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Original Research

Ecotourism Suitability and Zoning from the Tourist Perspective: a Nature Reserve Case Study

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Abstract

This paper uses eight criteria – slope, tourism attractiveness, drainage system density, grassland coverage, forest coverage, community remoteness, altitude, and road network density – to evaluate the ecotourism suitability of China's Liangheyuan (LHY) Nature Reserve. It calculates the criteria evaluation weights from 330 online tourist responses through an analytic hierarchy process (AHP) and uses GIS10.2 space analysis software to analyze the ecotourism suitability of the study area. It combines the results with the nature reserve's functions to consider ecotourism developments. There are a number of results:

1) The ecotourism suitability of LHY is divided into five levels, with level I having the lowest ecological value and being suitable for mass tourism or general ecotourism. Level V is of considerable ecological value, has high environmental sensitivity, and is suitable for ecotourism with strict environmental constraints.

2) The questionnaire results, reflecting tourist preferences, show that the maximum and minimum weights of suitability evaluation criteria are the drainage system network density (0.2375) and altitude (0.0405), respectively.

3) Large areas of the reserve are classified as moderately suitable, indicating that the study area has a relatively significant potential for ecotourism development.

4) According to the suitability evaluation result and the nature reserve's environmental characteristics, the scientific experimental zone of the reserve is divided into three functional areas and nine themed subareas, all of which have different functions and roles in terms of ecological protection and tourism development.

Keywords: ecotourism, suitability evaluation, tourist preference, Liangheyuan Nature Reserve, Xinjiang China

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Introduction

In the middle and late 20th century, the scope and intensity of traditional mass tourism activities exceeded the bearing capacity of the natural environment, leading to the destruction of the ecological environment around tourist spots and the devaluation of tourism resources, and hindering the sustainable development of the tourism industry. Ecotourism emerged as a bridge between tourism development and environmental protection. It has received the support of tourism researchers and participants, and has become a sector with the fastest growth in the whole tourism market recently [1-3]. Implementing ecotourism initiatives in areas where sustainable development is required could help to protect natural landscapes while also contributing to the wealth of local residents. Areas that are suitable for ecotourism tend to have high-quality primitive ecological environments and abundant tourism resources. Few external human activities impact such areas and the population tends to be small and the economy undeveloped. These areas have fragile and sensitive ecological systems, and too much external interference would lead to ecological imbalances or to environmental destruction that would be costly and take a long time to restore [4, 5]. Nature reserves, with unique ecological environments and natural landscapes, are now ecotourism hotspots. Tourism development has brought benefits to the reserves but also posed significant ecological protection challenges. Presently, there are no universal appraisal standards for ecotourism development in nature reserves, and previous research focuses on value protection or on protection management [6-11]. In terms of social demands for ecotourism [12, 13], research focuses on personal preference [14], psychological motivation [15], behavior [16], and population characteristics [17].

In relation to the long-term sustainable maintenance of nature reserves, evaluating the ecological quality of natural lands is of greater practical significance than evaluating tourism facilities [18]. Ecotourism suitability evaluation is also appropriate for evaluating the suitability of developing ecotourism activities in different sections of ecotourism areas. This evaluation is based on the influences that different natural factors have on the development of ecotourism activities and then identifies their respective weights and the spatial quality of their combination [1]. Previously, the suitability of ecotourism was measured based on ecological bearing capacity [19, 20] or by referring to the landscape visual evaluation method [21, 22]. In relation to reference indicators, studies have used evaluation criteria such as naturalness, wildlife distribution, ecotourism landscape and ecotourism community [23], ecological value, tourism attractiveness, the environment's self-recovery ability and resource diversity [24], landform and topography, land use, and slope [25]. Most research adopts the analytic hierarchy process (AHP) and Delphi methods to assign weights and to comprehensively calculate the various indicators. The suitability evaluation results are then improved and presented spatially in combination with geographic information system (GIS) [26-29]. Research on the relevant suitability evaluation is relatively mature for the general tourism sector. However, the suitability evaluation criteria and the weights that are used for ecotourism tend to arise from the opinions of experts and scholars in related research fields. Moreover, the evaluation results are based on the existing tourism resources and the tourists' motivation and participation are neglected. Ecotourism, which is dependent on the flow of tourists, needs to provide ecotourism products and management standards according to the tourists' preferences and characteristics [30, 31]. Overall, there is a need for further research on tourist preferences toward, and cognition of, tourist destinations.

Presently, Chinese ecotourism development is mainly undertaken in nature reserves, forest parks, and well-known scenic spots [32-34]. The administrators of nature reserves consider ecotourism to be an effective method of environmental protection. The eco-tourists hope to experience primitive environments and to be exposed to local traditional culture, and the local governments hope that ecotourism will help fuel local economic growth and create jobs. The challenge faced by nature reserves is to fulfill their tourism potential while protecting biodiversity, benefitting the local community residents and realizing the visions of the above-mentioned three parties.

The Altai mountain region in northwest China's Xinjiang territory is a natural transition belt that forms part of Central Asia's Altai mountain range. Liangheyuan (LHY) Nature Reserve is located in this region and is very sensitive to climate change and to ecological interference because of its particular geographic location. Recently, the constant expansion of human activities and the unplanned development and use of biological resources in the area mean that the reserve can no longer be self-regulated and that environmental protection and management have become increasingly serious. This paper evaluates ecotourism suitability and the functional zoning of the reserve area to provide guidance to and reference for LHY – and for other nature reserves – to develop ecotourism according to local conditions. It uses a questionnaire to obtain the evaluation criteria weights and analyzes the reserve's spatial factors (such as landform, topography, vegetation coverage, drainage system, road network, community, and scenic spots) to identify their relationships with ecotourism suitability.

Study Area

The LHY Nature Reserve is located in the Altai mountain biogeographic province and the Altai-Sayan ecoregion. It boasts an ecological system of mixed mountainous lands and a variety of ecological landscapes such as wetlands, rivers, forests, and grasslands, and is home to diverse biological resources including animals, insects, birds [35], etc. In addition, it has the richest wetland resources, natural forest resources, and rare wild animal and plant resources of China's inland arid areas, and is an important strategic water resource reserve in northwestern China. LHY was established in 2001 to protect the headstream ecological environments of the Irtysh and the Wulungu rivers, as well as the forest, wild animals and

plants, grasslands, marshy grasslands, and wetlands. The reserve covers the mountainous areas of three counties (Fuhai, Fuyun and Qinghe), and has a total area of 67.59 ha. It is divided into three zones: core, buffer, and scientific experimental (Fig. 1).

The study area is a southward extension of the Europe-Siberia taiga forest region, and forms a clear vertical landform zoning structure. Moreover, the study area boasts landscape resources like Arctic tundra, taiga, forest steppe, and desert. All of these aspects make it particularly suitable for developing ecotourism. The study area is home to many nationalities, where different lifestyles and traditional ethnic customs have become rich tourism resources. The area is attracting increasing numbers of domestic and overseas self-service (e.g. backpackers and self-driving) tourists.

