

# Evaluation of ecological suitability of rural tourism land — a case study of Xi'an city

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**Abstract.** Ecological suitability evaluation is an important prerequisite for rational distribution of tourism. Take Xi'an as an example, selecting six factors as evaluation indexes: elevation, slope, vegetation coverage, river, landscape quality and traffic. After using RS, GIS techniques and resorting to factor weighted superposition method and obtaining the results. The results show that the most suitable, suitable, basic suitable, unsuitable and unavailable land of Xi'an rural tourism respectively account for 17.5%, 25.4%, 20.63%, 22.12% and 14.35%. According to the distribution pattern of different suitability, the corresponding land use measures are put forward for development of rural tourism in Xi'an city, which provides a theoretical basis for Xi'an to explore the coordinated path of ecological protection and economic development.

Man-land relationship has always been an important scientific issue in geography, ecology, urban planning and other fields. Especially when population is growing rapidly, environment and resources are under great pressure and crisis. Specifically, the relationship between man and land is mainly the “mutual inductance”<sup>[1]</sup> relationship between human socio-economic activities and ecological resources such as land and spaces. Rural tourism is a new growth point of rural economic development under the “New Normal”. It can help effectively solve the “three-agriculture” issue and promote the construction of beautiful rural and ecological civilization<sup>[2]</sup>. Based on the perspective of human-land relationship, sensing rural ecological environment is significant for providing exploration path for rural tourism.

Land evaluation is an assessment of the land potential based on land attributes<sup>[3]</sup>. The land property is different, just as D.G Rossiter believes, “land is born unequal”. Land use is also different. “Suitability” can evaluate the degree of satisfaction of different ways of land. Land attributes are varied, and the factors affecting them are plenty. In recent years, the maturity of Geographic Information System (GIS) and Remote Sensing technology (RS) has promoted the development of urban land suitability evaluation<sup>[4]</sup>. Different index selection, weight judgment and model construction will produce different evaluation results.

In the Review of the study of evaluation of land ecological suitability, the land has been transformed from surface plane to stereoscopic space, from a single natural attribute to multiple attributes of ecology and socio-economic. The meaning of ecology is more complicated, which requires hierarchical, representative and comprehensive index construction.

## 1 Research areas and data sources

### 1.1 Research areas

Xi'an is located in the middle of Guanzhong Plain, the northern foothills of Qinling Mountains. (Shown in Figure.1) The profound historical and cultural accumulation and the vast legacy of monuments make Xi'an enjoy the reputation of “Natural History Museum”. From south to north Xi'an consists of the shallow mountain hilly area in the northern foothills of Qinling Mountains, the comprehensive development Zone of Guanzhong Plain, the low-lying area of Wei River main Stream valley and the Loess Plateau area of Weibei<sup>[5]</sup>. The Ba, Chan, Jing, Feng, Lao, Yu and Hao Rivers form a drainage system from east to West. Relying on the above humanistic and ecological resources, rural tourism in the suburban area of Xi'an is developing rapidly, but also facing the problems of declining environmental quality, dislocation of land use and low utilization of resources.



Fig. 1 Overview of the research area

### 1.2 Research data

(1) RS data: Landsat8 satellite images, obtained by Operational Land Image with a resolution of 30 m, cloud cover below 10, receiving time from June to July 2016, vegetation growth is vigorous. ENVI5.2 and ArcGIS10.3 are used to preprocess the image, such as radiation cor-

rection, atmospheric correction and so on. Referring to the *Land use status Distribution (GB/T21010- 2017)* issued in November 2017, combined with the specific land use situation. Land use in the study area is divided into farmland, garden land, forest land, water area and construction land. (2) Digital elevation model data (DEM), obtained by Geospatial Data Cloud.

