Evaluation of Driving Force for Farmland Landscape Heterogeneous Formation in Northern Foothills of Qinling Mountains under the Background of Urban Expansion

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Abstract: The research on the driving force of urban landscape pattern evolution has been an international research hotspot. This paper selects 5 administrative districts which are located to the north of Qinling mountains in Xi'an as the research object. Through the social economic data from 2013 to 2018 and the regional land use survey, analyzing the farmland landscape as the biggest changing area in the urban landscape use pattern. Using principal component analysis method to study the process of urbanization driving force and find the main influence factors of the farmland landscape change. The results show that urban social economic development and population growth are the main driving forces of farmland landscape change in the northern foothills of Qinling mountains in Xi 'an. It indicates that the northern foothills of Qinling mountains in Xi'an is still in the stage of rapid development of urbanization, which has a high demand for landuse at the urban-rural junction, mainly converting agricultural land into industrial and residential land.

1. Introduction

The Qinling mountains are located in the central part of Shaanxi province in China. Xi'an, as the capital city of Shaanxi province, borders the Qinling mountains in the south of the city, so the urban development has a great impact on the Qinling mountain eco-system. Through the theory of heterogeneity in landscape ecology, this paper studies the evolution of landscape pattern between the northernern foothills of Qinling mountains in Xi'an city in order to analyze the impact of urban development on the landscape ecosystem of Qinling mountains.

The formation of heterogeneous landscape is mainly influenced by natural factors, social and economic factors and policy factors. The influence of natural factors such as climate change on heterogeneous landscape is not negligible. Socio-economic factors such as the expansion of urbanization have a dramatic and rapid impact on heterogeneous landscapes. Policy factors such as urban planning are also important factors influencing the evolution of heterogeneous landscapes. Policy factors can sometimes completely change the landscape pattern in an area. For example, the change from farmland landscape type to factory landscape type is the result of government policy guidance. Compared with social and economic factors and policy factors, the impact of natural factors on landscape pattern develops slowly. In the context of rapid urbanization in China, the impact of natural factors on landscape pattern cannot be shown in a short period of time, while policy factors cannot be analyzed and expressed through quantitative methods. Therefore, the quantitative analysis of the influence of social and economic factors on the evolution of landscape pattern can more intuitively reveal the influence of urban expansion on urban suburban landscape.

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2. Materials and Methods

2.1 Study Area Selection

In this paper, the northern foothills of Qinling mountains in Xi'an city is selected as the research sample area for the following reasons: (1) Xi 'an is the city with the fastest urbanization development in the northern foothills of the Qinling mountains. Compared with other cities, urban area, population, industrial structure and economic development are more rapid, and the evolution of landscape pattern is more obvious and intuitive. (2) the urban development of Xi 'an is less influenced by natural factors, mainly by policy and social and economic factors. At the same time, the northern foothills of the Qinling mountains is more abundant in industry. Therefore, this paper adopts quantitative research method to reveal the mechanism of urbanization to the evolution of landscape pattern more intuitively.

2.2 Data Collection and Remote Sensing Impact Interpretation

The data sources used in this paper include SPOT5 remote sensing images from 2013 and 2018, 1:100,000 topographic map, xi 'an statistical yearbook and other literature. In this data processing, ERDAS IMAGINE9.1 and ARCGIS10.2 software was used to perform projection conversion, stitching and geometric correction of remote sensing images. Finally, remote sensing images of the northern foothills of Qinling mountains were obtained. The images are shown in Fig 1.

Fig.1 Remote Sensing Images of the Northern Foothills of the Qinling Mountains

2.3 Principal Component Analysis of Driving Force of Heterogeneous Landscape Evolution

Principal component analysis can reduce the number of variables, data information overlap, with less data information to reflect the maximum information of the original data. Therefore, it has been widely used in the study of driving force of land use and landscape dynamic change. Therefore, SPSS20.0 software was used in this paper to quantitatively analyze the driving factors of the heterogeneous landscape evolution in the study area by principal component analysis.

(a)Principle of principal component analysis method

Principal component analysis is to combine a number of variables with certain correlation into a new set of variables through linear combination. The information of the new set of variables and the original variables do not overlap each other, so as to avoid information overlap. In general, the original n indexes are combined linearly to form a new set of variables. It's expressed in terms of the variance of the original linear combination, and if the variance of the original linear combination is larger, then the original linear combination contains more information. In general, among all linear combinations, the one with the largest variance should be the original linear combination, that is, the first-line combination has the largest variance, so we call the first-line combination the first principal component.

