demand and implement timely management, leading to inefficient resource allocation. Additionally, the lack of data also limits the diversification of rural tourism products. To address this gap, this study substituted the spatial demand of tourists for recreational services with the "recreation and exhibition area" of the national park, setting the spatial representation to 1. In this research, the weights of recreational services for both residents and tourists were set to 0.5. The demand level of RRS was then obtained by combining and weighing the recreational services for both residents and tourists.

2.4. Spatial Match Between RRS Supply and Demand

2.4.1. The Ecological Supply–Demand Ratio

Identification of the spatial mismatches and matches within the region can be performed with Changhong Township's spatial distribution of RRS supply and demand. In this study, mismatch analysis was conducted by calculating the ecological supply–demand ratio (ESDR) to obtain the surplus and deficit of RRS [24]. The spatial component of surplus indicates that the region is supplying more RRS than demand. The spatial component of the deficit indicates that the demand for rural recreation services in the region is higher than the supply, and the demand for RRS from tourists and residents is not met. The ESDR visualizes the information about the match and mismatch between the supply and demand of RRS.

The specific formula is expressed as follows:

$$ESDR = \frac{RRSS - RRSD}{(RRSS_{max} + RRSD_{max})/2} \quad (3)$$

$RRSS$ and $RRSD$ represent the supply and demand of rural recreation services, respectively, and $RRSS_{max}$ and $RRSD_{max}$ are the maximum values of the supply and demand of rural recreation services, respectively. A service deficit is indicated by a value less than zero, while a service surplus is indicated by a value greater than zero.

2.4.2. The Supply and Demand Matching Patterns of RRS

The supply and demand of RRS obtained above were standardized by z-score [38,55]. The steps included generating a 100 × 100 m fishing grid of the study area in GIS, converting the generated grid to points, and assigning supply and demand values to the points using the Extract Values to Points tool. Then, after completing the z-score standardization process using the SPSS 27.0, the data were categorized into four groups through pairwise combinations based on the standardized supply and demand of RRS.

The specific formulas are as follows [55,56]:

$$x = \frac{x_i - \overline{x}}{s} \quad (4)$$

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (5)$$

$$s = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x - \overline{x})^2} \quad (6)$$

where X represents the standardized RRS supply and demand for the evaluation unit; X_i denotes the RRS supply and demand for the ith evaluation unit; $\overline{x}$ and s indicate the mean value and the standard deviation of the study area, respectively; and n refers to the total number of evaluation units.

3. Results

3.1. RRS Supply

Following the processing of the MaxEnt model, all AUC values in this research were above 0.85, suggesting that the MaxEnt model performed quite well in the assessment. As shown in Figure 3a,b, the spatial distribution of the two RRS service types was heterogeneous.

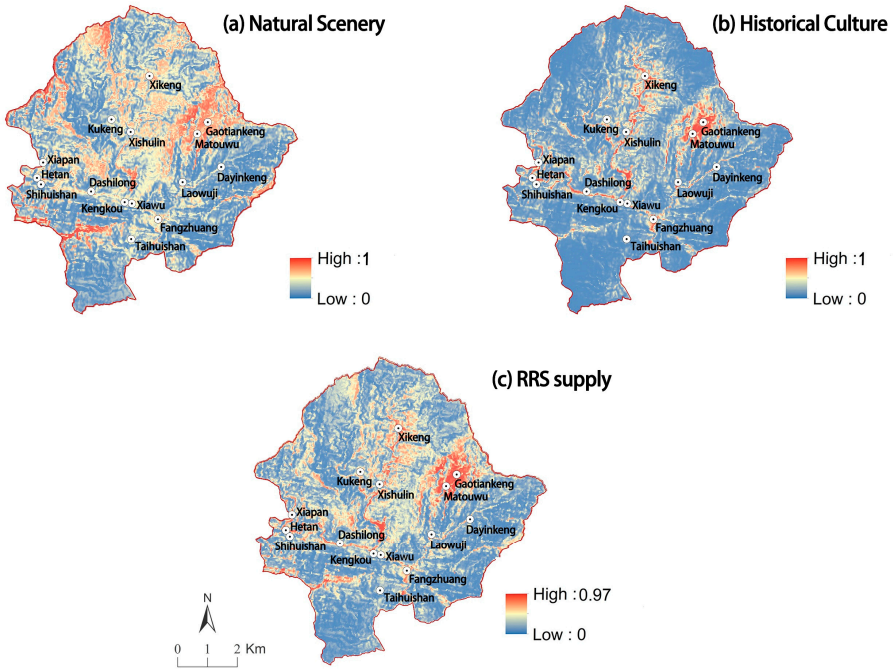

Figure 3. RRS supply.

