Spatial Response Analysis of Land use in National Development Zones based on Pattern and Process - taking Fuzhou new District as an Example

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Abstract: This paper analyzes the landsat remote sensing image of Fuzhou New District in 2000, 2009 and 2015. Based on AraGIS10.2 and fragstats software, it uses multi-distance spatial clustering, land use transfer matrix and moving window method to analyse the evolution characteristics and spatial response process of the landscape pattern in Fuzhou New District from 2000 to 2015. The results show that: (1) In the 15 years, the land use types of Fuzhou New District have undergone great changes, and various types of land are frequently converted with each other. The area of residential land, industrial, mining and traffic land has been increasing, and the area of other land types has been decreasing. (2) Cultivated land, residential land, forest land and water area are the main land use types in Fuzhou New Area. The scale of the cultivated land and water area has been increasing, and the scale of residential land has been decreasing. (3) The degree of landscape fragmentation in Fuzhou New District has been increasing continuously during the 15 years. The connectivity between the plaques becomes weak, and the internal shape of the plaques tend to be complicated. The spatial and temporal evolution characteristics of landscape diversity and contagion index are generally consistent. High-value areas are mainly distributed in urban construction, port terminal construction and airport construction; low-value areas are mainly distributed in areas where the landscape type is relatively single, such as forest land, water area and agricultural land.

Keywords: Pattern and process; Multi-distance spatial clustering; Moving window method; Spatial response; Fuzhou New Area

1. Introduction

At present, China is in the rapid development stage of urbanization, especially the construction and development of urban new districts are receiving more and more attention from the government[1]. In this process, the rapid transformation of high-intensity land development and land use directly affects the landscape function and ecological service system in the urban new districts[2-3]. By 2013, there were more than 3,000 urban new districts planned by provinces and cities in China (including county-level cities), in September 2017, the total number of China's national new districts has reached 19, in addition to some areas which were being declared. There is no doubt that the construction and development of urban new districts will become the most prominent feature of China's urbanization process, but the rapid urban new district construction process will also lead to landscape fragmentation, biodiversity reduction, heat island effect, air and water pollution and other ecological environmental problems[4-6]. Therefore, how to alleviate and cope with the negative impact brought by the construction of urban new districts has become a hot spot for experts in urban and rural planning, eco-city and other related fields.

Land use/cover change (LUCC) and landscape pattern reflect different aspects of the same thing. Land use/cover change (LUCC) emphasizes purposeful human activities in a given geographical space, reflecting the products of human activities on the surface[7-9]; Landscape pattern is a concrete manifestation of landscape heterogeneity, reflecting ecological processes of different landscapes[10-12]. The urbanization process includes not only the increase of urban population, but also the transformation of urban landscape types from natural and semi-natural landscapes to artificial landscapes and urban spatial expansion[13-14]. The transformation of landscape types and the expansion of urban space are all accompanied by land use/cover change (LUCC). Therefore, combining land use and landscape patterns in different historical periods can deeply study the evolution process of land use landscape pattern. At present, domestic scholars have studied the large-scale land use landscape pattern of the Huanghuaihai Plain agricultural area[15] and the Yellow River Delta[16], but the research on the land use landscape pattern of the mesoscale urban new area is rare.

As a state-level new district approved by the State Council, Fuzhou New District is an important supporting region for cross-strait cooperation and exchange and an ecological civilization pioneer. In recent years, with the implementation of the new district planning, large-scale industrial construction, the promotion of the port industry, and the development of innovation demonstration area make Fuzhou New Area's ecological environment face severe challenges. Secondly, the terrain of Fuzhou New Area is winding. The towns and constructions are mainly distributed along the rivers, and the land resources are relatively scarce. How to balance the population, land resources, economic construction and ecosystem development is particularly important. Based on the background of rapid urbanization in China, this paper analyzes the evolution characteristics and response process of land use landscape pattern in Fuzhou New District in the past 15 years, so as to provide scientific basis for the ecological environment protection and development of the region.

2. Overview of the Research Area

Fuzhou New District is located in the coastal area of Fuzhou City. It belongs to the subtropical monsoon climate. The annual average precipitation is 900-2100 mm, the annual average temperature is 20-25 °C, the summer is long and the winter is short, the rainfall is abundant, and the climate is pleasant. The Fuzhou New Area is close to the sea and has convenient transportation. It is a sea-linkage center on the southeast coast of China. It is also a transportation hub for radiating Taiwan and connecting with ASEAN. It has good conditions for strengthening cooperation with Taiwan and coordinating the development of the southeast coast and inland areas. On August 20, 2013, the Fuzhou Municipal Committee approved the “Opinions on Promoting the Opening of the Fuzhou New Area to Accelerate the Construction of the Golden Triangle Economic Circle at a Higher Starting Point”. On August 30, 2015, the State Council officially approved the establishment of the Fuzhou New Area. The initial planned area is 800 square kilometers, including 26 townships (streets), such as Mawei, Cangshan, Fuqing and Changle. It has two municipal, three provincial and seven national development zones (see Figure 1).

3. Data Source and Processing

Regarding the Landsat ETM+ remote sensing image of 2000, 2009 and 2015 as data source, this paper uses ENVI5.0 and ArcGIS10.2 to preprocess it. Based on this, by the maximum likelihood method in supervised classification, the land use types in Fuzhou New District are divided into nine categories: grassland, cultivated land, industrial mining and traffic land, sea area, residential area, forest land, garden land, water area and unused land (see Figure 2). The Kappa coefficient test shows that the interpretation accuracy is above 86%, so the research accuracy requirements are satisfied. Finally, based on the land use change data in different periods, the dynamic analysis is carried out to reveal the spatial and temporal differences of land use change in the research area.