(b) Calculation process of principal component analysis method

The core of principal component analysis is to reduce the dimension of variables by linear combination with the original variables and the solution of each principal component. Through the transformation of coordinates, the principal component analysis method makes linear combination of the original n correlated variables (xi) after standardization and converts them into another set of unrelated variables (yi), so as to obtain the mathematical model of principal component analysis:

$$\begin{cases} y_1 = \mu_{11}x_1 + \mu_{12}x_2 + \mu_{13}x_3 + \cdots + \mu_{1n}x_n \\ y_2 = \mu_{21}x_1 + \mu_{22}x_2 + \mu_{23}x_3 + \cdots + \mu_{2n}x_n \\ y_3 = \mu_{31}x_1 + \mu_{32}x_2 + \mu_{33}x_3 + \cdots + \mu_{3n}x_n \\ \cdots \\ y_4 = \mu_{41}x_1 + \mu_{42}x_2 + \mu_{43}x_3 + \cdots + \mu_{4n}x_n \end{cases} \quad (1)$$

The coefficients in Formula 1 should follow the following principles:

(i) yi and yj are independent of each other($i \neq j$,i,j=1,2,3,4,5...,n);

(ii) y_1 is the largest variance of all linear combinations, which is the first principal component, followed by y_3, y_4,y_5...,y_n

In practice, only the first few principal components with large variance are selected in principal component analysis.This can reduce the number of variables to reflect the majority of the original variables with fewer principal components.Usually, the contribution rate of the first principal component is higher than that of the other principal components, which is the most important one.

3. Result and Discussion

3.1 The Change of Farmland Landscape Area is the Most Significant in the Landscape Pattern of the Northern Foothills of Qinling Mountains in Xi 'An

Before studying the driving force of heterogeneous landscape, it is necessary to determine the main landscape types in heterogeneous landscape. Due to the variety of heterogeneous landscape types in the region and the number of external driving factors, in order to accurately grasp the evolution law of heterogeneous landscape in the study area, it is necessary to select the most representative heterogeneous landscape patch types as the main research objects. From previous studies, it can be found that the dominant heterogeneous landscape in the study area is farmland landscape, and farmland landscape area changes most significantly. Therefore, this paper makes a quantitative analysis on the driving factors of farmland landscape change in some research areas.

3.2 Correlation Analysis of Driving Force of Farmland Landscape Area Change

(i) Driving force factor data of farmland landscape area change

According to the Social and economic data of the northern foothills of Qinling mountains from 2013 to 2018 were selected as the basic data, and 8 influencing factors were selected as the independent variables: X_1-total population (person); X_2-non-agricultural population (people); X_3-gross industrial output value (10’000 RMB); X_4-total agricultural output value (10’000 RMB); X_5-GDP (10’000 RMB); X_6-GDP of primary industry (10’000 RMB); X_7-GDP of secondary industry (10’000 RMB); X_8 -GDP of the tertiary industry (10’000 RMB), as shown in table 1.

Table 1 Driving Force Factor Data of Farmland Landscape Area Change

Year	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
2013	99199	38469	1811168.4	13173	122978	4109	25255	17514
2014	132044	62668	1091304.9	66294.9	175048	13231	123281	38536
2015	132570	86730	2356986.4	81397.1	607614	29031	491160	87423
2016	121496	81103	3311670.8	50728	770376	31323	624842	285717
2017	122759	83494	3654114.7	93951.3	897698	34930	483899	179097.3
2018	123769	85504	3713024.5	98427	988101	38887	729860	218814

Data source: Xi 'an Statistical Yearbook

(ii) Correlation analysis of farmland landscape driving factor

The correlation analysis of 8 independent variables was carried out to calculate the correlation coefficient matrix of driving factors for the change of farmland landscape area. As can be seen from table 2, the correlation between non-agricultural population and GDP of primary industry, gross industrial output and GDP, and GDP and GDP of the three industries is very strong, with the correlation coefficient as high as 0.947, 0.952, 0.978, 0.951 and 0.856, indicating that there is a strong relationship between variables, and it is feasible to use principal component analysis method.