Data and Methodology

The Naturalness Continuum Framework

Ceballos-Lascurain [36] first defined the ecotourism concept as the responsible tourist behavior of enjoying and appreciating natural and cultural landscapes in a certain natural territory under the conditions of protecting the ecological environment, lowering the negative tourism influences, providing beneficial social and economic activities for local residents, and not disturbing the natural territory. The naturalness concept underlies the ecotourism environment, objective, and product: areas with high naturalness levels and significant primitive ecological values are usually most attractive to tourists. However, such areas usually have very sensitive ecological environments and tourism development and environmental protection need to be well balanced [37]. By referring to and changing the naturalness continuum framework brought forward by Boyd et al. [23], this paper applies it to ecotourism suitability evaluation (Fig. 2). As an area is less impacted by human activities, its naturalness will progressively increase. If tourism activities in that area are strictly controlled, then its ecotourism suitability will increase. There are some urban tourism landscapes in the study area that have relatively low naturalness because of human influences, and as human impacts increase, the suitability for developing ecotourism gradually weakens. The permanent residents in the study area are ethnic groups such as the Kazak, Hui, Uygur, and Han. This area is economically undeveloped and relies heavily on the agricultural and animal husbandry industries, along with the auxiliary industries of forest felling, grassland cultivation, and agricultural and stockbreeding product processing.

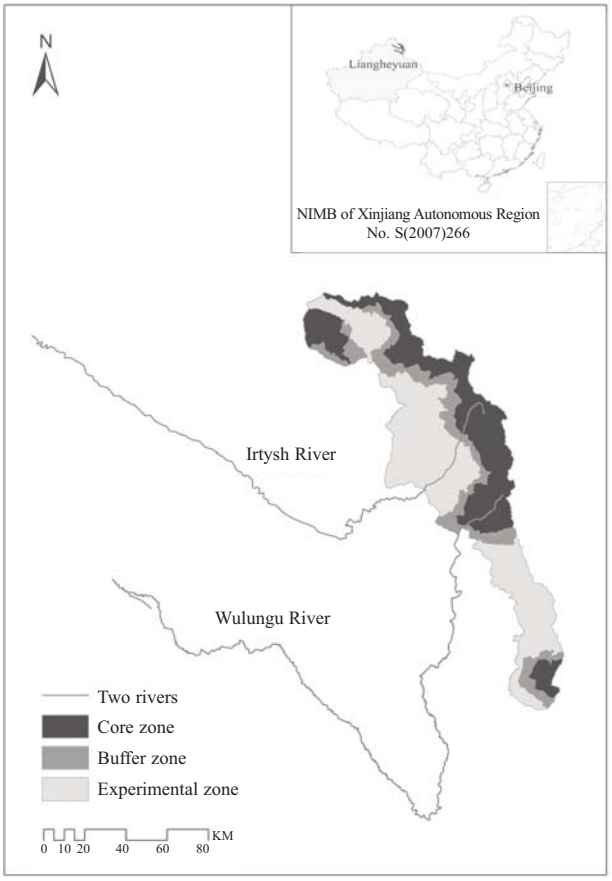


Fig. 1. LHY location and nature reserve.

Our paper divides the naturalness scores for developing ecotourism in LHY into five levels:

- Level I indicates a land parcel of relatively low naturalness that is not suitable for developing ecotourism, which requires strict environmental regulations, but that is suitable for mass tourism, or that can offer a better experience to tourists after its existing tourism service facilities are improved.
- Level II is an intermediate level between levels I and III.
- Level III indicates a land parcel of moderate naturalness that may optimize the existing tourism resources to properly develop mass ecotourism, and that can provide opportunities for mass tourists to participate in ecotourism.
- Level IV is an intermediate level between levels III and V.
- Level V indicates a land parcel of high naturalness that is located a considerable distance from towns and that is suitable for developing ecotourism, which needs to meet strict environmental regulations.

Guiding the behavior of ecotourism participants in such a land parcel can encourage them to take ecologically protective actions to minimize their influence on the primitive ecological environment and thereby offer it the greatest protection.

The People's Republic of China Nature Reserve Regulations state that it is strictly forbidden to develop tourism activities in the core and buffer zones of nature reserves, and that moderate sightseeing and tourism activities can be undertaken in the scientific experimental zone. This paper fully considers this restriction in relation to the ecotourism function zoning. However, ecotourism suitability is mainly based on the discussion on the background conditions of naturalness in an area, and this restriction is temporarily not considered during the evaluation.

Suitability Evaluation System and Classification

This paper referred to domestic and overseas research on ecotourism suitability evaluation [38-40], consulted experts in the field of ecotourism, and related the actual situation in the LHY Reserve with the available related accurate data to select eight suitability evaluation criteria: slope, tourism attractiveness, drainage system density, grassland coverage, forest coverage, community remoteness, altitude, and road network density (Table 1). Here, the altitude is divided into four levels because of the influences of LHY's ladder-shaped landform on the structure of vertical landform zoning and bio-climatic conditions. The slope is classified into five levels by referring to the ecological bearing capacity [41]. The steeper a slope, the more easily water and soil loss will occur. Moreover, its vegetation will be more easily destroyed and more difficult to recover. This will have a significant ecological and visual impact, but the naturalness of such slopes is high. A gentle slope boasts fertile soil and dense vegetation can tolerate high-intensity activities such as farming and construction, and is subject to greater human activity influences than a steep slope.

The drainage system and road network density are divided into five levels via GIS. The criterion of drainage system density indicates the water area (in this case rivers and lakes) proportion of the total area. So the denser the drainage system and the closer it is to water and wetland, the higher the naturalness. The metamorphosis from land cover to land use for urban, industrial, and other socio-economic developments has a remarkably evolved morphological landscape, but the process has resulted in various impacts on natural resources [42]. The criterion of road network density indicates the traffic road area (here indicating all the roads open to vehicles) proportion of the total area. Road facilities generally contain the footprints of human activities, and a developed road network tends to be in close proximity to the gathering areas of population and social economic activities, so the naturalness is weakened.