## 2 Research methods and steps

### 2.1 Acquisition of single factor evaluation information

#### (1) Slope

It is as an important control parameter that affects the investment of rural tourism project construction and the intensity of rural resource exploitation. In the southern part of the study area, the mountainous area with slopes above 25 degrees is 5319.64km<sup>2</sup> [6]. The data of DEM obtained from Geospatial Data Cloud platform is used to generate the slope by the Spatial Analyst tool in ArcGIS.

#### (2) Elevation

This is the measure of elevation ecological sensitivity. The study area has complex topography and diverse landscape. Xi'an has a vast mountainous area, and elevation is an important control item in the scope of ecological protection in Qinling Mountains, which is used to limit development behavior.

#### (3) Vegetation coverage

It is an indicator of the ecosystem diversity, the landscape abundance, and is an important index of rural tourism ecological resource endowment. In this study, vegetation index was used as indicator to reflect the growth and coverage of vegetation on the surface. This study uses Normalized Vegetation Index (NDVI) to estimate vegetation coverage. The formula of NDVI is:

$$\text{NDVI} = \frac{\text{NIR}-\text{Red}}{\text{NIR}+\text{Red}} \quad (1)$$

In this formula, NIR is the reflectivity value of near-infrared band. R is the infrared band reflectivity value.

#### (4) Distance from major rivers

River is an important linear element in landscape ecosystem, which enhances the interest and flexibility of space. However, construction is easy to cause urban flood and water pollution, which can resulted in enormous economic loss, serious threat to human security. Extracting the linear vector data of rivers crawling from Open Street Map in QGIS platform. The distribution of river is obtained by correcting the vector data of rivers based on present situation of river interpreting by RS. Based on the Distance Analysis in ArcGIS10.3, the Euclidean distance of the channel is calculated, and the distance distribution of the main river is formed.

#### (5) Landscape Ecological Quality

Study on the Present Situation of Land Use often neglect the influence of the spatial pattern of land use on the ecological process [7]. Rural tourism is mostly laid out the urban fringe, where the ecosystem is fragile, and the ability to resist the human activity interference is weak. This study introduces landscape pattern index, and con-

stitutes Landscape Ecological Quality (LEQ) by superposition calculation of different indices.(shown in table 1) LEQ reflects the comprehensive impact on the ecological environment system caused by many factors, such as nature and man, in the region.

**Tab.1** Landscape pattern indices

indices	Formula and Description
Landscape Fragmentation Index $C_i$	$C_i = ni/A_i$ , Its value expresses the fragmentation degree of a certain landscape, and the landscape disturbed by human tends to be complex, heterogeneous patch mosaics
Landscape Abruptness Index $F_i$	$F_i = D_i/S_i, D_i = 1/2\sqrt{ni/A}$ , Landscape Abruptness is the degree of separation of individual distribution of different patches in a certain landscape type
Landscape Fractal Index $S_i$	Use the Area-weighted Mean Fractal Dimension refer to $S_i$ , AWMPFD is an index to measure the complexity of landscape space shape, which is influenced by human

$ni$  for Landscape type  $i$  number of patch;  $A_i$  for Landscape type  $i$  area;  $A$  for landscape total area;  $S_i = (S_i - S_{i,min})/(S_{i,max} - S_{i,min})$ . These indices are all negative indices, so  $\text{LEQ} = 1/(C_i + F_i + S_i)$

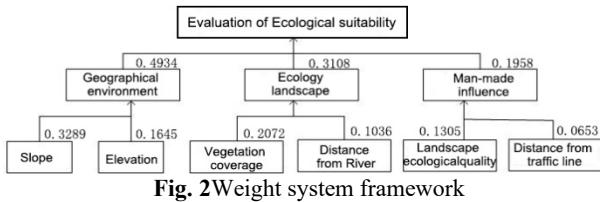
#### (6) Distance from the main traffic lines

Distance from the traffic line is a contradictory factor in the evaluation of ecological suitability of rural tourist land. Its positive significance is reflected in the convenience brought by the traffic line, at the same time, the traffic line has a strong interference to the landscape ecology, which brings displeasure to people's visual senses and psychological feelings, and produces noise pollution. Based on the ArcGIS10.3 platform, this study uses the road vector map of the study area to select the motorway, expressway, primary way to calculate its Euclidean distance, then the raster reclassification, from the road midline 200 meters range to consider its ecological negativity, 200 meters beyond the consideration of its traffic convenience.