4. Research Method

4.1. Analysis of land use change

The calculation of land use change is usually expressed by dynamic degree, and its formula is:

$$S = \frac{P_b - P_a}{p_a} \times \frac{1}{N} \times 100\% \quad (1)$$

In the formula: S represents the dynamic degree of a land use type during the research period, and P_a and P_b respectively represent the area of the land use type in the initial stage and the end stage of the research area, and N represents the research time scale. It can be seen from the above formula (1) that the S dynamic degree ignores the two-way change of land use transfer-in and transfer-out, and the calculation result can only reflect the annual average change during the research period. In order to calculate the dynamic degree of land use two-way change more accurately, now change S to S′, the formula is:

$$S' = \frac{(\Delta P_1 + \Delta P_2)}{P_a} \times \frac{1}{N} \times 100\% \quad (2)$$

In the formula: S′ represents the dynamic degree. ΔP_1 and ΔP_2 respectively represent the total area of a land use type transfer-in or transfer-out during the research period.

The meanings expressed by P_a and N are the same as formula (1). In order to observe the trends of land use types more intuitively, the following model is used to represent the trend status index of each land use type:

$$K = \frac{S'}{S} = \frac{P_b - P_a}{\Delta P_1 + \Delta P_2} \tag{3}$$

In the formula: *k* ranges from -0.5 to 0.5. When *k* is close to 0.5, it indicates the state of "rapid growth"; when 0< *k* <0.5, it indicates the trend of "growth"; when *k* =0 or *k* is close to 0, it indicates that there is no change in the area of a certain land use type or the change is not significant, indicating a "flat" state; when -0.5 < *k* < 0, it indicates a "decreasing" trend; when *k* is close to -0.5, it indicates a "rapidly decreasing" state.

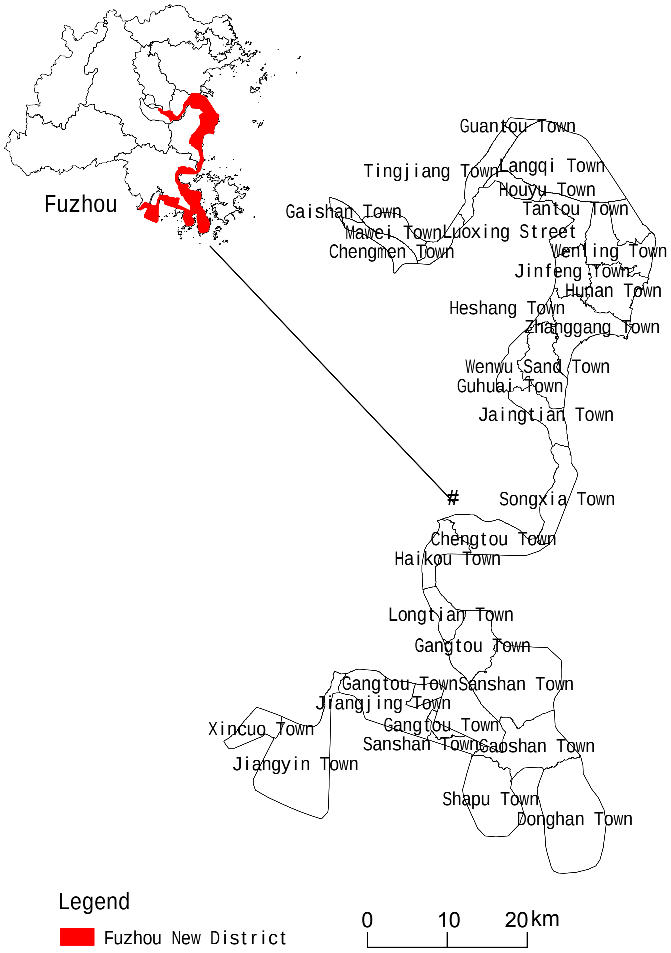


Figure 1. Schematic diagram of Fuzhou New District

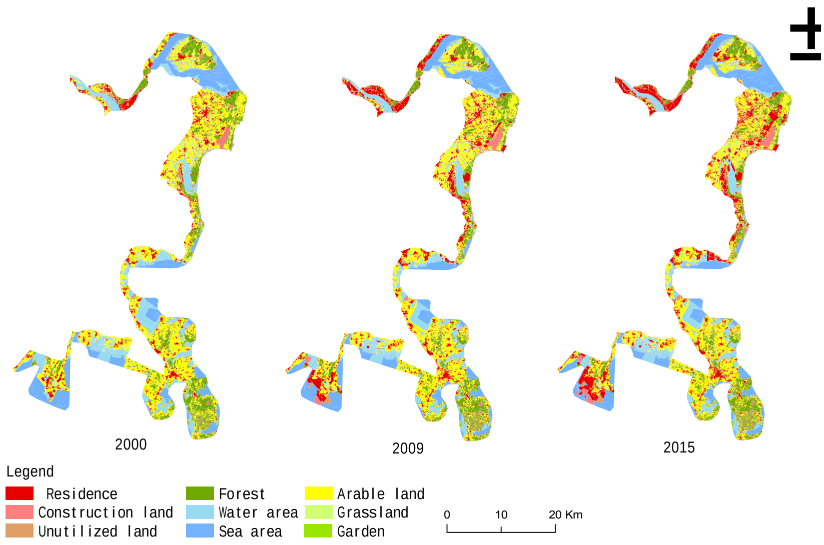


Figure 2. Land use type map of Fuzhou New District

4.2. Analysis of multi-distance spatial clustering

Multi-distance spatial clustering analysis summarizes the spatial correlation (element clustering or factor diffusion) within a certain distance range. The research results can show the corresponding changes of different land types when the distance changes[17-18]. This paper analyzes the spatial clustering of larger cultivated land, residential land, forest land and water area in the research area. Based on AraGIS 10.2, 1500 random point layers are generated, and the layers are superimposed with the third-stage land use types to determine the land use types of random points. Then, multi-distance spatial clustering tools are used to conduct Ripley K function analysis for land use types in different periods. The formula is shown as follows:

$$L(d)=\sqrt{\frac{A\sum_{i=1}^{n}\sum_{j=1,j\neq i}k(i,j)}{p\,n(n-1)}}(i,j=1,2,...,n) \qquad (4)$$