The areas with high natural scenery service supply were mainly located in Gaotiankeng and Matouwu in the northeastern part of Changhong Township and the western part of Taihuishan. The terrain in this area varies greatly, including a variety of geological and geomorphic landscapes with scientific demonstration value. The eastern and southern parts of Changhong Township had lower levels of service. The natural landscape types in this area are relatively simple.

In terms of the distribution of historical culture services, the areas with high supply were mainly distributed along the transportation roads, with high values in Matouwu, Gaotiankeng, Kengkou, and Xikeng. Gaotiankeng and Matouwu are traditional ancient villages in China with well-preserved historical buildings. In addition, these areas have emerged as premier destinations for stargazing due to their exceptional conditions. A dark night museum and a dark night star station have been constructed, enhancing the cultural service function of the region. On the other hand, areas with low historical culture services supply were located at the edge of the study area, which is a low-altitude native evergreen broad-leaved forest with almost no human construction.

In order to synthesize natural scenery and historical culture, the two service types were weighted and summed, each with a weight of 0.5, to obtain the RRS supply distribution map

(Figure 3c). Based on the distribution results, the integrated supply distribution resembled the two types of cultural services' distribution, with the high-supply areas mainly located in Gaotiankeng, Matouwu, and Xikeng in the northern part of Changhong Township, Kengkou, and Fangzhuang in the southern part of the township. In general, the distribution of RRS supply in Changhong Township exhibited significant spatial heterogeneity.

Table 2 shows estimates of the relative contributions of the environmental variables to the MaxEnt model. The cumulative contribution rate of slope, elevation, and land use to natural scenery is relatively high. Similarly, slope, land use, and distance to water have a higher cumulative contribution rate to historical culture. Distance to water had a high degree of non-displaceability for historical culture, indicating that water is very important for it.

Table 2. Contribution rate and importance of each variable.

Environmental Variables	Natural Scenery		Historical Culture	
	Permutation Importance	Percent Contribution	Permutation Importance	Percent Contribution
Slope	42.5	58.2	31.5	35.6
Elevation	16.8	14.9	9.9	7.7
Land use	8.1	15.1	1.3	34.1
NDVI	0.3	0.2	0.9	2.8
Distance to road	30.3	10.9	9.6	8.1
Distance to water	2	0.8	46.7	11.8

Overall, the slope had the highest cumulative contribution to both types of services, followed by land use and distance to road. Slope affected the ecological environment and had an impact on accessibility and availability. Different land use types also influenced the supply capacity of RRS. The distance to the road expressed transportation accessibility, and high accessibility had a strong promoting effect on RRS supply. Moreover, the permutation importance and permutation contribution of NDVI were found to be relatively low. This low significance was attributed to the high levels of vegetation present across Changhong Township, which suggested that NDVI variations had a minimal impact on the level of services being modeled.

3.2. RRS Demand

In terms of the resident RRS demand, as shown in Figure 4a, the permanent population of Changhong Township was mainly located in the areas of Xikeng and Kukeng in the north and Kengkou and Fangzhuang in the south, with each of these villages having a population greater than 300. This suggested that the area has a higher demand for recreational services. In this study, we used the recreation and exhibition area to represent tourist demand. As shown in Figure 4b, the recreation exhibition area contained most of the villages, with a primary distribution in the central part of the study area and along the main transportation routes. This area was equipped with certain recreational service facilities.

After superimposing the recreational demand of residents and visitors to obtain the combined RRS demand, the high-demand area included four clusters (Figure 4c): Xiawu and Kengkou, Gaotiankeng and Matouwu, Kukeng and Xilinlin, and Xikeng. It was clear that the areas with high RRS demand were mainly in the villages located in the middle of the Changhong Township, and the demand decreased with the distance from the village center, resulting in the lowest demand in the peripheral forest area.