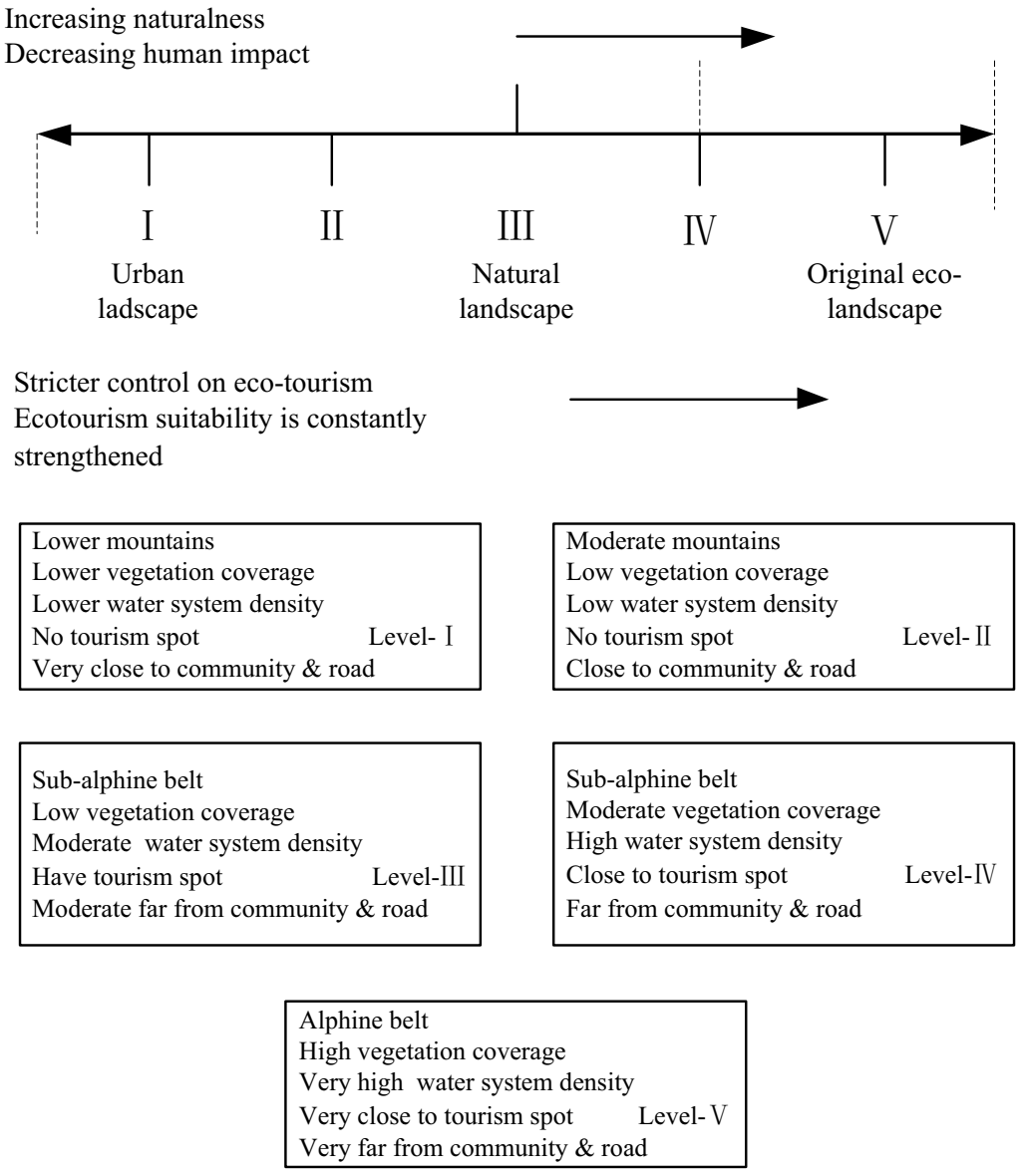


Fig. 2. The naturalness continuum framework and its classifications.

Table 1. Criteria and scores used to identify ecotourism suitability in the LHY Nature Reserve.

Criteria	Attributes	Suitability	Score
C1 Slope	>30º	Very high	5
	20-30º	High	4
	15-20º	Moderate	3
	10-15º	Low	2
	<10º	Very low	1
C2 Tourism attractiveness	<1 km	Very high	5
	1-3 km	High	4
	3-5 km	Moderate	3
	5-10 km	Low	2
	>10 km	Very low	1
C3 Drainage system density	>63%	Very high	5
	47-63%	High	4
	32-47%	Moderate	3
	16-32%	Low	2
	<16%	Very low	1
C4 Grassland coverage	High coverage grass	High	4
	Moderate coverage grass	Moderate	3
	Low coverage grass	Low	2
	Other types	Very low	1
C5 Forest coverage	Shrubbery	High	4
	Sparse wood	Moderate	3
	Forest land	Low	2
	Other types	Very low	1
C6 Community remoteness	>10 km	Very high	5
	5-10 km	High	4
	3-5 km	Moderate	3
	1-3 km	Low	2
	<1 km	Very low	1
C7 Altitude	>3 km	High	4
	2.5-3 km	Moderate	3
	1.8-2.5 km	Low	2
	<1.8 km	Very low	1
C8 Road network density	<10%	Very high	5
	10-20%	High	4
	20-30%	Moderate	3
	30-40%	Low	2
	>40%	Very low	1

Table 2. Rating scale for the relative importance between two criteria.

Intensity of importance	Notes
1	Two attributes are equally important
2	One attribute is slightly more important than the other
3	One attribute is moderately more important than the other
4	One attribute is much more important than the other
5	One attribute is extremely more important than the other

In accordance with the vegetation type or coverage standard in the National Standard of the People's Republic of China, Classification of Current State of Land Use, forest and grassland coverage are divided into four levels. Referring to Pierskalla et al. [43] for their distribution of the belts for participatory leisure and entertainment opportunities, this paper divides tourism attractiveness and community remoteness into five levels by distance. Tourism attractiveness refers to the tourism spots already developed in the reserve, while community indicates the residential communities of herdsmen scattered in the study area (population of the village < 1000). The eight suitability criteria are allocated scores from 1 to 5, with a higher score indicating a higher naturalness.

Questionnaire Design and Weights Assignment

One of the limitations of group response analysis is that each participation group can differ by social background, personal factors, behavior habits, and emotional preferences; therefore, the key suitability factors considered may vary per group. Recommendations arising from such analysis would possibly affect the development of regional ecotourism resources and products. This paper used an online questionnaire to seek the opinions of tourists on the importance of ecotourism suitability evaluation criteria at random. The questionnaire has two parts: the respondents' personal information and their evaluation of the importance of the ecotourism suitability criteria. This paper designs a pairwise comparison scale of the eight criteria [44] for suitability evaluation (Table 2) to identify the evaluation criteria weights and to provide reference for LHY ecotourism development function zoning.

Data Collection and Processing

This paper evaluates LHY ecotourism suitability by adopting a spatial analysis method that combines GIS and AHP. Table 3 lists the official basic data sources. To evaluate suitability, in this paper we:

1) Collected the questionnaire data and obtained the respondents' comparison and judgment matrix data

Table 3. Data types and sources.

Data	Source
Altitude and slope data (2015)	Geospatial Data Cloud (http://www.gscloud.cn/csearch.jsp#)
Land use type data (grassland, forest, resident community, water area, road) 2010	Atlas of Xinjiang Uygur Autonomous Region (2010)
Tourism spot data (2014)	Xinjiang, China Key Tourism Resources Investigation Database 2014

2) Checked the consistency of the judgment matrix and calculated the weights of the eight evaluation criteria using the YaAHP analysis software
3) Segmented the LHY Reserve into 7,731,247 grids of 30×30 m (900 m^2) using the GIS10.2 software analysis platform: each land parcel (grid) is considered as a basic spatial evaluation unit
4) Calculated the individual value for the eight evaluation indexes, assigned the weights according to the questionnaire's judgment matrix and summarized the weights to obtain the comprehensive suitability result for each grid.