In the formula, A is the area of the research area, n is the number of points, d is the expected value (random space mode), *L(d)* is the observation value (specific distance space mode in the research area), and $K_{i,j}$ are weights. *L(d)>d* indicates that the landscape types are aggregated, *L(d)<d* indicates that the landscape types are discretely distributed, and *L(d)=d* indicates that the landscape types are randomly distributed. The Ripley K function will generate a confidence interval in the result. If *L(d)* is greater than the upper limit of the confidence interval, the spatial aggregation of the distance is statistically significant. If *L(d)* is less than the lower limit of the confidence interval, then the spatial dispersion of this distance is statistically significant. The value corresponding to the first peak of *L(d)* represents the characteristic spatial scale of the aggregation among landscape types, which can be used to measure the distribution intensity or congestion degree [19].

4.3. Moving window method

This paper selects *PD, CONT, MPS, FRACT, CONTAG, MSI, SHEI*, and *SHDI* quantitative analysis to study the landscape pattern evolution characteristics of the research area. The spatial response of the landscape pattern index of the research area is explored by moving window method. According to the size of the research area, the windows of 100m, 300m, 500m and 600m are debugged, and the 500m window can better reflect the temporal and spatial evolution characteristics of the landscape pattern in the research area. Landscape index calculations and moving window analysis are performed by using Fragstats 3.4 software.

5. Results and Analysis

5.1. Analysis of land use change

5.1.1. Changes in the number of land use types

In 2000, in the land use types of Fuzhou New District, the area of cultivated land was the largest, and the area of grassland was the smallest. The order of the area of different land use types was: cultivated land > water area > sea area > forest land > residential land > industrial, mining and traffic land > unused land > garden land > grassland; In 2015, the area of garden land in Fuzhou New District has been declining, with the smallest share of land use types. In the past 15 years, the proportion of residential land and industrial, mining and traffic land to the total land area has been increasing. The residential land has increased from 10.2% (fifth) in 2000 to 19.3% (second) in 2015, and the area has increased by

8548.7hm^2. The industrial, mining and traffic land has increased from 3.43% in 2000 to 6.13% in 2015, and the area has increased by 2541.2hm^2. The area of other land types has shown a downward trend. The comprehensive order of dynamic degree was: residential land> industrial, mining and traffic land> garden land> grassland> forest land> cultivated land > water area > sea area > unused land (see Table 1).

Table 1. The Situation of Land use Change in Fuzhou New District

Land type	2000		2009		2015		2000-2009	2009-2015
	Area(hm^2)	*Percentage(%)*	*Area(hm^2)*	*Percentage(%)*	*Area(hm^2)*	*Percentage(%)*	*Dynamic degree*	*Dynamic degree*
Grassland	852.02	0.90	767.07	0.81	701.33	0.74	-0.997	-1.714
Cultivated land	31268.64	33.08	28301.69	30.03	26448.55	28.07	-0.949	-1.310
Industrial, mining and traffic land	3235.82	3.43	4344.64	4.61	5776.96	6.13	3.427	6.594
Sea area	15143.53	16.07	15560.06	16.51	15109.67	16.03	0.275	-0.579
Residential land	9634.84	10.12	15045.52	15.97	18183.52	19.30	5.616	4.171
Forest land	12032.11	12.77	10762.40	11.42	10156.75	10.78	-1.055	-1.125
Water area	18850.24	20.00	16378.56	17.38	14910.01	15.82	-1.311	-1.793
Unused land	2529.33	2.68	2445.99	2.60	2343.48	2.49	-0.329	-0.838
Garden land	961.21	1.02	631.80	0.67	607.47	0.64	-3.427	0.770

5.1.2. Transfer law of land use types

From the land use type transfer matrix (Table 2, Table 3 and Figure 3), it can be seen that in the land use types of Fuzhou New District from 2000 to 2009, the grassland transfer was mainly transferred to the residential land, and the transfer area was 852.02 hm^2. It was mainly transferred from unused land and cultivated land, which is more significant in the eastern part of the Langqi development zone, Hunan Town and Wenwu sand Town. The unused land is mainly transferred to the residential land, and the transfer area is 2529.33 hm^2. It is mainly transferred from forest land, cultivated land and water area, which is more significant in Jiangyin Town, Zhanggang Town and Langqi development zone. The forest land in Songxia Town and Donghan Town is mainly transferred to unused land. From 2009 to 2015, the change of grassland in Songxia Town was the most severe, and it was mainly transferred to industrial, mining and traffic land. The transfer-in and transfer-out of unused land were small, and the change of total area was small. The forest land and sea area is changed greatly in Wenling Town, Hunan Town and Jiangyin Town and is mainly transferred to residential land.

