Suitability analysis of archaeological sites in Linfen basin based on remote sensing and GIS technology

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Abstract: China is a country with a brilliant civilization. Lots of historic sites and ancient settlements are all around. Archaeological scholars got outstanding achievements by hard working, especially science the twentieth century, a large number of important archeological discovers give us a clear understanding about the development of Chinese early culture. Remote sensing in archeology expanded the horizons we explore the world, and also provide more technical support for studying the Chinese civilization.This paper combine the remote sensing and GIS technology to study the distribution regularity of ancient sites in Linfen basin in south of Shanxi. Take 59 sites in four periods which respectively in Yangshao, Longshan, Miaodigou and Zhou period as the study points, analysis the suitable distribution area. Using multi-factor analysis theory (AHP), take slope, aspect, DEM and the distance to river as the factor to establish the importance (resistance) model. Then we will know where is more suitable for living. By loading the existing sites, found that more than 95% of the site points are in the suitable area.

Key words: Suitability analysis, AHP, remote sensing archaeology, GIS

1   INTRODUCTION

China is a country with a long history. With the unceasing enhancement of the human ability to change the nature and to conquer the nature, the distribution of the settlements is from living near the river to gathering by culture. The distribution of the settlements has regularity. So analysis the appropriate distribution area of sites has guidance significance for detection and explorer new sites.

Suitability analysis now is widely used in the analysis of the suitability of the living environment, often based on population data, the bus station data, road data, and the surrounding shopping malls

medical facilities and other infrastructure data to analyze the most suitable area for human habitation. Renxue Hui (Renxue Hui et al. 2008) used Q-type cluster method to analysis the livability in Dalian city. Chen Yurong(Chen Yurong, et al.2007) combine with the factors of traffic, population, infrastructure, green space, and the heat island effect to evaluate the living environment of Beijing old city.But the suitability analysis of ancient sites are different with the analysis of settlement in nowadays. Because of no bus stations and elementary equipments, so need to re-select the factors that most likely to affect the distribution. So in this article using multi-factor analysis theory (AHP), take slope, aspect, DEM and the distance to river as the factor to analysis.

2 study area

Linfen Basin located in the southwestern part of the Shanxi Province, is a part of Shanxi fault basin. It is showing banded structure, around by Luliang Mountain, Ta'er Mountain, Zhongtiao Mountain, and then form a relatively closed independent area. Fen River runs through the basin from northeast to southwest, so water resources here are abundant, and good for agricultural development. Here is an ideal place to live also because there is a lot of plain region, and the river is stable. Since the Yangshao period to Han dynasty, settlement cultures here are developed and evolved constantly, deducing the important area in the human civilization.

3 Research Methods

3.1 choose factor

The suitability analysis for the ancient ruins is not like site analysis in nowadays. So take into account the particularity of the ancient ruins and composite of existing data and previous preliminary study, select the factors that most likely to affect the distribution: elevation, slope, aspect, and distance from the river system. Determine the resistance value of the different values   for each factor by expert advice and literature (see Table 1), The importance of various factors affect different, so also need to determine the relative weight between the various factors.

Table 1 different values   for each factor

Slope	0-3°	3-7°	7-15°	15-24°	24-64°

Resistance value	1	5	15	30	40
aspect	110-240		0-110 240-360		
Resistance value	5		20		
elevation	290-600m		600-980m	980-1300m	
Resistance value	1		5	10	
distance from the river system	200m		400m	600m	
Resistance value	8		10	15	

3.2 Identify weight

There are four factors, so introduce the way named multi-objective decision-making (AHP). AHP is a targeted research program, first identify the influence factors, and then determine the number of the priority of each factor, last according to the priority number to draw comprehensive assessment. Multi-objective decision-making method is widely used in the decision-making in various fields, such as Huanchen Zhao used this method in science and technology management in 1985; Xiaohua Yang al etc. used AHP to evaluate water resources renewable capacity; Bing Yue al etc. combined with AHP evaluate a comprehensive evaluation system used in the study of urban living standards.

AHP based on the nature and goal of the case to make the problem hierarchical, build a multi-level structure analysis model. Then construct the impact factor and the importance of the judgment matrix, the relative importance of the judgment by 1-9 values   , compared to two factors, grade 1 indicates equal importance, 3 said somewhat important, 5 means is obviously important, and 7 illustrates the important more and than 9 is extremely important. In this case, the importance of slope and elevation as the same level, aspect, relative to the slope, the important level is 1/5, so, based on experience and expert information is given in the judgment matrix (see Table 2).

