USING REMOTE SENSING IN LAND RESOURCES' EXPLOITATION IN CHINA

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ABSTRACT

By use of Remote Sensing information, the paper focused on the way that land resources were spatially exploited. As the ground properties of land resources, RS information such as the first and green part of tasseled cap transformation、bands of thermal radiance、and TM_4/TM_3 etc, are also the characteristic indicators of Land resources. Therefore, both ground properties and RS information could be used as indicators to classify the land resources. In the paper, a hierarchical structure model was applied for classification. As the result of the model, the paper demonstrated the systemic structure of land resources and the correlations among the land units in terms of the different classification goals. By the way, it was not only known in details the internal structure and function of land resources system, but also clearly revealed the spatial distribution frame of land resources. Finally, the land resources were divided functionally, meanwhile a comprehensive knowledge about regional land resources were formed.

KEY WORDS: Remote Sensing, Hierarchical structure model, Land resource, Spatial distribution

1. INTRODUCTION

Remote sensing information was directly used in the fields of regional land-use assessment and land exploitation which generally took administrative units as the evaluating cells for the convenience of administration. Factors impacting on the development method of a county 's land resource particularly for the agricultural usage were so numerous that in practice only a few factors could be informed with some indexes. Also it was impossible to collect the detailed index information everywhere, most of case the index information was collected from a few typical points, then by some mathematic inserting methods the regional index information could be obtained and showed in maps. But sometimes the index information through inserting calculation was not compatible with the measurement data[1]. However, remote sensing data may solve the problem, for example, TM data(30×30 square meters as the basic unit) recorded and reflected the ground information in real-time with fairly accuracy. Therefore, it would be a better tragedy to use regional RS information instead of some ground attributes in order to learn the spatial distribution of land resource. Combined with results of imagination procession and relation analysis, the paper used the first and green part of tasseled cap transformation, bands of thermal radiance, and TM_4/TM_3 etc. as the natural evaluating indexes to classify the exploitation and to study the spatial distribution of land resource[2].

2. METHODS

Systemic hierarchical structure model was used in the paper to depict the system structure and reflect the correlations and existent states among systemic components in different descriptive spaces[3]. As for land resources, land-use units are not only organically combined and united as a system, but also different in function and natural properties, which could be specified with a series of indexes on different levels, so systemic hierarchical structure model was suitable for studying the spatial distribution of land resources.

2.1 Frame of systemic hierarchical structure model

In a system, connections whether among the systemic components or between the system and its external environments could be demonstrated with systemic structural model. In the model, the relationship of systemic components is solely expressed with "yes" or "no". Presuming that system S is consisted of N units: S=[S1,S2,S3,…Sn], the adjacent matrix of S is A:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

Elements in the matrix is defined in the following equation:

$$a_{ij} = \begin{cases} 1, S_i \text{与} S_j \text{有关} \\ 0, S_i \text{与} S_j \text{无关} \end{cases}$$

Based on the equation, reach-matrix could be built up, and the system could be classified.

2.2 Systemic hierarchical structure model based on fuzzy-similarity relationship

In application, correlation of systemic units was expressed with the fuzzy-similarity coefficient. In the spatial distribution system of land resource, all land unites are not only adjacent to each other in geographical position, but also similar to each other in natural conditions. Therefore, a series of vectors could represent or reflect the characteristics of land units, and the model could be realized on the basis of fuzzy relationship between land units. In the model, sample characteristics were expressed as the fuzzy subsets which were consisted of classification indexes, the relationship of samples was expressed with a attached function. Then a fuzzy-similarity matrix was created. After selecting eigenvalue in different levels, the fuzzy-similarity matrix could be transferred into a new matrix (whose element value was between 0 and 1), finally a reach-matrix could be created . Based on the reach-matrix, the system could be classified and structurally described.

Because there was more or less relativity among indexes, factor analysis was used in the paper to make the indicators independent. Factor analysis is a kind of statistic method to convert many indexes into less comprehensive indexes. Usually it can degrade dimensions by concentrating the plentiful information of many variances on a few comprehensive indexes and making the comprehensive indexes independent to each other[5].

Overall, the model is used in the following steps: selecting characteristic indicators ⟶ data standardizing ⟶ factor analysis ⟶ building up fuzzy-similarity coefficient matrix and reach-matrix ⟶ classification.

