

Landscape Ecological Risk Assessment of Dianchi Lake Basin Based on Land Use Change

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Abstract. In order to explore the impact of land use type change on landscape ecological risk, this paper uses Landsat remote sensing image of Dianchi Lake Basin in 2003-2018 as the basis data to interpret its land use type by ENVI, and combines ArcGIS and Fragstats4.2 according to landscape ecology theory. The various landscape ecological indices were calculated, and the spatial pattern and process characteristics of landscape ecological risk in Dianchi Lake Basin from 2003 to 2018 were analyzed. The results show that: (1) The landscape pattern of Dianchi Lake Basin has changed significantly in 2003-2018. (2) The landscape ecological risk level has a gradually increasing trend, that is, the proportion of the medium risk area to the high-risk area is relatively large. (3) From the perspective of spatial distribution, the overall risk distribution of Dianchi Lake Basin has an increasing trend from Dianchi Lake to Dianchi Lake.

1. Introduction

Ecological risk assessment (ERA) refers to the assessment method, evaluation system and assessment of the possibility of damage to the ecosystem function due to changes in the natural environment or human activities, resulting in the loss of the composition or structure of the ecosystem.[1] In recent years, due to frequent human development activities and severe ecological and environmental problems, ecological risk assessment has gradually become an important means to study and solve environmental problems.[2] How to scientifically analyze the changing process of ecological risks, explore its impact mechanism on ecosystems, evaluate its impact on human society and natural ecosystems, and achieve sustainable socioeconomic development have become hotspots in social science, geography, and ecology research one of the problems.[3]

With the development of society, the ecological environment has faced tremendous pressure in recent years. However, since the US Environmental Protection Agency proposed ecological risk assessment in 1990, ecological risk assessment has made great progress.[4] At home and abroad, the ecological risk of regional space is calculated mainly through the change of land use type and the landscape ecological correlation index. For example: Potter et al.[5] extracted landscape pattern indices from 73 different watersheds in North Carolina, and explored the relationship between landscape ecological risk and non-point source pollution ecological risk. Obery et al.[6] used the Codorus Creek basin in the United States as a research area to explore the risk effects of the landscape ecological pattern in the basin on the fragile ecological environment of the region. Liu et al.[7] analyzed the road-to-region ecological risk image and indicated the potential ecological risk of the Lancang River with the intensity and ecological vulnerability of different soil erosion. Lu et al.[8]



used the Xi River Basin as the research basis to explore the impact of land use change on the landscape ecology of the Xi River Basin from the aspects of land use change, landscape ecological risk and spatial correlation analysis. Wang et al [9] used the spatial and spatial correlation of landscape to evaluate the landscape ecological risk of the Bohai Sea Basin. Liang et al.[10] based on the transformation of land use types in the Manas River Basin in Xinjiang, used the landscape ecological index and spatial analysis method to construct an ecological safety index for the Manas River Basin, and made a safety evaluation.

As a pearl on the Yunnan-Guizhou Plateau, Dianchi Lake is the only lake in the nine high-altitude lakes in Yunnan Province that is adjacent to the big city. The landscape pattern of the Dianchi Basin has also undergone tremendous changes in recent decades. With the advancement of urbanization, the Dianchi Basin has become a key area for development, and the ecosystem has been affected and destroyed to varying degrees. Therefore, this paper uses the Dianchi Basin as a research area to construct a landscape ecological risk index for the study area, for 2003-2018. The landscape pattern is analyzed by ecological risk assessment, revealing the temporal and spatial variation characteristics of ecological risk in the study area, in order to provide theoretical, technical support and decision-making basis for ecological risk management of Dianchi Basin in Yunnan Province.

2. Research Area Overview

The Dianchi Lake Basin is located in Kunming City in the central part of Yunnan Province. The drainage area is 2,970km². The geographical coordinates are 102°30'-103°02' east longitude, 24°28'-25°23' north latitude, and the average elevation is about 1900m. (Figure 1). The landscape structure is rich in the basin. It has the largest plateau lake and pond in Yunnan Province, and has a relatively wide flat land. It is the economic, political and cultural center of Yunnan Province, with developed economy, large population and rapid urbanization.

