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The spatial and temporal evolution of land use change and ecosystem service value in Dongting Lake Ecological Economic Zone from 2000 to 2020

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Abstract: *As a national development area, Dongting Lake is an important strategic support for the rise of the central region. In the past two decades, the water surface rate, river network density and the ratio of main stream area to length in Dongting Lake Basin have shown a decreasing trend, and the stability of water network structure has fluctuated significantly.The landscape pattern and land use pattern have changed greatly after the area has experienced " reclaiming land from lakes " and " returning farmland to lakes, " and the ecological vulnerability is very prominent.The research on the spatial-temporal coupling relationship between land use change and ecosystem service value in Dongting Lake Ecological Economic Zone is of great significance to regional ecosystem protection, land use assessment and planning adjustment.Based on the results of land classification and two-dimensional matrix, this paper summarizes the land use change of Dongting Lake Basin in 20 years with 5 years as the time interval, and uses Arc Map10.2 to tabulate the result area to obtain the ESV value under land use change in 2000,2005,2010,2015 and 2020. The influence of land use change on ESV was obtained by spatial autocorrelation analysis.The results show that : With the rapid development of society and the intensification of human activities, the area of construction land in Dongting Lake Ecological Economic Zone is increasing, the area of cultivated land is increasing, the area of forest land and water area is decreasing, which has a certain impact on the local ecology. Therefore the change rate of land use type of cultivated land and forest land is slowing down. Supply service and support service are the two most important ecological service functions in Dongting Lake Ecological Economic Zone. The total amount of ESV in the Dongting Lake Ecological Economic Zone is spatially aggregated. Forest land, cultivated land and water area are important factors affecting the total amount of ESV in the study area. ESV showed a downward trend in 20 years, and the conversion of forest land to cultivated land was an important reason for the decline of total ESV.*

Keywords: *Land use; Ecosystem service value; Spatial correlation; Dongting Lake Ecological Economic Zone*

1. Introduction

Land use is the use and utilization of land natural attributes by human beings. It refers to the activities of human beings to use land resources and obtain the products or services they need[1]. In today 's era of rapid economic take-off, continuous advancement of urbanization and increasing human activities, the interference of land use methods in the Dongting Lake Ecological Economic Zone has been intensified, and the land use methods in the Dongting Lake Ecological Economic Zone have undergone certain changes. The change of land use has an impact on the value of ecosystem services[2]. In the face of problems such as the deterioration of the ecological environment of Dongting Lake and the sharp decline in the water area, governments at all levels and relevant departments attach great importance to ecological protection, and have formulated the *Dongting Lake Ecological Economic Zone Plan (2014-2020)*, which has made positive and fruitful efforts. Ecosystem services are the supply of tangible material products and intangible services provided by human beings from the ecosystem in the process of production and life, which are mainly divided into supply services, regulation services, support services and cultural services[3]. In order to make ecosystem services comparable, we usually monetize the benefits we get from nature to obtain the value of ecosystem services(ESV)[4]. Land use also affects the health of the land ecosystem by changing the structure and function of the land ecosystem[5].

In recent years, domestic and foreign scholars have conducted extensive research on land use

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change, and the research content related to ecosystem service value has become increasingly mature. Most of the relevant researchers at home and abroad focus on the process of land use change for many year[6-7], the process of land use change at different sub-scales[8-9], driving force analysis[10-12], ecological effects[13-14], and future land use pattern simulation[14-15]. In terms of exploring the impact of land use change on ESV, foreign scholars mainly focus on the spatial and temporal pattern of ESV[16-17], simulation prediction[18], impact factors[19], and the correlation between ESV and land use carbon emissions[20]. There are also differences in ESV calculation methods, such as equivalent factor method[17,20-22], functional value method[21], full arrangement polygon graphic method[22], and profit earning method[23]. In summary, the existing literature is further summarized, and it is found that there are few studies on the spatial-temporal coupling between land use change and ecosystem service value in Dongting Lake Ecological Economic Zone and the impact of land use on ecosystem services. Dongting Lake is an important production base of grain, cotton, oil and fish in China, which plays an important role in ensuring food security in China. However, under the background of extensive development of climate change and single pursuit of growth, the ecological environment of the lake area has been seriously damaged. How to protect the ecological environment while helping the green development of the local economy is the problem that the whole society attaches great importance to. Based on this, we takes the Dongting Lake Ecological Economic Zone as the research object. Basing on the 5km×5km grid, the spatial and temporal variation characteristics of land use change and ecosystem service value in the Dongting Lake Ecological Economic Zone from 2000 to 2020 are obtained, and the impact of land use type change on ecosystem service value is analyzed. It provides a quantitative reference for constructing a more reasonable spatial pattern of land use, improving the value of ecosystem services, and improving the relationship between ecological protection and economic development in Dongting Lake Basin.

