Analysis on Spatio-Temporal Evolution Characteristics of Liaoning Urban Agglomeration

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Abstract. To address the problems in the development process of urban agglomerations, based on the different degrees of influence of different driving factors, spatial and temporal evolution is used to analyze the landscape pattern changes in land use and the relationship between population and land in anisotropic growth, so as to obtain favorable factors in the process of urban development and timely adjust the problems brought about by urban development. Taking the urban agglomerations in Liaoning Province as an example, according to the landscape pattern changes, the urban ecosystem is relatively stable from 2010 to 2020, which can balance the relationship between human and nature in the process of development; in the relationship between human and land in urban agglomerations, the economic development of each city is uneven due to the influence of industrial economy and local resources, and the cities that are lagging behind in development need to be transformed. The research results have some reference value for the future development of urban agglomerations.

Keywords: Land use, landscape patterns, anisotropic growth.

1. Introduction

In the international competitive landscape of the globalization era, the comprehensive competitiveness of a country increasingly depends on the existence of a number of urban agglomerations and global city regions with strong comprehensive economic strength [1-2]. Along with information technology and economic globalization, urban agglomerations have become the mainstream trend of urbanization in the world [3-4]. In China, with the change of information, technological innovation and rapid development of industries, provincial and administrative economies are no longer the main development mode of regional economy, but are gradually changing to urban agglomerations, which have become the main spatial form of regional development in China [3]. In this paper, the study area of Liaoning Province is bordered by the Bohai Sea and the Yellow Sea. The landscape pattern index is used to measure the spatial and temporal pattern evolution at different scales, mainly involving the three parts of landscape structure, change and function [6], which is conducive to the effective use of land and the estimation of the natural carrying capacity, so that society does not destroy the mutual relationship with nature in the process of development. The relationship between urban population and land for construction is used to rationalize the planning of overdevelopment and population development in the process of economic development.

2. Study population and data sources

As an important old industrial base of the country, Liaoning Province is one of the more complete provinces in the country in terms of industrial categories and is the cradle of the rise of industry in New China [7]. The evaluation study on the development of urban agglomerations in Liaoning Province is helpful to judge the development status of Liaoning cities and make corresponding suggestions for the future development direction. The statistical data are mainly obtained from the 2010-2020 China Urban Yearbook and the Resource and Environment Science and Data Center of the Chinese Academy of Sciences.

3. Content and methodology of the study

3.1. Changes in urban land use types

3.1.1 Landscape pattern analysis

Landscape ecology is a comprehensive discipline that combines geography and ecology to conduct research on the composition of landscape unit types, spatial patterns and their interactions with ecological processes, taking landscape types as the object of study [8]. The landscape pattern index can reflect the changes of landscape patches and can extract potential patterns in the mosaic of cluttered patches [9-10].

3.2. Analysis of the harmony between urban population and built-up area

3.2.1 Urban population-land anisotropic growth model

Anisotropic growth is a constant proportional relationship between the local relative growth rate of a system and the relative growth rate of the system as a whole or of another part of the system [7].

$$\frac{\mathrm{d}y}{ydt} = \alpha \frac{dx}{x} \tag{1}$$

Where *x is* some measure of one part of the system or the whole, y is some measure of another part of the system, and *α is the* anisotropy (growth) coefficient. Where *α* reflects the ratio of the growth rate of *y* to the relative growth rate of *x*, and *k is the* scaling factor.

$$y = kx^{\alpha} \tag{2}$$

4. Analysis of results

4.1. Change in landscape pattern

Based on the landscape classification data of Liaoning Province, the relevant landscape pattern indices were obtained by using Fragstats software, as shown in Table 1. The number of patches can reflect the spatial distribution of the landscape, and the high degree of fragmentation of cultivated land from 2010 to 2020 strengthens the stability of species interaction and synergistic symbiosis in space. The normalized landscape shape index reflects the increased degree of land class area and spatial heterogeneity. The number and density of patches of woodland are decreasing, but the area is increasing, indicating increased aggregation and minor fluctuations in the degree of spatial heterogeneity, and the number and density of patches of grassland, etc. are decreasing, mainly due to the conversion to woodland and the occupation of construction land, etc. The degree of aggregation is weakening and spatial heterogeneity and its complexity are increasing. The increase in the number and density of patches of land for construction indicates the development of the economy, which cannot be separated from the demand for land for construction.

