

# Spatio-temporal analysis of landscape pattern in water network area of Southern China-- A case study of Shuifumiao Reservoir basin in Hunan Province

Jingtao Liu

College of Architecture and Art, Central South University, Chang Sha, Hu Nan, China

467244128@qq.com

**Abstract.** Landscape pattern research is the premise of maintaining the stability of ecosystem structure, and is of great significance in guiding the orderly and rational planning of territorial space. In order to deal with the risk of landscape fragmentation of ecological environment in southern hilly region, taking Shuifumiao Reservoir basin of Hunan province as an example, Fragstats landscape pattern analysis software was used to analyze the landscape fragmentation. The patch area, patch number, density index, aggregation index, edge density, patch number, diversity index, evenness index, patch density, aggregation index, and sprawl index of each landscape type were obtained from 2002 to 2018, and the landscape pattern in this region was characterized by fragmentation. Finally, three rationalization landscape pattern optimization strategies were proposed to maintain the stability of regional landscape pattern and alleviate the negative impact of landscape fragmentation.

**Keywords:** Landscape pattern; Spatio-temporal analysis; Ecological security pattern; Regional ecological networks; Shuifumiao Reservoir basin.

## 1. Introduction

Southern water network region presents the landscape units of the rich ecological types but land pattern is broken, anti-interference ability is weak, the space ecological structure affected by climate change and spatial and temporal fluctuations, especially the internal components of high landscape heterogeneity, differences between component and component is too large, easy to cause the space marginalization effect, Therefore, ecologically fragile area is an important protected area where the ecological environment is vulnerable to damage and has potential ecological risks. Shuifumiao Reservoir basin is also located in the hilly region of red soil in south China [1], with rugged terrain and limited vision. The rivers and water systems are interlocking along the gullies and gullies, presenting a natural water system characteristic of "branching tree". Residents' living areas are densely arranged according to terrain and water network direction. In order to ensure the "safe and harmonious symbiosis" of various systems in the southern water network and maintain regional stability and effective management, the study of landscape pattern has become the focus of the concept of sustainability. The spatial-temporal analysis of landscape pattern can reflect the changes of spatial structure characteristics of land landscape and distinguish the level of regional sustainable development. And it also provides important data basis for eco-city construction and regional development [2-3].

## 2. Overview of the Study Area

According to GIS statistics, the area of forest and grass land was about 1647.3km<sup>2</sup>, accounting for 52.6% of the total area of the basin, among which the area of forest land was 1208.6km<sup>2</sup>. The water area is 60.4km<sup>2</sup>, including rivers, reservoirs, tidal flats and wetlands, etc. Other non-construction land 1161.7km<sup>2</sup> paddy field area is about 851.6km<sup>2</sup>; The land for urban construction in the whole region is 255.6km<sup>2</sup>, mainly including the built-up areas of Louxing and Lianyuan, as well as scattered land for rural residents of towns and villages [4]. The specific spatial and temporal distribution is shown in Figure 1. The basin is rich in ecosystem types, among which farmland ecosystem type and forest ecosystem type are the main community space in the basin, and

the vegetation coverage rate is relatively high. However, due to the rapid urbanization process, the most important ecological problems in this region are serious soil erosion, construction land occupation, forest ecosystem degradation, and sharp decrease of biodiversity, etc., resulting in a low level of environmental carrying capacity, with significant ecological vulnerability and sensitivity [5].

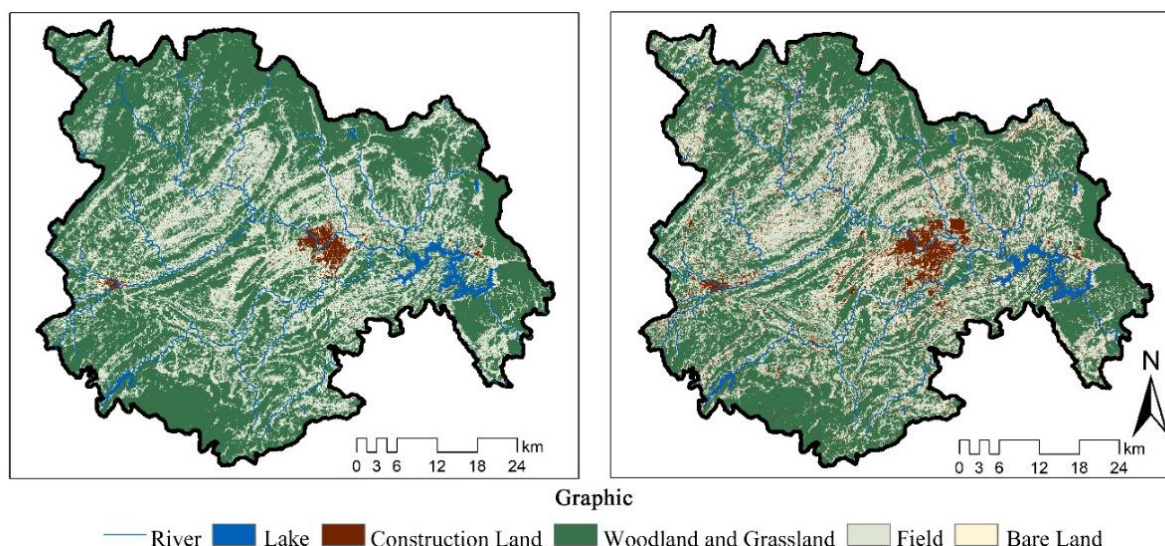


Figure 1. Landscape type distribution map of Shuifumiao Reservoir basin in 2002 and 2018 (Left: 2002; Right: 2018)