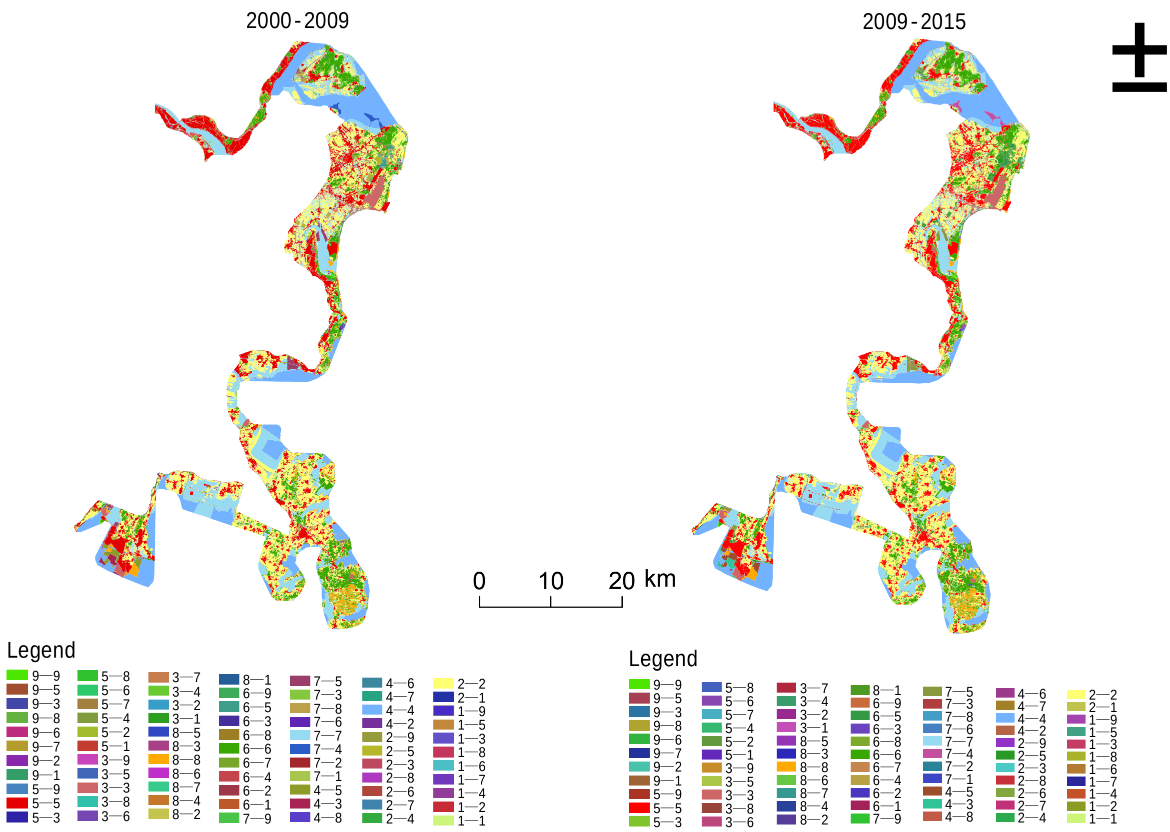
Table 2. Land use Type Transfer Matrix (hm^2) of Fuzhou New District from 2000 to 2009

2000	2009									
	Grassland	*Cultivated land*	*Industrial, mining and traffic land*	*Sea area*	*Residential land*	*Forest land*	*Water area*	*Unused land*	*Garden land*	*Trasfer-in*
Grassland	619.50	35.24	20.33	0.00	124.27	18.57	17.45	14.65	2.00	852.02
Cultivated land	41.87	26042.99	407.60	35.12	3579.18	122.04	700.58	309.10	30.16	31268.64
Industrial, mining and traffic land	5.70	25.81	3085.23	0.98	54.07	48.58	14.02	0.46	1.85	3235.82
Sea area	0.42	27.63	198.35	13939.08	121.21	2.98	547.97	305.87	0.00	15143.53
Residential land	13.03	284.21	47.79	1.31	9192.07	44.27	22.52	8.41	21.22	9634.84
Forest land	29.73	329.03	284.60	0.95	670.09	10206.79	110.87	377.21	22.84	12032.11
Water area	12.07	1452.22	207.80	1524.90	676.98	34.40	14849.54	82.83	9.49	18850.24
Unused land	42.92	73.31	60.64	58.59	586.48	262.92	91.82	1341.04	11.61	2529.33
Garden land	1.83	31.24	32.30	0.00	41.17	21.84	23.79	6.41	532.63	691.21
Trasfer-in	767.07	28301.69	4344.64	15560.06	15045.52	10762.40	16378.56	2446.99	631.80	94237.73

Table 3. Land use Type Transfer Matrix (hm^2) of Fuzhou New District from 2009 to 2015

2009	2015									
	Grassland	*Cultivated land*	*Industrial, mining*	*Sea area*	*Residential land*	*Forest land*	*Water area*	*Unused land*	*Garden land*	*Trasfer-out*

			and traffic land							
Grassland	694.05	3.47	38.74	0.03	27.10	1.92	1.00	0.58	0.19	767.07
Cultivated land	1.70	26043.09	504.03	0.00	1439.30	16.59	22.16	5.68	3.14	28301.69
Industrial, mining and traffic land	1.16	11.56	4258.50	0.71	62.68	3.96	4.34	0.75	0.98	4344.64
Sea area	0.00	0.23	320.55	14834.42	404.08	0.22	0.30	0.24	0.00	15560.06
Residential land	0.43	17.30	50.60	0.09	14968.37	2.77	4.03	0.39	1.55	15045.55
Forest land	2.18	44.62	192.70	0.02	382.67	10127.16	2.37	9.79	0.87	10762.40
Water area	1.18	54.12	359.90	274.33	802.96	1.53	14875.08	3.72	5.73	16378.56
Unused land	0.36	5.44	37.79	0.06	77.43	2.23	0.38	2322.31	0.00	2445.99
Garden land	0.27	2.73	14.15	0.00	18.92	0.36	0.35	0.01	595.01	631.80
Trasfer-out	701.32	26448.55	5776.96	15109.67	18183.52	10156.75	14910.01	2343.58	607.47	94237.73



In the figure: 1 stands for grassland; 2 stands for cultivated land; 3 stands for industrial, mining and traffic land; 4 stands for sea area; 5 stands for residential land; 6 stands for forest land; 7 stands for water area; 8 stands for unused land