The paper obtained the weights for the suitability evaluation criteria using the YaAHP analysis software. The average score from the valid questionnaires was input into judgment matrix *B* (Table 4). The matrix consistency was checked by calculating:

$$CI = \frac{\lambda_{\max} - n}{n-1}, \text{ n=8} \quad (1)$$

$$CR = \frac{CI}{RI} < 0.10 \quad (2)$$

...where *CI* is the consistency index, λ_{max} is the maximum characteristic root of the judgment matrix, *RI* is the average random consistency index [44], and *CR* is the random consistency proportion. For matrix *B* the calculation should satisfy:

$$BW = \lambda_{\max} W \quad (3)$$

...where *W* is the normalized eigenvector corresponding to λ_{max}, and *W*'s component W_i is the weight of the corresponding element single arrangement. In the case of *CR*<0.1, it is considered that the calculation results are consistent. The weight calculation results and judgment matrix are shown in Table 4.

This paper calculates and obtains the weights of the suitability evaluation criteria based on AHP, and completes a spatial analysis on LHY ecotourism using GIS10.2. The linear equation of spatial superposition computation is:

$$S = \begin{bmatrix} S_1 \\ \vdots \\ S_i \end{bmatrix} = \begin{bmatrix} C_{11} & \cdots & C_{1j} \\ \vdots & \ddots & \vdots \\ C_{j1} & \cdots & C_{ij} \end{bmatrix} * \begin{bmatrix} W_1 \\ \vdots \\ W_j \end{bmatrix} \quad (4)$$

...where *i* indicates the land parcel *i*, *j* indicates the evaluation criterion *j*, the matrix element C_{ij} indicates the suitability level of land parcel *i* in terms of evaluation criterion *j*, and S_i indicates the comprehensive suitability of land parcel i for developing ecotourism.

According to the comprehensive suitability calculation results, the paper adopts the "Natural Breaks" [45] of GIS software to divide the suitability for LHY ecotourism development into five levels. The areas of relatively high suitability are subject to little interference from human activities, have high naturalness levels, and are mostly endowed with primitive ecological landscapes. Therefore, such areas are suitable for ecotourism developments that have strict environmental constraints and the development of mass tourism, or the construction of large tourism projects must be restricted to maintain the primitiveness of the natural environment. This paper combines the tourists'

Table 4. Ecotourism suitability evaluation criteria importance judgment matrix and weights.

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	*W*
C1	1	2.5	0.2458	0.6375	0.575	1.6	1.825	0.925	0.1039
C2		1	0.3	0.2958	0.3375	1.6	2.075	0.7083	0.0711
C3			1	1.2	2.25	2.575	4.75	0.95	0.2375
C4				1	2	2.5	3.75	1.575	0.1962
C5					1	2.075	3.5	1.575	0.1487
C6						1	2.875	1.0625	0.0816
C7							1	0.325	0.0405
C8								1	0.1205

CI = 0.0521, *RI* = 1.41, *CR* = 0.0370, λ = 8.3651.

Table 5. Demographic and sociological characteristics of online questionnaire respondents.

Gender	Ratio
Male	56.97%
Female	43.03%
Age	Ratio
<20	15.76%
20-30	26.67%
30-40	35.76%
>40	21.81%
Education	Ratio
High school or lower	29.70%
Undergraduate	26.67%
Higher than Undergraduate	43.63%
Ecotourism participation experience	Ratio
Never	32.12%
Occasional	33.94%
Always	33.94%
Occupation	Ratio
Freelance work	21.21%
Company employee	21.82%
Student	22.42%
Civil servants	22.73%
Scholars	11.82%
Main travel purpose (one option only)	Ratio
Leisure	26.67%
Fitness	22.42%
Adventure	30.91%
Scientific investigation	20.00%
Ecotourism cognition degree	Ratio
Unknown	10.33%
Knows a little	33.15%
Knows well	31.52%
Knows very well	25.00%

preferences and the reserve's function zoning (Fig. 1) when considering the development of the ecological and tourism functions of the reserve. It takes land parcels of moderate suitability level as areas for moderate ecotourism development and areas of relatively low suitability level as mass tourism areas so as to allow development space for ecological and tourism functions of the reserve.

Our paper uses multinomial logistic regression for the questionnaire analysis via SPSS16.0 analysis software to determine the importance of the ecotourism suitability evaluation criteria selected by the different categories of respondents. This paper establishes a model: the sig value is smaller than 0.01 as obtained through a Chi^2 test of linear regression model, and irrelevant variable factors have been removed in line with the principle that the sig value is smaller than 0.01 as obtained through a Chi^2 test among likelihood ratio test results. The tourists have different demographic and sociological characteristics and different personal experiences; therefore, their ecotourism suitability evaluation focus may differ. To further understand the differences between respondents' evaluations, based on multiple logistic linear regression analysis (when probability P is smaller than 0.05, it indicates that samples have significant differences, otherwise samples don't have significant differences), this paper then conducts the analysis of two independence-sample T-Tests and one-way ANOVA. Wherein gender is a dichotomous variable and two independence-sample T-Test is used. The other six polytomous variables are analyzed by one-way ANOVA and subjected to intra-group multiple comparisons according to homogeneity of variance test results (read LSD value in icase of homogeneity of variance, and read Tamhane value in case of heterogeneity of variance).

Result Analysis and Discussions

Overall Situation of the Sample

The questionnaires were collected via the world's largest questionnaire investigation platform, the Sojump website (http://www.sojump.com/). The questionnaires were issued on April 3, 2015, and 368 questionnaires were completed in 75 days. Of these responses, 38 were considered to be invalid (the respondents had no knowledge of ecotourism), leaving a total of 330 valid samples. The respondents' demographic and sociological characteristics (Table 5) show that: the respondents with different genders, ages, educational backgrounds and careers have different experiences of participating in and degrees of cognition relating to ecotourism; their distribution proportion is generally compliant with the normal distribution; and the sample scope could ensure the authenticity and validity of the following analysis and conclusions.