Table 2 the Correlation Coefficient Matrix of the Driving Factors

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1.000	0.738	0.041	0.753	0.337	0.521	0.428	0.203
X_2	0.738	1.000	0.684	0.857	0.864	0.947	0.896	0.700
X_3	0.041	0.684	1.000	0.534	0.952	0.870	0.865	0.863
X_4	0.753	0.857	0.534	1.000	0.743	0.827	0.687	0.415
X_5	0.337	0.864	0.952	0.743	1.000	0.978	0.951	0.856
X_6	0.521	0.947	0.870	0.827	0.978	1.000	0.962	0.820
X_7	0.428	0.896	0.865	0.687	0.951	0.962	1.000	0.880
X_8	0.203	0.700	0.863	0.415	0.856	0.820	0.880	1.000

It can be seen from table 3 that the cumulative contribution rate of the first and second principal components is 94.711%, which can explain most of the original variable information. Therefore, the selection of the two principal components completely meets the requirements.

Table 3 Principal Component Characteristic Root Value and Contribution Rate

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	%of Variance	Cumul active %	Total	% of Varianc e	Cumul active%	Total	% of Varianc e	Cumul active%
1	6.186	77.329	77.329	6.186	77.329	77.329	4.752	59.404	59.404
2	1.391	17.383	94.711	1.391	17.383	94.711	2.825	35.308	94.711
3	0.318	3.969	98.680						
4	0.072	0.895	99.575						
5	0.034	0.425	100.00						
6	1.83E-016	2.23E-015	100.00						
7	9.04E-017	1.13E-015	100.00						
8	-1.57E-016	-2.0E-015	100.00						

As table 4 shows, the gross industrial output, GDP, GDP of the primary, secondary and the tertiary industry have a high load on the primary principal component. The first factor mainly explains these five variables, which can be understood as factors of economic development. Total population, non-agricultural population and total agricultural output value have higher loading on the second principal component. The second factor mainly explains these three variables, which can be understood as population factor. Thus it shows that there are two main factors influencing the evolution of farmland landscape area: economic development and population factor.

Table 4 Principal Component Load Matrix

	Component	
	1	2
Total Population	0.004	0.976
non-agricultural population	0.651	0.740
gross industrial output value	0.982	0.072
total agricultural output value	0.432	0.835
GDP	0.922	0.367
GDP of primary industry	0.838	0.543
GDP of secondary industry	0.881	0.420
GDP of tertiary industry	0.922	0.126

4. Conclusion

4.1 The Economic Development is the Most Important Driving Force to the Reduction of Farmland Landscape Area.

With the continuous industrial development of Xi'an city, especially the five administrative districts in the northern foothills of Qinling mountains, as an important area for the industrial development in Xi 'an city, the resident and floating population keeps increasing, and the land demand is increasing year by year. On the one hand, the economic development promotes the expansion of urbanization, which promotes the rural population to gather in cities and towns, and at the same time attracts a large number of migrants to move in. This has led to the construction of a large number of residential and public facilities, which in turn has led to the continuous reduction of farmland. The development of economy should be at the cost of occupying farmland, which also makes a large number of farmland landscape transition to industry and other landscape.

4.2 The Population Increase is the Second Driving Factor to Farmland Landscape Area Reduction.

The northern foothills of Qinling mountains is the fastest area of population growth and urbanization in Xi'an. Population factor is another important driving factor of farmland landscape area change. The economic development in the research area has brought a large number of jobs and a large number of people to work and live in, and led the rural population to gather in the city, prompting a large number of rural populations to change to non-agricultural population. With the development of towns and the construction of supporting public facilities, the farmland landscape changes to the direction of urban residential land and industrial site. Therefore, population increase is also an important driving factor of farmland landscape area reduction.

4.3 The Further Work and Suggestion of This Study

Economic development and population growth are the two most important driving factors for the decrease of farmland landscape area in the study area. This is without taking into account the unreasonable use of land, in fact, due to the unreasonable planning and use of land waste problems also exist. With the development of economy and the growth of population, it is inevitable for farmland to be occupied to reduce the area. However, in order to relieve the pressure of land shortage, we need to pay attention to the rational use and planning of land, so that more economic benefits can be produced on a small amount of land.

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