Spatial-temporal Dynamic Analysis of Landscape Ecological Security of Chishui River Basin in Guizhou Province, China

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Abstract. Using the technologies of GIS and RS for the perspective of landscape ecology, the characteristics of landscape ecological security changes of Chishui River Basin in Guizhou Province from 1995 to 2015 were analyzed. The results showed that: (1) In the past 20 years, the utilized land types in the study area were changed greatly. The disturbance of human factors on utilized land change was serious. The area of construction land was increased rapidly, while the cultivated land increased first and then decreased. (2) In the past 20 years, the landscape fragmentation index and landscape separation index of other utilized land types were increased except the construction land. The fractal dimension indices of other landscape types were increased, but the change was not obvious. With the continuous development of economy and society, the disturbance of human activities to various landscape types was increased. (3) From the point of view of temporal and spatial changes of landscape ecological security, the overall situation of landscape ecological security in the study area was better, and the area with high ecological security was increased in the past 20 years. Less than 10% of the area was in low ecological security, but the overall trend was increasing, and the problem of ecological security was serious. (4) In the past 20 years, the spatial aggregation of towns with similar landscape ecological security in the study area decreased first and then increased, and the spatial aggregation types were low to low and high to high.

1. Introduction

The ecological security pattern is crucial for maintaining normal water cycle, carbon cycle, energy flow, and information flow in a specific area, and ensuring biodiversity, a sustainable ecosystem and a continuous supply of Eco-service [1]. The ecological security pattern is considered to be the basic guarantee and important way to achieve regional ecological security [2, 3]. The river basin, as a relatively complete ecological and geographical unit, boasts unique natural geographical conditions, development patterns, ecological landscapes and laws of water circulation. It is of great significance to explore the issues related to ecological security in the basin. Based on the theories of remote sensing, geographic information technology, and landscape ecology, this study evaluates and analyzes the spatial and temporal variation characteristics of landscape ecological security in Chishui River Basin in Guizhou Province from 1995 to 2015, aiming to provide a scientific basis for ecological protection, decision-making on land use and harmonious and sustainable human-land relationship in Chishui River Basin.

The Chishui River is a large first-class tributary on the south bank of the upper reaches of the Yangtze River. It originates from Anjiaba, Zhenxiong County, Yunnan Province, and flows through...
Yunnan, Guizhou and Sichuan provinces with the total length of the main stream of 466 km, a total drop of about 1455 m and a catchment area of 20,440 km2 [4]. As the only tributary of the upper reaches of the Yangtze River, its main stream and most of its tributaries still connect with the Yangtze River. The climate along the river belongs to the mid-subtropical-southern-subtropical zone featuring warmth, humidity, long frost-free period, and heavy precipitation. It is also famous as the river with the most abundant biodiversity and beautiful natural landscape in China [5].

The Chishui River Basin is located in the northern part of Guizhou Province, which mainly includes Qixingguan District, Jinsha County, Dafang County in Bijie City and Renhuai, Tongzi, Xishui, Chishui, and Zunyi in Zunyi City. The total length of the main stream is 268.40 km, accounting for 61.50% of the total length of the main stream while the basin area accounts for 55.74% of the total area of the Chishui River [6]. The Basin is located in the transitional zone from the Yunnan-Guizhou Plateau to the Sichuan Basin. It has a subtropical monsoon humid climate with the average annual temperature ranging from 13.1°C to 17.6°C and the annual average precipitation ranging from 749 to 1286 mm.

2. Data and methods

2.1. Data source and pre-processing

The remote sensing data in this study is from the geospatial data cloud of the Computer Network Information Center, Chinese Academy of Sciences (http://www.gscloud.cn/), the landsat images provided by the US Geological Survey (http://earthexplorer.usgs.gov), and the remote sensing monitoring data about land use of 1:100,000 scale provided by the Resource and Environmental Science Data Center, Chinese Academy of Sciences (http://www.resdc.cn).

2.2. Research methods

2.2.1. Construction of landscape ecological security evaluation model. According to the scope of the study area, this paper takes 114 towns in a smaller and controllable scale in the Chishui River Basin of Guizhou as the evaluation unit to construct an evaluation model based on the landscape ecological security index of the land use landscape. The landscape analysis plug-in of ArcGIS 10.2 called Patch Analysis was used to obtain the landscape index such as the number of patches, its area and the total area to obtain the loss index, interference index, fragmentation index, and separation index of the landscape in the study area [7].