Evaluation Results and Analysis of the Eight Criteria

The study obtained a spatial distribution chart (Fig. 3) and an area proportion statistical chart (Fig. 4) relating to ecotourism suitability of the LHY Reserve. The current land use in the LHY Reserve is shown in Fig. 3(i) and the study found that the red land parcels (representing high suitability) cover large areas and are relatively concentrated in Figs. 3(c), (f), and (h). LHY has a dense drainage system, its road network is mainly comprised of rural roads, and

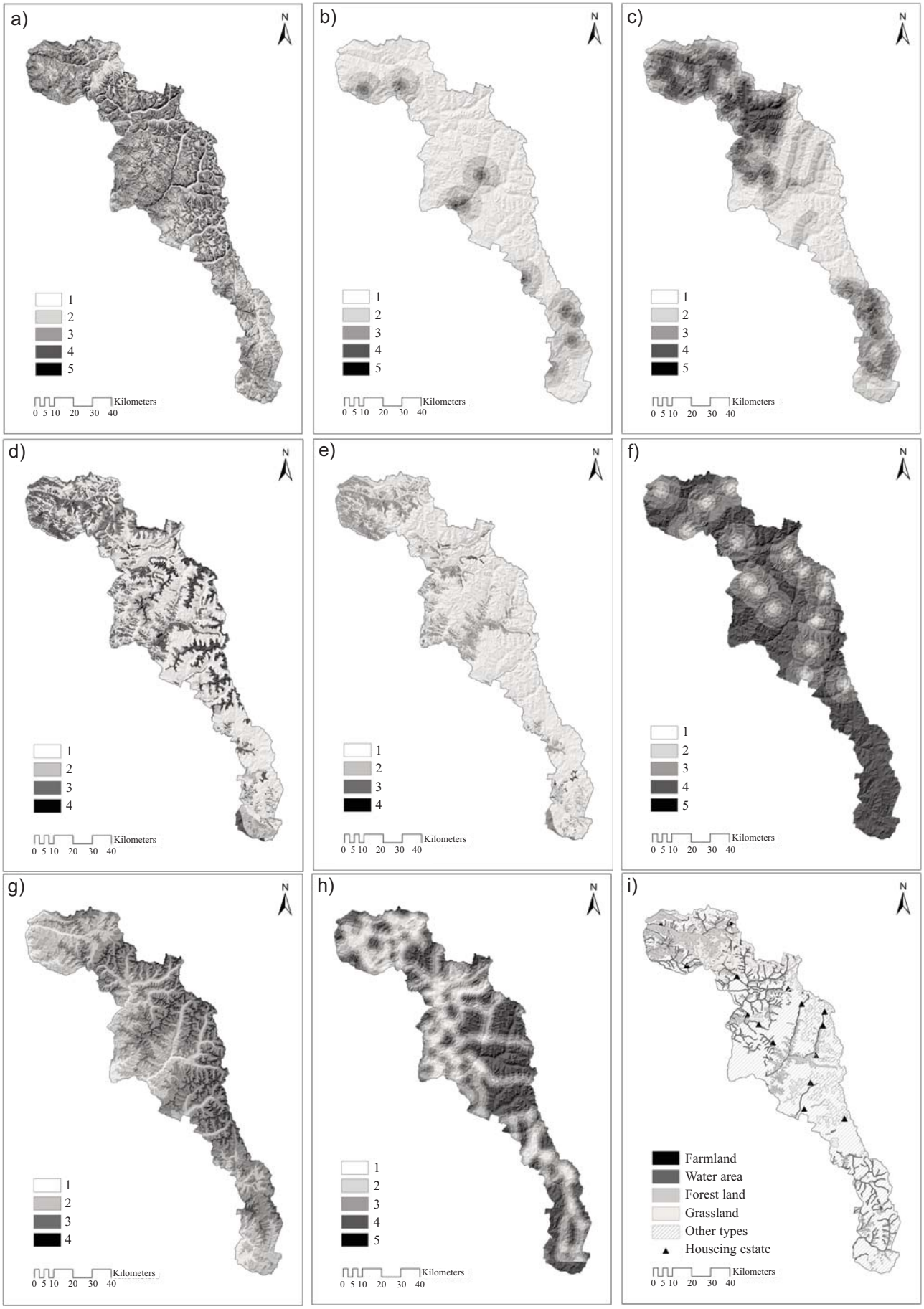


Fig. 3. Liangheyuan Nature Reserve maps based on criteria score for: (a) slope, (b) tourism attractiveness, (c) drainage system density, (d) grassland coverage, (e) forest coverage, (f) community remoteness, (g) altitude, (h) road network density, and (i) present land use.

small-scale residential communities are scattered along its river valleys. These results indicate that LHY ecotourism competitiveness lies with its water areas and wetlands that have low human activity impacts and that boast a primitive ecological environment. The orange land parcels (representing relatively high suitability) are widely distributed as shown in Figs. 3(a), (d), and (g). Grassland coverage exists in the form of primitive ecological landscapes with high naturalness, such as desert steppe, typical steppe, meadow steppe, and cold steppe; moreover, the natural grasslands with over 50% coverage mostly grow by water. The altitude and slope reflect the landform, the climate, and the natural attributes for developing ecotourism in the study area. Temperature and rainfall vary with altitude. The low-altitude areas are mostly winter pastures, while the high-altitude areas are mostly summer pastures. In terms of season, it is best to develop ecotourism initiatives for the summer here. The morphostructure in LHY has been formed by paleotectonic and neotectonic movements, resulting in various landforms such as mountains, rivers and lakes, intermountain basins, and glaciers. As the slope increases, the topography becomes more complicated. The primitive ecological environment becomes more fragile and has a smaller ecological bearing capacity: ecotourism developments in such areas must meet strict environmental constraints. The results reveal that the reserve areas with relatively large grassland coverage tend to be at relatively high altitudes with steep slopes. In Fig. 3(e), the shrub forests with relatively high suitability scores mainly grow on the windward slopes of high mountains and in river valley belts where warm and wet air currents pass by; these ecological landscapes are mainly natural forest farms adjoining water. The LHY Reserve is located in a high-altitude mountainous region that has widely-distributed glaciers. Its large areas of high-mountain vegetation fall into the alpine tundra landscape category listed under "other types" in Table 1 (criterion C4); this shows that such areas have a relatively low suitability score. Fig. 3(b) and related materials [35] reveal that there are a collection of physiographic landscapes, water area landscapes, biological landscapes, and leisure and fitness tourism resources in LHY, which makes the area a good choice for ecotourism development.

Fig. 4 shows how the LHY Reserve area relates to the eight suitability criteria: 7.86% of the lands in the LHY Reserve are within 5 km of an existing scenic area (spot) and 48.82% are more than 10 km from any residential communities; 41.7% of the coverage in the reserve is grasslands of middle and high vegetation coverage, while only 6.1% is shrub, wood, or forestland; 48.4% of the area has a drainage system density of over 30%; 28.5% has a road network density of less than 10%; the majority of the reserve is in the middle mountains with an altitude over 1,800 m; and areas with a slope greater than 20º account for nearly 50% of the reserve. Areas of low (1-2), middle (3), and high (4-5) naturalness scores account for 49.9%, 18.3%, and 31.8% of the land area, respectively.

