Analysis on Landscape Ecological Pattern of Fengshan and Surrounding Areas in Yuyao City from the Perspective of Sustainable Development

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Abstract. Taking Fengshan and surrounding areas in Yuyao City as the research object, the map GIS data of the land use status in the study area in the third national land survey data completed in August 2019 was used as the basic data, and using ArcGIS10.5, Fragstats 4.2 and other software for data analysis. This study quantitatively analyzes the landscape ecological pattern in the study area from the aspect of landscape ecological pattern characteristics, and proposes the optimization of landscape spatial layout, which provides a scientific basis for the rational use of land resources and regional sustainable development. The results show that the landscape ecological pattern in the study area is dominated by natural landscapes, with mixed distributions of urban, village, and agricultural landscapes. The urban construction is underdeveloped, and the stability of the landscape ecological pattern is affected during the urbanization process. The rate is lower. The types of landscape patches are relatively rich, and the distribution of each landscape type is even. The rapid urbanization has affected the ecological sustainable development of the study area.

1. Introduction
In the process of rapid urbanization in China, the scale of central cities has expanded to the surrounding areas, causing damage to the natural ecological environment in the surrounding areas of cities, which is not conducive to the sustainable development of cities. Taking Yuyao City, Ningbo, Zhejiang Province, China as an example, in recent years, with scope of the central urban area, the development of Fengshan and its surrounding areas which are important ecological buffer zone and a green core area in Yuyao City, has some contradictions with the maintenance of its original natural ecological environment. Facing the requirements for the development of the ecological environment in the new urbanization, the ecological sustainable development of the region is facing challenges. Landscape pattern analysis is one of the core issues of landscape ecology research, and it is the method of studying landscape structure composition and spatial allocation [1]. This research takes Fengshan and its surrounding areas in Yuyao City as the research object, and takes the characteristics of the regional landscape ecological pattern as the starting point. Using the current land use data and using GIS and other technologies, it reveals the relationship between landscape pattern and landscape function. Through quantitative analysis of related landscape pattern indicators, problems in the pattern were discovered [2]. Finally, the characteristics of the landscape structure composition and spatial allocation of the study area are summarized, which provides a scientific basis for the optimization of
the landscape spatial pattern, the rational use of land resources and sustainable development in the study area.

2. Study area overview
Fengshan and the surrounding area are located in the western part of Yuyao City. It is an important ecological buffer zone in Yuyao City and a transition zone between city center and suburbs. It is planned into urban core areas in the higher-level planning and a total area of 41.49 square kilometers. The terrain in the area is dominated by plains, and there are several mountains and hills concentrated in the area. There are mainly green mountains such as Fengshan, Niutou Mountain, and Huajia Mountain. The altitude of Fengshan is 198.8m, the altitude of Niutou Mountain is 173.6m, and the altitude of Huajia Mountain is 126.0m and the main slope of the mountainous area is about 25-50%. The cultivated land located in the plain area is mostly between 1.6m-2.8m. Most of the construction land such as village construction land and industrial land has an altitude of 2.2m-3.8m. The rivers in the study area are criss-crossed and the water network is dense. There are major rivers such as Xijiang River and Shilu River, and there are many ponds distributed between them. The current land use types include cultivated land, forest land, garden land, water body and other non-construction land and industrial land, rural construction land, and other urban and rural construction land. According to the description of relevant materials and the preliminary understanding of field investigation, some construction land is in a state of disorderly construction and extensive development.

3. Research process

3.1. Data sources
The data mainly uses various types of map GIS data related to the land use status of the study area in the third national land survey data completed by Yuyao City in August 2019, and combined with relevant data such as landscape patch types obtained from field survey. The information source is accurate and can meet the needs of this study.

3.2. Classification of landscape types
Combined with previous scholars' analysis and research of landscape pattern [3-5], according to the characteristics of the current land use characteristics and the current landscape type and functional characteristics, the study area is located in the urban area and rural mosaic, and the suburban area where industrial parks gather. The landscape types in the study area are divided into 10 categories, namely cultivated land, forest land, garden land, water bodies, nature reserves, other agricultural land, village construction land, industrial land, regional transportation facilities land and other urban construction land.

