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Impacts of landscape pattern changes on ecosystem service values in Ulat Qianqi Banner, Inner Mongolia

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Abstract

Using land use data from 2000 to 2020, the spatial and temporal evolution characteristics of landscape pattern and ecosystem service value (ESV) from 2000 to 2020 were explored using Fragstats4.2 software and the equivalent factor method, and the geographically weighted regression (GWR) model was used to explore the influence of landscape pattern on ESV. The results showed that: (1) during the period of 2000-2020, the landscape pattern of Ulat Qianqi Banner changed more significantly, the fragmentation of each landscape type, the degree of heterogeneity deepened, and the landscape tended to develop centrally; (2) The rate of change of ESV in Ulat Qianqi was -7.07%, showing a general characteristic of high in the central and southwestern part of the country and low in the western part; (3) The effects of the separateness index (SPLIT) and Shannon's diversity index (SHDI) on ESV in Ulat Qianqi broadly showed a negative effect, whereas the effects of the number of plaques (NP), the index of dispersion and juxtaposition (IJI), and the average nearest neighbor distance (ENN_MN) on the ESV all showed positive effects. The study helps to recognize the relationship between landscape pattern and ecosystem services in Ulat Qianqi, and provides scientific reference for exploring the management of regional landscape ecological security and the implementation of ecological protection policies.

Keywords

Ecosystem service values; Landscape patterns; Geographically weighted regression; Ulat Qianqi Banner.

1. Introduction

Due to rapid socio-economic development and continuous population growth, exploring the influence of landscape patterns on ESV is important for understanding regional ecosystem and resource issues [1,2,3]. Ecological Service Value (ESV), as the ecosystem service that bridges nature and society, and the well-being that human beings obtain directly or indirectly through ecosystems, consists of four main categories, namely provisioning services, cultural services, regulating services, and supporting services [4,5,6]. The principles and methods of ESV assessment were first presented in 1997 by Costanza [7] et al. Since then, domestic scholars have also conducted in-depth studies on ESV, among which the “China Terrestrial Ecosystem Service Value Basis Equivalent Scale”, which has been widely utilized in the assessment of ESV at different scales in China, was formulated by Xie Gao Di [8] et al. Landscape pattern refers to the different scales and forms of various landscape elements manifested in different forms of spatial combination [9], reflecting the ecosystem process, is the result of human-nature interaction [10].Currently, Zheng Bofu [11] et al, studied the characteristics of landscape pattern changes in Gannan and its impact on ecosystem service capacity, and concluded that

landscape pattern changes caused by anthropogenic activities in the context of rapid urbanization reduced the ecosystem service capacity of Gannan, and that optimizing and adjusting the landscape pattern of the regional or county urban areas would enhance the ecosystem service capacity of the region.Meng Yangyang [12] et al. studied the evolution and prediction of wetland landscape pattern and ESV in the Henan section of the Yellow River Basin, applying the CA-Markov model to predict the characteristics of wetland pattern in 2060, and utilizing the benefit transfer method to assess wetland ESV.Hu Yuxuan [13] et al, studied the evolution of landscape pattern and its ecosystem service impacts in the circum-Taihu Lake region, and the results showed that the landscape types in the study area have shown a trend of decreasing arable land and increasing built-up land in the past four decades.Zhang Yinhui [14] et al, studied the land use and landscape pattern changes in the Hetao irrigation area of Inner Mongolia, and the landscape changes were mainly manifested in the trend of landscape fragmentation, increased landscape diversity, and the patch types tended to be discrete.
There are relatively few existing studies on the relationship between landscape patterns and ecosystem services in Ulat Qianqi. Ulat Qianqi, belonging to Bayannur city, located in the western part of the Inner Mongolia Autonomous Region, the southeast of the Hetao Plain, located in the hinterland of Hu, Bao, Eu “golden triangle” [15], as the country's only set of “mountains, water, forests, fields, lakes, grasses, sand,” in the integration of the community of life in the Bayannur city of The “eastern gate”. Wuliangsu Sea in the territory of Ulat Qianqi is the largest lake wetland in the Yellow River Basin, and it is also the intersection area of several ecological functions in the north of China, and it is a natural ecological barrier to control the source of wind and sand in Beijing and Tianjin, at the same time, the Hetao Irrigation Area, located in the hinterland of the Wuliangsu Sea Basin, is a “key area” for ensuring food security in our country[16,17,18]. In view of this, Ulat Qianqi in Inner Mongolia was taken as the study area to explore the changes of landscape pattern and ESV in Ulat Qianqi based on land use data from 2000 to 2020, and used a geographically weighted regression (GWR) model to measure the effect of landscape pattern on ESV from 2000 to 2020. The aim is to enhance the scientific knowledge of the relationship between landscape pattern and ecosystem services in Ulat Qianqi, and to provide scientific basis for exploring the factors influencing regional landscape ecological security and implementing ecological protection policies.

2. Study Area and Data Sources

2.1. Study Area

Ulat Qianqi is located in 108°11′ ~ 109°54′, latitude 40°28′~ 41°16′, is located in the western part of the Inner Mongolia Autonomous Region, belonging to the city of Bayannur, the flag has a total land area of 7,464 km^2, jurisdiction of 11 towns, with a total population of 343,000 people, the average elevation of 1,050 m. The flag is located in the western part of the Inner Mongolia Autonomous Region, belonging to the city of Bayannur. Ulat Qianqi has a mesothermal continental monsoon climate, with an average annual temperature of 10 ℃, a frost-free period of 100-145 d, an average annual precipitation of 225.4 mm, an annual evaporation of 1,900-2,300 mm, and an average wind speed of 1.9 m/s. The average wind speed is 1.9 m/s. The average wind speed is 1.9 m/s.Ulat Qianqi geomorphology can be summarized as“three mountains, two rivers and a sea, a thousand miles of plains and two beaches”.