2. Materials and methods

2.1 Study area

Dongting Lake is located on the south bank of Jingjiang River in the middle and lower reaches of the Yangtze River. It is the second largest freshwater lake in China. Following the development of Changsha-Zhuzhou-Xiangtan, southern Hunan and western Hunan into the national strategic level, as the fourth largest plate of regional economic development in Hunan Province, Dongting Lake Ecological Economic Zone includes Yueyang, Changde and Yiyang, Wangcheng District of Changsha and Jingzhou City of Hubei Province. The Dongting Lake Ecological Economic Zone contains 33 counties and cities, and the shape of the planned area is hexagonal (Figure 1). It has a total area of 60,500 square kilometers and a permanent population of 22 million in 2020. Dongting Lake Ecological Economic Zone belongs to the subtropical monsoon humid climate. The climate here is distinct in four seasons, high temperature and rainy in summer, mild and humid in winter. Its annual average temperature is between 15.6 °C and 17.5 °C, and the annual precipitation is about 1429mm. It has four major water systems: Yuanjiang River, Zishui River, Lishui River and Xiangjiang River. The terrain of the study area is lower in the northeast, higher in the west and southeast. The land use types are mainly cultivated land, followed by forest land, water body, construction land and grassland. In 2021, the regional GDP of the Dongting Lake Ecological Economic Zone had been 14195 billion yuan (1147.9 billion yuan in Hunan 's three cities and one district).

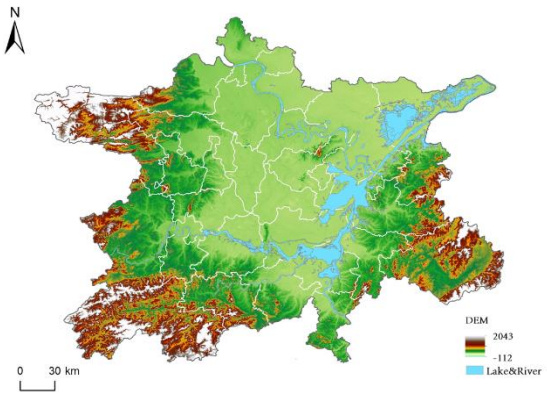

Fig. 1 Study area

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2.2 Data sources

In order to obtain the land use change of Dongting Lake Ecological Economic Zone and the impact of land use on ecosystem service value, we studies the spatial scale of 5km × 5km grid. The main research data are: land use data and ESI coefficient in 2000,2005,2010,2015 and 2020. The land use data of Huang Xin's team of Wuhan University is mainly used. The data is based on Landsat data, constructs spatio-temporal features, and combines random forest classifier to obtain classification results. Based on 5,463 visual interpretation samples, the overall accuracy of CLCD is 80 %. The data divides the land use types of Dongting Lake Ecological Economic Zone into six categories: cultivated land, forest land, grassland, water area, unused land and construction land. ESI coefficient is the ESI coefficient of each land use type obtained by Chen Wanxu and other scholars using the benefit transfer method[23].

2.3 Methods

2.3.1 Land use type transfer matrix

We take the Dongting Lake Ecological Economic Zone as the research scope, referring to the research of Huang Xin and other scholars, covering the 30 m resolution data of land use in the basin from 2000 to 2020. A two-dimensional matrix of land use transfer was established to quantitatively describe the complex transfer changes of land use types, and to explore the quantity transfer and flow direction of each land use type in the basin during 20 years. At the same time, it also lays a solid foundation for the later exploration of the impact of land use change on the value of ecosystem services. The formula is :

$$S_{ij} = \begin{bmatrix} S_{11} & S_{12} \cdots & S_{1n} \\ S_{21} & S_{22} \cdots & S_{2n} \\ \cdots & \cdots \ddots & \cdots \\ S_{n1} & S_{n2} \cdots & S_{nn} \end{bmatrix} \quad (1)$$

In ***(Eq.(1))***, S_{ij} denotes the area of land ; n is 6 ; $i\ and\ j$ are the serial numbers of land types from 2000 to 2020 respectively. The land use data from 2000 to 2020 are used to reclassify the basin into six categories : cultivated land, forest land, grassland, water area, construction land and unused land, and a two-dimensional matrix of land use transfer was established.

Based on the results of land classification and two-dimensional matrix, we summarize the land use changes in the Dongting Lake Ecological Economic Zone over the past 20 years with a time interval of 5 years. We use Arc Map10.2 to tabulate the area of the results to obtain the land area of each county in 2000,2005,2010,2015 and 2020, and to lay a solid data foundation for the exploration of land use change and spatial and temporal changes of ecosystem service value in Dongting Lake Ecological Economic Zone.

