

Research on spatiotemporal changes and driving factors of ecosystem service value in Ningxia Hui Autonomous Region

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Abstract. With the continuous development of society, people gradually shift from focusing on "food and clothing" to focusing on "environmental protection." This study studies the spatiotemporal changes in land use, ecosystem service value (ESV) and the change-driving mechanisms, with the purpose of caring for the sustainable development of Ningxia. Provide reasonable suggestions to policymakers to ensure the rational and scientific development of the Ningxia Hui Autonomous Region. This article adopts long-term dynamic analysis of the Ningxia region. In order to ensure that the sample data analysis results are closer to reality, the sensitivity index (CS) is introduced to reasonably evaluate the ESV equivalent coefficient table, and the principal component analysis method (PCA) is used to determine the relationship with ESV changes. The most relevant drivers. The results show: (1) Between 1985 and 2000, a large amount of Barren, grassland and cultivated land flowed to Impervious, and the ESV decreased by 103 million yuan. After 2000, the area of forest continued to increase, and the changes in the area of cultivated land and grassland tended to be stable. In Ningxia, local The total amount of ESV shows a rising trend, and ESV increased by 3.1807 billion yuan (2) from 1985 to 2020, mainly due to the increase in the total population and the increase in per capita GDP, which led to a weakening of the ESV increase trend, and even a reverse growth trend. Between 2000 and 2020 Due to the increasing emphasis on the ecological environment, the total amount of ESV continues to grow, but the growth rate continues to slow down.

Keywords: Ningxia Hui Autonomous Region, Land Use, Ecosystem Service Value, Sensitivity Analysis.

1. Introduction

The accurate prediction of power load is of great significance for the electric power production and the safe operation of the power grid and the national economy [1]. Short term load forecasting is an important part of energy management system. The prediction error directly affects the analysis results of subsequent safety check of power grid, which is of great significance for dynamic state estimation, load scheduling and cost reduction. Traditional prediction methods are based on linear regression, such as time series method, analysis method and pattern recognition method has defects of respectively.

Ecosystem services represent the benefits that humans gain from ecosystems. ESV refers to the monetary or non-monetary value of the benefits that nature provides to society. It is of great significance to the formulation of reasonable ecological protection policies in the region and helps Guide policy decisions . Changes in land use will have a direct impact on the ecosystem, which mainly changes the structure and function of the ecosystem, thereby affecting changes in ESV. Therefore, studying the spatial and temporal changes of ESV based on land use changes plays an important role in the sustainable development of local economy and ecology.

Ningxia Hui Autonomous Region is located in the inland northwest region of my country. It is the province with the least water resources in China, and the entire region is an arid and semi-arid area. Since 1985, the ecosystem of the Yellow River Basin has been seriously threatened due to the region's rapid population growth, rapid urbanization, deforestation, serious soil erosion and other problems. Therefore, this article uses ESV to effectively assess the regional ecosystem. The research by



Costanza et al. [2] is the most influential. They were the first to divide the world's ecosystems into 16 ecosystem structures and 17 ecological service functions. They analyzed and evaluated the world's ESV, allowing ecosystem services to be analyzed for the first time. Hou et al. [3] combined with urban planning theory, used concentric buffer zones to explore the characteristics and relationships of LPI and ESV on the urban-rural gradient, and constructed a multiple linear regression model. Liu et al. [4] used the benefit transfer method to evaluate the ecology of the Bohai Rim coastal areas. ESV studies the impact of land use changes on ecosystem services. Li et al. [5] analyzed the spatiotemporal ESV evolution of China's Sichuan-Yunnan ecological barrier and used the PLUS model to evaluate the prediction of ESV spatiotemporal changes under three scenarios. At present, research on ESV in Ningxia mainly focuses on some counties [6] and mountainous areas [7]. Chen et al. [8] only conducted a grid analysis of ESV in Ningxia from 2000 to 2018, without analyzing the impact in detail. Drivers of ESV changes. Although Cheng Jing et al. [9] studied the spatiotemporal nature of ESV and its driving forces in the entire Ningxia region, the spatiotemporal research on the Ningxia Hui Autonomous Region was not complete enough, resulting in a low reference rationality and practicality of the obtained ESV value table. And there is no more scientific evaluation method for the calculated ESV. This article uses long-term series to improve previous research on the spatiotemporal changes in Ningxia ESV, and introduces the CS evaluation system to ensure that the establishment of the ESV value equivalent table is scientific and reasonable.