3. RESULTS

3.1 Systemic Structure Analysis of Land resource

Taking land-use of Longyou County, Zhejiang province as example, based on the view of systemic theory, the paper used RS data and ground monitoring information to study the spatial layout of land use. It applied systemic hierarchical structure model which could describe the structure state of the system and reflect the difference of mutual relationship and existing state among the composition parts in the system.

How to decide the index system of land resource was the key step for land classification and land planning[4]. It was necessary to find out the desirable index groups which could best reflect the true relations among land-use units by studying as many indexes as possible. The paper selected 15 indexes drawn from soil statistics data and RS information of 32 villages in Longyou county (saw table 1).

According to the practical significance and mutual relationship of indexes, under the guidance of target-tree concept in systemic theory, indexes could be divided into 3 layers for describing or classifying the spatial distribution feature of land use: economic condition, fertility of soil and natural condition of land units:

First layer: Aim layer: Land resource

Second layer: The first layer of classification: Natural condition, Soil fertility, Economic condition

Third Layer: Index layer

Natural condition--- Annual temperature, percentage of land with slope; RS information such as brightness, wetness, thermal radiance, TM_4/TM_3.

Soil fertility ---Soil organism, total nitrogen, PH, effective phosphorus, effective kalium.

Economic condition---Ratio of irrigated area to farmland area, Distance from town, Income level, Ratio of planting production to general agricultural production.

3.2 Spatial distribution of economic condition for land exploitation in Longyou county

The four indexes which reflected the economic condition of land-use included Income level, Ratio of planting production to general agricultural production, Distance from town and Ratio of irrigated area to farmland area. By factor analysis, the four economic indexes may be replaced by the first and second factors (the variance cumulative percentage was larger than 90.6%). The factors had a line relation with the original indexes.

$y1=0.501x1-0.501x2-0.489x3+0.515x4$

$y2=0.54x1+0.279x2+0.688x3+0.398x4$

y1 was the first factor ,and y2 the second factor.

X1 is the average income, x2 the ratio of planting production to general agrarian production, x3 the distance from town, x4 ratio of irrigated area to farmland area.

Result showed the rule of “declining economically along with distance” in Longyou . Centered around the town of Longyou, three agricultural economic groups were formed: the nearest(the first group) was the hill or plain districts in the middle part of the county and some hill districts in the north of the county including 17 towns or villages such as Hengshan, Hutoushan et al. The first group was composed of many villages or towns near to the Longyou county town, its economic condition was well and a little worse than that

of the Longyou county town because of the convenient agrarian condition and many irrigated fields; Outwardly from the first group, was the second group that covered parts of mountainous field in the southern Loungyou and parts of districts in the northern Longyou such as Guantan, Lingshan and Zhitang et al. seven villages. The second group was a little far from the town and less influenced by the radiation of "center town", so its agrarian condition and average income were slightly unfavorable. The most of mountainous lands in the southern Longyou was the third group, including five villages: Dajie, Kangtou and Wucun et al., in addition to the seven villages such as Luojia and Shegong et al. These villages were in mountains with highly elevation, the agrarian condition of the third group was worst, for instance, the ratio of irrigated area to the farmland area was only 44% , and the general agrarian production was mainly dependent on the plantation.

Spatial distribution of soil fertility

Four fertility indexes included soil organic composition, total nitrogen, effective phosphorus and effective potassium. After standardization and factors analysis, the fertility indexes were converted into three factors whose variance cumulative percentage was 98% while the critical variance cumulative percentage was 85%, the transform equations were listed as following:

$$y1 = 0.655x1 + 0.634x2 + 0.0174x3 + 0.417x4$$

$$y2 = -0.110x1 - 0.0424x2 + 0.974x3 + 0.198x4$$

$$y3 = -0.188x1 - 0.381x2 - 0.217x3 + 0.879x4$$

In the equation, y1,y2 and y3 represented the first ,the second and the third factor respectively. X1, X2, X3 and X4 reflected orderly soil organic composition, soil nitrogen, soil effective phosphorus and effective potassium.

Result showed that fields in the southern and top northern of Longyou had highly organic matters, and were fit for planting special forestry particularly the bamboo as the prevailing product in addition to other special woods product to make full use of the land resource's superiority. Soil in the middle part and the north of Longyou was lack of organic matters but plenty of effective phosphorus, and could meet the nutrient demand of most crops.