### 3. Landscape pattern analysis

In order to confirm the ecological vulnerability and temporal and spatial change of Shuifumiao reservoir basin, the Fragstats landscape pattern analysis software was used to approximate calculate the landscape types and landscape pattern indexes in 2002 and 2008. According to the results in Table 1 and Table 2, from the perspective of landscape type, the area of forest patch in the basin was 1,955 km<sup>2</sup> in 2002, and decreased to 1,647 km<sup>2</sup> until 2018, while the area of bare land and construction land increased significantly. The area of construction land in 2018 was about 6 times of that in 2002, showing a high degree of basin construction. In addition, the number and density of each type of patches increased, and the spatial heterogeneity became stronger and stronger. The aggregation degree of all landscape types also showed a decreasing trend, indicating that the structure of all landscape types in the basin was more discrete and less able to resist external invasion. The marginal density of construction land increased significantly, indicating that urban development was concentrated, but it was still far lower than that of non-construction land such as forest and farmland except for water system, indicating that the construction land of basin had not formed an orderly expansion mode, and the conflict effect of landscape edge was strong. From a global perspective, the ratio of patch number to patch area can reflect the landscape fragmentation degree of landscape types. Patches and density increase, and landscape fragmentation degree and habitat degradation become more obvious. The increase of Shannon diversity index and evenness index indicated that landscape tended to be heterogeneous, land pattern developed to be uniform, ecological importance patch dominance decreased, ecological sensitivity increased, and spatial uncertainty became stronger. The decrease of aggregation index and sprawl index indicated that the landscape connectivity of all patch types in the basin decreased, and the dispersion degree of ecological structure increased, leading to the decline of anti-interference ability and ecological security level. Various indications show that the Shuifumiao reservoir basin has been characterized by landscape fragmentation and ecological sensitivity and fragility. Therefore, spatial planning at

the level of ecological security has become the key to the sustainable development of Shuifumiao area [6-7].

Table 1. Landscape pattern indices of various types in the basin

Landscape types	Year	Patch Area (ha.)	Number of Patches	Density Index	Aggregation Index	Edge Density
Forest、Meadow	2002	195523.56	9400	2.9930	92.0670	65.3204
	2018	164730.2	9970	3.1903	81.471	64.4882
Bare Land	2002	21262.32	21308	6.7846	63.135	33.1755
	2018	31014	30563	9.7798	24.6494	49.7748
Farmland	2002	86434.92	11791	3.7543	80.3977	71.8240
	2018	85158	13121	4.1986	57.0391	77.8997
Construction Land	2002	4256.64	1735	0.5524	82.9359	3.1471
	2018	25563.24	21751	6.9601	40.1329	32.6501
Drainage	2002	6585.48	1936	0.6164	85.1964	4.2099
	2018	6044.76	1979	0.6333	67.706	4.2146

Table 2. Temporal and spatial analysis of landscape pattern in basin

Year	Number of Patches	Diversity Index	Evenness Index	Patch Density	Aggregation Index	CONTAG
2002	46170	0.9718	0.6038	14.7009	86.6289	55.2526
2018	77384	1.2022	0.747	24.7621	65.5266	33.7445

## 4. Optimization strategy of landscape pattern

### 4.1 Introduction of ecological security pattern

Ecological security pattern is the bottom line for the guidelines on regional security, forming a kind of identification in ecological processes under the action of key components and the contact between the pattern of land distribution and plaques, especially in the process of horizontal vertical, to ensure that regional space structure, ecological service function complete, reasonable to deal with people relationship and support ecological a state space control. And introduction of ecological security pattern is rigid bottom line thought as a kind of development for the city, its essence is with a kind of land for ecology "trade", coordinate the potential ecological risk of landscape heterogeneity, is the key to repair, improve, protect area landscape components of the control condition, to development as the goal, to the bottom line for the principle, both, It can guarantee the stability of landscape pattern of each component in the region and ensure the health of land [8].

### 4.2 The establishment of regional ecological networks

Ecological network is generally defined by spatial relations, based on the theoretical framework of "matrix, corridor and patch" in landscape ecology, which mainly reflects a certain connection between land and space. Ecological flow exchange exists between patches, and its essence is coordinated with ecological security pattern. Its complex theoretical description can be connected in series with simple points, lines and planes in drawings to form a visual spatial information map with easy to understand and ecological efficiency. Its spatial components include: ecological corridor, ecological patch, ecological node and ecological base. Closely linked to the various ecological components, with good ecological structure, the space form and space distribution has practical guidance in the planning, and to a certain extent, be able to assist planners is sensitive to the ecological fragile areas provide space coping strategies and measures, to guarantee and optimizing the regional landscape pattern has a strong guiding role [9].

### 4.3 Demarcation of "Three Regions and Three Lines"

According to the requirements of China's territorial space planning, the demarcation of "three zones and three lines" under territorial space planning should be strengthened and improved. The three zones are ecological protection space, urban construction space and agricultural space, and the three lines are urban growth boundary, ecological red line and permanent basic farmland protection red line. Several Opinions on Demarcating and Accepting the Red Line for Ecological Protection stressed that, in order to clarify the landscape types of mountains, rivers, forests, fields and lakes, beautify the natural environment and improve the ecological service function of national space as the core purpose, demarcating and strictly controlling the ecological red line and ensuring the ecological security of national land, Its essence is to optimize the existing landscape pattern and deal with the risks caused by landscape pattern fragmentation [10].

## 5. conclusion

The study of landscape pattern index aims to clarify the sustainable level of regional development, understand the relationship between human society and natural environment, and better keep up with the pace of urban ecological infrastructure construction. Research on landscape pattern is the need of building a beautiful China, and the key premise of sustainable development for coordinating ecological and urban issues in the process of urbanization, trying to achieve the purpose of "segregation between clusters".

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