The land use data used in this article spans a large time span (1985-2020), and the data is calculated in stages, with one period every five years. In addition, the sensitivity index is used to evaluate the ESV calculation results to ensure the validity of the results. This paper conducts mathematical statistical analysis on 8-period land use data in the study area, calculates the dynamic changes in land use, and uses the principal component analysis (PCA) method to obtain the driving factors most relevant to ESV, and finds the driving factors that have the greatest impact on ESV changes. Provide scientific and reasonable decision-making reference for Ningxia's ecological environment construction and landscape optimization.

2. The overview of the study area

As shown in Figure 1, the Ningxia region (104°17'-107°40'E, 35°14'-39°22'N) covers an area of approximately 66,000 square kilometers, of which mountainous and plateau terrains account for most of the area. Most of them are located in the interior of northwest China. Ningxia is located on the main stream of the Yellow River, with an average altitude of more than 1,000 meters. The terrain is higher in the southwest and lower in the northeast, showing a declining trend. It is a typical semi-arid arid region. The terrain of Ningxia gradually rises from northeast to southwest. Due to natural activities, many hills and valleys have been formed (Figure 1 left). Ningxia is the province with the most scarce water resources in China. The terrain of Ningxia decreases like a staircase from south to north. Temperature and evaporation show an increasing trend, while precipitation gradually decreases. These characteristics jointly shape Ningxia's unique geographical environment and climatic conditions.

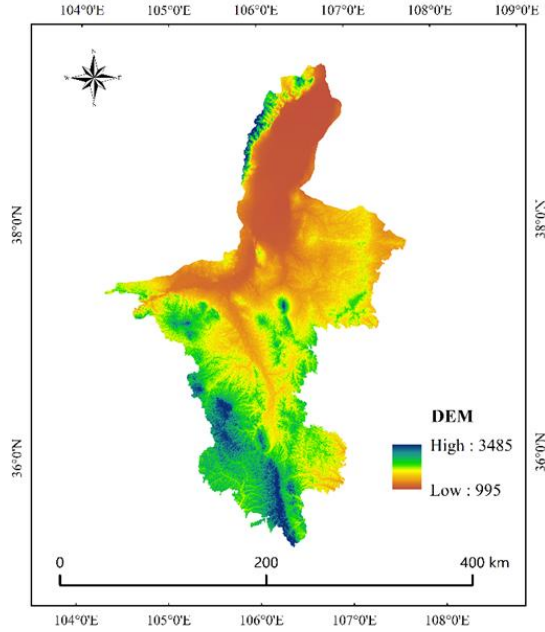


Figure 1. Schematic diagram of the research area

3. The Data sources and research methods

3.1. The Data sources and processing

The socioeconomic data in this article mainly come from the "Ningxia Statistical Yearbook", and the land use data mainly come from the 《 "National CLCD Data from 1985 to 2020" with a spatial resolution of 30 m published by Yang Jie and Huang Xin of Wuhan University”》 [10]. The China Land Cover Dataset (CLCD) data includes nine land use types: cropland, forest, shrub, grassland, water body, ice and snow, barren, impervious, and wetland. ArcGIS Pro software was used to reclassify the nine types of land use types in Ningxia Hui Autonomous Region into six categories, namely cropland, forest, grassland, water, impervious and barren, and conduct change analysis and ESV spatiotemporal changes on the eight periods of land use data. analyze.

3.2. Research methods

3.2.1. The Construct land use transfer matrix

The land use transfer matrix can describe the transformation of a certain land type into other land types through flow, and can also reflect the transferred area and transferred objects, and can represent clear changes in each type during the study period [11]. This article analyzes the land use types in the Ningxia Hui Autonomous Region in 1985 and 2020, and obtains the degree and details of changes in land use types during this period. The land use transfer matrix formula is as follows:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{bmatrix} \quad (1)$$

This article makes statistics on the area of each land use type in 1985 and 2020, and uses ArcGis Pro software to analyze the land use transfer matrix of the land type area in different years. The results are shown in Table 1.

Table.1. Land transfer matrix in 1985 and 2020 (unit: km²)

class	Cropland	Forest	Grassland	Water	Barren	Impervious	decrease
Cropland	8993.9774	33.8065	3427.4840	100.1264	22.2943	445.6686	13023.3572
Forest	0.3406	564.7754	2.7990	0.0154	0	0.0112	567.9416
Grassland	3907.3735	259.9301	28528.7421	103.6569	595.3256	216.4338	33611.4620
Water	101.4107	0.0718	12.6703	120.5718	2.4244	13.9565	251.1054
Barren	519.3209	0.0332	2267.6163	27.9011	1129.4740	172.0164	4116.3619
Impervious	6.0003	0	0.7043	11.1122	0.1946	234.0446	252.0559
increase	13528.4233	858.6169	34240.0160	363.3839	1749.7130	1082.1311	51822.2841

3.2.2. Changes in land use dynamics

Land use dynamics reflects the rate of area change of a certain land use type in the study area within a certain time range, focusing on analyzing the changes in each land use type [12]. The calculation formula is:

$$K = \frac{U_j - U_i}{U_i} \times \frac{1}{T} \quad (2)$$

Among them, K are the dynamic degree of each category during the study period, that is, the annual change rate; U_i 、 U_j are the areas of a certain land type at the beginning and end of the study; T are the differences between the end of the study period and the beginning of the study.