2.3.2 Ecosystem services value

Basing on the purpose of ecological environment protection and the area data of land use types in the basin, referring to the study of ESI coefficients of various land use types obtained by Chen Wanxu and other scholars using the benefit transfer method , see ***(Table 1)***. The study area is divided into 5km ×5km grids, and the area of each land use type of each grid was multiplied by the weighted sum of ESI coefficients of 9 types of ecosystem functions to calculate the ESV of Dongting Lake Ecological Economic Zone[23]. The calculation formula is as follows :

$$V_{ES} = \sum_{j=1}^{n} V_{ESj} = \sum_{j=1}^{m} \sum_{i=1}^{n} W_{ij} \times LA_{(i,t)} \quad (2)$$

In ***(Eq.(2))***, $W_{ij}$is the ESI coefficient of class$j$ ecosystem function of class$i$ land use type,$LA_{(i,t)}$is the area of the ith land use type at time t. m is 9, indicating the number of ecosystem functions, n is 6, indicating the number of land use types. The ecosystem service value of Dongting Lake Basin from 2000 to 2020 can be obtained by calculation, and the spatial and temporal evolution characteristics of ESV in 20 years can be obtained by tabulation and drawing.

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Table 1 ESI coefficients of various land use types and various ecosystem functions

Type	Subtype	Cultivated land	Forest land	Grass land	Water	unutilized land	Construction land
Supplying Services	Food	100.00	33.00	43.00	53.00	2.00	0.00
	Raw materials	13.00	100.00	12.00	12.00	1.34	0.00
Regulating services	Gas regulation	17.00	100.00	35.00	12.00	1.39	0.00
	Climate regulation	7.00	30.00	12.00	15.00	0.96	0.00
	Water supply	4.00	22.00	8.00	100.00	0.37	0.00
	Waste treatment	9.00	12.00	9.00	100.00	1.75	0.00
Supporting Services	Soil formation retention	37.00	100.00	56.00	10.00	4.23	0.00
	Biodiversity protection	23.00	100.00	41.00	76.00	8.87	0.00
Cultural service	Recreation and culture	4.00	44.00	19.00	95.00	5.12	0.00

Based on the land use data and ESI coefficient, the ESV of Dongting Lake Ecological Economic Zone is calculated. The five-period ESV data are superimposed and analyzed to obtain the ESV rising area, stable area and falling area. Finally, the ecological status of each land use type in the basin is more intuitively presented, so as to provide reference for the development direction of ecological work in the basin.

2.3.3 Spatial autocorrelation analysis

In this stage, based on the previous ESV calculation results, this stage will use GeoDa4.0 software to use univariate global spatial autocorrelation method and univariate local spatial autocorrelation research method for ESV. The univariate global spatial autocorrelation method mainly studies whether there is spatial correlation and its degree in the Dongting Lake ecological economic zone. The local bivariate Moran 's I method mainly shows the spatial correlation of the two variables on the spatial scale of the Dongting Lake ecological economic zone. The calculation formula is as follows :

$$\mathrm{I} = \frac{\sum_{\mathrm{i}=1}^{\mathrm{n}}\sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{w_{ij}}(\mathrm{x_i}-\bar{\mathrm{x}})(\mathrm{x_j}-\bar{\mathrm{x}})}{\mathrm{S}^2 \sum_{\mathrm{i}=1}^{\mathrm{n}}\sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{w_{ij}}} \tag{3}$$

$$\mathrm{I_i} = \frac{(\mathrm{x_i}-\bar{\mathrm{x}}) \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{w_{ij}}(\mathrm{x_i}-\bar{\mathrm{x}})}{\mathrm{S}^2} \tag{4}$$

In ***(Eq.(3)(4)),*** The equations I andI_i are the global bivariate Moran's I and local bivariate Moran's I for land use carbon emissions and ESV, respectively.$n$is the number of counties and districts in the study area.w_{ij} is an $n \times n$ spatial weight matrix. $x_i$andx_j are the attribute values of the counties and districts, and$\bar{x}$ is the mean of the attribute values, and S^2 is the variance. Based on the calculation of local bivariate Moran's I values, this project analyzed the bivariate LISA clustering map with visual local spatial correlation using ArcMap10.2, and Finally, the spatial clustering and discrete results between land use carbon emissions and ESV are explored, and the spatial autocorrelation relationship between the two variables is obtained.

2.3.4 Analysis of the impact of land use change on ESV

In order to analyze the impact of land use change on ESV more specifically, we will use land use change data and ESV results to analyze the correlation and variation contribution rate. The correlation analysis is mainly based on the Pearson correlation coefficient to obtain the degree of strong and weak relationship between land use types and ESV, and the significance of the correlation coefficient is tested at the level of 0.05.

The contribution rate of variation is mainly used to analyze the contribution of various land use types to ESV in the same period, so as to obtain the influence degree of various land use types on ESV more clearly and provide direction for the implementation of specific policy measures in the region[24].

$$ESV_{cc} = \frac{ESV_{ib}-ESV_{ia}}{\sum_{i=1}^{n}(ESV_{ib}-ESV_{ia})} \tag{5}$$

In ***(Eq.(5))***,ESV_{cc} represents the variation contribution rate of $i$land use types to ecosystem service value ;ESV_i represents the ecosystem service value of i land use types ; a, b represents the beginning and end of the study; $n$represents the total number of land use types.

