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Ecological Security Assessment of Yuan River Watershed Based on Landscape Pattern and Soil Erosion

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Abstract

Abstract: Ecological security is an important part of regional security and society stability, which is also becoming a hot issue at present. Based on landscape pattern index, constructed by fragmentation, isolation and dominance indexes, and soil erosion index, the ecological security characteristic in Yuan River watershed was analyzed using GIS and RS method. The landscape of Yuan River watershed were divided into six types, arable land, woodland, meadow, water, land for construction, and unused land. Results showed that land for construction, unused land and waters had higher integrated landscape pattern index that suggested the three had lower ecological security in pattern changes compared to the other three. However, the soil erosion levels of woodland, arable land and meadow were relatively higher which implied these three land types were liable to losing soil. The soil erosion index of the upper reaches of Yuan River was 5.05 times more than that of the low reaches, while the integrated landscape pattern index had not considerable variation. Landscape ecological security index based pattern and soil erosion could more comprehensive reflect the real ecological security situation. Land for construction, unused land and water had higher ecological security index compared to the other three. We should pay attention to woodland and arable land in the large proportion of total area in local environmental protection in the future.

Keywords: Ecological security; Landscape pattern; Soil erosion; Yuan River

1. Introduction

Ecological security, which has been developed in recent years, has gotten plenty of attentions, and ecological problems have become a hot topic of national security[1]. Scholars both abroad and at home have different interpretations to ecological security, for it is a new concept[2-4].The concept of ecological security contains two parts, the broader sense and the narrower sense. In a broader sense, ecological security means human life, essential right, life safeguard origin and others place in to be free from threat, including natural, economic, social ecological security, presented by International Institute for Applied Systems Analysis(IIASA) in 1989, while in a narrower

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sense, it refers to the security of natural and half natural ecological system, including ecological system and environment security[5].

A Chinese scholar[6]divided the research of ecological security abroad into four stages: the first stage is extension of security definition, the second stage is empirical research on environment changes and security, the third stage is integrated studies on environment changes and security, and the fourth stage is the research on the inner relations between environment changes and security. At present, the research in our country has not become system, without a consistent understanding on ecological security. Some scholars presented rough framework of establishing the pre-alarm and protection on ecological security, and some did research on ecological security assessment[7-10].

Research scales on ecological security range from individual to system in natural ecology, from person to state in human ecology[5]. Currently, attention has been paid to scientific research in meso-scale and large-scale, such as landscape scale, basin scale, regional scale[11-14]. Ecological security emphasized pattern and progress security in meso-large scale[5]. However, the current studies are limited to landscape pattern or process security, there are few studies focused on ecological security based on pattern and process[12,15]

The paper analyzed the ecological security characteristic using GIS and RS method, based on landscape pattern index, constructed by fragmentation, isolation and dominance indexes, and soil erosion index, taking a case study of Yuan River watershed. In order to sustain local ecological heath and achieve sustainable development, environmental mangers and decision-makers should take human disturbance on both landscape pattern and erosion into account.

2. Material and Methods

2.1. Study area

Yuan River watershed is located south-central of Yunnan province, China, along the riverside of Yuan River(100°35′-104°58′E, 22°30′-25°30′N), and encompasses a total area of 54026km^2. Terrain northern to southern high-low, the highest point of the study area is about 3123m, the lowest point is about 71m, and the average is about 1544m. The climate of study area is subtropical monsoon climate, characterized by wet and dry season clear, with hot rainy season

2.2. Data source

In the case study, we got the coverage factor grid data, slope length and slope gradient index, soil erodibility factor, and landscape pattern index necessary based on 1:100000 land use map and TM satellite image remote sensing data in 2004, corrected 1:50000 DEM data.

2.3. Analysis methods

2.3.1. Integrated landscape pattern index(E_i)

Fragmentation, isolation and dominance indexes are chose to construct a landscape composite pattern index to represent the effect of human disturbance on landscape pattern[16].

2.3.2. Integrated landscape process index(P_i)

We choose landscape vulnerability index and soil erosion index to represent the effect of human disturbance on landscape process.

2.3.3. Landscape ecological security index(ES_k)

Due to the workload and field in study area, Yuan River watershed is divided into 190 assessment units, 20km× 20km squires. Based on formula(1), we calculate landscape ecological security index of the 190 units.

$$ES_k = \sum_{i=1}^{N} \frac{A_{ki}}{A_k}(1 - 10 \times E_i \times P_i) \quad (1)$$

Where ES_k means landscape ecological security index in the sampling zone k, A_{ki} the landscape area of sampling zone, A_k the area of sampling zone.