2.2. Data Sources

According to the land use/cover classification standards of the Chinese Academy of Sciences and the actual conditions of Ulat Qianqi, the land use types were classified into cropland, forest land, grassland, watershed, construction land and unutilized land [19]. This paper uses five periods of land use data provided by the Resource and Environment Science Data Center of the

Chinese Academy of Sciences (https://www.resdc.cn/) for the years 2000, 2005, 2010, 2015 and 2020.Grain data come from the Inner Mongolia Survey Yearbook and the Inner Mongolia Economic and Social Survey Yearbook of past years, and grain price data come from the National Compendium of Cost and Benefit Information on Agricultural Products.

3. Research Methodology

3.1. Landscape Pattern Analysis Methods

Landscape pattern indicators are used to quantitatively analyze the structure and characteristics of a single landscape so as to characterize its dynamic evolution in terms of structural composition and spatial layout [20]. Fragstats 4.2 software was used to calculate the landscape pattern indices in the study area, and combined with relevant cases [21], 5 landscape pattern indices were selected from 2 aspects, namely type level and landscape level (Table 1).

Table 1 The meaning of landscape indices

Index Name	Index Description
NP	Refers to the number of patches in the landscape.
ENN_MN	Refers to the degree of physical connectivity between patches within the landscape.
IJI	The closer the value is to 100, the more equal the probability that each type of patch is neighboring each other and the higher the dispersion is.
SPLIT	Spatial dispersion of patches, with higher values indicating greater dispersion.
SHDI	Complexity and heterogeneity of various types of patches in the landscape.

3.2. Estimating the Value of Ecosystem Services

The average value of ESV equivalent in Ulat Qianqi is 1041.4033 yuan/hm^2. Referring to the equivalence table proposed by Xie Gao Di [8] et al. and the equivalent value of ecosystem services in Ulat Qianqi, the equivalence table of raw ESV in Ulat Qianqi was derived (Table 2). The formula for its calculation is as follows:

$$E_a = \frac{1}{7}\sum_{i=1}^{n}\frac{m_i p_i q_i}{M} \tag{1}$$

$$VC_k = VC_o \times E_a \tag{2}$$

$$ESV = \sum_{k=1}^{n} VC_k A_k \tag{3}$$

Where E_a is the economic value of ecosystem services per unit area (yuan/(hm^2·a^{-1})); i is the type of crop; m_i is the average price (yuan/t);p_i is the yield per unit area (kg/hm^2); q_i is the cultivated area (hm^2); M is the total cultivated area of the crop;VC_k is the ecosystem service value equivalent per unit area of the kth landscape type (yuan/(hm^2·a^{-1})); VC_o is the value equivalent of ecosystem services per unit area; ESV is the total value of ecosystem services (yuan); and A_k is the area of the kth landscape type(hm^2)[22].

Table 2 Table of ESV per unit area of the Ulat Qianqi Banner Unit: yuan/(hm2·a-1)

Primary services	Secondary services	Cultivated land	Woodland	Grasslands	Water area	Unused land
Supply service	Food production	885.19	262.95	242.99	833.12	0.00
	Raw material production	416.56	604.01	357.55	239.52	0.00
	Water supply	20.83	312.42	197.87	8633.23	0.00
Regulatory services	Gas regulation	697.74	1986.48	1256.63	801.88	20.83
	Climate regulation	374.91	5943.81	3322.08	2384.81	0.00
	Purifying regulation	104.14	1741.75	1096.94	5779.79	104.14
	Hydrological regulation	281.18	3889.64	2433.41	106473.07	31.24
Support services	Soil conservation	1072.65	2418.66	1530.86	968.51	20.83
	Maintaining nutrient cycling	124.97	184.85	118.03	72.90	0.00
	Biodiversity	135.38	2202.57	1392.01	2655.58	20.83
Cultural service	Aesthetic landscape	62.48	809.69	614.43	1968.25	10.41
Total	—	4176.03	20356.83	12562.80	130810.67	208.28

3.3. Geographically Weighted Regression Models

GWR can be used to represent the spatially non-stationary relationship between the independent and dependent variables since it was first introduced by Fotheringham [23] et al. The mathematical expression of the model is as follows:

$$y_i = \beta_o(u_i, v_i) + \sum_{m=1}^{n} \beta_m(u_i, v_i)x_{im} + \varepsilon_i \tag{4}$$

Where y_i is the explained variable, β_o is the intercept, (u_i, v_i) is the geographic coordinate at i, x_{im} is the mth landscape pattern index at i, $\beta_m(u_i, v_i)$is the mth local regression coefficient of x_{im}, and ε_i is the random error.

4. Results and analysis

4.1. Characterization of Changes in Land Use Types

As can be seen from Figures 1 and 2, grassland, as the most dominant type of land use in Ulat Qianqi from 2000 to 2020, is widely distributed throughout the study area, with an area share of more than 50%. The second is arable land, mostly in the western plains, with an area share of around 20%. The central portion of the study area contains a collection of undeveloped lands, including sandy, saline, marshy, and bare rocky terrain.During the 20-year period, the area of watersheds decreased from 5.55% to 4.69%, and the area of forested and built-up land did not change much.