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3. Analysis of results

3.1 Analysis of land use change

According to ***Fig. 2***, the main land use type of Dongting Lake Ecological Economic Zone is cultivated land, as its accounting for more than 50 % of the total area, mainly distributed in the central and northern parts of Dongting Lake Ecological Economic Zone. Following by forest land and water, and the forest land is mainly distributed in the southeast, west and southwest of the study area, accounting for about 34%. The water body is mainly distributed in the Dongting Lake Basin in the eastern part of the study area, accounting for about 8%. The proportion of land use types such as grassland, construction land and unused land is small.

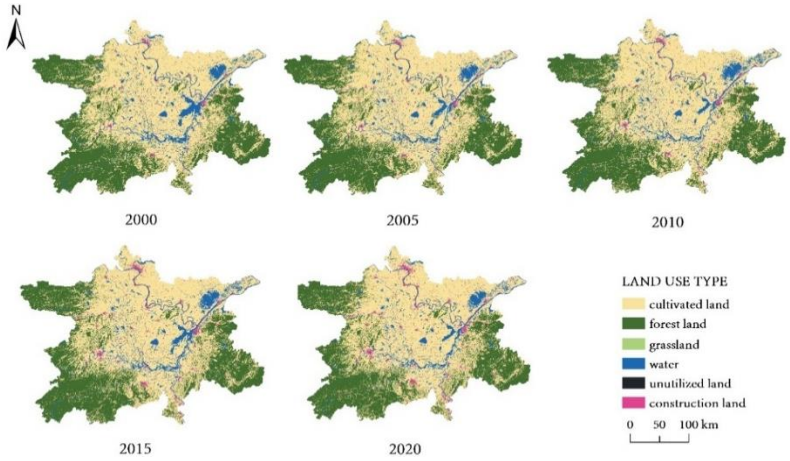

Fig. 2 Land use type map of Dongting Lake basin ecological economic zone, 2000-2020

According to ***Table 2*** and ***Fig. 2***, from 2000 to 2020, the land use types in the Dongting Lake Ecological Economic Zone have always maintained cultivated land > forest land > water body > grassland > construction land > unused land. Except for cultivated land and construction land, other land use types showed a decreasing trend. Among them, the area of forest land decreased the most, a total of 800 km^2, followed by water body with a total of 739.86 km^2, and the reduction of grassland and unused land was relatively small. Among the increasing land use types, the construction land increased the most, which was 923.8km^2, which was the land use type with the largest change, and the cultivated land increased by 600km^2.

Table 2 The area of land use types in Dongting Lake Ecological Economic Zone, 2000-2020

Year	Cultivated land /10^4km^2	Forest land /10^4km^2	Grassland /km^2	Water /km^2	Unutilized land /km^2	Construction land /km^2
2000	3.34	2.15	10.25	5030.66	0.61	908.34
2005	3.37	2.12	8.15	4770.75	0.43	1064.85
2010	3.39	2.09	7.27	4776.79	0.37	1247.47
2015	3.35	2.08	6.76	4939.92	0.13	1519.16
2020	3.40	2.07	4.44	4290.80	0.22	1832.12

Through calculation and summary ***(see Table 3)***, the land use types in the Dongting Lake Ecological Economic Zone have undergone complex transfer from 2000 to 2020. The total area of transfer is 6117.5 km^2, which is 10.11 % of the total area of the basin. The transfer area of cultivated land is the largest, which is 2629.64 km^2 There are 1231.72 km^2 cultivated land into forest land, and the transfer rate is as high as 46.84 %. The second is forest land, the transfer amount is 2053.814 km^2, of which 96.26 % of the forest land is converted to cultivated land. The transfer amount of construction land is 32.97km^2. Although the area is small, most of them have been converted to water, accounting for 84.19 %.It is indicating that the local relocation and resettlement work has achieved certain results. The Dongting Lake area belongs to the main producing area of agricultural products in the Yangtze River Basin The reason for the above situation is that the region has increased construction land and cultivated land for economic development and construction while striving to maintain green ecology.