3.3. Selection and calculation method of landscape index
The landscape index can condense the information of the landscape pattern in a high concentration, and clearly and quantitatively reflect the characteristics of some aspects of the landscape structural composition and spatial allocation [6]. In order to better and quantitatively analyse the landscape pattern characteristics of the study area, with reference to relevant literature, 11 types of landscape pattern indexes were selected to analyse the landscape pattern characteristics of the study area. Some indexes and meanings are shown in Table 1.

3.4. Data processing and calculation results
The data processing software used in this study are: ArcGIS10.5, Fragstats4.2, AutoCAD2014, and Excel2007. Using the selection function of the attribute table in ArcGIS10.5, the original patch data was reclassified according to the delineated regional landscape type characteristics. Using the Spatial Analysis module in ArcGIS10.5, it was converted into a grid (Geotiffs.) format and made landscape pattern map (Figure 1). Next, import the raster file with data information into Fragstats 4.2 landscape
index calculation software, set related parameters, select the type of landscape index to be calculated for data calculation, and the calculation results are shown in Table 2 and Table 3.

Table 1. Landscape pattern index and significance.

| Index    | Index name          | Calculation formula | Ecological significance                                                                 |
|----------|---------------------|---------------------|----------------------------------------------------------------------------------------|
| PD       | Patch Density       | \( PD = \frac{1}{A} \sum_{i=1}^{n} N_i \) | Reflects the number of patches per unit area, and to some extent reflects the fragmentation of the overall landscape. |
| AWMPFD   | Area-weighted Mean Patch Fractal Dimension | \( AWMPFD = \frac{1}{N} \sum_{i=1}^{n} \frac{2\ln(0.25P_i)}{\ln(2)} \) | Describe the complexity of patch shapes in different landscape types. |
| S        | Separation Degree   | \( S_i = \frac{(n / A_i)^{1/2}}{2(A_i / A)} \) | Describes the degree of dispersion of plaques in the spatial distribution. A larger value indicates that the type of element is more dispersed. Reflecting the complexity of the landscape spatial structure, the stability of the landscape and the degree of human disturbance can be appropriately evaluated from a certain angle. |
| FN2      | Fragmentation Index | \( FN_i = MPS \frac{(N_i - 1) / N_c}{N_c} \) | This indicator can reflect landscape heterogeneity, and is particularly sensitive to the uneven distribution of various patch types in the landscape. |
| SHDI     | Shannon’s Diversity Index | \( SHDI = -\sum_{i=1}^{n} (p_i \times \ln p_i) \) | Represents the unevenness of the area distribution of different patch types in the landscape. |
| SHEI     | Shannon’s Evenness Index | \( SHEI = -\sum_{i=1}^{n} (p_i \times \ln p_i) / \ln n \) | Represents the degree of superiority of patch types in the landscape, and is also used to describe the deviation between landscape diversity and maximum diversity. |
| Dominance| Landscape Dominance Index | \( D = H_{max} + \sum_{i=1}^{m} p_i \times \ln p_i \) |
Table 2. Landscape pattern indicator table of study area (Landscape type).

| Landscape type          | CA    | PLAND | NP    | PD    | AREA_MN | AREA_S | AWMPFD | S    | FN2  |
|------------------------|-------|-------|-------|-------|---------|--------|--------|------|------|
| Cultivated Land        | 1350.68 | 32.55 | 509   | 12.27 | 2.6536  | 12.2237 | 1.1067 | 1.8857 | 0.3247|
| Other Agricultural Land| 192.65   | 4.64  | 3297  | 79.47 | 0.0584  | 0.3970  | 1.0470 | 89.0938 | 0.0464|
| Nature Reserve Land    | 124.83  | 3.01  | 244   | 5.88  | 0.5116  | 1.4024  | 1.0818 | 46.4684 | 0.0299|
| Garden Land            | 256.46  | 6.18  | 296   | 7.13  | 0.8664  | 2.2856  | 1.0733 | 17.3803 | 0.0615|
| Water Body             | 175.8   | 4.24  | 631   | 15.21 | 0.2786  | 1.1813  | 1.1276 | 44.7124 | 0.0423|
| Forest Land            | 498.32  | 12.01 | 346   | 8.34  | 1.4402  | 11.4263 | 1.0954 | 6.9377  | 0.1196|
| Rural Construction Land| 650.21  | 15.67 | 435   | 10.48 | 1.4947  | 2.9769  | 1.0982 | 5.2192  | 0.1564|
| Regional Transportation Facilities Land | 292.58 | 7.05  | 1563  | 37.67 | 0.1872  | 2.0922  | 1.0560 | 32.7758 | 0.0704|
| Industrial Land        | 24.74   | 0.60  | 47    | 1.13  | 0.5264  | 1.0856  | 1.0810 | 231.1483| 0.0058|
| Other Town Construction Land | 582.71 | 14.04 | 286   | 6.89  | 2.0374  | 4.2143  | 1.0784 | 4.9882  | 0.1397|
| Overall Landscape      | 4148.98 | 100.00| 7654  | 184.48| 0.5421  | 4.3542  | 1.0680 | —      | —    |