3.2.3. Construct ecosystem service value coefficient table

The ESV coefficient is adjusted based on the Chinese land value equivalent table produced by Xie Gaodi[13] and others, as well as the natural geographical environment and economic factors of the Ningxia Hui Autonomous Region. According to calculations from the "Ningxia Statistical Yearbook" and "Compilation of Cost and Benefit Data of China's Agricultural Products" [14], the average grain output in Ningxia Hui Autonomous Region from 1985 to 2020 was 4,164 (kg/hm²), and the average grain price was 2.42 (yuan/kg), when there is no human input, ESV is the ecosystem service value of food production per unit area of farmland (i.e. 1 standard equivalent factor), which is equivalent to 1/7 of the national average grain yield market value, Ningxia Hui The economic value of farmland grain output in the autonomous region is 1,438 (yuan/hm²), and the final calculation is shown in Table 2.

Table.2. ESV calculation indicators for various land use types (yuan/hm²)

First level	Ecological Service System	Cropland	Forest	Grassland	Water	Impervious	
Supply Services	Food Production	1588.516	333.430	230.011	941.609	0.000	
	Raw material Production	352.205	762.819	337.829	524.714	0.000	
	Water Supply	-	1876.031	393.406	186.884	7820.389	0.000
	Gas Conditioning	1279.439	2506.751	1185.996	1919.158	28.751	
	Climate Regulation	668.471	7505.848	3133.906	4233.648	0.000	
Conditioning Services	Purify The Environment	194.072	2218.848	1035.051	6576.889	143.757	
	Hydrological Regulation	2149.169	5190.395	2292.926	90904.829	43.127	
	Soil Conservation	747.537	3053.675	1444.759	2328.866	28.751	
Support Services	Maintain Nutrients	222.824	232.685	115.006	179.696	0.000	
	Biodiversity	244.387	2782.606	1315.378	7489.747	28.751	
Cultural Services	Aesthetic Landscape	107.818	1220.987	582.216	4758.361	14.376	
Total		5678.407	26201.450	11859.964	127677.906	287.514	

3.2.4. Sensitivity analysis

Sensitivity modeling is a method used to evaluate the sensitivity of model output results to changes in input parameters [15]. Referring to existing research results [5], this article uses a sensitivity model to show the degree of correlation between ESV and the ESV coefficient as ESV changes over time by calculating the CS. This paper measures and determines changes in the total ESV by adjusting the ESV coefficients of various types of landscapes up and down by 50% respectively. The sensitivity index calculation formula is as follows:

$$CS = \left| \frac{(ESV_j - ESV_i) / ESV_i}{(VC_{jk} - VC_{ik}) / VC_{ik}} \right| \quad (3)$$

In the formula, *ESV* the unit is (yuan/hm²); *VC* (Value Coefficient of Ecosystem Services) represents the ESV coefficient; *k* expressed as *k* different land types; *i* and *j* represent the initial value before adjustment and the adjusted value respectively (up and down adjustment by 50%); *CS* indicates the sensitivity index, which refers to the change in ESV caused by a change of one unit

(1%) of the ecological service function value coefficient. If $CS > 1$, it indicates that ESV is relatively elastic; if $CS < 1$, ESV is considered to be inelastic. The larger, Indicates that the accuracy of the ESV coefficient is more important.

3.2.5. Driving force analysis

Referring to relevant literature[16], it is known that driving factors mainly include socioeconomic factors and physical geographical factors, and various driving factors will affect land use changes, and different factors have different effects. The physical geographical factors mainly include factors such as annual precipitation, average annual temperature, soil and wind speed, and the socio-economic factors include factors such as total GDP, per capita GDP, urbanization rate and population density. This paper selects 14 driving factors that may affect changes in land dynamics, uses the PCA method to analyze the driving factors, determines one or more variables most relevant to ESV from 1985 to 2020, and then uses multiple linear regression analysis to obtain The functional relationship between variables with respect to ESV.