3.4 Spatial distribution of natural condition

Similarly, six natural condition indexes included Annual temperature, percentage of land with slope, RS information indexes such as the first and green part of tasseled cap transformation (or brightness, wetness), thermal radiance and TM_4/TM_3. After standardization and factors analysis, the natural condition indexes were converted into three factors whose variance cumulative percentage was 85.6% while the critical variance cumulative percentage was 85%, the transform equations were listed as following:

$$y1 = -0.247x1 - 0.215x2 + 0.289x3 - 0.136x4 - 0.088x5 + 0.292x6$$

$$y2 = -0.117x1 - 0.07x2 + 0.009x3 - 0.56x4 + 0.81x5 + 0.024x6$$

$$y3 = 0.179x1 - 0.475x2 + 0.145x3 + 0.755x4 + 0.509x5 - 0.143x6$$

In the equation, y1,y2 and y3 represented the first ,the second and the third factor respectively. X1, X2, X3, X4, X5, X6 reflected orderly annual temperature, slope land area, and indexes extracted from RS information such as the first and green part of tasseled cap transformation (or brightness, wetness), thermal radiance, and TM_4/TM_3.

Result showed that the annual temperature changed greatly with elevation. In southern Longyou, Slope land shared 98% of the land resource, the annual temperature was lowest and the vegetarian cover percentage was high, so its ecological environment was satisfactory. Oppositely in the middle part of Longyou, the annual temperature and the thermal radiation were high, soil water and the vegetation cover percentage were low,

therefore the ecological environment of this region should be improved urgently.

3.5 Comprehensive feature of Longyou land resource

Spatial distribution of Longyou land resource had respectively been studied in economic condition, soil fertility and natural condition above. It could get a integrated knowledge about the systemic structure, the function of land units and the land resource's system from the three parts (economy, fertility and natural condition) at the first layer of classification. However, the simple composition of subsystem could not reflect the feature and function of the whole land system[6]. It was necessary to learn the systemic function and character of 32 land units according to all indexes.

RS information, ground measurement data and statistic data of 32 land units made up the dataset which revealed the comprehensive feature of land resource. A primary fuzzy subset composed with 15 indexes was formed. After standardization and factors analysis, indexes were converted into five factors whose variance cumulative percentage was 87.8% while the critical variance cumulative percentage was 85%, the transform relations were constructed.

Result(saw figure 1 and table 2) showed that Longyou land resource could be divided into three groups: the first was the southern mountainous villages including Dajie, Guantan, Kangtou, Muchen, Lingshan, Lingshan, Luojia, Miaoxia, Sheyang , Wucun, Xikou. These villages were prevailed in bamboo and forest-planting district, its economic strength was middle, therefore, the region should extend bamboo area, prosper the tea and fruit tree, protect the present farmland, take the way of special economy focused on forest products.

The five villages of Tashi, Hengshan, Xiazhai, Zhitang and Henghuan in the northern Longyou , were economically worse, it should be strengthened in provisions and developed the provisions bases according to its natural condition, planning the farm structure and layout and taking the way of various business.

The 17 villages including Hutoushan, Huzhen, Lantang, Longyou, Maye, Qidu, Ruotang, Shangyutou, Shifu, Shiyuan, Sihou, Tuanshi, Xiajin, Xiaku, Yacun, Zesui, Zanjia, were centered in the plain of the Longyou's middle part which was also the economic center of the county. In this district, villages were distributed densely, the annual income of one person was 1701.88 ￥ , and the irrigating condition was best with 84.17% of the irrigated area percentage. Therefore, in land resource development, it should make full use of its superior natural condition, plentiful soil resource, heavy soil depth and wide adaptation to most plants to cultivate mulberry, tea, fruit and other agricultural production, and achieve the harmony improvement of agriculture ,industry and business for accelerating the economy of the whole county.

4. Discussion

Traditional information indexes for land classification came from measurement and statistic data which could represent the regional information in one period. But RS information could represent the current state of land resource and provide real-time meaningful information for land planning. The classification method based on the "hierarchical structure model formatted through fuzzy similarity relation " set out from the system structure of land resource, researched on the mutual relationship of land units which aimed for the different classification, target, and finally gained the spatial distribution of land units in different target layer. Thus the structure and function of land resource could be understood in detail, and a clear outline and concept about the land resource may be formulated. At last, it formed a kind of comprehensive knowledge about the land exploitation types for function division of land units , thus achieved the organic combination and unity on the systemic structure.

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