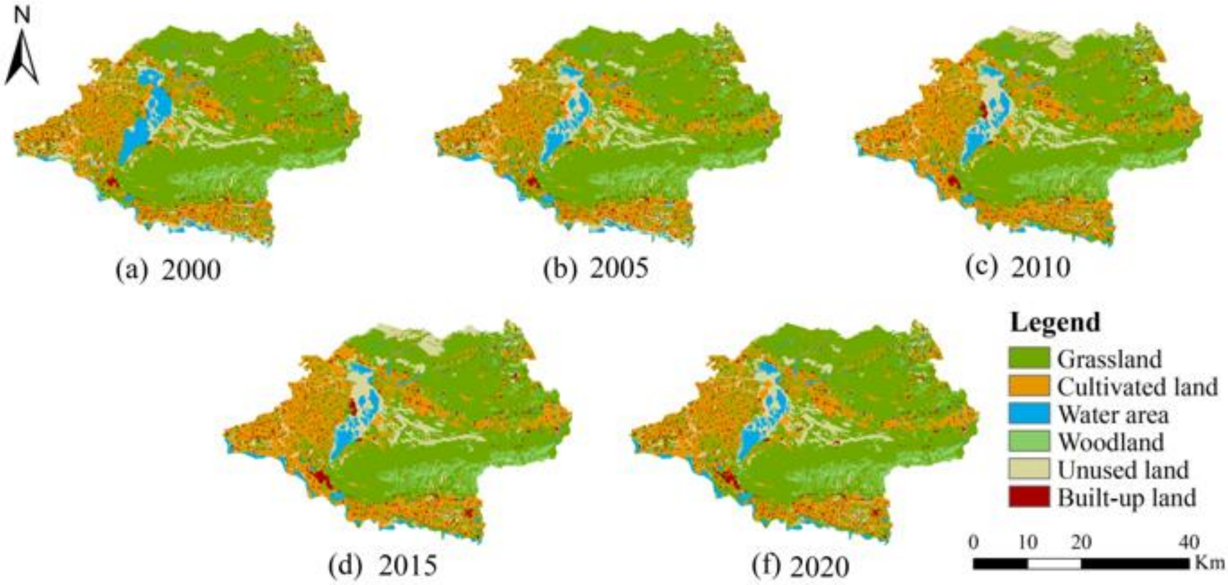


Fig. 1 The distribution and change of land use in Ulat Qianqi Banner from 2000 to 2020

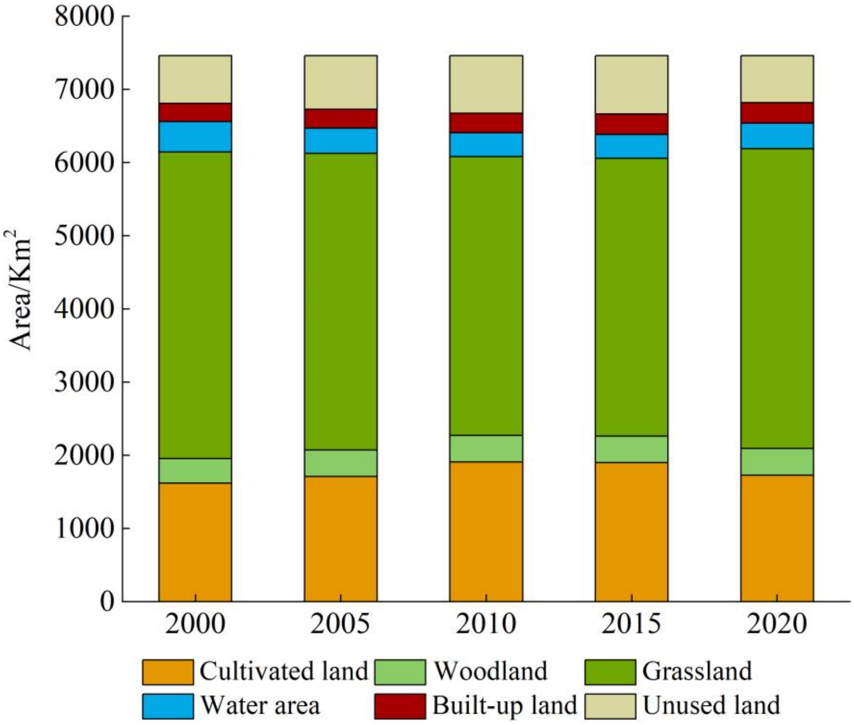


Fig. 2 The change of land use area in Ulat Qianqi Banner from 2000 to 2020

4.2. Land Use Type Transfer Matrix Analysis

The land transfer matrix was used to further explore the changes in land use types in Ulat Qianqi. As can be seen from Table 3 and Figure 3, during the study period, the largest area of grassland was transferred out, and its conversion to cropland amounted to 153.06 km^2, followed by conversion to forest land and unutilized land, which were35.23 $km^2$and 28.63 km^2, respectively,suggests that the grassland landscape types in the pre-Ulat have changed significantly during the study period; The transfer out of the watershed is also relatively large, with the main transfer out being unutilized land with an area of 119.39 km^2; The transfer of unutilized land is dominated by grassland with an area of 84.51 km^2, followed by conversion to arable land and water with an area of 35.32 km^2 and 41.84 km^2 respectively.