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Table 3 Land use transfer in Dongting Lake Ecological Economic Zone, 2000-2020

Year	Type	Items	2020						
			Cultivated land	**Forest land**	**Grass land**	**Water**	**Unutilized land**	**Construction land**	**Transfer out**
2000	Cultivated land	Area/km^2	30731.47	1231.72	1.20	617.11	0.107	779.50	33361.11
		Transfer rate/%		46.840	0.046	23.467	0.004	29.643	100.000
	Forest land	Area/km^2	1976.95	19422.16	1.69	5.631	0.038	69.505	21471.88
		Transfer rate/%	96.257		0.082	0.274	0.002	3.384	100.000
	Grass land	Area/km^2	4.94	2.01	1.39	1.14	0.018	0.766	10.26
		Transfer rate/%	55.668	22.650		12.847	0.203	8.632	100.000
	Water	Area/km^2	1276.42	8.17	0.15	3640.19	0.025	106.86	5031.81
		Transfer rate/%	91.722	0.587	0.011		0.002	7.679	100.000
	Unutilized land	Area/km^2	0.324	0.0027	0.019	0.09	0.029	0.149	0.613
		Transfer rate/%	55.413	0.462	3.250	15.393		25.483	100.000
	Construction land	Area/km^2	5.18	0.026	0.0009	27.76	0	875.41	908.37
		Transfer rate/%	15.713	0.079	0.003	84.206	0.000		100.000

3.2 Spatial-temporal evolution of ESV

3.2.1 Temporal variation characteristics of ecosystem service value

From the perspective of time ***(Fig. 3)***, the total value of ecosystem services in the Dongting Lake Basin Ecological Economic Zone decreased year by year from 2000 to 2020, the total value decreased from 21.14 × 10^8 yuan to 20.48 × 10^8 yuan, a decrease of 3.12 %. Especially from 2015 to 2020, the degree of reduction is the most obvious. From the perspective of the first-level ESV classification, the contribution to ESV from large to small is supply service, support service, adjustment service and cultural service. The four types of ecosystem functions showed a downward trend, and the regulation service decreased the most among the four types of ecosystem functions, with a decrease of 2.8 × 10^7 yuan in 20 years, which was the most important function affecting the total decline of ESV. The reason for the decline is related to the decline of five functions of gas regulation, climate regulation, hydrological regulation, waste treatment and soil conservation in the Dongting Lake Basin Ecological Economic Zone. The decline of supply services, support services and cultural services are less than that of adjustment services, which decreases by 8 × 10^6 yuan, 9 × 10^6 yuan and 1.1 × 10^7 yuan respectively from small to large.

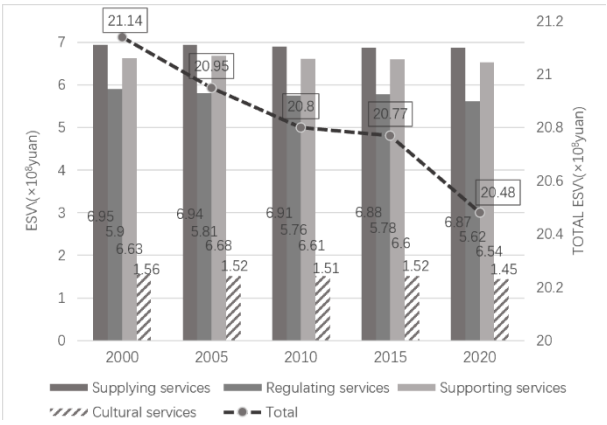

Fig. 3 Statistical map of ecosystem service function value and total amount,2000-2020

From the perspective of various types of land use (***see Table 4***), the land use types of ecosystem service value mainly provided by the ecological economic zone of Dongting Lake Basin are forest land and cultivated land, with an average proportion of 54.57 % and 34.62 % respectively. The ESV provided by forest land is above 11.18 × 10^8 yuan, and the ESV provided by cultivated land is above 7.14 × 10^8 yuan. Followed by water, grassland, unused land. Among the various land use types, only the cultivated land ESV continued to maintain an increasing trend during the 20 years, increasing by 1357.09 × 10^4 yuan. The ESV provided by the water area mainly decreased first, then increased and then decreased, but the total amount decreased by 3499.54 × 10^4 yuan in 20 years. The main reason for the increase of ESV value is the increase of water area. The ESV provided by the remaining land use

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types showed a decreasing trend, and the forest land and water area accounted for the main position, which decreased by 4392.17 × 10^4 yuan and 13.66 × 10^4 yuan respectively, which was also an important factor leading to the decrease of the total ESV. Unused land has less change than other land.

Table 4 Dongting Lake Ecological Economic Zone ESV results table

Year	Cultivated land/10^8yuan	Forest land/10^8yuan	Grassland /10^4yuan	Water /10^8yuan	Unutilized land/104yuan	Total /108yuan
2000	7.14	11.62	24.09	2.38	0.16	21.14
2005	7.22	11.48	19.14	2.25	0.11	20.95
2010	7.25	11.29	17.09	2.26	0.10	20.80
2015	7.17	11.26	15.89	2.34	0.03	20.77
2020	7.27	11.18	10.44	2.03	0.06	20.48
2000-2020 ESV variation	0.14	-0.44	-13.66	-0.35	-0.10	-0.65