Table 1. Landscape Pattern Index for Liaoning Province, 2010-2020

Year	TL	NP	PD	SDAI	AI	RI	LSI	APAR
2010	arable land	2828	0.0194	0.1450	66.1518	0.9033	0.3385	34.7657
	woodland	2425	0.0166	0.1580	71.7479	0.9247	0.2825	34.7637
	lawn	1708	0.0117	0.1435	45.7124	0.9998	0.5429	35.5472
	waters	1317	0.0090	0.1360	39.7477	1	0.6025	36.1725
	construction land	4407	0.0302	0.1043	27.0571	1	0.7294	37.8238
2020	arable land	3100	0.0211	0.1440	62.9542	0.9117	0.3705	34.6322
	woodland	2141	0.0145	0.1598	72.0950	0.9269	0.2791	34.7112
	lawn	1512	0.0103	0.1371	32.1812	1	0.6782	35.7696
	waters	1870	0.0127	0.1304	38.9775	1	0.6102	36.6010
	construction land	5378	0.0365	0.1055	31.9612	0.9999	0.6804	37.7363

4.2. The urban human-land relationship is growing at a different pace

The scope of the study area is each city in Liaoning Province, with urban population *y as the* dependent variable and urban built-up area as the independent variable, and the study years are 2009-2019. if the constant *k* and growth rate *α are* required, a non-linear regression model is required.

Take logarithms on both sides of equation (2) to reduce it to log-linear form;

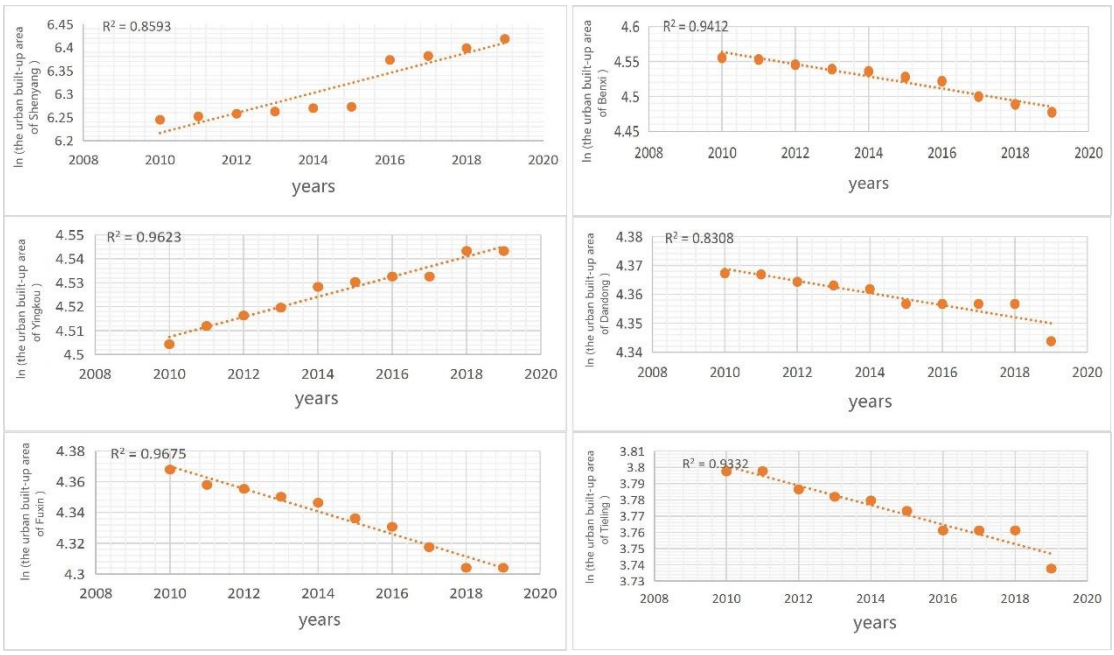

Figure 1. Double logarithmic relationship between urban population and urban built-up area in Liaoning Province