Weighted and Unweighted Result Comparison

The online questionnaire results were analyzed *via* YaAHP software, giving the weights of the eight criteria for ecotourism suitability evaluation: slope 0.1039, tourism attractiveness 0.0711, drainage system density 0.2375, grassland coverage 0.1962, forest coverage 0.1487, community remoteness 0.0816, altitude 0.0405, and road network density 0.1205. The analysis shows that the respondents consider that drainage system density is the most important criterion for ecotourism suitability evaluation, followed by vegetation coverage and road network density. LHY is an important water source reserve in China's northwest inland arid area, and the glaciers, lakes, rivers, forests, and grasslands are important natural ecological landscapes here. The reserve has complicated landforms, significant altitude variations, and poor accessibility, and most of the roads are non-graded highways with some not open to vehicles; hence the integrity and naturalness of its primitive landscapes are well preserved. Additionally, the reserve is located in the orogenic belt of the Altai Mountains, giving it a complicated mountainous landform, and its slope factor has a relatively large influence on its ecotourism suitability evaluation. The reserve has a minimum and maximum altitude of 1,136 m and 3,844 m, respectively; however, because it is abundant in mountainous land resources, the weight assigned to altitude is relatively low. Overall, the

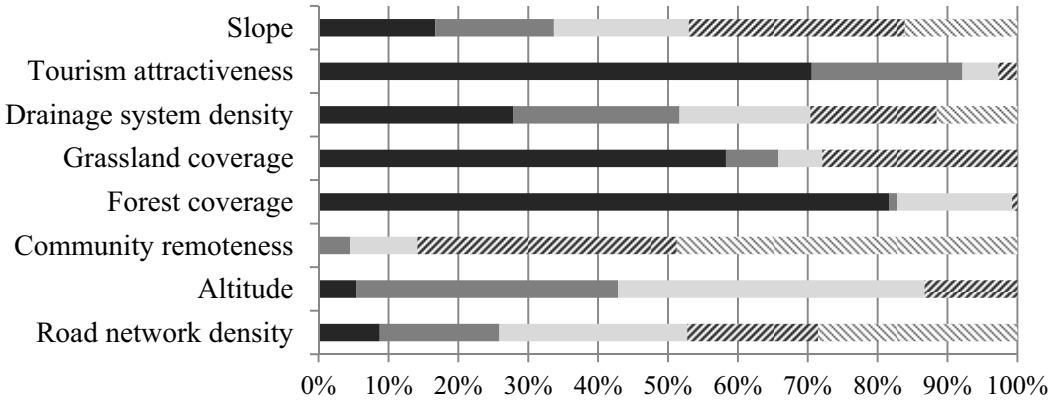


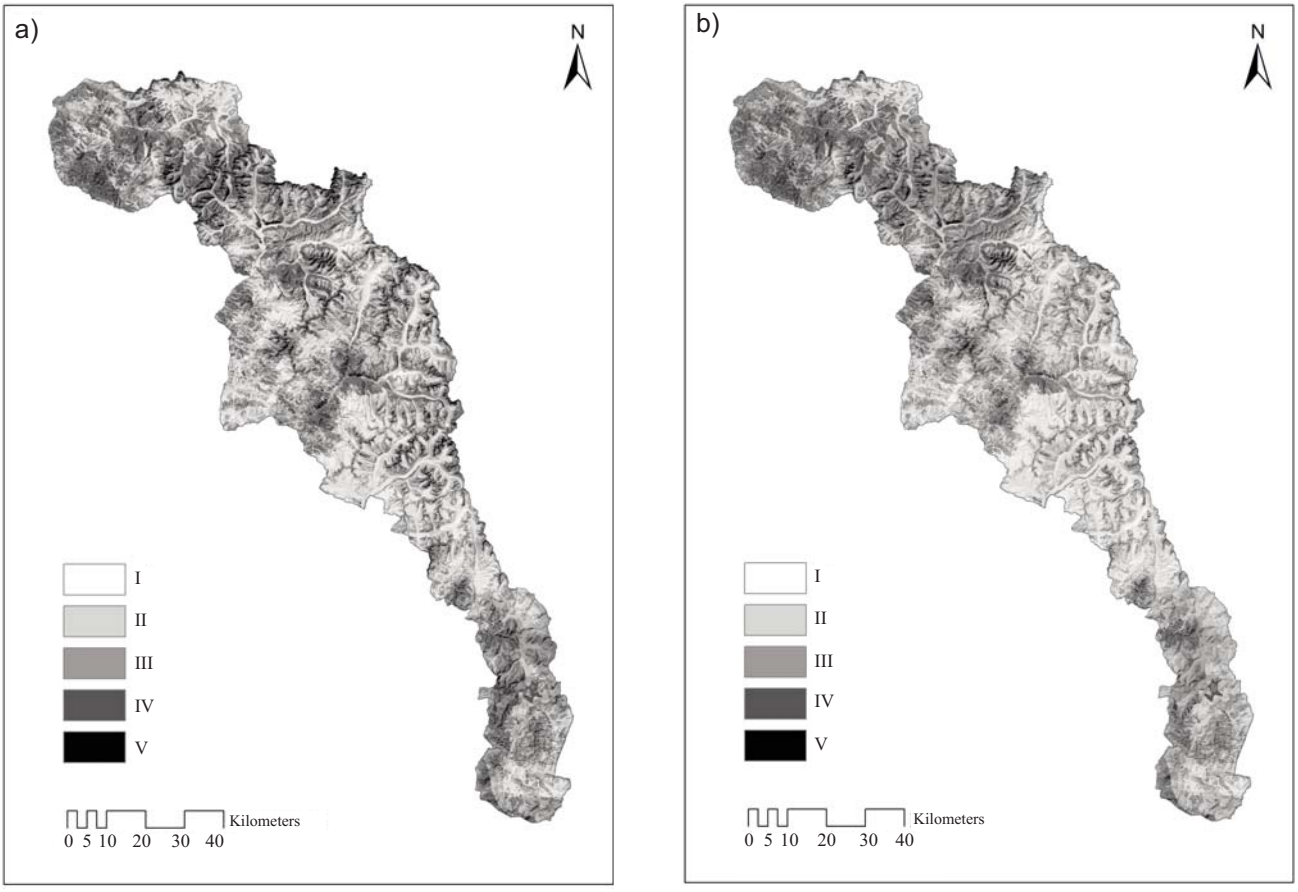
Fig. 4. LHY Nature Reserve coverage rate for each criterion measured by naturalness scores (colors from left to right indicate scores 1-5).

weights calculated according to the questionnaire investigation and AHP generally meet the actual situation in the study area. The eight criteria weights underwent GIS superposition analysis and were classified using the "Natural Breaks" [45] method to obtain the spatial distribution of comprehensive suitability for ecotourism in the reserve shown in Fig. 5(b). Figs. 5(a) and (b) show that the tourists' personal preferences have some effects on the area ratios and on the LHY ecotourism suitability level distributions. For example, Table 6 summarizes the land parcel scores based on the suitability and eco-landscape results. It shows that nearly 50% of the land parcels are classified as level II or level III suitability, and their weighted area results are slightly larger than their unweighted results; however, the weighted area results for level I, level IV, and level V suitability are slightly smaller than the unweighted results (Table 6).