4. Results

4.1. Analysis of spatial and temporal changes in land use

As can be seen from Figure 2, the land use types in the Ningxia Hui Autonomous Region were divided into six major categories between 1985 and 2020. The largest area in 1985 was grassland, followed by cultivated land, followed by Barren, Forest, Waters and Impervious. . By 2020, the order of area of various types in Ningxia Hui Autonomous Region is: Grassland > Cropland > Barren > Impervious > Forest > Water.

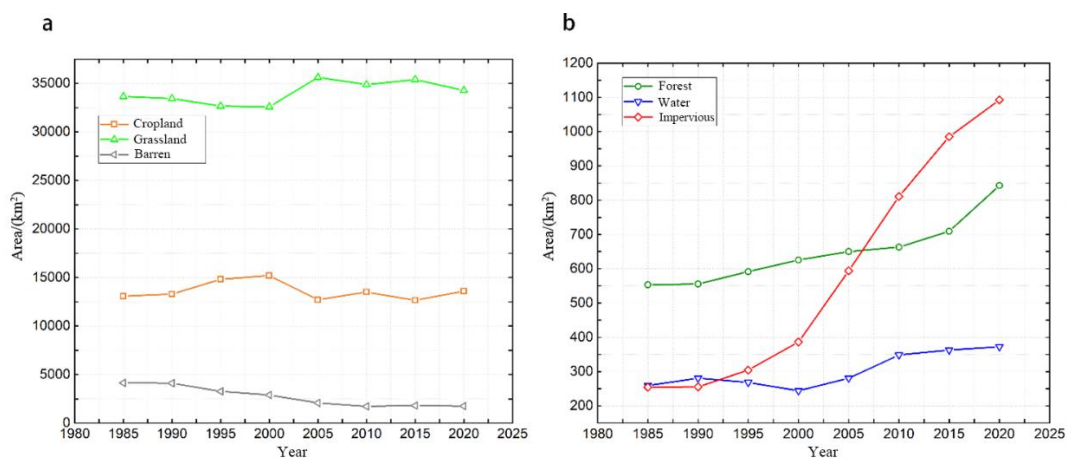


Figure 2. Landscape changes in Ningxia Hui Autonomous Region from 1985 to 2020

From the analysis of land transfer (Table 1 and Figure 3), in Ningxia Hui Autonomous Region, only the transfer-out of Barren is greater than the transfer-in. The remaining five land types all have an increase in area. The most frequent conversions are grassland, cultivated land, and woodland. The flow to other land types was the least, and the transfer of Impervious area was relatively stable, second only to forest. However, due to excessive inflow, the overall increase increased significantly, indicating that between 1985 and 2020, especially after 2000, the urban area in Ningxia Expansion relies on the encroachment of cultivated land, grassland and Barren. The grassland area showed a downward trend from 1985 to 2000, and a large amount of grassland area was transferred to cultivated land.

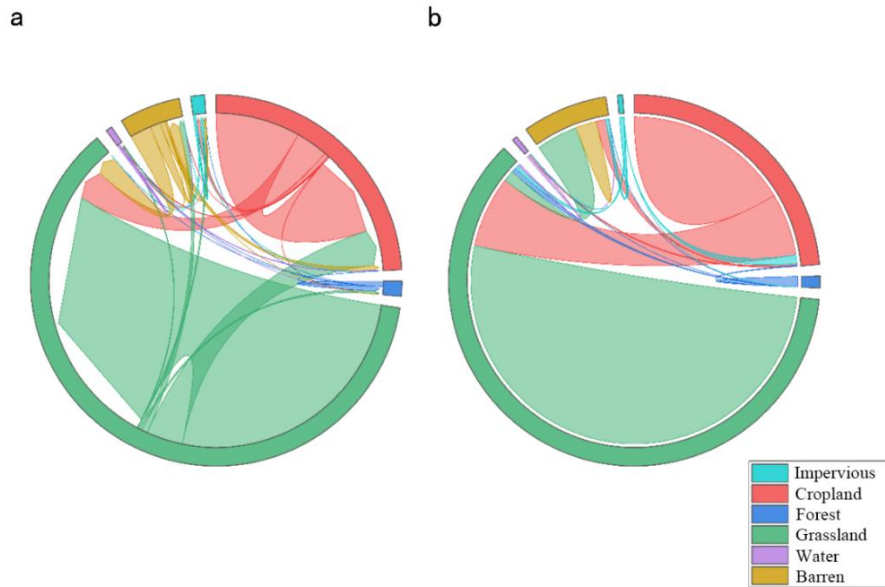


Figure 3. Land use transfer matrix (a) chord diagram and (b) proportional chord diagram from 1985 to 2020

Analyzing the dynamic degree of land use (Figures 4 and 5), the change rate of Impervious showed a trend of first increasing and then decreasing. From 1990 to 2015, the dynamic degree of Impervious was the highest, indicating the urbanization process of Ningxia Hui Autonomous Region. Gradually speed up. The forestland change rate showed a slowly increasing trend.