### 2.2 Factor weight determination

Using Analytic Hierarchy Process (AHP) to determine the weight of evaluation factors in this study, AHP is a simple method for quantitative analysis of non-quantitative things in system engineering. The various complex factors are expressed in the form of hierarchical structure and analyzed layer by layer.

Taking the geographical environment, ecological landscape, man-made influence as the middle layer, connecting the decision-making and index layers, together constitute the ecological suitability evaluation system of rural tourist land. Using Delphi method to discuss the relative importance of elements of the middle layer and the index layer, as shown in Figure 2, the weight of the factor is obtained. Random Consistency Ratio CR=0.0516<0.10 to meet testing.



### 2.3 Evaluation model of ecological suitability

The evaluation model as follows:

$$S_i = \sum_{k=1}^n w_k \times C_i(k) \quad (2)$$

In the formula,  $i$  is the raster number;  $k$  is the evaluation factor number;  $n$  is the total number of evaluation factors;  $S_i$  is the comprehensive evaluation value of the first grid, and  $w_k$  is the weight of the  $k$  factor;  $C_i(k)$  is the value of the evaluation factor suitability for the  $K$  of the first grid.

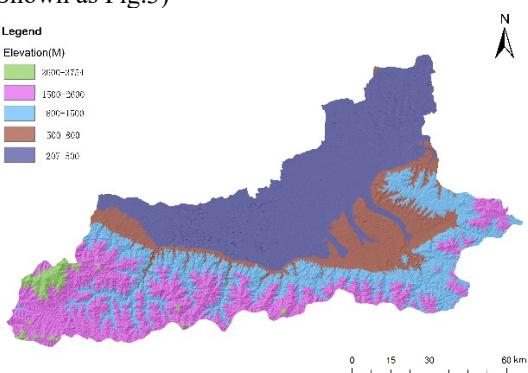
According to the single Factor evaluation standard, each factor is divided into five levels, which are assigned according to 9, 7, 5, 3 ,1 respectively.

## 3 Research results

### 3.1 results of single factor evaluation

#### (1) Elevation

According to the DEM analysis of Xi'an digital elevation model, the lowest elevation of Xi'an is 207 meters and the highest elevation is 3754 meters. The altitude of 800 meters above the mountain area is 4865.234 square kilometers, accounting for 48% of the land area of Xi'an. Mountain area is broad, the contradiction between ecological benefit and economic benefit is sharp. That is the main problem of urban construction in Xi'an, and is also the main bottleneck of rural tourism development. (Shown as Fig.3)



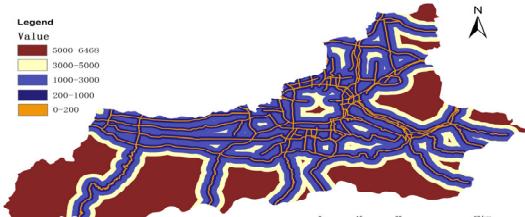
### (5) Landscape Ecological Quality

Using Fragststs4.2 to calculate the landscape pattern index. It can be seen from the table that the frost land area of Xi'an is large, the number of patches is small, the degree of Landscape Fragmentation and Abruptness are small. That is because the forest land is mainly distributed in Qinling Mountains on a large scale, less human interference and the ecological environment is stable. The area of construction land is second only to frost land area with a largest number of patches, but its Landscape Fragmentation and Abruptness degree are small, which is due to human continuous development and construction causing a density construction, connecting scattered patch into pieces, which is simple, monotonous and universal. The water land is small but the patch number is large, and its Fragmentation and Abruptness degree is larger. That is mainly because the aquiculture occupation, which is obvious in the rural tourism land because there are all kinds of leisure agriculture.