Table 3. Landscape pattern indicators of the study area (Overall landscape).

| Overall Landscape Index | SHDI | SHEI | Dominance | Hmax |
|------------------------|------|------|-----------|------|
| Data                   | 1.9575 | 0.8501 | 0.1499 | 2.3026 |

4. Discussion and analysis

4.1. Landscape pattern composition characteristics

4.1.1. Landscape patch area characteristics. The area index of landscape patches can reflect the distribution characteristics and overall landscape characteristics of each landscape type. The total area of the study area is 4148.98hm². The largest patch type is cultivated land, with a total area of 1350.68hm², accounting for 32.55% of the entire study area, followed by rural construction land (15.67%), other town construction land (14.04%), forest land (12.01%). The average patch area of cultivated land is the largest, at 2.6536hm², followed by other town construction land, rural construction land, and forest land. This can indicate that the study area is dominated by natural landscapes, and is close to the central urban area.

According to the data analysis in Table 2, the area of patches in each landscape area in the study area varies greatly. The PSSD (Patch area standard deviation) of cultivated land is the largest, followed by forest land, and the PSSD of other agricultural land is the smallest. The maximum patch area of cultivated land is 201.89hm², and its average patch area is 2.6536hm². The maximum patch area of forest land is 148.42hm², and its average patch area is 1.4402hm². This is related to the terrain with a large area of mountainous hills in the area. The cultivated land is mostly concentrated in areas with flat terrain, good water sources and soil environment, while the forest land is distributed in mountainous and hilly areas, which is regional.

4.1.2. Number of landscape patches. As shown in Table 2, the number of patches of each landscape type in the study area is unevenly distributed, in order: other agricultural land> regional transportation facilities land> water body> cultivated land> rural construction land> forest land> garden land> other town construction land> nature reserve land> industrial land, the larger ones are other agricultural land and regional transportation facilities land, which are 3297 and 1563 respectively.

The patch density can reflect the degree to which the landscape matrix is divided by types of patches, and has an important impact on the ecology and environmental protection of a region and the
rational use of land [7]. The patches of other agricultural land and regional transportation facilities have a higher patch density, the largest number of patches and a smaller landscape area, which shows that these two landscape types are widely distributed and scattered, and are greatly affected by human activities. If the land for regional transportation facilities is too scattered, it will lead humans to enter ecological protection areas to carry out construction activities and destroy the original natural ecological environment.

4.2. Spatial characteristics of landscape pattern

4.2.1. Analysis of spatial characteristics of landscape patch shape. The shape of the patch affects its landscape function to a certain extent. Generally, an irregular patch may have more heterogeneous ecological processes than regular patches [8]. The AWMPFD (Area-weighted mean patch fractal dimension) can be used to determine the process of affecting the internal plaque by the shape of the plaque. The ratio of AWMPFD is 1~2. The closer the value is to 1, the simpler the shape of the landscape patch, which is greatly affected by human activities. The closer it is to 2, the more complex the patch shape is, and the less it is disturbed by human activities [9].

As shown in Table 2, the AWMPFD of other agricultural land and regional transport facility land in the study area is closest to 1, and the data are 1.047 and 1.056, respectively. These two landscape types are basically the products of human action and the shape is relatively simple. The AWMPFD of the water body is the largest, which is related to the fact that the type of water body in the area is mostly rivers. The river has a slender shape, which is restricted by the topography and other factors to increase the complexity of its shape, which indicates that the regional water bodies are mostly naturally formed rivers and maintain a good natural state.