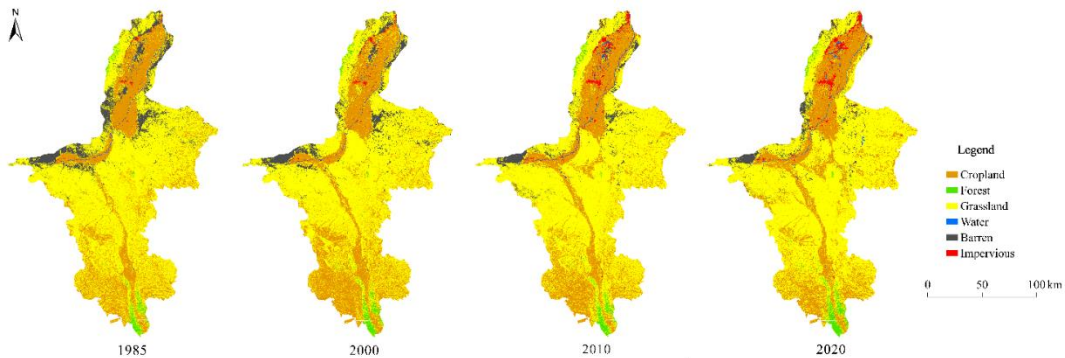


Figure 4. Distribution of land use types in 1985, 2000, 2010 and 2020

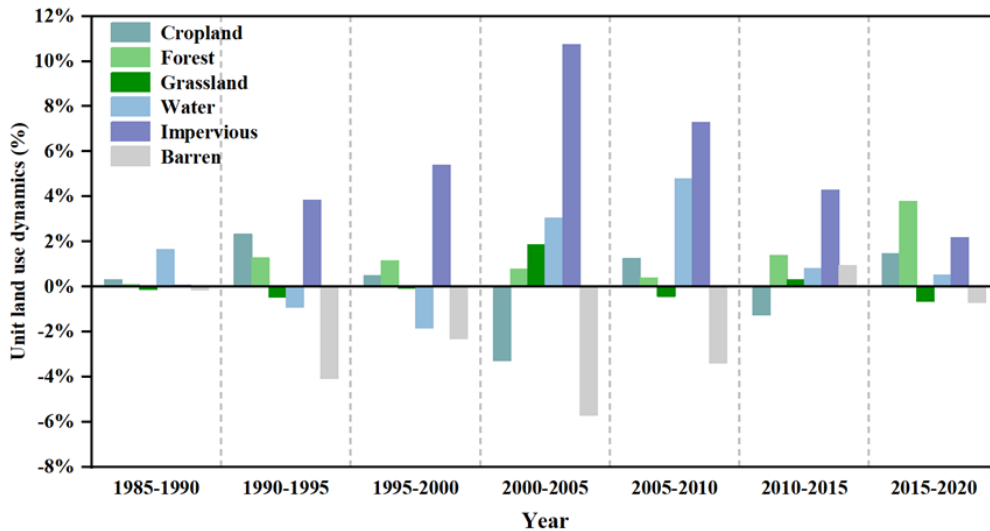


Figure 5. Dynamic attitude of each land use type

4.2. Analysis of spatial and temporal changes in Ningxia ESV

As can be seen from Figure 6, the land type that contributes the most to the ecological environment in Ningxia is grassland. The ESV value is far higher than that of other land types, and the change in grassland ESV is almost consistent with the change in grassland area (Figure 2). Analyzing the ESV of other types of land use, only forestland showed an upward trend, with an increase of 759.7 million yuan, reflecting that the implementation of ecological restoration projects such as returning farmland to forest projects has greatly improved regional ESV; the ESV equivalent of water areas is It is the highest among the five land types, so changes in the proportion of water area have the most significant impact on the total ESV. Therefore, ESV responds significantly to strong fluctuations in land use type changes in the study area.

