THE APPLICATION ON SUSTAINABLE LAND USE EVALUATION BY '3S' TECHNOLOGY

ZHAO Bin [a,b,c], ZHAO Wen-ji[a,b,c*], LI Jia-cun[a,b,c]

[a] College of Resources Environment and Tourism, Capital Normal University, 100048,Beijing, China
[b] Laboratory of 3D Information Acquisition and Application, 100048, Beijing, China
[c] Beijing Municipal Key Laboratory of Resources Environment and GIS, 100048, Beijing, China

KEY WORDS: sustainable land use, evaluation, '3S' technology, indicator system, spatialization, statistical indicator, geospatial indicator, statistical unit

ABSTRACT:

With land resource lack and environment pollution, land conflict between supply and demand problems has affected human survival environment sustainable development badly. Sustainable land use evaluation could explore the land resource exploitation direction, level and mechanism, it provides gist for land resource planning and management to make it in favour of social environment development. '3S' technology is useful in land resource evaluation, GPS provides the precise space position, RS provides land cover image frequently and accurately, and GIS provides a tool for spatial analysis and cartography. This paper introduced the process and method of sustainable land use evaluation, mainly about the indicator spatialization. The indicator can be divided into statistical indicator and geospatial indicator. Take Guyuan county, Kangbao county and Zhangbei county in Bashang region as examples, an sustainable land use evaluation indicator system was set up. Evaluating the sustainable land use in Bashang region in 2003, the result distributes continuous. It illuminates that the sustainable land use level is low in Bashang region. From the land use view, the distribution of farm land has higher level than water and useless land.

1. INTRODUCTION

With the rapid development of economic construction, shortage and abuse of land resources have become important factors that affecting social development and land management. Land resource evaluation analysis determines whether the requirements of land use are adequately met by the properties of the land (Bandyopadhyay, S. et al., 2009). It is the basis of land resource plan and management, play an important part on land resource evaluation in a long term.

Along with the rapid advance of '3S' technology, integrate '3S' technology to evaluate the sustainable land use capacity proves great potential capacity. GPS provides the precise space position, RS provides the image of land cover condition frequently and accurately, GIS provides a tool for spatial analysis and cartography. Therefore, it's available to use '3S' technology on the evaluation research of sustainable land use, it has important theoretical significance and practical value.

The object of this paper was to build a sustainable land use evaluation system with '3S' technology to evaluate the land resource level. The approach in this paper was based on '3S' technology to collect and calculate the indicators, especially about spatializing the indicators to let them distributed continuous.

2. STUDY AREA

Bashang region is generally called as a highland in north Hebei Province, located in the transition region among Inner Mongolia Plateau, Yanshan Mountains and North China Plain. It was located between 41°13′ to 40°57′N, and 114°50′ to 116°05′E, and the total area is 18,202 square kilometres. It is a narrow nearly east-west direction belt, continental monsoon and arid climate, north temperate broad-leaved forest with grasslands, agricultural and pastoral areas transition zone (Zhou, 2004). The maximum ground elevation in Bashang region is 1200 to 1500 meters above sea level. The mean yearly temperature is -0.3 to 3.5 ℃, the mean annual rainfall is about 400 mm, and it's also the ecological barrier between Beijing and Tianjin, even North China (Zhou, 2004). The agricultural activities depend on rainfall, the water are mainly from small tanks and underground water. The soils of the area are chestnut soil, poor adhesion, easy physical weathering, with low organic, predominantly yellowish to brown in colour. Bashang region including Zhangjiakou Guyuan county, Zhangbei county, Kangbao county, and part of Shangyi county, Yixian County, Fengning county, and Weichang county (Yuan, 2006). This paper takes Guyuan County, Kangbao County, and Zhangbei County as a study area.

The data mainly used contain Landsat-7 ETM + images on September 10, 2008, 1:50000 scale DEM, Statistical Yearbook, and detail vector map. After get the data, image pre-process was first step, including geometric correct with GPS point gathered from the field, mosaic, clip the images to the study area. Take the typical land use/cover types noted from field investigations as interesting area to classify the image. The result classified into farmland, woodland, grassland, water, urban and industrial land, useless land (bare land, saline soil, sand) total 6 land-use types.