**Tab. 2** Landscape pattern index

landscape type	Area/m <sup>2</sup>	Patch Number	$C_i$	$F_i$	$S_i$
Construction land	318037.6	18896	0.0594	0.2173	1
garden land	76681.1	14301	0.1865	0.7840	0.4440
Water land	28993.3	15861	0.5471	2.1836	0
Frost land	476592.9	4140	0.0087	0.0679	0.6422
farmland	110534.7	9368	0.0848	0.4402	0.4109

### (6) Distance from the main traffic lines



**Fig. 7** Distance from the main traffic lines

Distance from the main lines of transport based on the acquisition of linear traffic network data from OSM data, three road levels of motorway, expressway, primary way are needed. Extract the road centerline and calculate the mileage of each level of road (km). As of 2017, Xi'an has 542.9018 kilometers of motorway, 190.531 kilometers of expressway, and 1112.5967 kilometers of primary way. As can be seen from the figure (7), the roads in the central urban areas of Xi'an are reticulated, while the urban fringe areas are simply transverse parallel arrangement, with some vertical lines of transport.

### 3.2 Comprehensive evaluation results of ecological suitability

Based on the evaluation model of rural tourism land suitability, the suitability evaluation is completed by ARCGIS10.3 platform according to the score and weight assigned as the Table.3.

In the ArcGIS platform, six single vectorization factors are rasterized, the image is 50 meters long, and using the weighted sum in the spatial Analyst tool to calculate the results, as shown in the figure (8)

**Tab. 3** Single factor classification

Order	Factors	Level	Score	Weight
1	Elevation	207 ~ 500	9	
		500 ~ 800	7	
		800 ~ 1500	5	0.3289
		1500 ~ 2600	3	
		2600 ~ 3754	1	
2	Slope	0 ~ 5	9	
		5 ~ 8	7	
		8 ~ 15	5	0.1645
		15 ~ 25	3	
		25 ~ 77	1	
3	Vegetation coverage	199 ~ 220	7	
		178 ~ 199	5	0.2072
		155 ~ 178	3	
		0 ~ 155	1	
		0 ~ 200	3	
4	Distance from major rivers	200 ~ 1000	9	
		1000 ~ 3000	7	0.1036
		3000 ~ 5000	5	
		5000 ~ 27008	1	
		Construction land	5	
5	Landscape Ecological Quality	Landscape garden land	3	
		Ecological Water land	1	0.1305
		Quality Frost land	9	
		farmland	7	
		0 ~ 200	3	
6	Distance from the main traffic lines	200 ~ 1000	9	
		1000 ~ 3000	7	0.0653
		3000 ~ 5000	5	
		5000 ~ 6468	1	

### 3.3 Result analysis

The suitability rating shows, shown as the figure8, that the most suitable land, suitable land and basic suitable land total 6265.027km<sup>2</sup>, accounting for 63% of the city area, indicating that Xi'an has the potential to develop rural tourism. However, due to the ecological value of Qinling Mountains and Li Mountains, the development of rural tourism should focus on the contradictory relationship between development and protection.

**Tab. 4** Evaluation results and feature

Rating	Score	feature
The most suitable	(7.2,9]	Strong ecological self-healing ability, strong immunity of external environment to human destruction
suitable	(6.1,7.2]	Strong ecological self-healing ability, Ecological cost of land development and utilization is low
Basic suitable	(5,6.1]	The ecological environment potential is more barren, the ecological environment is more sensitive, can only carry on the conditional development behavior
Unsuitable	(4,5]	Fragile ecological environment, difficult ecological restoration, prohibition of development and construction
Not available	(1.5,4]	Extremely fragile ecological environment, extremely difficult ecological restoration, prohibition of development and construction

#### (1) The Most Suitable Land for use

1725.887km<sup>2</sup>, 17.50% of the total city area. Most of them are low-lying areas below 500 meters above sea level. At present, the type of land use is mainly high-quality farmland and orchards, which is an important resource for the development of rural tourism. This places close to the river network, away from urban construction areas, having a better quality of ecological landscape. The most suitable land is mainly located in the flat area extended from the northern foothills of Qinling Mountains. These places have a good environment

and a low ecological sensitivity, are extremely suitable for the development of rural tourism.