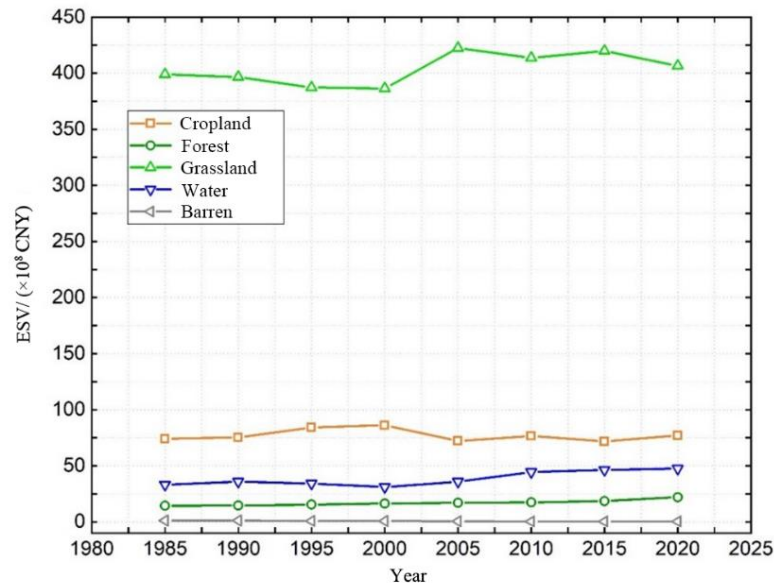


Figure 6. ESV changes of various land use types from 1985 to 2020

The spatial distribution of ESV in Ningxia Hui Autonomous Region from 1985 to 2020 (Figure 7). ESV in Ningxia shows a slowly decreasing trend from the central to the south and north, while the ESV distribution in the north is very uneven. The main stream of the Yellow River is in a high ESV area and decreases first in the north. There is an increasing trend, and some grids in the northwest region have almost no ESV. From 1985 to 2020, low ESV areas gradually decreased, and high ESV areas also increased slightly, mainly in the middle and southern areas of eastern Ningxia. A large number of low ESV areas in central Ningxia were converted into medium ESV areas, and the ESV distribution in the north remained almost unchanged. The low ESV area, bounded by the southern part of Zhongwei City, gradually transforms into a low ESV area and a medium ESV area to the south. Compared with 1985 and 2000, some areas in the central part changed from a high ESV area to a medium ESV area, and the eastern part has a higher ESV area. Appearing in clusters.

It can be seen from Figure 4, Figure 6 and Figure 7 that ESV changes are closely related to land use changes. The reason for the above transformation of ESV in Ningxia is that large areas of grassland are distributed in the central part, while cultivated land is mainly distributed in the north and south. The ESV coefficient of grassland It is larger than cultivated land, and Barren in the northwest is clustered, resulting in a large number of low ESV areas. Overall, ESV shows an increasing trend. Based on the above analysis, the main reason is that Barren continues to increase due to rational development and environmental protection. Decrease and gradually flow to land types with higher ESV coefficients, such as grassland and cultivated land. Among them, the ESV of Yinchuan City, Wuzhong City and Guyuan City increased significantly. The ESV changes in the main stream of the Yellow River are relatively stable and have always been maintained at a high ESV level (Figure 7), especially between 2000 and 2020, which reflects the great contribution that Ningxia has made to the protection and management of the Yellow River.

In summary, ESV in Ningxia is extremely sensitive to changes in land use types. Therefore, in order to achieve coordinated economic and ecological development in Ningxia, it is necessary to integrate regional socioeconomic and ecological resources and improve land use quality. The expansion of cultivated land area should be controlled, the frequency of agricultural and animal husbandry activities should be kept appropriate, ecological improvement measures adapted to local conditions should be adopted for the wastelands in northern and western Ningxia that are still not fully developed, and the ecological environment of surrounding areas should be protected to prevent degradation caused by unreasonable use. Achieve the optimization of agricultural economic and ecological benefits, rather than simply pursuing economic benefits and ignoring ecological benefits.

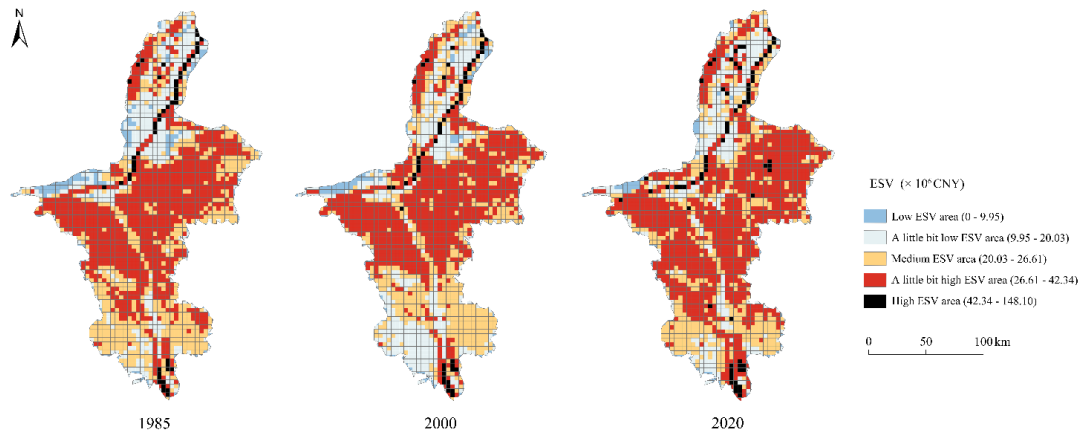


Figure 7. ESV distribution in 1985, 2000 and 2020

4.3. Sensitivity index analysis

This paper uses Formula 2 to adjust various ecosystem service value coefficients VC up or down by 50%, and then calculates the sensitivity index CS related to various ecosystem service value coefficients, and finally obtains the correlation degree between the value coefficient and ESV.