3.2.2 Spatial variation characteristics of ecosystem service value

Based on the calculation results of ESV in Dongting Lake Ecological Economic Zone, we visually expresses its spatial characteristics ***(Fig. 4)***, and divides the grid data into five grades from low to high by using the natural discontinuity classification method.By analyzing the spatial distribution of ESV, it can be seen that the spatial difference of ESV in Dongting Lake Ecological Economic Zone is obvious. In general, the ESV on the east and west sides is higher than that in the central region. Among them, the areas belonging to the middle, high and higher grades of ESV are mainly distributed near Shimen County, Anhua County, Pingjiang County and Dongting Lake Basin. The high grade of ESV in this kind of area is mainly due to the wide distribution of forest waters, less human disturbance and relatively less construction land. The areas with low and lower levels of ESV are mainly distributed in the central plains with relatively high population density and dense construction land in the Dongting Lake Ecological Economic Zone, and the low-value areas are the most widely distributed in the five categories. By comparing the ESV distribution maps of Dongting Lake Ecological Economic Zone in 2000, 2005, 2010, 2015 and 20205, it is found that the number of ESV belonging to low and lower grade areas has increased year by year in the past 20 years, and some of them appear sporadically in high-grade gathering areas; the number of areas belonging to the middle and high levels decreased year by year, and the change of high-level areas was not obvious.

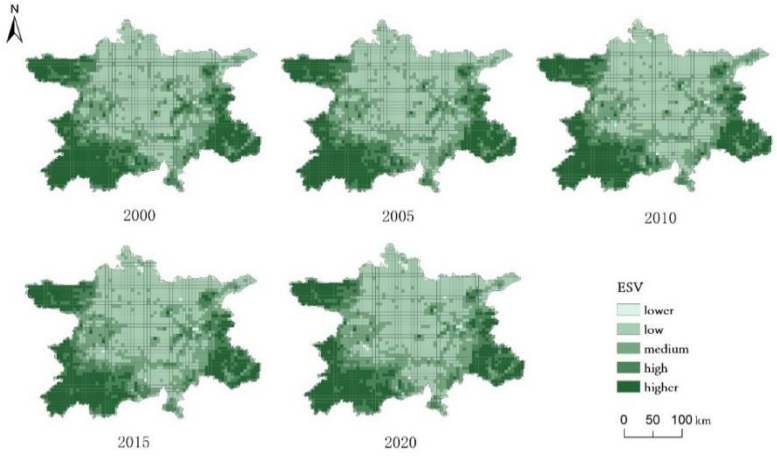

Fig. 4 The temporal evolution of ecosystem service value in Dongting Lake Ecological Economic Zone, 2000- 2020

From ***Fig. 5***, it can be seen that the spatial variation of ESV is mainly stable area in terms of quantity. In the past 20 years, the number of rising areas has increased first and then decreased, but the trend of falling areas is opposite, and the number of falling areas is slightly higher than that of rising areas, which also proves that the total amount of ESV in Dongting Lake Ecological Economic Zone has decreased. Spatially, the stable area is the most widely distributed, and the falling area is mainly distributed around the water area, the junction of forest land and cultivated land, and the construction land of urban and rural areas. The rising area is mainly located at the intersection of cultivated land and forest land on both sides of the east and west of the Dongting Lake Ecological Economic Zone, and the

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rising area gathers near the Dongting Lake waters during the period of increasing the number of rising areas.

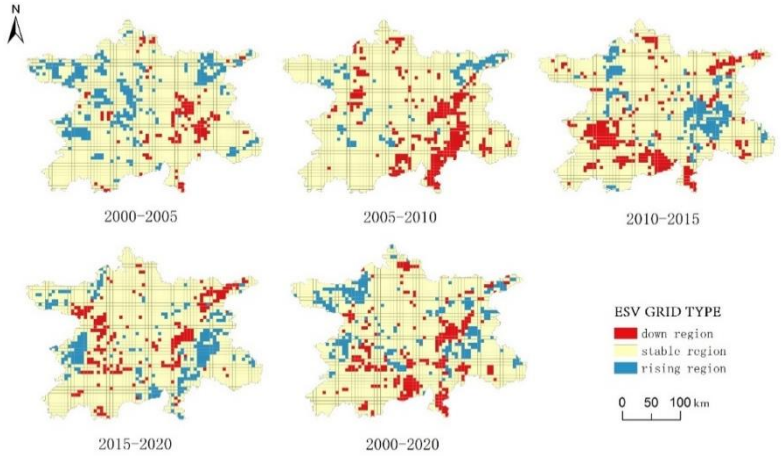

Fig. 5 Spatial variation of ESV in Dongting Lake Ecological Economic Zone

3.3 Spatial autocorrelation analysis of ecosystem service value

Based on the univariate spatial autocorrelation model, GeoDa4.0 software have been used to analyze the spatial correlation between ESVs under the land use change in the ecological economic zone of Dongting Lake Basin ***(see Table 5)***.It is concluded that there is a significant spatial positive correlation between ESVs under land use change, and the adjacent grids show an aggregated distribution in space. The Moran 's I of each year is greater than 0, the P value is less than 0.001, and the Z score is greater than 2.58, indicating that the spatial agglomeration degree of ESV in the ecological economic zone of Dongting Lake Basin is generally on the rise in the past 20 years. The main reason for this is that in recent years, the basin has adhered to the principle of joint protection and non-development, so that the overall layout of regional land use types is relatively stable, which increases the degree of spatial aggregation and correlation of various land use types.