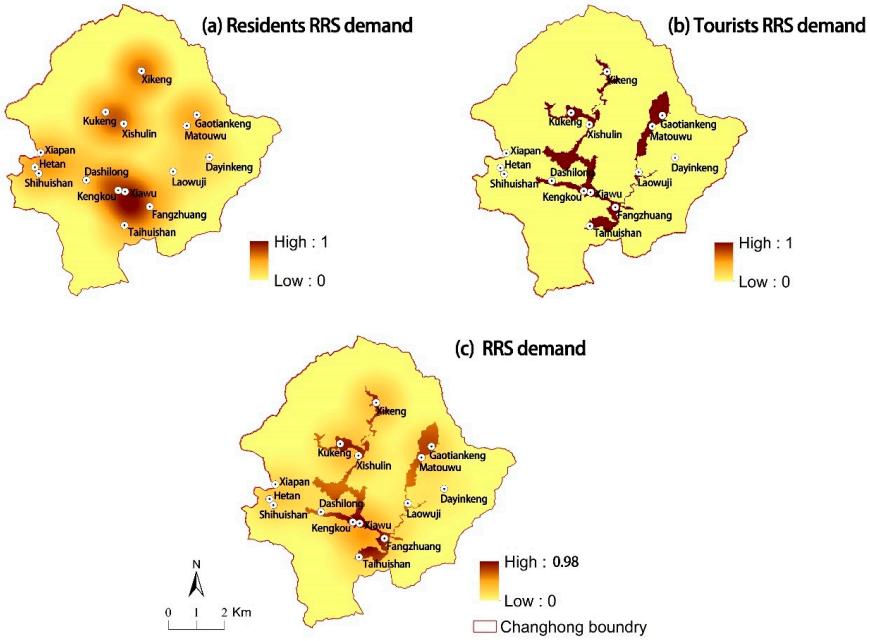

Figure 4. RRS demand.

3.3. Mismatch Analysis Between RRS Supply and Demand

Information for spatial planning was gained from the ESDR's visual feedback based on the spatial matching relationship between RRS supply and demand. Based on the calculation results of the ArcGIS platform grid calculator, the ESDR of RRS in Changhong Township is shown in Figure 5. The areas where supply exceeded demand and areas where demand exceeded supply were relatively concentrated. In particular, the proportion of the area where demand exceeded supply was 27.42%, which was mainly the area where the population was more concentrated and had been planned as a recreational development area. Particularly, the distribution is concentrated and well-defined in the Taihuishan, Fangzhuang, Kengkou, and Xiawu. The RRS in this area were not satisfied and may pose a threat to the ecological environment. In addition, the proportion of areas where supply exceeded demand was 72.58%, which were primarily distributed in the study area's periphery, near natural features like forests and water bodies. The level of recreational use in this area was very low, and the ecological environment was relatively good, suggesting potential for future development.

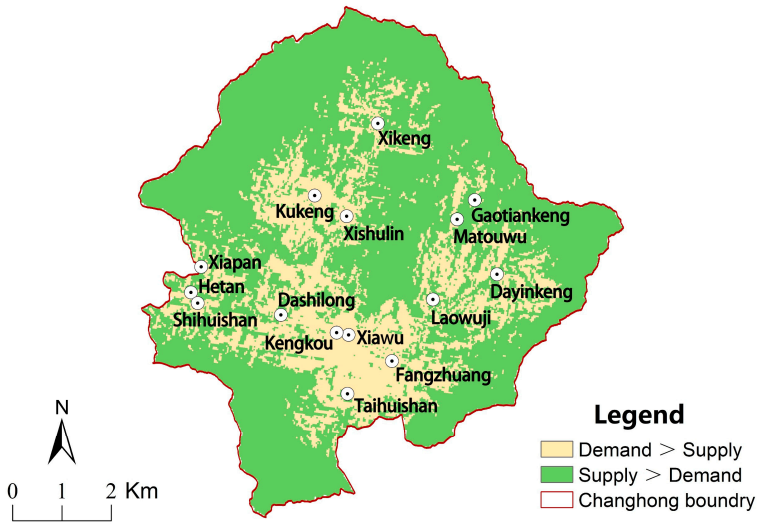

Figure 5. Spatial pattern of mismatches between the supply and demand of RRS based on the ESDR.

3.4. Spatial Patterns of RRS Supply and Demand

According to Figure 6, the zoning map of the supply–demand relationship based on RRS in Changhong Township shows that low supply–low demand had the largest share of 43.73%. The other types of zones, in descending order of size, were high supply–low demand (22.34%), high supply–high demand (18.93%), and low supply–high demand (15.01%). According to the relationship between RRS supply and demand, we divided Changhong Township into four types of zones: developed recreation service area, potential recreation service area, recreation service demand area, and marginal recreation service area.