As can be seen from Table 3, the CS value of grassland far exceeds the CS value of other land types, ranging from 0.7 to 0.8, indicating that this type is more sensitive, that is, the higher the correlation with ESV, followed by cultivated land, ranging from 0.12 to 0.17. time, indicating that the status of these two land types in the ecosystem of Ningxia Hui Autonomous Region is very important, and the ESV sensitivity index of Barren is the smallest, indicating that changes in CS of this land type have little impact on ESV. The CS values of all land types in the table are less than 1, indicating that the total ESV in the study area is inelastic to VS. The ESV coefficient used in this article is relatively appropriate, and the research results have good credibility.

Table.3. Sensitivity index CS from 1985 to 2020

Land Type	1985	1990	1995	2000	2005	2010	2015	2020
Cropland	0.1422	0.1440	0.1611	0.1655	0.1315	0.1386	0.1289	0.1393
VC±50%VC	0	0	9	9	7	6	8	4
Forest	0.0277	0.0278	0.0296	0.0314	0.0310	0.0314	0.0333	0.0398
VC±50%VC	6	1	8	8	9	5	6	9
Grassland	0.7643	0.7574	0.7417	0.7415	0.7707	0.7485	0.7536	0.7340
VC±50%VC	1	5	2	3	7	0	1	4
Water	0.0634	0.0684	0.0656	0.0598	0.0654	0.0805	0.0831	0.0858
VC±50%VC	5	9	3	1	9	1	3	3
Barren	0.0022	0.0022	0.0018	0.0016	0.0010	0.0009	0.0009	0.0009
VC±50%VC	8	6	0	0	9	0	3	0

4.4. Analysis of the driving mechanism of Ningxia ESV changes

This article selects 14 driving factors that may affect changes in land dynamics, including annual precipitation, average annual temperature, soil, wind speed, total GDP and per capita GDP, and uses the PCA method to analyze the driving factors.

This article extracts two principal components with larger eigenvalues, whose contribution values are 83.007% and 16.177% respectively. These two principal components can effectively express 99.184% of the information of the 14 driving factors. Select the principal component with a larger factor loading coefficient to make Table 4. From the principal component loading table, we can see that the main influencing factors of the first principal component are X1, X2, and X3, and the main influencing factor of the second principal component is X4. Therefore, the driving factors of Ningxia Hui Autonomous Region can be summarized as socioeconomic factors and climatic factors. The socioeconomic factors mainly include urbanization rate, total population and per capita GDP, and the climatic factors mainly include average temperature.

Table.4. Principal component loading table

	The first principal component	The second principal component
X ₁	0.977	-0.203
X ₂	0.986	-0.165
X ₃	0.980	0.101
X ₄	0.555	0.830

Conduct linear regression analysis on these four driving factors and ecosystem service value, and obtain the linear regression equation between the two. The fitting degree is 0.936, which is greater than 0.90, and the fitting degree is good. The fitting formula is as follows:

$$Y = -1.196X_1 + 8.684X_2 - 0.001X_3 + 3.648X_4 \quad (4)$$

In the formula, Y represents the total ESV during the study time, X1 is the total population (person); X2 is the urbanization rate (%); X3 is per capita GDP, and X4 is the average temperature.

According to Equation 3, X1 and X3 are inversely proportional to ESV, indicating that as the total population and per capita GDP continue to increase, the ESV in the study area will continue to decrease. Mainly due to population increase and continuous economic development, which have had a certain impact on the local ecological environment and ecological structure, ESV has changed.

5. Conclusions

This paper analyzes the spatiotemporal changes in land use in the study area, evaluates ESV, and analyzes the spatiotemporal changes in ESV. Then sensitivity index analysis is used to ensure the rationality of the established ESV coefficient, and finally the principal component analysis method is used to quantify the contribution of factors driving ESV and build a model. The main research results show that the land use coverage structure in the study area is generally stable, and land use changes are concentrated in areas with intensive human activities in the Yellow River Basin and central Ningxia. During the 35-year study period, forest and Impervious continued to expand, and the rate of change of Impervious was relatively large. The total area of grassland and cultivated land changes little, but the conversion between the two types of land features is larger. It shows that with regional economic development, the ecological environment has also generally improved.