3. Results and Discussion

3.1. Landscape pattern analysis

We calculated the integrated landscape pattern index of 190 sampling zones(Table 1), based on fragmentation index, isolation index and dominance index. We found that the minimum of integrated landscape pattern index was 0.002248, the maximum was 0.9572, and 97% of that were between 0.05and 0.35.

Table 1. Landscape indexes of sampling zones

Sampling Zone Number	Number of patches	Fragmentation Index	Isolation Index	Dominance Index	Composite Pattern Index
001	43	0.005090	0.03567	0.1334	0.03993
002	32	0.002900	0.02693	0.05182	0.01989
…	…	…	…	…	…
099	215	0.005374	0.03665	0.3342	0.08052
100	107	0.002675	0.02586	0.4214	0.09337
…	…	…	…	…	…

The landscape of the study area was divided into six types, arable land, woodland, meadow, water, land for construction, and unused land. In Figure 1, number of patches of arable land was largest and the area ratio was smaller, which suggested arable land had more serious fragmentation, compared to woodland and meadow. From Figure 2, the integrated landscape pattern indexes of water, land for construction, and unused land, were significantly higher than the other three types. Among them, the integrated landscape pattern index of land for construction was biggest.

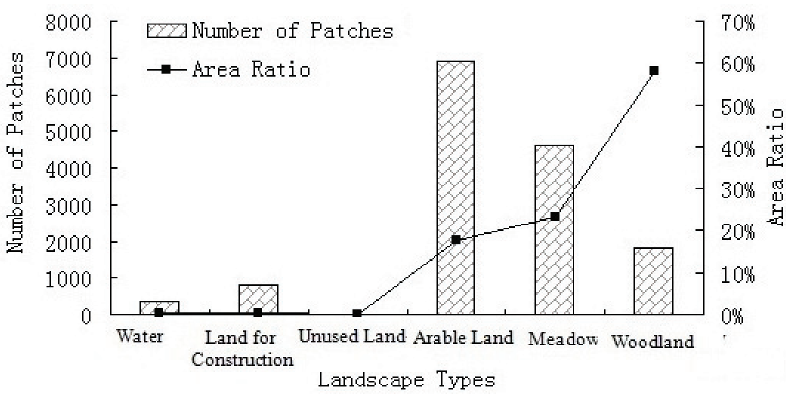

Figure 1. Number of patches and area ratio of the six landscape types

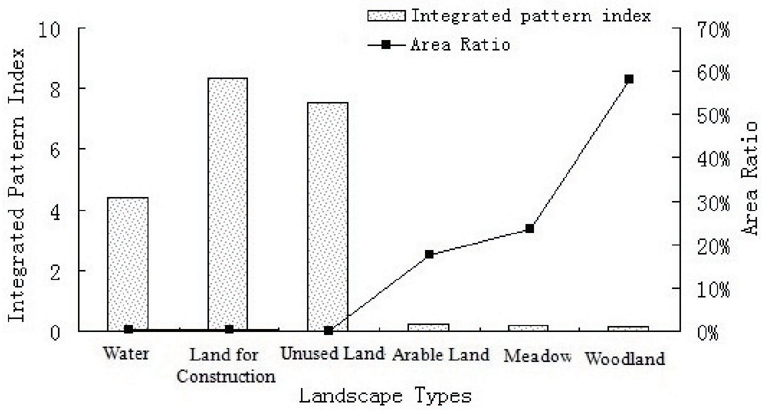

Figure 2. Integrated pattern index of the six landscape types

3.2. Soil erosion analysis

We calculated the soil erosion index of sampling zones along Yuan River and six landscape types(Figure 3 and Figure 4). Soil erosion index of the upper reaches of Yuan River was 5.05 times more than that of the low reaches, because of lower vegetation coverage and undulating terrain.

The soil erosion of unused land was severest, and the mean soil erosion index was 1.12 $t{\cdot}ha^{-1}{\cdot}a^{-1}$, arable land, woodland, meadow followed. Water and land for construction had less serious soil erosion. Unused land, land bare and vegetation coverage low, easily lead to serious soil erosion, to destroy the ecological environment.