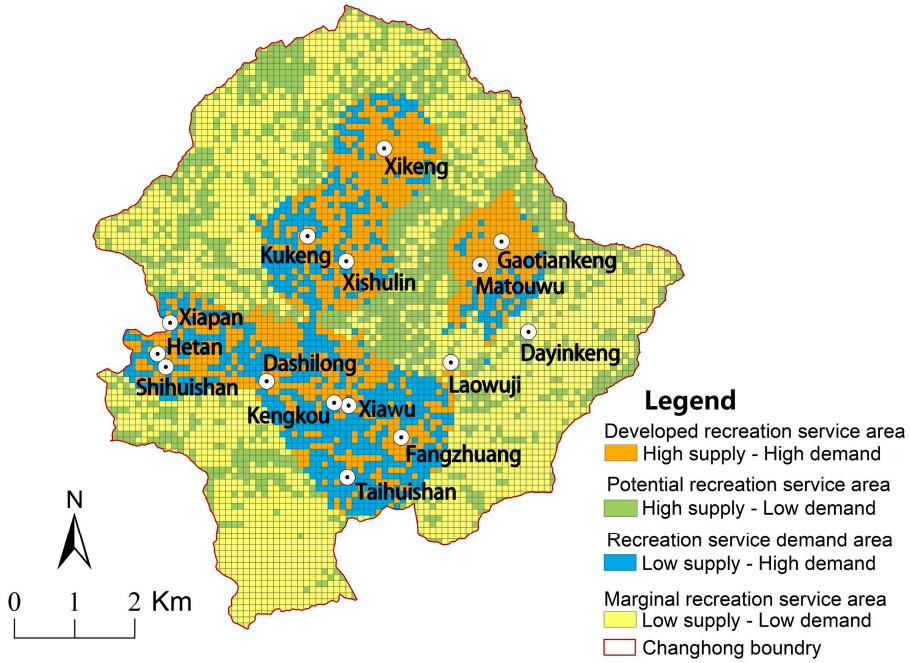

Figure 6. Supply and demand divisions of RRS in rural areas.

From the perspective of spatial distribution, high supply–high demand represented the developed recreation service area, which was characterized by high supply and strong demand for RRS, and the overall supply–demand relationship was matched to a relatively high degree. Developed cultural service areas were mainly distributed along roads around villages and towns, especially Xikeng, Gaotiankeng, and Matouwu.

The potential recreation service area had high supply–low demand, which had a high provision of cultural services but a low demand, with potential for future development. This zone was more sporadically distributed, mainly in areas with rich natural landscapes.

The recreation services demand area had low supply–high demand for recreation ES, and the service supply needed to be improved. The majority of this region was in the countryside, close to Taihuishan and Fangzhuang. Fangzhuang was located near the national park entrance and served as a tourist hotspot, but it had insufficient supply capacity.

Low supply–low demand represented the marginal recreation service area, where the supply and demand of cultural services were low. This type of area represented the largest proportion of the study area and was predominantly located in the periphery of Changhong Township, which was primarily forested at higher elevations and generally functioned as an ecological conservation zone. In addition, it was difficult for tourists to reach, and no residents lived there. Thus, the demand for cultural services was low.

4. Discussion

In this research, we constructed an integrated framework to map and evaluate the spatial distribution of RRS supply and demand in Changhong Township, subsequently exploring the supply–demand relationships and proposing management strategies. Furthermore, this study was intended to propose a scientific framework for informing spatial planning and policymaking in national park recreation.

4.1. Mismatch Between RRS Supply and Demand

Many studies have considered recreation as part of cultural ecosystem services, but only a few have considered recreation as a separate product of ecosystems [7,21]. In addition, most studies on recreation services have primarily concentrated on large urban areas [19,57]. There is a deficiency in research concerning recreation services in rural areas, particularly in protected areas [20]. Quantification and spatial mapping of cultural ecosystem services can distinguish between their supply and demand and clarify their spatial distribution. Research findings can pinpoint areas with unmet demand and provide precise spatial information for planners and decision-makers. Moreover, this approach can support sustainable use and the fair distribution of resources [39,58]. In this study, we proposed an integrated RRS model grounded in the two primary dimensions of ecosystem service: supply and demand. Then, we used the MaxEnt model with spatialization to quantify services and supply spatially. Finally, the graphical results can serve as a scientific basis for the scientific utilization and management of recreation.

The MaxEnt provides robust results in human-dimensional spatial problems [33] and performs excellently even with small sample sizes [49,59]. We applied the MaxEnt to estimate potential supply areas, and the AUC values of RRS for the two service types in this study were above 0.85, indicating that the method provided robust results. Slope, land use, and distance to the road had high cumulative contributions for the two service types, and NDVI had the lowest cumulative contribution.

The majority of studies consider the long-term residents or tourists as the demand for ecosystem services [39]. However, since the research object of this study is a township in the national park, the scale is relatively small. Changhong Township's recreational development is still in a relatively early stage. Yu et al. [47] divided The QNP into four areas, including the core protection area, ecological conservation area, recreation and exhibition area, and traditional utilization area. There was a lack of data on the number of visitors, so the recreation and exhibition area was chosen to represent tourist demand, which was then combined with the resident population data to obtain the demand for RRS. The framework constructed in this study quantified and mapped the RRSupply and demand in national parks.