2.2.2. Classification of landscape ecological security. The landscape ecological security of each towns unit in Chishui River Basin of Guizhou Province is calculated using the spatial overlay analysis function of ArcGIS10.2. Based on the spatial probability of landscape ecological security and the actual situation in the study area, landscape ecological security is classified into five levels: high security, medium-high security, medium security, medium-low security and low security using Natural Breaks [8].

2.2.3. Study on the spatial and temporal variation characteristics of landscape ecological security. The spatial autocorrelation analysis of the landscape ecological security index of the study area is carried out by using Arcelin Local Moran I of the ArcGIS spatial statistical tool [9]. The global Moran’s I index can reflect the similarity of adjacent unit values, and is commonly used to test the spatial distribution pattern of a certain element [10]. This study adopts the global Moran’s I index is used to represent the correlation of landscape ecological security of neighboring towns in the study area and uses ArcGIS spatial autocorrelation analysis to obtain the global Moran’s I index in order to reveal the impact of spatial structural elements on landscape ecological security.
3. Results and analysis

3.1. Analysis of landscape ecological security in Chishui River Basin

By studying the types of land use in the Chishui River Basin of Guizhou Province from 1995 to 2015 and obtaining the landscape index, patch area, total area and other landscape indices in the study area using the landscape analysis plug-in of ArcGIS 10.2 called Patch Analysis, the land use landscape type and area and landscape pattern index from 1995 to 2015 is shown in Table 1. In the past 20 years, the area of cultivated land in the Chishui River Basin increased first and then decreased with increasing landscape separation of all land except for construction land. The latter 10 years saw greater landscape fragmentation of forest land and cultivated land landscape separation to the first 10 years while the grassland and water landscape showed the opposite trend. The landscape separation degree of construction land increased first and then decreased while that of unutilized land was overall increasing with a decreasing area, indicating that the unutilized landscape has been converted to other land types with an increasing degree of land separation. In the past 20 years, there was a great increase in the landscape fractal dimension of construction land, a slight increase in landscape fractal dimension of other land types, and an increase in the interference degree of each landscape type.

Table 1. The changes of different landscape types and landscape pattern indices in the study area from 1995 to 2015

| Year | landscape types | area(hm²) | landscape fragmentation | landscape separation | landscape fractal dimension | landscape interferenc e degree | landscape damage degree |
|------|----------------|----------|------------------------|----------------------|-----------------------------|-----------------------------|-------------------------|
| 1995 | cultivated land | 360583.528 | 0.012 | 0.097 | 0.405 | 0.116 | 0.022 |
|      | forest land     | 699930.982 | 0.003 | 0.032 | 0.428 | 0.097 | 0.009 |
|      | grassland       | 75628.705  | 0.013 | 0.222 | 0.393 | 0.152 | 0.022 |
|      | water           | 1679.075   | 0.036 | 2.484 | 0.329 | 0.829 | 0.197 |
|      | construction land| 1716.649  | 0.048 | 2.834 | 0.348 | 0.944 | 0.045 |
|      | unutilized land | 646.286    | 0.014 | 2.479 | 0.342 | 0.819 | 0.234 |
| 2005 | cultivated land | 361079.066 | 0.020 | 0.124 | 0.406 | 0.128 | 0.024 |
|      | forest land     | 696741.358 | 0.004 | 0.038 | 0.428 | 0.099 | 0.009 |
|      | grassland       | 78346.316  | 0.044 | 0.402 | 0.393 | 0.222 | 0.032 |
|      | water           | 1685.727   | 0.077 | 3.611 | 0.330 | 1.188 | 0.283 |
|      | construction land| 1780.004  | 0.054 | 2.954 | 0.349 | 0.983 | 0.047 |
|      | unutilized land | 552.754    | 0.033 | 4.098 | 0.340 | 1.314 | 0.375 |
| 2015 | cultivated land | 357242.423 | 0.021 | 0.131 | 0.406 | 0.131 | 0.025 |
|      | forest land     | 696244.143 | 0.004 | 0.039 | 0.428 | 0.099 | 0.009 |
|      | grassland       | 78169.415  | 0.047 | 0.412 | 0.393 | 0.226 | 0.032 |
|      | water           | 1688.005   | 0.078 | 3.634 | 0.330 | 1.195 | 0.285 |
|      | construction land| 6277.294  | 0.042 | 1.379 | 0.366 | 0.508 | 0.024 |
|      | unutilized land | 563.946    | 0.034 | 4.127 | 0.340 | 1.323 | 0.378 |