3. Data Source and Processing

The remote sensing image data of this paper is from geospatial data cloud (<http://www.gscloud.cn/>) with a spatial resolution of 30m. Using ENVI5.3 software to preprocess remote sensing images, refer to the 2017 Land Use Classification Standards of the People's Republic of China, refer to existing domestic The land use cover classification system, combined with ArcGIS10.2 software, divides the study into six major landscape types. Combined with Fragstats4.2 software, the ecological risk index spatial distribution map of Dianchi Lake Basin was obtained, and its temporal and spatial variation characteristics of ecological risk were analyzed.

4. Research Methods

4.1. Analysis of Land Use Change Characteristics

In the transformation of land use types, the number of land use types is constantly changing, and the transformation between land types is also two-way. The land use change classification map and transfer matrix are used to analyze the land use change process. Use land use dynamics to measure the degree of change in land resource use types. The formula is as follows:

$$K = \frac{U_{ib} - U_{ia}}{U_{ia}} \times \frac{1}{T} \times 100\% \quad (1)$$

Where K is land use dynamics; U_{ia} , U_{ib} is the beginning and end area of a certain land type in the study area; T is the start and end time period of land use change.

4.2. Analysis of the Characteristics of Landscape Pattern Change

The landscape pattern is the result of the combination of natural and human factors in a certain period of time. The landscape pattern index can accurately reflect the landscape pattern change. According to the research content of this paper, the following indices were calculated using Fragstats4.2 software: plaque number (NP), plaque density (PD), landscape shape index (LSI), maximum plaque index (LPI),

Shannon diversity index (SHDI), Contagion Index (CONTAG), Perimeter Area Dimensionality (PAFRAC), Aggregation Index (AL), and Cohesion Index (COHESION).

4.3. Landscape Ecological Risk Analysis

4.3.1. Landscape ecological risk assessment unit division

Using ArcGIS10.2 software, a fishing net was created for the Dianchi Lake Basin to generate an ecological risk assessment unit. According to the average area of landscape ecological patches in Dianchi Lake Basin, combined with the scope and workload of the study area, a 2km×2km risk area sampling grid was used to generate 843 ecological risk assessment units, and then the landscape ecological risk index of each unit was calculated in turn, as the ecological risk value of the sample.

4.3.2. Landscape ecological risk index and model

In this paper, the spatial pattern of landscape is transformed into spatialized ecological risk variable by sampling method. An ecological risk assessment model based on multiple integrated landscape pattern indices is established by using landscape pattern index to quantitatively reflect the correlation between landscape pattern and ecological risk. The landscape ecological risk index ERI is constructed according to the area specific gravity of the land use type and the landscape loss index. The calculation formula is as follows:

$$ERI_n = \sum_{i=1}^N \frac{A_{ni}}{A_n} \times R_i \quad (2)$$

Where ERI_n is the landscape ecological risk index of the landscape ecological risk assessment unit n , A_{ni} is the area of the i -type landscape in the landscape ecological risk assessment unit n , A_n is the total area of the landscape ecological risk assessment unit n , and R_i is the loss index of the i -type landscape, its calculation formula is as follows:

$$R_i = S_i \times F_i \times 10 \quad (3)$$

Among them, the calculation formula of the landscape structure index is as follows:

$$S_i = aC_i + bN_i + cD_i \quad (4)$$

In the formula, C_i is the landscape fragmentation index, N_i is the landscape separation index, D_i is the landscape dominance index. a , b , c is the weight of each landscape index, and $a+b+c=1$. According to the relevant research, the fragmentation index, the separation index, and the dominance index are assigned 0.5, 0.3, and 0.2, respectively.[11]

5. Results and Analysis

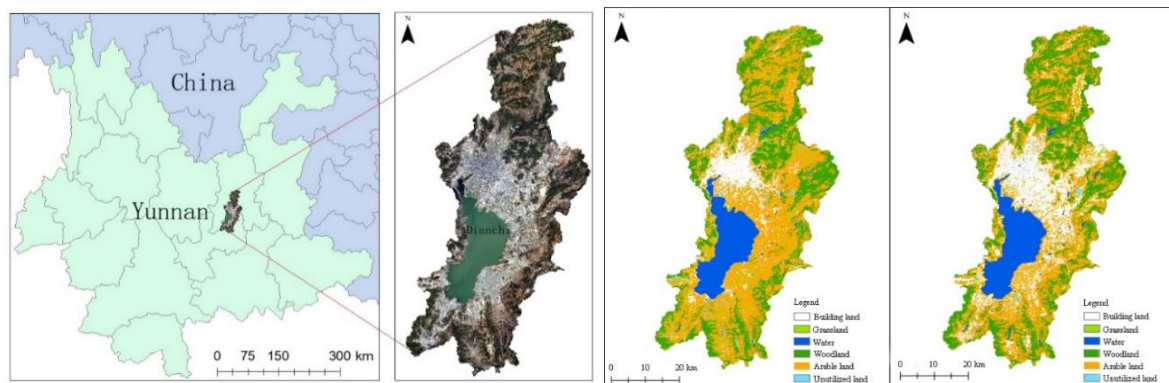
5.1. Analysis on the Characteristics of Land Use Change in Dianchi Lake Basin