Table 5 ESV global spatial autocorrelation significance test

Year	Moran's I exponents	P-value	Z-score
2000	0.596	<0.001	55.0304
2005	0.603	<0.001	57.1509
2010	0.608	<0.001	56.4671
2015	0.602	<0.001	58.4236
2020	0.607	<0.001	54.4504

Then, the LISA agglomeration map of ESV under land use change is compared and analyzed (Figure 6), in which a large blue area indicates a low value area of local ecosystem services ; the red area indicates the area with high value of ecosystem services in the region ; the green area indicates the area where the ESV of the spatial unit is low and the ESV of the surrounding unit is high; the yellow area indicates the area where the ESV of the spatial unit is high and the ESV of the surrounding unit is low. After analysis, we conclude that the spatial correlation between ESVs under land use change in the Dongting Lake Ecological Economic Zone is the following four points: First, the spatial pattern of ESV in the Dongting Lake Ecological Economic Zone remained unchanged from 2000 to 2020. Second, the high-high type areas in the past 20 years were mainly concentrated in mountainous and hilly areas such as Shimen County, Anhua County, and Pingjiang County, and a few were distributed in water areas. Among them, from 2000 to 2020, the high-high aggregation area in the southwest narrowed in a small range, which was related to the transformation of some forest land into cultivated land for economic development in this area. Third, the low-low agglomeration areas were mainly distributed in the Dongting Lake Ecological Economic Zone, which belonged to the county area of Hubei Province, and showed a trend of diffusion from north to south. The reason may be that in order to facilitate the development of urbanization, the water plain area in this area is affected by human activities, resulting in drastic changes in land use patterns, and the ecological environment is destroyed, resulting in a decrease in ESV. Fourth, the range of low-high and high-low aggregation areas was small and did not change much.

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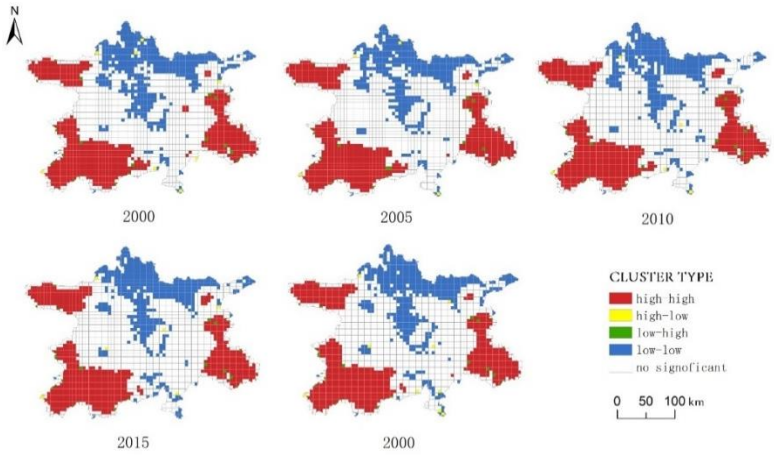

Fig.6 LISA agglomeration map of ecosystem service value, 2000-2020

3.4 Analysis of the impact of land use change on ESV

From ***Table 6***, it can be seen that there is a negative correlation between cultivated land and the total value of ecosystem services, indicating that a large number of cultivated land will be reclaimed from forest land. Although the ecological service value of the supply side is increased, the overall ecological service value provided by the forest land is much higher than the ecological service value originally generated by the cultivated land. The Pearson correlation coefficients r of forest land, grassland and total ESV are 0.952 and 0.995, respectively, which are positively correlated and infinitely close to 1, indicating that the change of forest land and grassland area is the dominant factor affecting the change of total ESV in Dongting Lake Ecological Economic Zone. Among them, the correlation coefficient of grassland is the highest, and the two-tailed test at the 0.01 level shows significant correlation. Therefore, the Dongting Lake Ecological Economic Zone should focus on controlling the disorderly expansion of cultivated land in terms of the increase of ESV value, and further promote the policy of returning farmland to forests and lakes.