Through sensitivity index analysis, the established ESV coefficient is more appropriate. The total ESV of the study area increased during the survey period. The services provided by the grassland ecosystem dominate the fluctuation of ESV in the entire study area, but the water ecosystem provides the largest ESV per unit area. Moreover, the spatial distribution of ESV is relatively uneven, mainly concentrated in the Yellow River Basin and southern Ningxia. The driving factors for changes in ESV are mainly affected by population and per capita GDP.

To sum up, in the future development of the study area, this article mainly considers the rational use of wasteland and transfers it to land types with large ecosystem service value coefficients such as water bodies and woodlands. At the same time, the speed of urban expansion must be reasonably controlled to ensure that urban expansion does not squeeze the area of water bodies, woodlands, grasslands and other land types that have a greater impact on the ecosystem, but also ensures the agglomeration of similar land types. The purpose is to maintain the stability of the ecosystem and ultimately ensure the sustainable development of the local ecology and economy.

References

- [1] Fu Bojie, Zhang Liwei. Land use change and ecosystem services: concepts, methods and progress [J]. *Progress in Geographic Science (in Chinese)*, 2014, 33(04): 441-446.
- [2] Costanza R, d'Arge R, De Groot R, et al. The value of the world's ecosystem services and natural capital[J]. *nature*, 1997, 387(6630): 253-260.
- [3] Hou L, Wu F, Xie X. The spatial characteristics and relationships between landscape pattern and ecosystem service value along an urban-rural gradient in Xi'an city, China[J]. *Ecological indicators*, 2020, 108: 105720.
- [4] Liu Y, Hou X, Li X, et al. Assessing and predicting changes in ecosystem service values based on land use/cover change in the Bohai Rim coastal zone[J]. *Ecological Indicators*, 2020, 111: 106004.
- [5] Li C, Wu Y, Gao B, et al. Multi-scenario simulation of ecosystem service value for optimization of land use in the Sichuan-Yunnan ecological barrier, China[J]. *Ecological Indicators*, 2021, 132: 108328.
- [6] Wang B, Yang T. Assessing Impact of Land Use Change on the Ecosystem Service Value in Yinchuan City from 1980 to 2018[J]. *Sustainability*, 2021, 13(15): 8311.
- [7] Ren Y, Chen Y, Chen D, et al. Spatial and temporal effects on the value of ecosystem services in arid and semi-arid mountain areas—A case study from Helan Mountain in Ningxia, China[J]. *Frontiers in Ecology and Evolution*, 2023, 10: 1072015.
- [8] Chen W. Spatial–Temporal Evolution and Spatial Differentiation of Ecosystem Service Value in Ningxia at the Grid Scale[C]//International Conference on Environmental Pollution and Governance. Cham: Springer International Publishing, 2022: 409-421.
- [9] Cheng Jing, Huang Yue. Spatiotemporal evolution of ecosystem service value and its driving forces in Ningxia Hui Autonomous Region [J]. *Soil and Water Conservation Research (in Chinese)*, 2021, 28(02): 382-389.
- [10] Yang J, Huang X. 30 m annual land cover and its dynamics in China from 1990 to 2019[J]. *Earth System Science Data Discussions*, 2021, 2021: 1-29.
- [11] Ju X, Wang S. Dynamic City Land use Changes of Jinan City based on the Transfer Matrix from 2014 to 2019[C]//Proceedings of the 2020 4th International Conference on Big Data and Internet of Things. 2020: 29-32.
- [12] Zhuang Dafang, Liu Jiyuan. Research on regional differentiation model of land use degree in China [J]. *Journal of Natural Resources (in Chinese)*, 1997(02): 10-16
- [13] Xie Gaodi, Zhang Caixia, Zhang Leiming, et al. Improvement of ecosystem service valuing method based on unit area value equivalent factor [J]. *Journal of Natural Resources (in Chinese)*, 2015, 30(08): 1243-1254.
- [14] [National Development and Reform Commission. *Compilation of National Agricultural Products Cost and Benefit Data 2020* [M]. Beijing: China Statistics Press (in Chinese), 2020.
- [15] Kreuter U P, Harris H G, Matlock M D, et al. Change in ecosystem service values in the San Antonio area, Texas[J]. *ECOLOGICAL ECONOMICS*, 2001
- [16] Zhou Y, Li X, Liu Y. Land use change and driving factors in rural China during the period 1995-2015[J]. *Land use policy*, 2020, 99: 105048.