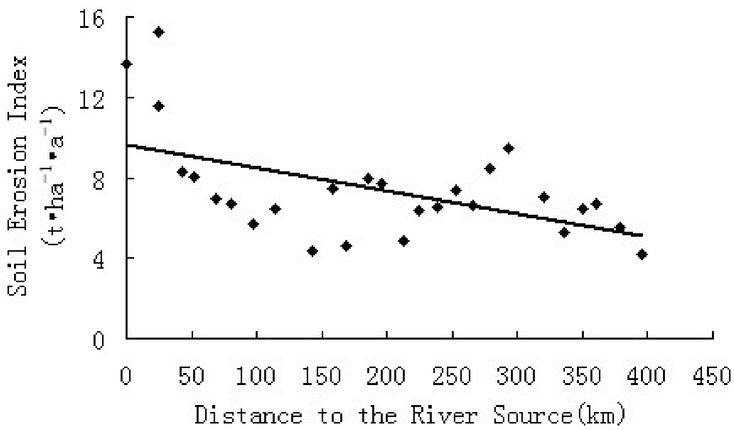

Figure 3. Soil erosion index along Yuan River

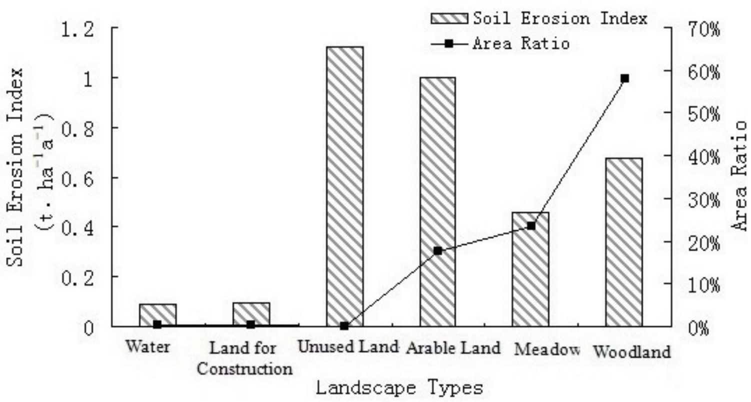

Figure 4. Soil erosion index of the six landscape types

3.3. Landscape ecological security index

Using equation(1), landscape ecological security index, based on integrated pattern index and integrated process index, were computed(Figure 5). From Figure 5, the landscape ecological security index of woodland was lowest, and it was 0.52. The second and third lower ecological security was arable land and meadow. Although the integrated pattern indexes of woodland, arable land, and meadow were lower than the other three types(Figure 2), they were more ecological insecurity and vulnerable to human or natural disturbance for more severe soil erosion(Figure 3).

Form the comparison of in integrated landscape pattern, process and ecological security index in Figure 5 we can see that the single index based on landscape pattern or process cannot fully reflect the impact of human disturbance on landscape.

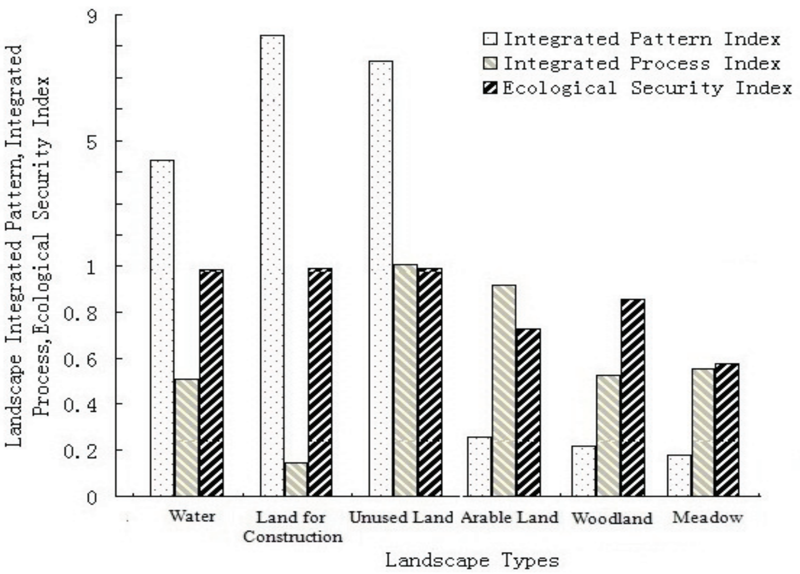

Figure 5. Landscape ecological security index in different landscape types

4. Conclusions

Ecological security has been more and more attracted the attention of domestic and foreign scholars. How to evaluate it in meso-large scale has also become a hot topic. The paper analyzed the ecological security characteristic in Yuan River watershed. It is founded ecological security indexes, based on landscape pattern, process, and both, had obvious differences in different landscape types.

In the paper, fragmentation, separation and dominance indexes were used to establish the integrated landscape index, while soil erosion and vulnerability indexes were to build integrated landscape process index. Landscape ecological security index, with landscape pattern and soil erosion indexes as indicators, has more comprehensive consideration of the impact of interference on landscape.

The development and utilization of environmental resources are not inevitably during human society being and development, and it would unavoidably lead to environmental change but not necessarily damage if human actives in the extent permitted by ecological security. The studies on ecological security are conductive to protection of fragile ecological environment and local sustainable development of eco-environmental resources.

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