Table 3 Ulat Qianqi Banner land use transfer matrix from 2000 to 2020 (Unit: km²)

2000	2020						
	Cultivated land	Woodland	Grassland	Water area	Built-up land	Unused land	Total
Cultivated land	1516.69	3.88	48.12	16.12	17.31	14.49	1616.61
Woodland	0.65	321.86	9.61	1.49	0.18	0.62	334.42
Grassland	153.06	35.23	3936.19	19.30	18.41	28.63	4190.82
Water area	11.64	2.29	9.32	270.45	0.48	119.39	413.57
Built-up land	9.48	0.22	4.74	0.15	237.67	0.66	252.92
Unused land	35.32	3.04	84.51	41.84	4.24	483.95	652.91
Total	1726.84	366.52	4092.49	349.36	278.30	647.74	7461.25

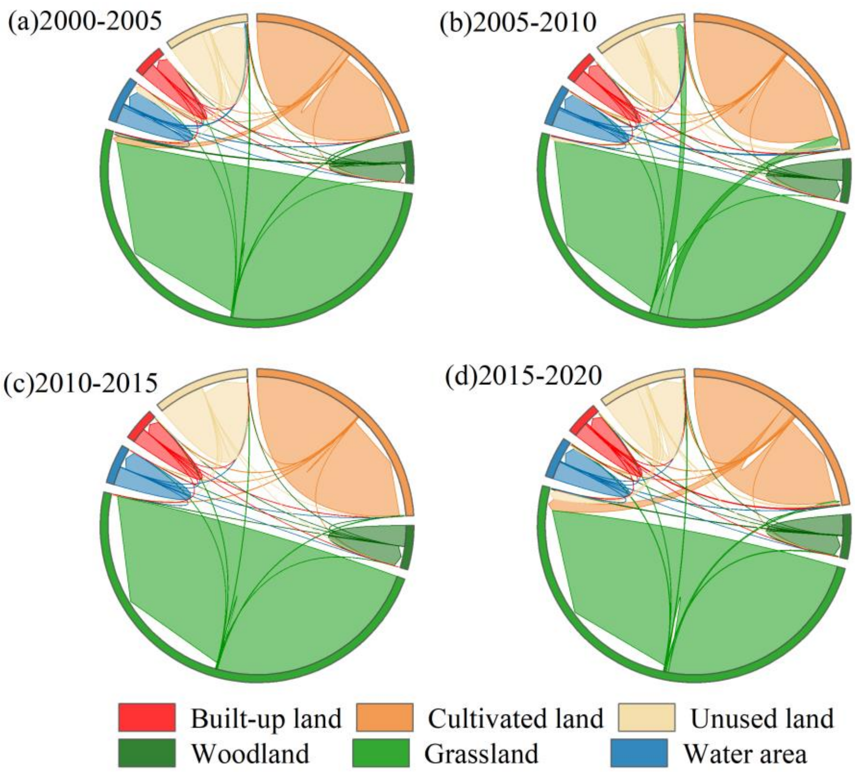


Fig. 3 The chord diagram of land use transfer matrix in Ulat Qianqi Banner from 2000 to 2020

4.3. Analysis of Landscape Pattern Changes

4.3.1. Landscape Level Analysis

As can be seen from Figure 4, during the period of 2000-2020, NP in Ulat Qianqi showed a trend of increasing, then decreasing and then increasing, with an overall growth rate of 10.69%; ENN showed a trend of decreasing, then increasing and then decreasing, with a decrease of 1.79%, and IJI showed a general trend of increasing and then decreasing, with an increase of 1.36 %, indicating that there was a decreasing trend of landscape connectivity in the study area from 2000 to 2020, and there was an increase in the interpenetration of landscape patches; SPLIT showed a trend of increasing and then decreasing, and went from a rapid increase to a slow decrease. SPLIT showed a trend of increasing and then decreasing, and from rapid growth to slow decline, with an increase of 12.98 %, and reached the maximum value of 4.91 in 2015, generally speaking, there was an increase in the degree of separation between landscape patches; SHDI showed a sustained growth and then decreased, with an increase of 0.90 %, which indicates that the landscape diversity of the study area increased, and the heterogeneity of the landscape showed fluctuating changes.