#### (2) Suitable Land for use

2504.69km<sup>2</sup>, 25.4% of the total city area. Construction land is mainly concentrated in it. This places have a small slope and low ecological sensitivity. Some of the land is distributed in the shallow mountain and gentle slope of the northern foothills of Qinling Mountains, with a good ecological quality and satisfying traffic conditions. But it is necessary to guide the development of this area reasonably and pay attention to the coordination of ecological damage and ecological compensation. Most suitable land and construction land blends miscellaneous, in the region to develop rural tourism should adhere to the fragmentation layout, to create a distinctive brand and extremely against the large-scale, low connotation, high energy consumption construction activities.

#### (3) Basic suitable land for use

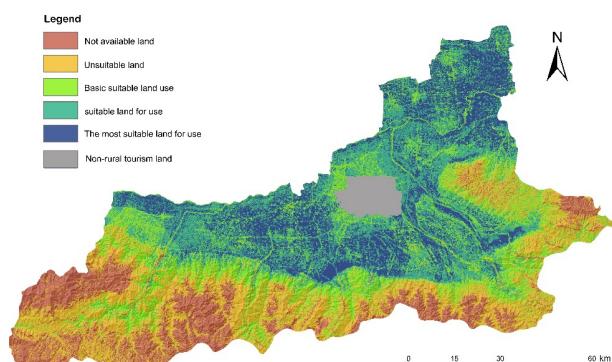
2034.45km<sup>2</sup>, 20.63% of the total. It is mainly along the Qinling Mountains and Li Mountains of the low and even valley with the slope is mainly between 15 to 25 degrees. And there are some in the loess tableland with the elevation between 500 to 800 meters. There are some rural built-up areas in the valleys and mountain basins of Qinling Mountains and Li Mountains, with high vegetation cover and excellent ecological landscape quality. And rural tourism can be developed after strict environmental compensation measures and planning approval. Traffic accessibility is an important limiting factor for the development of rural tourism in this area.

#### (4) Unsuitable land

2180.9305km<sup>2</sup>, 22.12% of the total. They are mainly distributed at altitudes of 800 to 1500 meters, with slope greater than 25 degree. Its ecological environmental is very sensitive. This area is an important water source in Xi'an City. From the point of view of ecological protection, the region should strictly control the development and construction behavior.

#### (5) Not available

1414.9395km<sup>2</sup>, 14.35% of the total. Mainly distributed in the depths of the Qinling Mountains, where the ecosystem is the worst stable and highly susceptible to interference by the external environment. It is an important animal-plant nature reserve and water source protection, which undertaking the function of ecological service.



**Fig. 8** Evaluation Results

## 4 Conclusion

Based on the characteristics of rural tourism and the objective characteristics of ecological environment, this study establishes an evaluation system of land ecological suitability by GIS and ENVI. Finally, the weighted sum analysis of each factor is carried out, and the evaluation result of ecological suitability of rural tourism land in Xi'an is obtained.

Nearly one-third of the land area of Xi'an is the Qinling Mountains region. These are main problems that how to innovate coordination path between development and protection, how to excavate the ecological agricultural resources, and how to stimulate the green economy development in the deep mountain, facing of Xi'an. As an important economic model in the suburbs of Xi'an, rural tourism has some problems, such as chaos of land use, waste of land resources, encroachment on ecological land and inadequate use of suitable land. And the final part of this study provides an exploration way for the solution of the above problems.

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