In the management of ecosystems, supply and demand are more important. In this research, the distribution of spatial mismatch between the supply and demand of RRS was determined after the ESDR. The findings demonstrated that the demand for recreation was high in the rural areas of Changhong Township, whereas recreation supply was abundant in highly naturalized environments, like forests and water bodies, which was in alignment with the findings of previous studies [3].

4.2. Implication for Planning and Management

The supply and demand for cultural services can inform spatial planning and utilization, providing a scientific basis for decision-making [39,58]. Changhong Township in the central part of Qianjiangyuan National Park attracts a large number of tourists with its rich recreational resources, but this has led to the destruction of the pristine state and integrity of the nationally important ecosystems, which affects the harmonious interaction

and symbiotic development of human and nature. This study's assessment and spatial mapping of the supply and demand of RRS in Changhong Township will assist planners and policymakers in determining the ecosystem's capacity to provide recreational services and the level of societal demand.

Based on the results of the zoning of the RRS supply–demand relationship in Changhong Township, the four types of areas are, in descending order of size, marginal recreation service area, potential area, developed area, and demand area. The marginal recreation service area is dominated by high-altitude forests, and ecological protection and restoration should be the core of any effort to reduce human interference. The distribution of recreation service in potential areas is fragmented, mainly in areas with rich natural landscapes. According to the area's natural landscape resources, nature education, ecotourism, and other special cultural experience programs can be developed moderately. The developed recreation service area is mainly distributed along roads around villages and towns. Tourism facilities need to be improved in the area, and the number of tourists must be controlled to prevent excessive tourism from damaging cultural and natural resources and to ensure the sustainability of the balance between supply and demand. The demand area for recreation service is mainly located around villages, and it is important to guide local communities in participating in the supply of cultural services. To improve the supply of services, we need to develop community-specific offerings such as agricultural product experiences. In addition, tourists should be diverted to neighboring areas with strong supply capacity to alleviate the pressure.

It is also important to note that for areas where demand exceeds supply, the impact on the environment and sustainability should be considered rather than the unlimited use of recreational resources. National parks contain important forest ecosystems and animal habitats, which should also be strictly protected. In addition, simply improving the RRS supply capacity does not necessarily lead to sustainable service provision; we also need to consider improving the accessibility of services [20].

5. Conclusions

This study took the Changhong Township in Qianjiangyuan National Park as an example and proposed a comprehensive framework to map and assess the spatial distribution of RRS supply and demand. This study used a combination of GIS and MaxEnt as tools, which played a positive role in saving time when modeling areas providing cultural ecosystem services. The results showed that the high supply areas of RRS were mainly located in Gaotiankeng, Matouwu, and Xikeng in the northern part of Changhong Township and in Kengkou and Fangzhuang in the southern part of the township. The high-demand areas of RRS consisted of four clusters: Xiawu and Kengkou, Gaotiankeng and Matouwu, Kukeng and Xishulin, and Xikeng. While these areas are reasonably used for recreation, management should also pay attention to the protection of ecology, especially the surrounding areas of villages, roads, and farmlands in the study area.

In addition, based on the relationships between the supply capacity of rural recreation services and the level of demand, this study found that a greater proportion of areas where the supply of RRS is greater than the demand was mainly located in areas with a high degree of naturalization. This study also divided Changhong Township into four types of zones: developed recreation service area, potential recreation service area, recreation service demand area, and marginal recreation service area. Then, we put forward corresponding suggestions for the development and management of RRS in the four types of zones. In conclusion, by spatializing the supply and demand of RRS, the results of this study can offer a theoretical framework for the scientific application and decision-making of rural cultural services.

The limitations of this study need to be acknowledged. Although there are statistics on the overall tourist visits to Changhong Township, historical statistical data specific to each village is lacking. Therefore, the recreation and exhibition area was used to represent the recreational demand of tourists. With the improvement of local management and data statistics, the availability of spatial distribution data of tourists in the future can make the study of recreational demand more accurate. In our future research, we aim to improve the accuracy of this study by obtaining tourism visitation data specific to each village. Furthermore, the following study can also consider the spatial and temporal evolution of the RRS supply and demand in national park rural areas in order to propose dynamic management strategies.

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Abbreviations

The following abbreviations are used in this manuscript:

CES	cultural ecosystem services
RRS	rural recreation services
QNP	The Qianjiangyuan National Park

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