* Corresponding author. Email:. zhwenji1215@163.com

Figure 1. study area in Bashang region chart

3. METHOD

The work flow of this paper is: accord with the sustainable evaluation target, as well as spatial and temporal scales characteristic built a multi-level evaluation indicator system; based on available, acquire and compositive principles selected indicators; then quantified it with acquire method, selected threshold value and standardized method for evaluating indicator standardization; displayed it in the map step which called spatialization, mainly related to spatial interpolation methods; select a appropriate weight assignment methods on evaluation index system; at last, establish an GIS evaluation model to get the evaluation result(Figure 2).

3.1 Build Evaluation Indicator System

The evaluation indicator system was empirical assessment systems and based on the knowledge and understanding of the study area. So the factor involves in land evaluation either single or multiple parameters converted to an integrated indicators (Guo et al., 2005).
Accord to comprehensive operability, and dynamic principle, classed the indicators from three levels: objective level, criterion level and indicators level. There aer many factors influence the land resource condition, So selected FAO promoted from the production, productivity, stability, environmental protection, economic viability, social acceptability of five aspects to establish evaluation indicator system of sustainable land use (FAO, 1990). The indicator includes slope, vegetation coverage, crop productivity index, multiple cropping indexes and so on of 13 indicators. The indicators were collected from remote sensing, GIS analysis, yearbook and field survy.

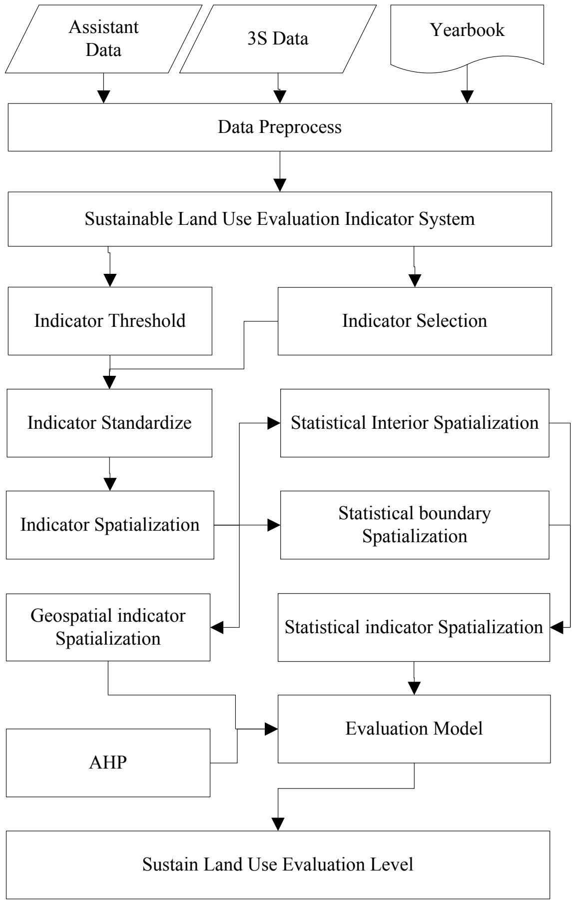

Figure 2. Sustainable Land Use flow chart

3.2 Standardize Indicator

Select the indicator's threshold is difficult, it always in accordance with the regulations and standard. Some indicators didn't have clear threshold, such as multiple cropping indexes; and some were hard to quantitative, such as land deal value index. So we have to base on the local condition to select a proper threshold.
Due to different units, the Quantitative evaluation indicator can not be compared with each other, it's a necessary step to standard it. It contains three steps: indicator type and standardized methodology. The general relationship of the indicators was divided into three categories: positive type, negative type, and moderate-type (Zhou, 2004) Standardized methods include extreme-minus method, percentage ratio method, fuzzy mathematics method, power conversion method and so on.