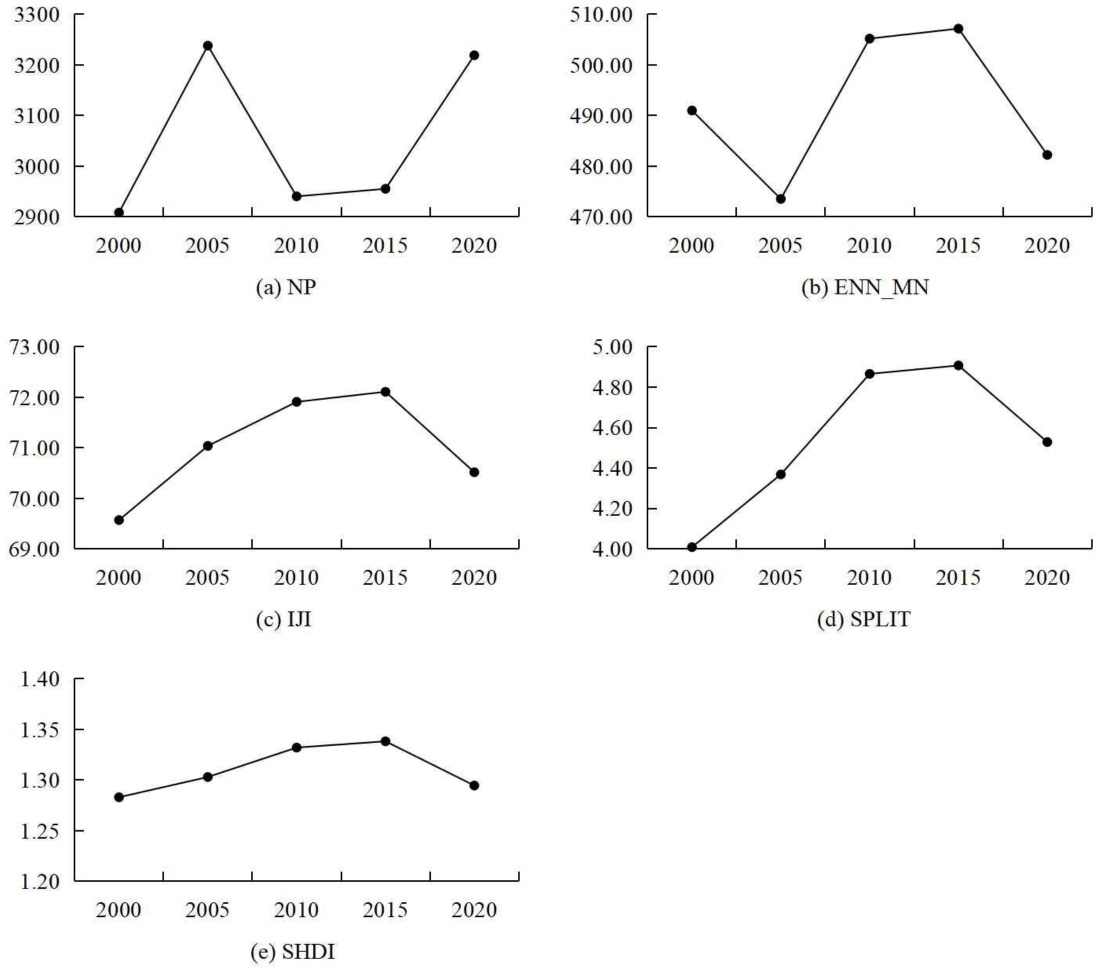


Fig. 4 Exponential change sat the land scape level of the Ulat Qianqi Banner from 2000 to 2020

4.3.2. Type level analysis

From Table 4, it can be seen that the NP of all types of landscapes from 2000 to 2020 showed a trend of small decrease and significant increase, of which the growth rate of forested land significantly increased by 25%; in addition to a slight increase in ENN_MN of forested land, ENN_MN of all types of landscapes during the study period maintained a decreasing trend, and the ENN of the grasslands showed the largest decrease of 10.37%, indicating that the grasslands' The IJI of water and construction land decreased slightly, and the IJI of the rest of the landscapes had a slight increase overall; the SPLIT of water increased from 1734.49 to 5982.57, an increase of 244.92%, while the SPLIT of the construction land landscape declined from 202,958.61 to 70,658.86, a decrease of 65.19%, and overall the SPLIT of the construction land landscape declined from 202,958.61 to 70,658.86, a decrease of 65.19%. of 65.19%.

Overall, the aggregation of construction land patches deepened, and the study area enhanced its resistance to ecological risks.

Table 4 Exponential changes at type level of the Ulat Qianqi Banner from 2000 to 2020

Years	Parameters	Typology					
		Cultivated land	Woodland	Grassland	Water area	Built-up land	Unused land
2000	NP	642	256	740	113	796	361
	ENN_MN	332.03	755.38	223.50	927.34	649.88	647.53
	IJI	59.57	35.16	75.93	79.95	58.69	73.62
	SPLIT	139.41	16947.68	4.14	1734.49	202958.61	3545.18
2005	NP	661.00	327.00	862.00	144.00	801.00	443.00
	ENN_MN	316.79	788.66	212.82	783.16	643.36	574.09
	IJI	61.13	38.36	76.04	77.85	58.93	77.08
	SPLIT	128.56	16734.46	4.54	6365.42	180605.20	1178.46
2010	NP	531.00	316.00	735.00	139.00	794.00	425.00
	ENN_MN	338.55	800.49	230.93	818.61	647.90	599.05
	IJI	63.82	35.36	79.83	79.64	56.26	70.86
	SPLIT	59.14	13027.27	5.34	6717.97	104889.44	845.29
2015	NP	536.00	314.00	749.00	136.00	778.00	442.00
	ENN_MN	345.02	805.98	239.54	842.04	647.58	594.86
	IJI	64.05	35.52	80.09	79.51	56.13	70.97
	SPLIT	60.33	13030.63	5.38	6729.05	52074.00	847.31
2020	NP	650.00	320.00	862.00	136.00	816.00	435.00
	ENN_MN	319.12	761.88	200.32	892.43	648.58	638.36
	IJI	60.25	36.49	77.69	78.67	57.87	73.84
	SPLIT	118.13	16691.99	4.73	5982.57	70658.86	1290.52

4.4. Characterization of changes in the value of ecosystem services

4.4.1. Analysis of quantitative changes in the value of ecosystem services

The ESV of Ulat Qianqi declined from 12,053.26 million from 2000 to 2020 to 11,201.53 million in 2020, an overall decrease of 851.92 million or 7.07% (Table 5).

As can be seen from the individual ESV (Table 6), the ecosystem regulation service function with the highest value reaches more than 47% of the total value, which mainly focuses on hydrological regulation and climate regulation, followed by the support service function which mainly focuses on soil conservation and biodiversity, with a share of 43.60%.During the period 2000-2020, changes in the value of each service showed a trend of decreasing, then increasing, then decreasing and then increasing, with large fluctuations, among which the increase in food regulation was the highest at 24.95%, followed by raw material production and maintenance of nutrient cycling, at 24.42% and 24.22%, respectively.