Figure 3. Map of land type transfer in Fuzhou New Area

5.1.3. Land use type transfer dynamic degree

The land use type transfer dynamic degree in Fuzhou New District from 2000 to 2015 shows that (Table 4 and Table 5): During the 15 years, the transformation among the various land use types of Fuzhou New District was frequent and intense, especially in the past five years, it achieved the historical peak. Among the land use types, the residensial land had the fastest change from 2000 to 2009, and the garden land had the slowest change; the industrial, mining and traffic land had the fastest change from 2009 to 2015, and the grassland had the slowest change. From the trend status index, during the past 15 years, the area of industrial, mining and traffic land and residential land continued to increase, and the area of grassland, cultivated land, sea area, forest land, water area, unused land and garden land continued to decrease. The decline rate of grassland, cultivated land, forest land and garden land continued to decline, and the decline rate of sea area, water area, and unused land remained unchanged.

In summary, the research is in line with the actual situation in Fuzhou New District, which is mainly because Fuzhou New District has risen to the national development strategy in recent years, and the government's preferential policies have attracted a large number of factories and enterprises to come in, the road traffic laying and the booming development of the real estate industry has changed the original land use appearance, a large number of cultivated land, garden land, forest land has been levied or occupied, they are replaced by a sharp increase in the population, a significant expansion of industrial, mining and traffic land and residential land. At the same time, the rapid urbanization process in Fuzhou New District has also caused serious damage to the local ecological environment, which is not conducive to the protection of biodiversity and the display of ecological service value.

Table 4. Land use Type Transfer Dynamic Degree of Fuzhou New District from 2000 to 2009 (hm^2)

Land type	Grassland	Cultivated land	Industrial, mining and traffic land	Sea area	Residential land	Forest land	Water area	Unused land	Garden land
Dynamic degree(K)	-0.05	-0.05	0.15	-0.02	0.22	-0.06	-0.04	-0.02	-0.25
Change trend state index ($S^{'}$)	19.00	19.05	23.43	18.64	25.62	18.94	20.10	19.67	13.76

Table 5. Land use Type Transfer Dynamic Degree of Fuzhou New District from 2009 to 2015 (hm^2)

Land type	Grassland	Cultivated land	Industrial, mining and traffic land	Sea area	Residential land	Forest land	Water area	Unused land	Garden land
Dynamic degree(K)	-0.04	-0.03	0.14	-0.02	0.09	-0.03	-0.04	-0.02	-0.06
Change trend state index($S^{'}$)	38.28	38.69	46.59	38.74	44.17	38.87	38.85	40.85	39.23

5.2. Spatial cluster analysis of land use type

In 2000, the maximum scale of cultivated land aggregation in the research area was 14Km, and then the intensity of aggregation decreased continuously. When the observation distance increased to 23Km, a discrete distribution appeared, which was statistically significant. Compared with 2000, there was no change in the aggregate and discrete scale of cultivated land in the year of 2009, but it was not statistically significant. In 2015, the maximum scale of cultivated land aggregation was 15Km. When the observation distance increased to 24Km, a discrete distribution appeared.

Table 6. Land use Type Maximum Scale and Discrete Threshold of Spatial Aggregation/Km

Year	Cultivated land		Residential land		Forest land		Water area	
	Aggregation	*Discrete*	*Aggregation*	*Discrete*	*Aggregation*	*Discrete*	*Aggregation*	*Discrete*
2000	14	23	9	20	10	20	8	23
2009	14	23	8	19	10	22	9	23
2015	15	24	8	19	10	22	9	24

The maximum scale of Residential land aggregation in 2000, 2009 and 2015 were 9Km, 8Km and 8Km, the spatial distribution range was reduced, the uniformity was reduced, and the discrete threshold appeared at 20Km in 2000, which appeared at 19 Km in 2009 and 2015. The land use type was statistically significant during the research period.

The maximum scale of forest land aggregation in 2000, 2009 and 2015 was 10Km. The spatial distribution range did not change significantly, and the uniformity did not change. In 2000, the observation distance increased to 20Km, and a discrete distribution appeared. In 2009 and 2015, the observation distance increased to 22Km, and a discrete distribution appeared.

The water area has the largest aggregation in all land use types. The aggregate scales in 2000, 2009 and 2015 are 8Km, 9Km and 9Km, respectively. At the same time, within the set maximum observation distance, the largest discrete threshold appears, which values are 23Km, 23Km and 24Km, respectively.

In the past 15 years, the scale of cultivated land and water area aggregation has been increasing, and the maximum scale of residential land aggregation has been decreasing. This indicates that the spatial distribution of cultivated land and water area was gradually dispersed during the research period, and the spatial distribution of residential land was gradually aggregate. This is mainly because of the large-scale development and construction of Fuzhou New Area under the background of rapid urbanization led to the division of cultivated land into clusters with discrete distribution and the increase of water conduit network and marine aquaculture resulted in a reduction in water area and a trend of further pollution. A large number of enterprises have entered, the number of workers has increased, and the real estate industry has developed rapidly, which resulted in aggregate distribution of residential land (see Table 6, Figure 4).