Positive type：

$$Ri = 100 \times r_i = \begin{cases} 1 & ; \quad (x_i > z_i) \\ x_i / z_i & ; \quad (0 < x_i \le z_i) \\ 0 & ; \quad (x_i \le 0) \end{cases} \tag{1}$$

Negative type：

$$Ri = 100 \times r_i = \begin{cases} 0 & ; \quad (x_i > z_i) \\ 1 - x_i / z_i & ; \quad (0 < x_i \le z_i) \\ 1 & ; \quad (x_i \le 0) \end{cases} \tag{2}$$

Moderate type：

$$Ri = 100 \times r_i = \begin{cases} x_i / z_i & ; \quad (x_i > z_i) \\ 1 & ; \quad (x_i = z_i) \\ z_i / x_i & ; \quad (0 \le x_i < z_i) \end{cases} \tag{3}$$

Where: x_i = actual index value
z_i = threshold
r_i = standardized index
R_i = ri × 100

3.3 Spatialize Method

Expression of Sustainable land evaluation result on map was the direct form to monitor the land use situation; and indicator spatialization was its core method. From the '3S' technology content, Spatialization was the excellent representation to express its advantage. The spatialization of population was pointed out at the beginning of the study before the widely used of '3S' technology. It's mainly using population gravity, potential models, Lorenz curve and spatial autocorrelation theory etc (Liu, 2002). These traditional methods tried to combine qualitative methods with quantitative methods to reflecting the population spatial distribution (Li, 2008), however, it didn't meet with the population distribution in the physical geography. With '3S' technology improves, researchers has been developed a lot of complex models and methods to simulate population's distribution precisely. Jiang (2002) based on '3S' technology summarized the population's spatialization development. Now, spatialize methods mainly composed of correlation analysis, interpolation, grid spatialization (Li, 2008).

Interpolation method was based on the known value of the region to estimate the value of the unknown region (Li, 2000). It was a crucial technique in analyzing spatial data and had been used in a wide range of disciplines (Lam, 2009). The interpolation of spatial data had been considered in many different forms. The various forms of kriging and inverse distance weighting (IDW) were among the best known in the earth sciences (Myers, 1994).

Spatial interpolation is widely used to create continuous surfaces from discrete data points (Wang, 2003).Evaluation indicator mainly included statistical indicator and geospatial indicator. Statistical indicators (such as population density, per capital GDP etc.) had an accurately statistical value, but there was no geographic coordinates and projection information, therefore it's difficult to locate on map accurately, and its value was homogeneous interior the statistical unit and exist gaps between them. Geospatial indicator (such as vegetation cover, slope, etc.) with precise location and projection information inherently that easy to map, however, the different spatial resolution was difficult to topological and overlay analysis. Spatialization focus on these problems to establish a continuous spatial distribute interpolation method (Pan, 2002; Lu, 2008).

3.4 Spatialize Statistical Indicator

Spatialize statistical indicator is based on the values collected by statistical units to establish the relationship between statistics value and models. It was feasible on the premise that the statistical indicators uniformly distributed in the region that didn't match the physical geography (Lv, 2002). Statistical indicators spatialization was to break the statistical unit boundary and make it close to the real situation farthest (Ma, 2008). Grid cell size's areal weighting interpolation method (GCAWIM) could use grid to spatialize statistical unit boundary. The basic idea was taken small grid to instead big statistical unit, use grid area as power recalculated its value. Its key was selected a proper grid size.

Use GCAWIM only can spatialize the statistical unit boundary, and spatialize the interior statistical unit is also important. Inverse distance weighting (IDW) method was a common deterministic spatial interpolation method. Its general idea was based on the assumption that the attribute value of an unknown point is the weighted average of known values within theneighborhood, and the weights are inversely related to the distances between the prediction location and the sampled locations (Lu, 2008).it can use the land use types as weight to spatialize the statistical interior. At last, integrated the boundary and interior spatialize result to get the indicator spatial distribution.

3.5 Spatialize Geospatial Indicator

Geospatial indicator was spatialized through resample and band calculator. RS index can be used as parameters in the evaluation directly. Vegetation coverage index (VCI) was an important parameter to reflect the extent of vegetation cover. It's one of important ecological indicators about environmental change, the higher value, the more vegetation is flourishing, It could be got from DNVI based on the pixel and NDVI moiety model to calculate the vegetation coverage (Chen, 2008). NDVIs and NDVIv are representing the pure bare land and pure vegetation's NDVI values; they can be got from field measurement or image. The simple method was to choose the minimum and maximum of NDVI directly act as them respectively (Sun, 2006). A more precise method was select 1% and 99% of the total pixels' NDVI as the corresponding value. Compared with the former, the Latter has fewer extreme points and bad lines, stripes.

$$VCI = \frac{NDVI - NDVI_s}{NDVI_v - NDVI_s} \tag{4}$$

Where: NDVIs = pure bare land's NDVI
NDVIv = pure vegetation's NDVI
VCI= Vegetation coverage index

According to this method we can spatialize other indicators. The indicators associate with population, such as population density in each village to spatialize per capital GDP.