3.2. Assessment of landscape ecological security and analysis of spatiotemporal variation characteristics

In order to understand the spatial and temporal variation characteristics of landscape ecological security in Chishui River Basin in order to make more targeted ecological protection policies, this paper studies the landscape ecological security of the 114 towns in Chishui River Basin of Guizhou, or the evaluation unit, using the landscape ecological security evaluation model and ArcGIS. The results were showed in Table 2. In the past 20 years, overall good ecological security of land use in the Chishui River Basin in Guizhou with the area with high ecological security increasing from 13.480% in 1995 to 15.107% in 2015 and the landscape ecological security of land use in the middle, low, medium-high security areas of the Chishui River Basin maintaining above 75%.

Based on the global autocorrelation Moran I index of the landscape ecological security of the Chishui River Basin obtained by the ArcGIS spatial autocorrelation analysis tool, the Moran I indices in 1995, 2005 and 2015 were 0.402491, 0.377079 and 0.387131, respectively; the standardized Z were 6.319172, 5.9364383, 6.085927, respectively, all greater than 2. In the past 20 years, the Moran I
index and the standardized Z value of the study area all decreased first and then increased with an overall downward trend, indicating that the spatial clustering of towns similar in landscape security from 1995 to 2005 was decreasing and that from 2005 and 2015 was increasing.

Table 2. The landscape ecological security levels of different towns in the study area from 1995 to 2015

| landscape ecological security level | 1995 area (hm²) | percentage (%) | towns | 2005 area (hm²) | percentage (%) | towns | 2015 area (hm²) | percentage (%) | towns |
|------------------------------------|----------------|----------------|-------|----------------|----------------|-------|----------------|----------------|-------|
| low ecological security            | 73207.301      | 6.421          | 10    | 39468.839      | 3.462          | 6     | 97750.969      | 8.573          | 11    |
| high ecological security           | 153700.989     | 13.480         | 14    | 172248.875     | 15.107         | 16    | 172248.882     | 15.107         | 16    |
| middle ecological security         | 299351.899     | 26.255         | 29    | 380280.447     | 33.353         | 43    | 303645.350     | 26.631         | 34    |
| medium-low ecological security     | 354363.405     | 31.079         | 38    | 205786.176     | 18.048         | 21    | 234394.381     | 20.558         | 26    |
| medium-high ecological security    | 259561.631     | 22.765         | 23    | 342400.888     | 30.030         | 28    | 332145.643     | 29.131         | 27    |

4. Conclusion

This study takes the towns in the Chishui River Basin in Guizhou as the basic study unit, constructs a model for evaluating landscape ecological security based on the landscape pattern of land use and basic theories of landscape ecology, and studies the landscape ecological security level of each town in the study area. This paper also analyzes the spatial and temporal variation characteristics of landscape pattern of land use and landscape ecological security in the Chishui River Basin in Guizhou in the past 20 years using spatial statistical analysis methods such as global autocorrelation and local autocorrelation with the years of 1995, 2005 and 2015 as the base. The results are as follows:

(1) In the past 20 years, the type of land use in the study area has undergone major changes. With the development of economy and society and the acceleration of urbanization, human beings exert a larger impact on the change of land use with continues rapid increase of construction land area and increase-decrease cultivated land area.

(2) In the past 20 years, the landscape fragmentation of all land use types in the Chishui River Basin of Guizhou increased, except for the construction land. Landscape separation shows an increasing trend in all land use types.

(3) In the past 20 years, the overall ecological security in the study area is good with the area with high ecological security increasing. There is less than 10% of the area with low ecological security, but is increasing with more prominent ecological security issues. From the perspective of space, the low security area is mainly located at the junction of Guizhou and Sichuan where the Chishui River passes by while the ecological security in the middle, low, medium and high-security areas has maintained above 75%, but showing a downward trend.

(4) In the past 20 years, as is shown in spatial correlation analysis, spatial clustering of towns with similar landscape ecological security decreased first and then increased. Most towns have low-low and high-high type special clustering.

This study takes the towns in the Chishui River Basin in Guizhou Province as the research unit, starting from a small scale and controllable unit, thus providing scientific basis for the rational planning of subsequent land use. However, the range of regional ecological security assessment is wide, this study focussed on the regional ecological security only from the perspective of change of utilized land. In the further study, we should consider the impact of nature, human and climate change and the Karst topography, which are all important directions for further study.

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