5.3. Spatial response analysis of landscape pattern index

The landscape pattern index of Fuzhou New District from 2000 to 2015 (Table 7) shows that the plaque density in Fuzhou New District has been increasing and the degree of aggregation has been decreasing in the 15 years, indicating that the number of plaques in the entire research area is increasing, and the degree of fragmentation of landscapes is intensifying constantly. The average plaque area in the research area is decreasing and the FRACT is increasing, indicating that the types of plaques in the area are becoming more and more complex. Because as the Fuzhou New Area rises to the national development strategy in recent years, the interference degree of human activities is deepening and the number of industrial and mining enterprises is increasing, so the plaques is divided continuously and the heterogeneity of landscapes is becoming more and more significant. The CONTAG has been decreasing over the past 15 years, from 33.95 in 2000 to 30.77 in 2015, indicating that the connectivity among the plaques in Fuzhou New District is declining and the integrality is becoming weak, which is not conducive to the protection of biodiversity. From 2000 to 2015, the SHEI and the SHDI has been increasing, indicating that the land use types in Fuzhou New District are becoming more and more abundant, and the plaque types are more and more dominant in the research area.

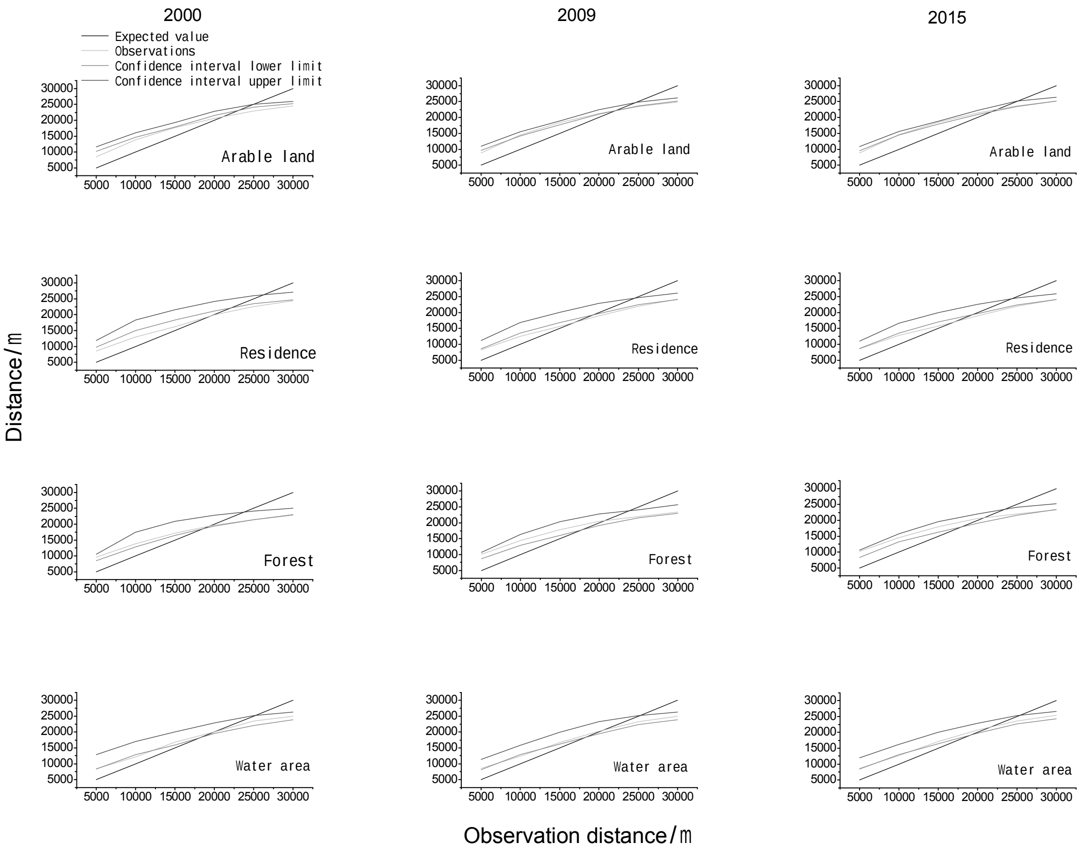


Figure 4. Land use type multi-distance spatial clustering map

Table 7. Landscape Pattern Index of Fuzhou New District from 2000 to 2015

Landscape index	Year of 2000	Year of 2009	Year of 2015
PD	2.500	2.699	2.861
MPS	40.058	37.048	34.957
CONT	63.454	62.221	61.103
CONTAG	33.955	31.936	30.772
FRACT	1.491	1.498	1.506
MSI	1.216	1.210	1.211

SHEI	0.804	0.825	0.834
SHDI	1.767	1.813	1.832

The SHDI is positively correlated with the degree of landscape fragmentation and is a reflection of landscape heterogeneity. The CONTAG refers to the agglomeration degree or extension trend of different plaque types, and represents the interference intensity of human activity to region. This paper selects these two indexes to research the spatial response process of land use landscape pattern evolution in Fuzhou New District in the 15 years.

The high peak values of positive changes in the diversity index are mainly in Mawei Town, Tingjiang Town, the northeastern part of the Langqi development zone, the eastern part of Hunan Town in Changle City, the northern part of Jiangtian Town, and the southwestern part of Jiangyin Town in Fuqing City. These areas are active areas of human activities, most of them are urban construction, port terminal construction and airport construction land areas, resulting in increased fragmentation of landscapes and increased landscape diversity. The high peak values of negative changes in the diversity index is mainly in the northwest of Chengmen Town in Cangshan District, the western part of the Langqi development zone, the Wenwu sand Town and Guhuai Town in the middle of Changle City, and the southeastern part of Fuqing City including Sanshan Town and Gaoshan Town, Donghan Town, etc. Most of these areas are concentrated distribution areas of forest land, water area and agricultural land. The landscape types are relatively simple, and the influence degree of human activities is relatively low.

The high value area of the CONTAG indicates that the intensity of human activity has strong interference for this area, and its distribution area is generally consistent with the high value area of the landscape diversity (except the sea area), which is mainly distributed along the urban construction land, township and traffic trunk line. The area with low CONTAG is the area with low impact on human activities, that is, the concentrated area of forest land, agricultural land and water area (Figure 5).