5.1.1. Analysis on the change of land use structure in Dianchi Lake Basin

During the 15 years from 2003 to 2018, with the continuous development of the economic and social development of the Dianchi Lake Basin, the types of land use are constantly changing. It can be seen from Table 1 that there is a small increase in the water area within the basin, forest land and buildings. The increase in land area is the most obvious. The area of cultivated land, grassland and unused land has declined to varying degrees, with the most decline being cultivated land. In 2003, the cultivated land area was 686.72km², accounting for 23.12%, while the 2018 was down by 38.38km², accounting for 10.20%; the construction land increased by 49.04km², from the original ratio of 12.01% to 28.68%; grassland and unused land decreased from 750.43km² and 95.5km² to 268.78km² and 49.46km² respectively; the water area and forest area increased from 11.30% and 25.09% respectively to 11.45% and 38.95%.(Table 1) It can be seen from Figure 1 that the construction land is growing rapidly along the coast of Dianchi Lake and the eastern part of the basin, and the forest land has increased in the northern mountainous areas and the eastern and southern mountainous areas of the basin.

Table 1. Land use change in Dianchi Lake Basin

Years	Project	Water	Arable land	Forest	Grass	Building land	Unutilized land
2003	area/km ²	335.63	686.72	745.04	750.43	356.68	95.50
	rate/%	11.30	23.12	25.09	25.26	12.01	3.22
2018	area/km ²	340.09	303.00	1156.89	268.78	851.72	49.46
	rate/%	11.45	10.20	38.95	9.05	28.68	1.67

**Figure 1.** Research area and Classification of land use in Dianchi Lake Basin in 2003 and 2018

5.1.2. Analysis of land use transfer in Dianchi Lake Basin

Using ENVI5.3 to extract the land use transfer matrix and combine the matrix model to transfer the land type: from 2003 to 2018, there will be different degrees of change between various types of land, of which the area of cultivated land and grassland is greatly reduced, and the grassland has 153.31km² was transformed into construction land, 263.13km² was converted into forest land, 74.03km² was converted into cultivated land; cultivated land was converted into construction land with 267.64km², and 201.33km² was transformed into forest land. (Table 2)

Table 2. Dianchi Basin Land Use Conversion Matrix(km²)

Land use type		Various land areas in 2018					
		Building	Grass	Water	Forest	Arable	Unutilized
Various land areas in 2018	Building	---	20.01	0.31	4.15	3.78	2.92
	Grass	153.31	---	2.00	263.13	74.03	1.32
	Water	0.03	2.12	---	0.04	0.02	0.01
	Forest	67.25	6.33	2.21	---	6.79	7.21
	Arable	267.64	1.04	1.32	201.33	---	5.00
	Unutilized	21.02	0.65	0.83	22.99	18.99	---

5.1.3. Dynamic analysis of land use in Dianchi Lake Basin

Through the use of land use dynamic formulas in the continuous change of land use types in Dianchi Lake Basin, it is analyzed that the average annual reductions of cultivated land, grassland and unused land in Dianchi Lake Basin during the 15-years period from 2003 to 2018 are -3.74% and -4.30%, respectively. And -3.23%, the proportion of reduction is relatively large. Among them, the grassland decreased by 481.65km², the largest reduction; the construction land use area increased by 9.30% annually, which is the fastest growing among all land use types.