Convert (2) to logarithmic form in order to find the constant and anisotropic growth coefficients

$$\ln y = \ln a + b \ln x \tag{3}$$

Where *a* is a constant, *b* is the anisotropic growth coefficient, using the data from 2009-2019 to calculate these two quantities, according to the results of previous studies, the growth coefficient obtained has a corresponding critical value, with 0.85 as the boundary, when $b = 0.85$, the amount of urban population growth and the increase in built-up area at the same rate, is a relatively harmonious state, when $b<0.85$, for negative anisotropic growth, the growth rate of urban built-up area is less than the urban population When the growth rate is negative, the growth rate of urban built-up area is smaller than the growth rate of urban population, and the excessive growth of population should be controlled; similarly, when $b>0.85$ the growth rate is positive, the city tends to be flattened. When the expansion of urban built-up area is smaller than the growth of urban population, the shortage of urban land resources, or urban development is in a stagnant state, is also the cause of the reduction of urban construction land area per capita.

In order to more clearly express the relationship between people and land in cities in Liaoning Province from 2009 to 2019, a hierarchical method was used to segment the cities into four subcategories: positive anisotropy level 1, which indicates that the relative growth rate of land is slightly higher than the relative growth rate of population; positive anisotropy level 2, which indicates that the relative growth rate of land is higher than the relative growth rate of population; negative anisotropy level 1, which indicates that the relative growth rate of land is lower than the relative growth rate of population. Negative anisotropy level 2, indicating that the relative growth rate of land is much lower than the relative growth rate of population. See Table 2 below.

Table 2. Harmonization grading table for the relationship between human and land anisotropy

Isochronous speed type	isospeed class	classification criteria	Type of human-land coordination	Characteristics of human-land relations
delta-azimuth growth	orthogonal speed II	1.5<b<2	Significant expansion of land	Relative growth rate of land is higher than relative population growth
	orthogonal speed class I	0.85<b<1.5	Basic human-land coordination	Relative land growth is slightly higher than relative population growth
negative isokinetic growth	Negative isochronous speed class I	0.5<b<0.85	Significant population growth	Relative land growth is slower than relative population growth
	negative isokinetic II	0<b<0.5	Significant population growth	Relative land growth is much slower than relative population growth

5. Conclusion

This study uses remote sensing and GIS to extract urban land use information and spatial characteristics information to propose the problems of urban clusters in Liaoning Province in the development process and make reference for future development. The following conclusions are drawn from the analysis.

(1) Through the calculation of the land use landscape pattern index, the evolution of the landscape pattern has an important role and significance for economic development from the perspective of ecology. From the trend of landscape pattern transformation, people focus on economic development while living in harmony with nature and try to compensate for the damage caused to the ecological environment. Land use in the process of urban advancement is directly related to the capacity for economic development.

(2) Using the urban human-land relationship anisotropic growth model to analyze the size of the development capacity of cities in Liaoning Province over time, the results show that urban development tends to flatten out, the economy is in a relative development state, and cities with basic human-land coordination are in a relatively stable economic development. On the whole, the economic development of urban clusters in Liaoning province is uneven, showing three forms of stable development, slow development and lagging development, which should focus on cities with lagging development and help these cities transform into cities with characteristics suitable for development. Shorten the gap between cities and try to avoid the emergence of bipolar cities.

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