Fig. 5(b) shows that spaces with different suitability levels are scattered across the reserve. The level V areas are mainly in the north sub-alpine belt. Such areas have a dense drainage system, a relatively steep slope, a large forest and grassland coverage ratio, a high primitive ecological naturalness, and few residential communities. They tend to be rich in water areas, wetlands, grasslands, and forestland landscapes. The level IV and level III areas are distributed in the middle and low mountain belt areas with a relatively high slope and large forest coverage ratio, and are located far from the residential communities in the northeast and south. The level I and level II areas are mainly distributed in the middle part of the reserve. The landforms there make such areas relatively scattered with a dense road network and centralized residential communities; however, the drainage system is sparse and the vegetation coverage ratio is relatively small here.

Ecotourism Suitability Evaluation Variations

This paper highlights "Naturalness" when establishing its ecotourism suitability evaluation system. However, because those participating in ecotourism have different social or natural characteristics, their definitions of the comprehensive suitability of an ecotourism destination may vary. This can affect ecotourism function zoning and market orientation. SPSS16.0 statistical analysis identified that there is a significant correlation between: tourist age and road network density, travel objective and tourism attractiveness, the degree of cognition with and understanding of ecotourism, and the importance of drainage system density. Moreover, there is a significant correlation between educational background and forest coverage, career and grassland coverage, and participation degree and natural factors of altitude and slope. There was no significant correlation between gender and any of the eight suitability evaluation criteria. Table 7 lists the variables of significance and the



Weighted Unweighted

Fig. 5. Ecotourism suitability maps for LHY Nature Reserve.

Table 6. Area percentage and score range based on suitability levels and eco-landscape involved in the LHY Natural Reserve.

Level	Score range	Weighted ratio	Unweighted ratio	Main eco-landscape
I	1.122-2.0298	18.05%	18.93%	Qinggeli river, Kalanuola spring, Summer pasture
II	2.0298-2.4042	27.36%	21.44%	Irtysh River, Birch forest park, Chaganguole Lake
III	2.4042-2.7819	25.69%	23.21%	Sandao Lake, Woertaku Lake, Alpine coniferous forest
IV	2.7819-3.2267	18.20%	18.43%	Laoyingzuii rock painting, Kayierte River, Jilande spring, Winter pasture
V	3.2267-4.2728	10.70%	17.99%	Kumualashan spring, Haierte River, Nuoerte River, Shibaerku Lake, Forest and Nursery

average value of the various categories within the item groups. There is a significant correlation between aging and the road network development degree: the older respondents pay more attention to road infrastructure than the younger respondents. The educational background and career differences significantly affect the respondents' preference for vegetation coverage. Respondents with a high educational background or having an academic-type career highly value vegetation coverage. The travel objectives significantly affect the respondents' evaluation of the importance of tourism attractiveness, and the mass tourism groups aiming for personal fitness and leisure value tourism attractiveness more than groups aiming for exploration or scientific investigation. Those who participate in ecotourism, or deeply understand ecotourism, often strongly agree with the importance of altitude and slope as naturalness evaluation criteria.

Ecotourism Functional Zoning

Our paper undertakes an ecotourism function zoning of the study area based on the ecotourism suitability evaluation results and on the special requirements for water source and grassland vegetation protection in the study area [35], in combination with the functional zoning of the LHY Nature Reserve (Fig. 1). Separate from the core and buffer areas in the reserve, the paper divides the experimental zone into three functional areas: an ecotourism development area with strict constraints, an ecotourism development area with moderate constraints, and a mass tourism area. According to its ecological landscape advantages, the experimental zone can be further divided into nine ecotourism theme areas: water, forest, high-mountain pasture, glacier exploration, scientific popularization and education, natural exploration, pasture experience, folk customs, and natural sightseeing (Fig. 6). These tourism theme areas have different functions and roles in terms of ecological protection and tourism development (Table 8).

The three ecotourism functional areas (the scientific experimental zone) account for 54.26% of the total reserve, with the strict constraints area – primarily in the north of the reserve – accounting for 17.29%. This strict constraints area contains primitive ecological landscapes such as wetlands, densely-covered steppes, and shrub communities. Its landscapes are strongly attractive and it offers an ideal destination for tourists to get close to and enjoy nature. However, its primitive ecological landscapes are ecologically sensitive and are relatively weak in self-recovery and restoration because of the slow self-purification of the water areas and the slow growth of vegetation. Therefore, ecological protection must be prioritized in this functional area and a strict access system must be implemented for eco-tourists.

The moderate constraints ecotourism development area accounts for 18.34% of the reserve, and is mainly distributed in the north and south. The area is composed of complicated mountain landforms of steppe and pasture, and the landscapes here have relatively strong attractiveness. The area does not have as high an ecological value as the strict constraints area, but it has important ecological functions such as regional water and soil preservation. Moreover, it

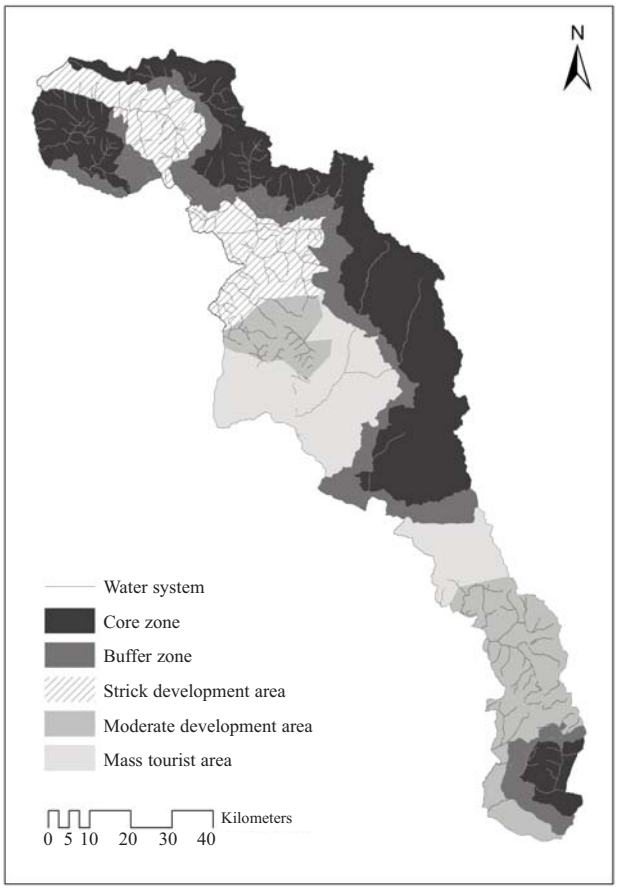


Fig. 6. Functional zone map of the LHY Nature Reserve.