5.2. Analysis on the Change Characteristics of Landscape Pattern of Dianchi Lake Basin

5.2.1. Analysis of landscape pattern Index change on horizontal scale of landscape

The total number of patches in the Dianchi Lake Basin is increasing, from 23,876 in 2003 to 35,526 in 2018. The plaque density increased from 2.68 to 3.13, and the number of plaques per unit area continued to increase, showing fragmentation. The patch shape index increased from 44.98 in 2003 to 50.79 in 2018, and the degree of landscape irregularity increased. The maximum plaque index decreased from 30.74% to 22.10%, the dominance was decreasing, and the fragmentation was increasing. The Shannon diversity index increased from 1.32 to 1.37, the dominance of the landscape species decreased, and each patch type tended to be evenly distributed in the landscape. The spread has dropped from 62.12 to 60.36, the connectivity of the dominant patch types is poor, and the landscape landscape in the watershed is severely fragmented.

5.2.2. Analysis of plaque type landscape pattern index change

The changes in the plaque type index from 2003 to 2018 are shown in Table 3. (1) From 2003 to 2018, the number of patches in waters, cultivated land, woodland, and grassland increased, and the increase in the number of patches in waters and grassland was the most significant. (2) The water area index in the patch shape index of the Dianchi Basin from 2003 to 2018 increased from 5.31 in 2003 to 16.01 in 2018. Cultivated land and grassland increased from 76.29 and 52.69 in 2003 to 90.93 and 69.96 in 2018, respectively. (3) From 2003 to 2018, the largest patch reduction amount on the landscape scale of the Dianchi Basin was cultivated land, which dropped from 20.74% to 12.10%. The maximum patch index of construction land is rising, from 4.77% to 11.06%. (4) Among the types of land use in the Dianchi Basin from 2003 to 2018: the perimeter area fractal dimensions of water areas, cultivated land, forest land, grassland, building land, and unused land have all shown an increasing trend. (5) From 2003 to 2018, the aggregation index of water area, cultivated land, forest land, grassland, and unused land have all declined, and construction land has increased. (6) Except for construction land, the combination index of other land types has decreased, among which the grassland decreased by 3.67, the largest decline. Building land increased from 98.77 in 2003 to 99.63 in 2018.

Table 3. Changes in plaque type index in Dianchi Lake Basin from 2003 to 2018

Years	Landscape	NP	LSI	LPI(%)	PAFRAC	AI(%)	COHESION
2003	Water	1157	5.31	9.64	1.19	99.26	99.63
	Arable land	4731	76.29	20.74	1.32	94.12	99.86
	Wood land	4515	65.90	10.28	1.32	92.95	99.18
	Grass land	4282	52.69	10.48	1.26	75.49	86.37
	Building land	6653	66.52	4.77	1.27	88.25	98.77
	Unutilized land	2538	43.32	1.04	1.25	78.57	88.10
2018	Water	4517	16.01	10.22	1.23	97.55	99.07
	Arable land	7604	90.93	12.10	1.36	92.31	99.84
	Wood land	8577	66.15	13.68	1.36	92.87	98.76
	Grass land	6881	69.96	6.09	1.27	69.62	82.70
	Building land	5896	65.48	11.06	1.36	91.43	99.63
	Unutilized land	2051	34.34	0.80	1.28	77.76	87.06

5.3. Landscape Ecological Risk Assessment of Dianchi Lake Basin

5.3.1. Analysis on the change of landscape ecological loss index in Dianchi Lake Basin

Landscape ecological loss is an important indicator to measure landscape ecological risk. The loss is mainly composed of landscape fragmentation index, separation index and dominance index. In addition to construction land and unused land, landscape ecological fragmentation of waters, forest, arable land, and grassland are all increasing. The fragmentation index of waters has increased the most,

from 0.05 in 2003 to 0.13 in 2018; The overall increase in land fragmentation reflects the increase in the number of patches in the landscape type of the Dianchi Lake Basin, and the patches show a trend of fragmentation, which promotes an increase in the ecological risk value of the river basin landscape.

5.3.2. Analysis on spatial variability of landscape ecological risk in Dianchi Lake Basin

Combined with previous research, the ecological risk index is divided into five levels, namely high ecological risk area, higher ecological risk area, middle ecological risk area, lower ecological risk area, and low ecological risk area. It can be seen from Figure 2 that from 2003 to 2018, most of the lower ecological risk areas and middle ecological risk areas were transformed into higher ecological risk areas and high ecological risk areas, and the overall trend of the risk index shifted to higher levels of risk. Ecological risk zone in the past 15 years, the landscape ecological risk index has continued to increase, and the overall regional environment has deteriorated. In the future land use process, the land use structure should be optimized, the construction land should be reasonably planned, a certain amount of grassland, cultivated land, and water area should be reserved, and the complete patches should be avoided as much as possible, and the land use type should be intensive.