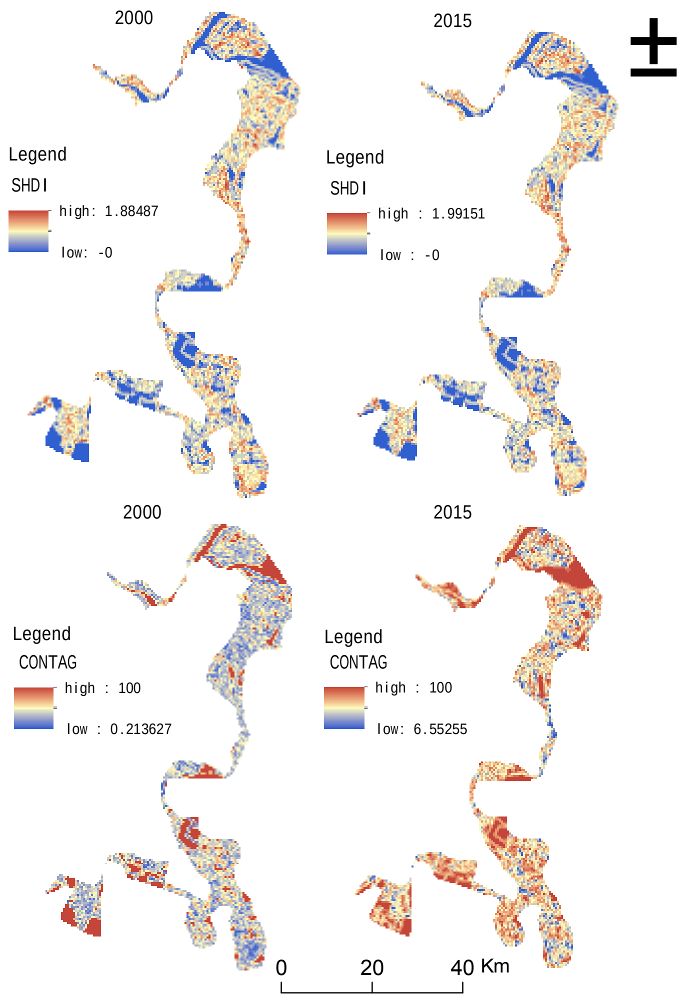


Figure 5. Spatial response of landscape index in Fuzhou New Area

5.4. Land use change driving mechanism

5.4.1. Social and economic factors

With the operation of the Xiangpu Railway and the Hefu Railway, Fuzhou New District has frequent personal exchanges. By 2014, the resident population has exceeded 15.55 million, directly causing the expansion of the residential area and the conversion of cultivated land, forest land and water area to the residential land. Fuzhou Port is one of the major ports along the coast of China. It is also one of the pilot ports for direct route to Taiwan. With the advancement of harbor industry, the current cargo throughput is 119 million tons and the container is 2.22 million TEUs. In addition, large-scale industrial construction has formed the industrial system with machinized equipment, metallurgy, food, textiles, plastics, medicine, petrochemicals, etc., the total industrial output value of industrial enterprises above designated size accounts for more than one third of Fuzhou City, with a number of innovative demonstration zones, such as bonded logistics park, airport economic zone, Fujian and Taiwan (Fuzhou) blue economy industrial park, leading to an increase in the demand for construction land, which has indirectly triggered changes in landscape types, landscape structures and landscape patterns in the research area.

5.4.2. Policy factors

As a national new district, Fuzhou New District has more open and preferential policies support. In terms of land policy, it introduces market mechanisms, encourages private investment to participate in land consolidation and reclamation development, and rationally adjusts the basic farmland protection tasks and layout. In terms of the policy of using the sea, it establishes the sea area use rights reserve trading platform, reasonable arranges the reclamation plan, priority to ensure the construction of the sea, and timely starts the comprehensive development and utilization of the coastal zone. In terms of financial policy, it relaxes the operation entrance of domestic and foreign financial institutions, and allows enterprises and banks in the Fuzhou area of the China (Fujian) Pilot Free Trade Zone to borrow local and foreign currency funds from abroad to support the development and construction of the new district. In terms of trade cooperation, it supports to develop the cross-strait regional cooperation pilot projects with Taiwan's free trade port areas, and the cross-strait cargo inspection and inspection results refer to mutual recognition. This series of preferential policies has fundamentally promoted the change of land use landscape pattern in Fuzhou New District.

6. Discussion and Conclusion

6.1. Discussion

This paper analyzes the spatial and temporal evolution characteristics and spatial response process of land use in Fuzhou New District during the 15 years from the perspectives of land use type change, multi-distance spatial clustering and spatial response of landscape pattern index. As the pioneer zone of ecological civilization, Fuzhou New District pays attention to strengthening the concept of ecological civilization. For the current situation that the cultivated land, garden land and forest land in Fuzhou New District are occupied largely, the population is increasing rapidly, the ecological environment is destroyed and the biodiversity is reduced, first of all, we must clarify the basic ecological control line of the new district, scientifically plan the ecological function structure of the new district, build a green new district and an ecological new district, so as to lead the trend of the Fujian ecological civilization test area. Secondly, we must attach great importance to the construction of marine ecological civilization and protect the coastal wetlands, tidal flats, estuaries, bays and other ecosystem functions, delineate the scope of river management, and strengthen the protection, treatment and restoration of rivers and lakes in the new district. Finally, we must rationally plan the spatial pattern of land use in the new district, adhere to intensive use of land resources, focus on strategic “empty space”, avoid disorderly spread, improve ecological carrying capacity, and leave room for the development of Fuzhou New District.

6.2. Conclusion

From 2000 to 2015, the land use types of Fuzhou New District have undergone great changes, and different land types have changed frequently. The area of residential land and industrial, mining and traffic land is increasing, and the area of other land types is decreasing. The area of industrial, mining and traffic land in the past five years is 1.3 times than the sum of that in past 10 years, indicating that Fuzhou New Area is currently in the stage of urbanization rapid development.