Table 5 ESV and changes of the Ulat Qianqi Banner from 2000 to 2020 (Unit: million yuan)

Typology	ESV					Amount of change	rate of change/ %
	2000	2005	2010	2015	2020		
Cultivated land	675.38	713.28	797.45	792.66	721.39	46.01	6.81
Woodland	681.16	740.34	737.67	737.39	746.53	65.37	9.60
Grassland	5266.25	5091.56	4786.65	4770.72	5142.87	-123.38	-2.34
Water area	5416.87	4496.36	4246.11	4256.06	4577.07	-839.80	-15.50
Unused land	13.61	15.39	16.49	16.66	13.50	-0.11	-0.80
Total	12053.26	11056.92	10584.37	10573.48	11201.35	-851.92	-7.07

Table 6 ESV of the Ulat Qianqi Banner from 2000 to 2020 (Unit: million yuan)

Primary services	Secondary services	Years				
		2000	2005	2010	2015	2020
Supply service	Food production	198.61	224.27	281.24	261.47	289.14
	Raw material production	416.56	191.91	231.48	215.32	247.12
	Water supply	365.18	305.78	349.83	326.97	395.35
Regulatory services	Gas regulation	594.77	568.89	671.23	624.66	732.06
	Climate regulation	1406.30	1332.12	1537.46	1431.51	1714.07
	Purifying regulation	627.59	570.95	657.19	612.72	734.73
	Hydrological regulation	4507.17	3775.01	4319.94	4037.59	4880.51
Support services	Soil conservation	752.88	722.11	857.17	797.59	929.37
	Maintaining nutrient cycling	63.34	61.11	73.47	68.34	78.68
	Biodiversity	634.96	592.78	682.73	635.94	762.90
Cultural service	Aesthetic landscape	302.83	278.84	320.76	298.87	359.03

4.4.2. Analysis of spatial and temporal changes in the value of ecosystem services

A grid with a side length of 1 km was divided into the study unit in the Ulat Qianqi flag, thus presenting the changes in the spatial distribution of ESV under different spatial and temporal conditions (Fig. 5). The median zone decreases slightly in the northern region between 2000 and 2020, with the share of grids decreasing from 43.45% to 42.80%. In 2000, high ESV areas were less concentrated in the central and southwestern parts of the Ulat Qianqi. There is a significant decrease in ESV in the high value zone in 2005 and 2020, and the medium value zone is widely distributed in 2005, accounting for 50.86% of the total number of grids.The low-value zone is first concentrated in the western part of the Ulat Qianqi Banner, and then expands to the central part of the region, expanding southward to Pioneer Town and northward to Sudulun Town. Overall, the proportion of low ESV zones in the total number of grids in Ulat Qianqi increased from 23.98% to 25.43%, and there was a shift in the spatial distribution from high to low value zones.

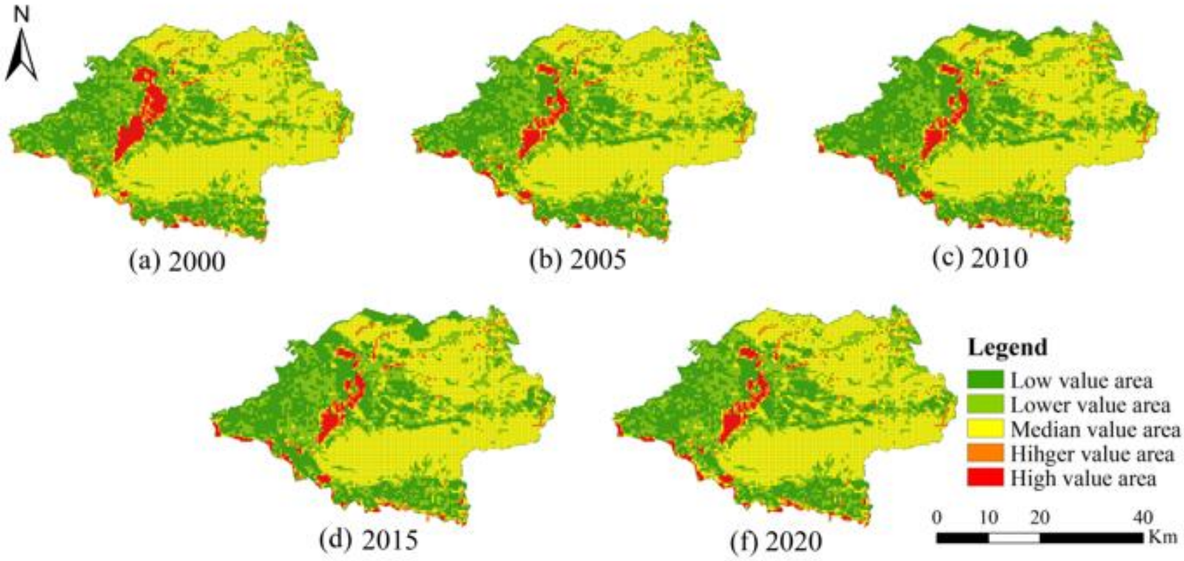
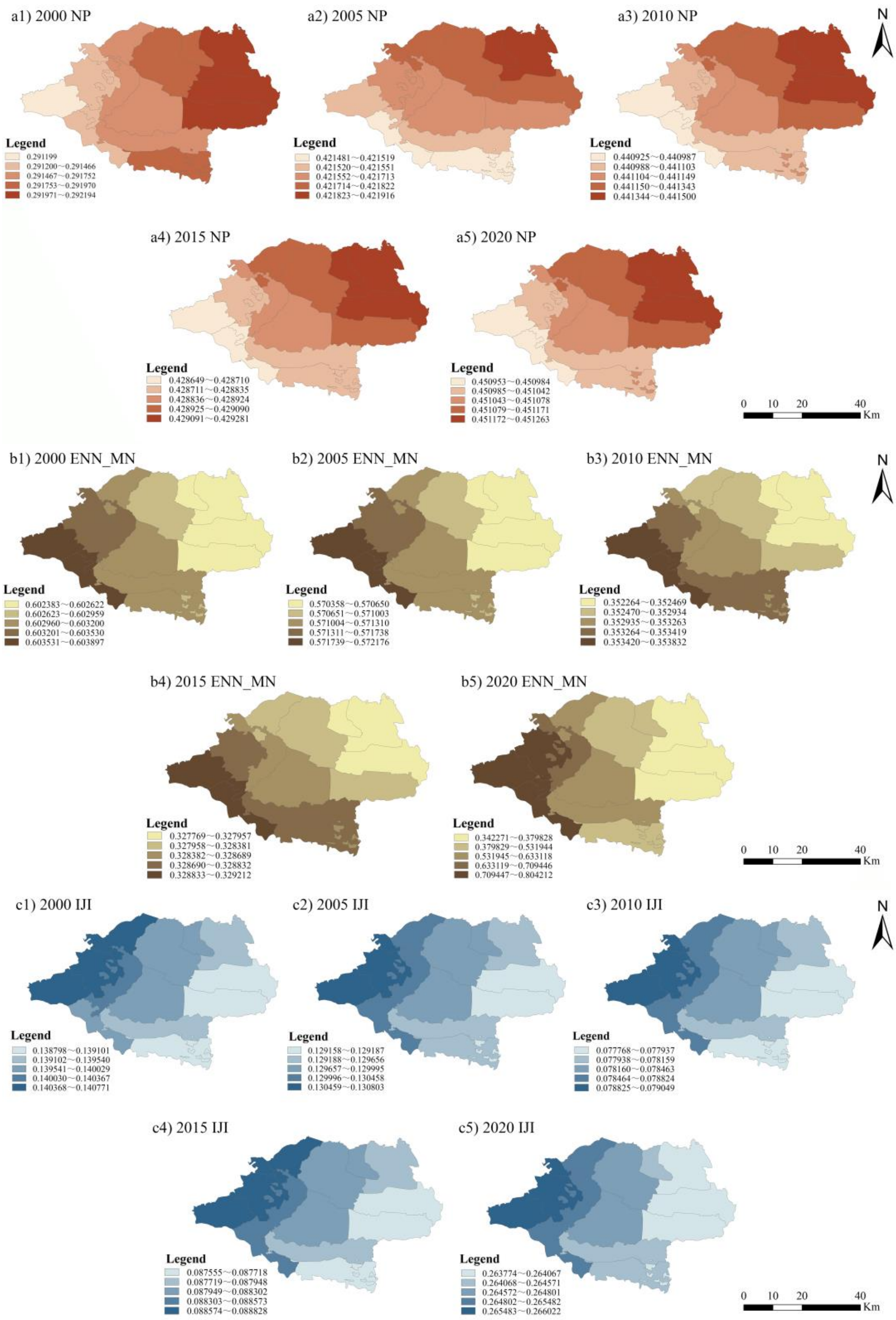