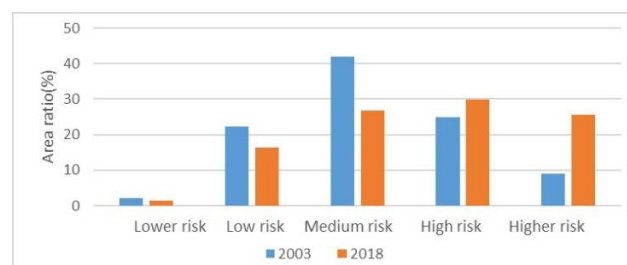


Figure 2. Proportion of landscape ecological risk ratio in Dianchi Lake Basin from 2003 to 2018

In 2003, the higher ecological risk and high ecological risk areas were mainly located in the mountainous areas around the Dianchi Basin. The middle ecological area is mainly located in the plain area in the east of Dianchi Lake, and the lower ecological risk areas and low ecological risk areas are mainly located in Kunming's main urban area and Dianchi Lake. In 2018, high ecological risk areas were mainly distributed around Dianchi Lake and newly developed small and medium-sized urban areas. Medium ecological risk areas were mainly distributed around forest areas and Kunming urban areas, and low ecological risk areas were distributed in central Kunming and Dianchi waters. (Figure 3)

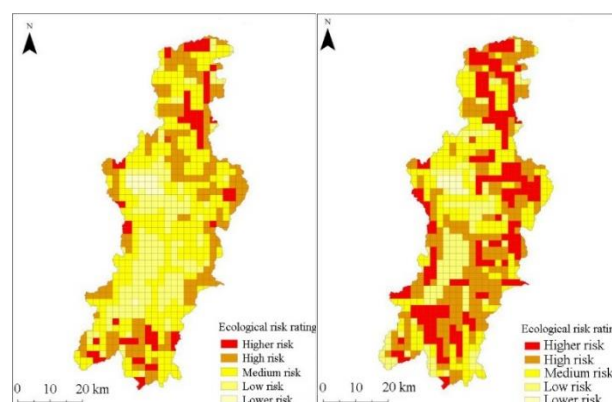


Figure 3. Distribution of ecological risk levels in Dianchi Lake Basin in 2003-2018

Combined with the land use classification maps, it can be seen that the spatial distribution of landscape ecological risk in Dianchi Lake Basin is affected by land use types and human activities. The ecological risk change of the landscape around Dianchi Lake was the most obvious in 2003-2018, and it changed from medium ecological risk and low ecological risk area to high and high ecological

risk area. This was mainly due to the continuous development of the Dianchi Lake in the past 15 years: the construction of ecological parks. The development of tourism, the development of real estate, and the construction of university towns have led to a significant reduction in the area of cultivated land around Dianchi Lake. The landscape types have changed from cultivated land and grassland to construction land, landscapes have been fragmented, and the risk index has increased. The above results are consistent with the development of the Dianchi Lake Basin in the past 15 years. In the future, the development process around Dianchi Lake should increase planning efforts to promote the growth of construction land within a reasonable range, and protect basic cultivated land, original forest land and existing waters.

6. Conclusion

Based on the analysis of land use dynamic change and landscape pattern change in Dianchi Lake Basin, through the above research, mainly got the following conclusions: (1) During the period of 2003-2018, the landscape pattern of the Dianchi Lake Basin has undergone significant changes. (2) The landscape ecological risk level has a gradually increasing trend, that is, the proportion of the medium risk area to the high-risk area is relatively large. (3) From the perspective of spatial distribution, the overall risk distribution of Dianchi Lake Basin has an increasing trend. Aiming at the above research results, this paper explores countermeasures for ecological risk management in the study area. The Dianchi Lake Basin should optimize the land use pattern, increase vegetation coverage, continue to implement the policy of returning farmland to forests and grasslands, and increase landscape connectivity; it is forbidden to expand construction land to ecological function areas, water conservation areas, conservation forest areas, and key tourist attractions. Reduce regional ecological risks, strengthen soil environmental governance, and reduce the use of highly polluting pesticides and fertilizers.

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