Rapid urbanization has increased the scale of cultivated land and water erea aggregation in Fuzhou New Area, which has gradually dispersed in the spatial distribution. The maximum scale of residential land aggregation has been decreasing, and the spatial distribution has gradually become concentrated.

In the 15 years, the degree of landscape fragmentation in the Fuzhou New District has been increasing, the shapes of the plaques have become more complicated, and the connectivity among the plaques has become weaker overall. The spatial and temporal evolution characteristics of SHDI and CONTAG are generally consistent. High-value areas are mainly distributed in urban construction, port terminal construction and airport construction; low-value areas are mainly distributed in forest land, water areas, agricultural land and other regions with relative simple landscape type.

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References

[1] YAN Shen, SUN Ran-hao, CAO Ming-ming. An assessment of the synchronization between urbanization intensity and environmentalquality in Beijing-Tianjin-Hebei region. Chinese Journal of Ecology, 2018, 37(2): 506-513

[2] PENG Jian, ZHAO Huijuan, LIU Yanxu, WU Jiansheng. Research progress and prospect on regional ecological security pattern construction. Geographical Research March, 2017, 36(03): 407-419.

[3] QI Yuanjing, JIN Fengjun, LIU Tao, JIAO Jingjuan. Implementation methods and economic impacts of national node strategies. Acta Geographica Sinica, 2016, 71(12): 2103-2118.

[4] WANG Xiaoyue, LI Shuangcheng. Progress and prospects of diagnostic analysis and risk prediction of urban problems based on multiple perspectives. Progress in Geography, 2017, 36(02): 231-243.

[5] LI Shuancheng, ZHAO Zhiqiang, WANG Yanglin. Urbanization Process and Effects of Natural Resource and Environment in China:Research Trends and Future Directions. Progress in Geography, 2009, 28(01): 63-70.

[6] FANG Chuang-lin,YANG Yu-mei. Basic laws of the interactive coupling system of urbanization and ecological environment. Arid Land geography. 2006,(01):1-8.

[7] SONG Zhiqing, Wang Yanglin. Progress in research on ecological impact of urban landscape structure. Progress in Geography, 2004(02): 97-106.

[8] LIU Jiyuan, KUANG Wenhui, ZHANG Zengxiang, XU Xinliang, QIN Yuanwei, NING Jia, ZHOU Wancun, ZHANG Shuwen, LI Rendong, YAN Changzhen, WU Shixin, SHI Xuezheng, JIANG Nan, YU Dongsheng, PAN Xianzhang, CHI Wenfeng. Spatiotemporal characteristics, patterns and causes of land use changes in China since the late 1980s. Acta Geographica Sinica, 2014, 69(01): 3-14.

[9] SONG Zhang-jian, CAO Yu, TAN Yong-zhong, CHEN Xiao-dong, CHEN Xian-peng. Land use and land cover change(LUCC) and landscape service: Evaluation,mapping and modeling. Chinese Journal of Applied Ecology, 2015, 26(05): 1594-1600.

[10] WANG Jun, YAN Shen-chun, BAI Zhong-ke, YU Li, GUO Yi-qiang.Review on Landscape Patterns of Land Consolidation and the Ecological Effects. China Land Sciences. 2012, 26(09): 87-94.

[11] FU Hong-yan. A Summary of Present Urban Landscape Pattern Evolution. Geomatics spatial infor mation technology. 2014, 37(04): 73-74+77.

[12] LIU Ya-xiang, LI Yang-bing, YI Xing-song, CHENG Xing. Spatial evolution of land use intensity and landscape pattern response of the typical basins in Guizhou Province, China, Chinese Journal of Applied Ecology, 2017, 28(11): 3691-3702.

[13] YANG Huimin, LOU Fan, LI Xiaojian, BAI Yanfei. Changing patterns of settlement landscape in the Eastern Plain of Henan Province. Acta Ecologica Sinica, 2017, 37(16): 5313-5323.

[14] WANG Liqun, ZHANG Zhiqiang, LI Ge, MA Fengwei, CHEN Lixin. Landscape pattern change in Beijing fringe area and its impact on the ecosystem services:a case study in Niulanshan-Mapo town, Acta Ecologica Sinica. 2018(03): 1-10.

[15] QI Wei, ZHANG Feng-rong. Landscape Pattern Analysis at County Level in Huang-Huai-Hai Plain and Suggestions for Sustainable Land Management, China Land Science, 2003(01): 27-33.

[16] BI Xiao-Li, ZHOU Rui, LIU Li-Juan, HONG Jun, WAN G Xi-Zhi, SUO An-Ning, GE Jian-Ping, Gradient variat ions in landscape pattern along the Jinghe River and their driving forces. Acta Ecologica Sinica, 2005(05): 1041-1047+1238.

[17] YANG Jun, GUO Andong, XI Jianchao, GE Quansheng, LI Xueming. Spatial-temporal differentiation of three-dimensional urban landscape pattern: A case study of Zhongshan District in Dalian. Acta Geographica Sinica, 2017, 72(04): 646-656.

[18] ZHAO Yonghua, JIA Xia, LIU Jianchao, LIU Geng. Analysis and forecast of landscape pattern in Xi'an from to 2011. Acta Ecologica Sinica, 2013, 33(08): 2556-2564.

[19] ZHONG Lina, ZHAO Wenwu, LV Yihe, LIU Yuanxin. Analysis of landscape pattern evolution characteristic in the hilly and gully area of loess plateau: a case study in Yan'an City, Shaanxi Province. Acta Ecologica Sinica, 2014, 34(12): 3368-3377.