Table 7. Average importance value and significance level of ecotourism suitability indexes among different demographic characteristics.

Items	Classification	Altitude	Slope	Forest	Grassland	Tourism attractiveness	Road network	Drainage system
Age	<20	-	-	-	-	-	2.19	-
	20-30	-	-	-	-	-	3.09	-
	30-40	-	-	-	-	-	3.28	-
	>40	-	-	-	-	-	3.54	-
	F value and significance level	-	-	-	-	-	12.61**	-
Educational background	High school	-	-	2.1	-	-	-	-
	Undergraduate	-	-	2.55	-	-	-	-
	Postgraduate and above	-	-	3.56	-	-	-	-
	F value and significance level	-	-	27.11***	-	-	-	-
Travel objective	Leisure	-	-	-	-	2.33	-	-
	Bodybuilding	-	-	-	-	2.47	-	-
	Exploration	-	-	-	-	2.74	-	-
	Scientific investigation	-	-	-	-	3.34	-	-
	F value and significance level	-	-	-	-	5.05*	-	-
Career	Freelancer	-	-	-	2.08	-	-	-
	Employee	-	-	-	2.86	-	-	-
	Public servant	-	-	-	3.44	-	-	-
	On-campus student	-	-	-	3.73	-	-	-
	Scholar	-	-	-	3.89	-	-	-
	F value and significance level	-	-	-	16.83***	-	-	-
Cognition	Having heard	-	-	-	-	-	-	2.3
	Know something about it	-	-	-	-	-	-	3.7
	Know it very well	-	-	-	-	-	-	4
	F value and significance level	-	-	-	-	-	-	16.16**
Participation degree	Never	1.87	1.91	-	-	-	-	-
	Occasional	2.63	2.62	-	-	-	-	-
	Often	3.27	3.53	-	-	-	-	-
	F value and significance level	21.68***	28.70***	-	-	-	-	-

*p<0.1, **p<0.05, ***p<0.01,
"-" indicates that there is no relevance, or that the relevance is insignificant between the demographic characteristic and the evaluated value, and that there is no significant difference among intra-group populations.

has environmental protection, scientific popularization and education functions. Tourism projects that have relatively weak impacts on the ecological environment can be initiated in this area to facilitate its ecological protection function and to improve the local communities' living environment.

The mass tourism area is mainly located in the middle of the reserve, where residential communities are concentrated. It is located far from the core area and accounts for 18.63% of the reserve. The landscapes here have relatively weak primitiveness and are partially affected by human society. However, the unique natural villages and the summer pastures here have strong tourism attractiveness, so the area is suitable for general sightseeing. Tourism projects based on maintaining the quality of the ecological environment are suitable here.

A joint consideration of Figs. 5 and 6 reveal that the strict constraints ecotourism development area has a high suitability level, the moderate constraints ecotourism devel-

Table 8. LHY Nature Reserve ecotourism development function zoning and main service functions within the experimental zone.

Ecotourism functional area	Ecotourism theme area	Area proportion (%)	Ecological protection functions	Tourism development functions
Ecotourism area with strict constraint	Water area ecotourism	17.29%	Biodiversity protection and water source conservation	Water source protection
	Forest ecotourism		Air regulation and lowering carbon emission	Ecological adjustment
	High-mountain pasture tourism		Preventing wind, consolidating sand, maintaining soil	Conservation of water and soil
	Glacier exploration tourism		Protecting water source and adjusting climate	Ecological services
Ecotourism area with moderate constraint	Scientific popularization and education tourism	18.34%	Popularizing knowledge and strengthening awareness of environmental protection	Strengthening the awareness of ecotourism
	Natural exploration tourism		Nature immersion and discovery	Physical and mental health
	Pasture experience tourism		Water source preservation and ecological animal husbandry	Habitat security
Mass tourism area	Folk customs tourism	18.63%	Promoting the harmony and unification of humans and nature	Supporting communities
	Natural sightseeing tourism		Providing aesthetic landscapes	Ecological services and mind cultivation

opment area has a moderate suitability level, and the mass tourism area has a low suitability level. Research shows that a negative correlation exists between ecotourism suitability and tourism development and use intensity: the higher the ecotourism suitability, the stricter the tourism development constraints and the smaller the pertinent ecotourism participating groups will be. The functional area division is mainly to provide related restrictions on tourism development strength and tourist admittance numbers. The ecotourism functional areas are divided this way to best protect and maintain the reserve. They aim to avoid the unnatural impact and negative influence of the tourism industry on the buffer and core zones of the reserve. This will leave a transition space for ecological system protection and water source conservation in arid areas.

Conclusions

Ecotourism is a rational method for nature reserves to both realize ecological protection and to benefit their local residents. The LHY Nature Reserve in northwestern China is an important water source reserve for the inland arid area. It also has outstanding ecological functions and tourism value. This paper evaluates the ecotourism suitability of the LHY Nature Reserve by applying a GIS spatial analysis technique and AHP analysis software. It divides tourism into functional areas by analyzing the boundary and function of the nature reserve. According to the naturalness continuum framework, the eight evaluation criteria selected for the suitability evaluation process solely relate to the regional naturalness characteristics, and their weights are determined by questionnaire respondents and AHP analysis software. The combined quantification and qualification method used in this study avoids the interference arising from the subjective selection of evaluation criteria. The study has several results:

1) The ecotourism suitability of the LHY Reserve is divided into five levels, where level I has the lowest naturalness and is suitable for mass tourism or general ecotourism. In contrast, level V is of great ecological value, has high environmental sensitivity, and is suitable for ecotourism developments that need strict environmental constraints.
2) The questionnaire results show that the maximum and minimum suitability evaluation criteria weights relate to the drainage system network density (0.2375) and the altitude (0.0405), respectively.
3) Large areas of the reserve are deemed moderately suitable, indicating that the study area has a significant ecotourism development potential.
4) According to the suitability evaluation result and the reserve's environmental characteristics, its experimental zone is divided into three functional areas and nine themed subareas. All of these areas have different functions and roles in terms of ecological protection and tourism development.

This paper takes naturalness to evaluate the suitability for ecotourism development, it determines the criteria weights through an online survey of tourist preferences, and it obtains reasonable conclusions. However, the criteria and their respective evaluations will possibly change as human activities increasingly exert influences on such areas or as the tourists accumulated personal experiences change their perspectives on ecotourism. The present research will assist ecotourism development according to the local reserve conditions by identifying the pertinent tourism products, pro-

tecting the regional ecological environment, and bringing the future tourism functions into full play. The questionnaire will be kept online to obtain further data. The development of ecotourism will benefit from the improvement of the geographical space method [46]. A comprehensive research method is adopted in this paper, and different key criteria can be considered for different reserves in the process of developing their ecotourism. In the future, it will be possible to adapt other methods or further comprehensive website platforms as they emerge to evaluate ecotourism suitability on the precondition of guaranteeing credible results.

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