Fig. 5 Spatiotemporal distribution of ESV of the Ulat Qianqi Banner

4.5. Impact of landscape pattern indices on the value of ecosystem services

As can be seen in Figure 6, the effects of NP, ENN_MN, and IJI on ESV during the 2000-2020 period are all positive, and the effects of SPLIT on ESV are all predominantly negative. The effect of NP on ESV varied considerably from 2000 to 2020, with the regression coefficient rising from 0.291199 to 0.451263. The areas with the deepest degree of positive effect of NP on ESV were mainly concentrated in Xixiaozhao and Wulashan townships, which were dominated by cropland and construction land. The impact of ENN_MN on ESV is the deepest degree of positive impact in the town of West Little Call during the period 2000-2020. The land use types in the area are mainly interspersed with cropland and built-up land. The change in regression coefficient of IJI during 2000-2020 is from 0.138798 to 0.266022. The change in the magnitude of the effect of IJI on ESV is a gradual intensification from east to west. It can be seen that the effect of IJI on ESV is more significant on the plains than on the mountains. The places where SPLIT had the highest level of impact on ESV in 2000 were Dayutai Ranch, Xiaoyutai Township, and Ming'an Township in Bayannur City, and the places with the lowest level of impact were Xixiaozhao Township, Xishangju Ranch, and Wulashan Township in Bayannur City; The 2005-2015 impacts show a high degree of influence in the south, gradually decreasing from the south to the north; The change in the level of negative impacts in 2020 shows a high level in the south, gradually weakening from the south to the northwest and northeast, respectively. However, SHDI impacts on ESV between 2000 and 2005 were primarily negative, with the deepest impacts in 2000 occurring in the northern part of the region and Pioneer Township being the area with the shallowest level of negative impacts; the change in the level of impacts in 2005 was a pattern of high impacts in the northwest and a gradual decrease to the east. The impact of SHDI on ESV during 2010-2015, on the other hand, has equal positive and negative effects, with the positive effects mainly in the Northwest and the negative effects concentrated in the Southeast. The impacts of SHDI on ESV in 2020 mainly show positive effects, with Xixiaozhao Town, Xin'an Town, and Bayannur City Sudulun Farm mainly dominated by positive impacts, and the ESV of the basic landscape types of these areas is improved under the conditions of anthropogenic protection of their landscape types.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a2) 2005 NP
a3) 2010 NP
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a5) 2020 NP
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b1) 2000 ENN_MN
b2) 2005 ENN_MN
b3) 2010 ENN_MN
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b4) 2015 ENN_MN
b5) 2020 ENN_MN
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c2) 2005 IJI
c3) 2010 IJI
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0.129657～0.129995
0.129996～0.130458
0.130459～0.130803
Legend
0.077768～0.077937
0.077938～0.078159
0.078160～0.078463
0.078464～0.078824
0.078825～0.079049
c4) 2015 IJI
c5) 2020 IJI
Legend
0.087555～0.087718
0.087719～0.087948
0.087949～0.088302
0.088303～0.088573
0.088574～0.088828
Legend
0.263774～0.264067
0.264068～0.264571
0.264572～0.264801
0.264802～0.265482
0.265483～0.266022
0 10 20 40 Km