Table 6 The correlation between land use types and ESV in Dongting Lake Ecological Economic Zone

Land use type	Cultivated land	Forest land	Grassland	Water	Unutilized land	Total
Cultivated land	1.000					
Forest land	-0.703	1.000				
Grassland	-0.774	0.947*	1			
Water	-0.873	0.671	0.850	1		
Unutilized land	-0.409	0.903*	0.845	0.447	1	
Total	-0.775	0.952*	0.995**	0.852	0.823	1

*Tips: *. Significant correlation at 0.05 level (two-tailed)*
***. Significant correlation at 0.01 level (two-tailed)*

As shown in ***Table 7***, the contribution rate of cultivated land in 20 years is mainly negative. The main reason is the increase of cultivated land area. Although the ESV generated by itself increases, the value provided is lower than that provided by the land type before the transfer, and the total value of ESV have been decreacing year by year. From 2010 to 2015, the decrease of cultivated land area made the contribution rate positive. The contribution rate of forest land variation during 2000-2020 is positive, indicating that forest land is a key factor affecting ESV, and the improvement of ESV can need to pay more attention to the increase of forest land area. The absolute value of water contribution rate from 2010 to 2020 is large, indicating that the change of water area also has an important impact on the change of total ESV. The contribution rate of grassland and unused land is low, because the land use types of Dongting Lake Ecological Economic Zone are mainly cultivated land, forest land and water area.

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Table 7 The contribution rate of ESV variation in Dongting Lake Ecological Economic Zone

Land use type	2000-2005		2005-2010		2010-2015		2015-2020	
	Variation (10^4yuan)	Variation contribution rate (%)	Variation (10^4yuan)	Variation contribution rate (%)	Variation (10^4yuan)	Variation contribution rate (%)	Variation (10^4yuan)	Variation contribution rate (%)
Cultivated land	764.85	-41.77	365.17	-23.60	-831.53	270.47	1058.60	-36.98
Forest land	-1361.79	74.36	-1938.69	125.32	-246.23	80.09	-845.46	29.53
Grassland	-4.95	0.27	-2.06	0.13	-1.20	0.39	-5.45	0.19
Water	-1229.36	67.13	28.55	-1.85	771.59	-250.97	-3070.31	107.26
Unutilized land	-0.048	0.003	-0.016	0.001	-0.06	0.020	0.022	-0.0008

4. Results and discuss

4.1 Results

From 2000 to 2020, with the acceleration of urbanization and the rapid development of regional economy, the area of construction land in Dongting Lake Ecological Economic Zone was increasing, the area of cultivated land was increasing, the area of forest land and water area was decreasing, but the change rate of land use type of cultivated land and forest land was slowing down. ESV showed a downward trend in 20 years. Supply service and support service are the two most important ecological service functions in Dongting Lake Ecological Economic Zone. The total amount of ESV in the Dongting Lake Ecological Economic Zone is spatially aggregated, and the forest land, cultivated land and water area have an important impact on the total amount of ESV in the study area. The research shows that the Dongting Lake Basin Ecological Economic Zone should pay more attention to the protection of forest land and water body in the future, and adhere to the policy of returning farmland to forest and lake. We should protect the main, supplement by development, adhere to the water to the city, water to the land, water to the people, water to the production, to further coordinate the ecological protection and economic development of the lake area, the establishment of a new balance, take the Dongting Lake Ecological Economic Zone into a more beautiful and rich Great Lakes Economic Zone.

4.2 Discussion

Based on the 5km×5km grid, we study the land use change and the spatial and temporal evolution of ecosystem service value in the Dongting Lake Ecological Economic Zone from 2000 to 2020. It is different from the previous research on the Dongting Lake Basin in Hunan Province, and pays more attention to the Dongting Lake Ecological Economic Zone as a whole. This study is not only different in the study area, but also different in the spatial scale. Most of the research is based on the perspective of the county, but the analysis from the perspective of the grid can get more accurate spatial and temporal evolution characteristics and differences [9]. Because the data used in the study are different in source, accuracy and processing methods, the research results are different from other literatures. We use data with higher accuracy and more scientific and reasonable processing methods, which has more reference value. Government departments can combine the research results, reasonably control the transfer of land use types, pay attention to the protection of forest land and water areas, more reasonably delineate the ecological red line, and do a good job in the transformation and upgrading of green industries. Through these measures, the local ecosystem can be effectively protected and the local green coordinated development can be promoted.

Although we use more accurate data to obtain the spatial and temporal evolution characteristics of local land use change and ecosystem service value in 20 years, there is still room for improvement. First, we do not take into account the spatial heterogeneity, and directly use the ESI coefficient of Chen[23]. The coefficient is obtained by using the interest transfer method nationwide. There is a horizontal zonal differentiation in China 's vast territory. Therefore, the ESI coefficient may more accurately reflect the unique situation of the study area, and it is necessary to improve the method scientifically and reasonably in the future. Secondly, we only discuss the impact of land use types on the value of ecosystem services in terms of quantity and spatial pattern changes, and do not discuss the impact of land quality and productivity on the value of ecosystem services. In the future, land use types can be classified into two levels to more accurately obtain their impact on ESV, so as to provide a more accurate ecological protection direction for the society.

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