Table 2 the judgment matrix of the factors

	Slope	aspect	elevation	distance from the river system	权重
Slope	1	5	1	1/3	0.2261
aspect	1/5	1	1/3	1/5	0.0681
elevation	1	3	1	1/3	0.1930

distance from the river system	3	5	3	1	0.5128

In MATLAB, calculate eigenvalues and eigenvectors of the matrix, if the largest eigenvalue closer to the M which means the number of factors, that means the consistency of the matrix is higher, and then introduce the consistency index (CI), see formula 1.1, the smaller of C.I., the higher consistency of the matrix.

```
>> b=[1 5 1 0.3333; 0.2 1 0.3333 0.2; 1 3 1 0.3333; 3 5 3 1];
>> [v1,d1]=eig(b);
>> v1(:,1)=v1(:,1)/sum(v1(:,1))

v1 =

    0.2261          -0.2908 + 0.2957i   -0.2908 - 0.2957i    0.4265
    0.0681          -0.0508 - 0.1262i   -0.0508 + 0.1262i    0.0000
    0.1930           0.0617 + 0.1183i    0.0617 - 0.1183i   -0.6397
    0.5128           0.8898              0.8898              0.6395

>> d1

d1 =

    4.1154              0                   0                   0
         0         -0.0577 + 0.6869i        0                   0
         0              0             -0.0577 - 0.6869i         0
         0              0                   0              0.0000
```

<div align="center">Fig 1 Process of calculating weight in MATLAB</div>

After calculation, obtained the largest eigenvalue is 4.1154, and then calculate consistency index, the result is 0.0385, this shows that the consistency level is very good.

$$C.I. = \frac{\lambda_{max} - m}{m-1} = \frac{4.1154 - 4}{3} = 0.0385 \tag{1.1}$$

3.3 Establish the importance (resistance) grid

The importance of each factors are different, so it needs to re-classify each factor by Reclassify Tool in ArcGIS software. Given different resistance value (same as Table 2) for different levels, then put the weight values to the four factors, got the whole importance (resistance) grid.
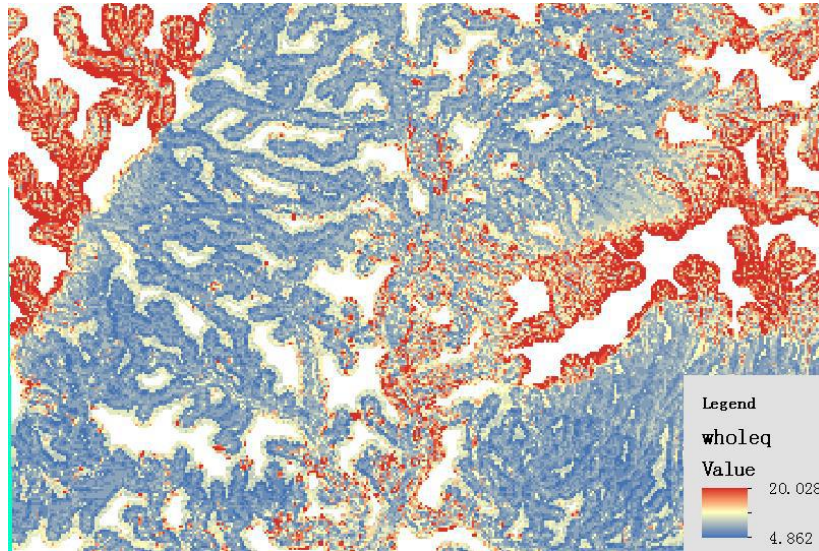
Fig2 the importance (resistance) grid (the red color means less important)

3.4 Suitability analysis

Combination of ruins point information and the importance of (resistance) raster layer to analysis the suitability area. Take Longshan sites as the source information, analysis the appropriate area of the site of point.
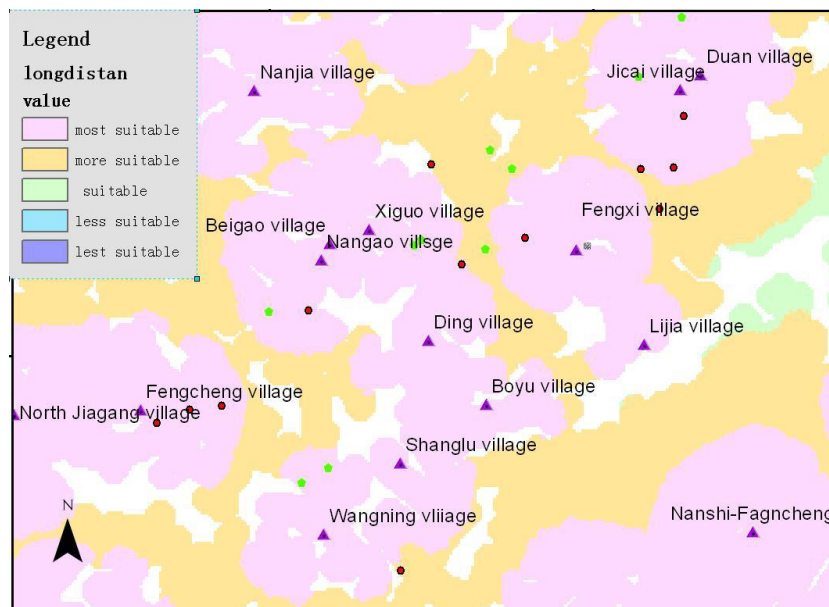

Fig3 the result of Suitability analysis

4 Results and Discussion

In this paper, using the AHP multi-objective decision method to establish the importance

(resistance) model got the result that 95% sites are in the suitability area. We can see from the result that the choice of the ancient ruins is intelligent.

Due to the rapid development of urban civilization, have no exactly road information of old times. The analysis is not that so perfect, but overall it shows a certain trend. GIS technology in archaeological research could get geomorphology, hydrology, soil, vegetation, and settlement distribution information together to reveal ancient man-land relationship.

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