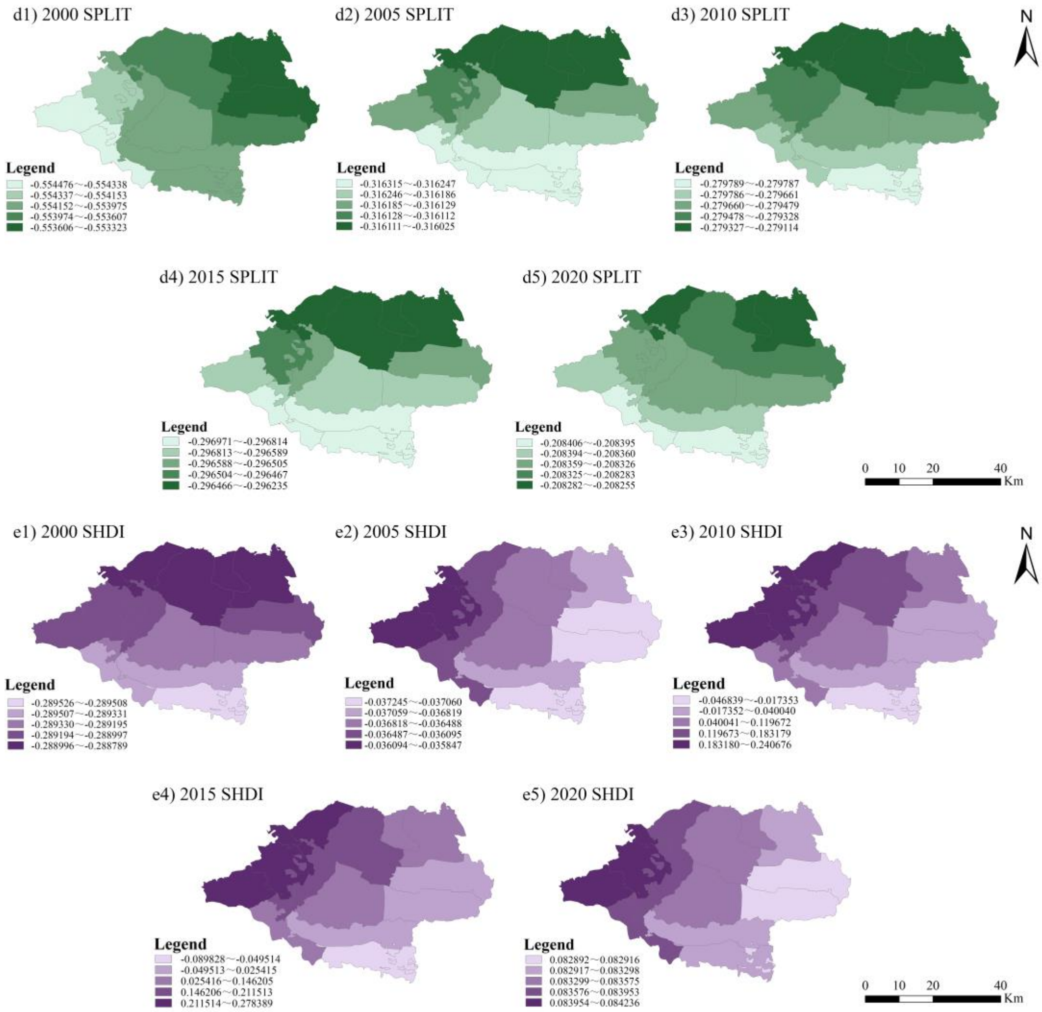

Fig. 6 Spatial distribution of landscape index regression coefficient of the Ulat Qianqi Banner from 2000 to 2020

5. Conclusions and discussion

(1) As the most dominant type of land use in the study area during the period 2000-2020, grassland in Ulat Qianqi was widely distributed throughout the study area, accounting for more than 50% of the area. Also, grassland has the highest converted area of 153.06km^2. The landscape pattern changes are more significant, in which NP, SPLIT, SHDI and IJI show an increasing trend, with growth rates of 10.69, 12.98, 0.9 and 1.36, respectively, while ENN_MN shows a decreasing trend, with a decrease rate of 1.79. The degree of fragmentation and heterogeneity of each landscape type increases, and the landscapes tend to develop centrally.

(2) The ESV provided by the ecosystem of Ulat Qianqi in 2000, 2005, 2010, 2015 and 2020 were 12,053.2 million yuan, 11,056.92 million yuan, 10,584.37 million yuan, 10,573.48 million yuan, and 1,120,135 million yuan, respectively, which indicates that the capacity of the ESV provided by the Ulat Qianqi decreases first and then increases. Among the secondary ecosystem service types, hydrological regulation and climate regulation accounted for a relatively high share of about 60% of the total, and the function of maintaining nutrient cycling accounted for only 0.7%. Overall, ESV in the study area are characterized by high levels in the central and southwestern portions and low levels in the western portion.

(3) The impacts of SPLIT and SHDI on ESV during 2000-2020 in Ulat Qianqi broadly show negative impacts, while the impacts of NP, IJI, and ENN_MN on ESV all show positive effects.

The results of this research will deepen the understanding and knowledge of the relationship between landscape pattern and ecosystem services in Ulat Qianqi, provide scientific basis for revealing the factors influencing landscape ecological security and implementing ecological protection measures, and provide reference value for the sustainable development of the region's social, economic and ecological environment.

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