4.2.2. Analysis of Landscape Patch Separation and Fragmentation. The degree of separation describes the degree of dispersion of the plaques in the spatial distribution, and a larger value indicates that the type of element is more dispersed [10]. From the data in Table 2, it can be seen that the industrial land has the highest degree of separation, which is 231.1483. This indicates that the patch of industrial land is scattered, and some patches are inlaid with residential houses. It has low land utilization.

The fragmentation index can reflect the complexity of the spatial structure of the landscape, and appropriately evaluate the stability of the landscape and the degree of human disturbance from a certain angle [9]. The cultivated land has the highest fragmentation index, its instability and degree of fragmentation are large, and it is highly affected by human interference. Although most of the cultivated land will be concentrated in a certain area due to the natural environment, some patches will still be affected by factors such as terrain, rivers, and human activities. Due to the erosion of other patches such as residential and industrial land, the fragmentation of cultivated land patches has increased, and its structure is more complicated, which is not conducive to the stability of the landscape pattern.

4.2.3. Landscape diversity analysis. Landscape diversity reflects the complexity of landscape structure and function, which can be measured by Shannon’s Diversity Index (SHDI), Shannon’s Evenness Index (SHEI), and Landscape Dominance Index (D). The SHEI and the Dominance are negatively correlated, and they can be converted to each other. Evenness = 1-Dominance, therefore when the data of SHEI is small, the data of dominance is generally higher; when the SHEI approaches 1, the data of dominance is low[3]. As shown in Table 3, the data of SHDI in the study area is 1.9575, and the Maximum Diversity Index (Hmax) is 2.3026. The difference between the two is 0.3451, indicating that the diversity of each landscape type in the study area is high, the proportion is not large, and the distribution is even. The data of SHEI is 0.8501, and the Landscape Dominance Index (D) can be deduced to be 0.1499, which indicates that due to the progress of regional urbanization, the cultivated land in the landscape as the dominant patch is not obvious. The overall landscape patch type in the study area is richer and the distribution is even.
5. Conclusions and Recommendations

5.1. Conclusion
By analysing the characteristics of the landscape ecological pattern in Fengshan and surrounding areas in Yuyao City, the following conclusions are obtained: the landscape ecological pattern in the study area is dominated by natural landscapes, with mixed distributions of urban, village, and agricultural landscapes. The urban construction is underdeveloped, and the irrational use of land resources in the process of urbanization affects the stability of the landscape ecological pattern. The construction land, cultivated land, and forest land are the main landscape types in the study area, and the patch distribution is relatively concentrated, while the patch distribution of industrial land, regional transportation facilities land, and other agricultural land is scattered, and the degree of land intensiveness and utilization is low, which has a greater impact on the original natural ecological environment. The water bodies in the study area are mostly naturally formed rivers and artificial ponds, which maintain a good natural state. The types of landscape patches are relatively rich, and the degree of uniform distribution is average. In the process of urbanization, human activities did not cause severe landscape fragmentation, but the fragmentation of cultivated land was higher, the anti-interference ability was poor, and it was vulnerable to future urban development. The rapid urbanization development has affected the ecological sustainable development of the research area to a certain extent. Next, the research area which is the ecological buffer zone and the green core of the city should be rationally and scientifically planned for land use. On the basis of meeting ecological functions, optimize the landscape ecological pattern, rationally develop and utilize land, and improve landscape diversity and stability.

5.2. Future sustainable development optimization suggestions
Based on the above analysis of the landscape ecological pattern of Fengshan and surrounding areas, in order to achieve further rationalization of land use, development and construction, and landscape ecological pattern. The author believes that the landscape pattern can be optimized and controlled from the following aspects to ensure synchronization with the use of land and space in the new period.

The first is to maintain the existing landscape ecological pattern, protect cultivated land resources, and strictly delineate basic farmland areas; use and optimize forest land resources reasonably, increase the diversity of tree species, increase forest land ecological benefits, and achieve sustainable development. The second is to strictly control the expansion of construction land through administrative legislation, integrate and optimize land, avoid the formation of large-scale construction land patches, and sort out key elements such as the integration of land for regional transportation facilities. Finally, in combination with the current land resources, it is necessary to further sort out the internal land of the block, make intensive use of it and improve its integration, strengthen the research on the key development space of the block in the era of incremental austerity, optimize the landscape type and the number of patches, and adjust and optimize the spatial layout of patches of various landscape types.

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