The weight assignment methods can divide into subjective and objective kinds, the former lean to experience but the later mathematics. Compared with the living method, Analytic Hierarchy Process (AHP) integrates both advantages, so use

AHP method to give each indicator a suitable weight based on their sensitivity. Build the integrate evaluation model based on GIS to get the sustainable land resources level distribution (Figure 3).

$$S = \sum_{i=1}^{5} (R_i \times W_i) \quad (5)$$

Where: Ri = Standardized indicator value
Wi = Indicator weight
S= Integrate evaluation value

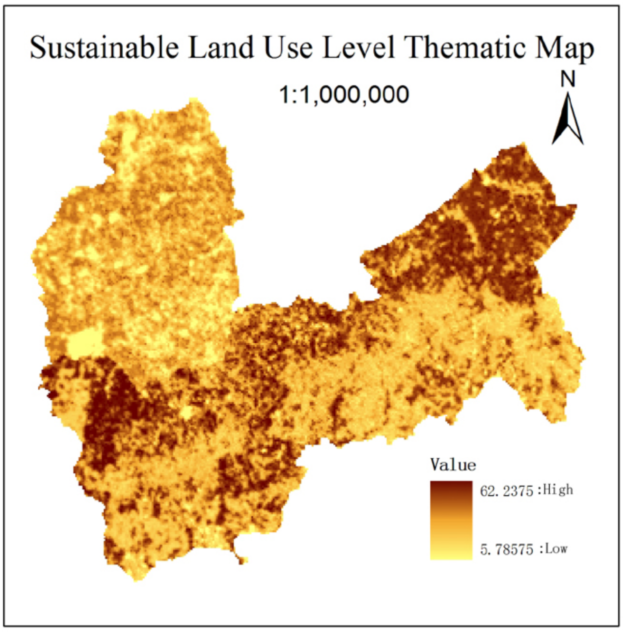

Figure 3. sustainable land use level in Bashing region 2003 chart

4. CONCLUSION

This paper attempts to develop an index system integrating the collected information using '3S' technology. The result distributes continuous in the study area, and it indicated that the sustainable land use level in study area was low. The land resources condition in Kangbao county and north of Zhangbei county are better than other regions. From the land-use perspective, the three counties damaged relatively serious, especially about agriculture and stockbreeding land. Bashang region only suitable for drought-hardy plants growth, land productivity is low, typically of extensive cultivation agriculture. Land desertification is an important factor in the decline of soil quality. Data analysis showed that the desertification was positive correlation with farmland, and negative with forest and grassland (Zhou, 2004). Increase farmland and desertification caused land degradation affected sustainable land use condition. Therefore, change existing leanness farmland to reconstruct forest or grasslands is very necessary.

5. DISCUSSION

This paper establishes a sustainable land use evaluation system in Bashang region, including statistical indicators and geographical indicators. The statistical indicators spatialized by GCAWIM combine with land use weight interpolation method. Geospatial indicators mainly come from '3S' indicator. Evaluate the Guyuan county, Kangbao county, and Zhangbei county sustainable land resources. The result indicated that the sustainable land use level in study area was low. Kangbao county and north Zhangbei county's land resources condition are better than other regions; farmland has higher level than the other land use types.

Sustainable land use evaluation has been proposed for a few years, a lot of researchers pay great effort study on it. Some difficulties still exist, such as indicator selection veracity, indicator threshold selection, spatialization method.

'3S' technology provides precise and quantitative parameters and analysis methods to improve the quality of sustainable land use evaluation. There are many ways to select the indicator systems, how to avoid their disadvantages and integrates their advantages is still have to study. Now, we select the indicators mainly based on the easy quantitative ones; ignore those hard to quantitate.

Spatialization is about areal interpolation, but until now we have to use point interpolation and line interpolation to instead. With the '3S' technology development, more indexes contain clear physical meaning can be applied to the evaluation index of the space. In the future a appropriate spatialization method should be founded.

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