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The Impact of Land Use Change on The Ecosystem Service Value of The Agricultural Pastoral Ecotone

-- Taking Jishishan County as an example

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Abstract: Understanding the dynamics and relationships among ecosystem services value (ESV) and land use change (LUCC) has great importance to achieve sustainable development. In this study, taking Jishishan County as the research area, based on land use and socio-economic data from 2010 to 2020, estimate the ESV and explore the impact of LUCC on the ESV at the grid scale. The results indicate that:(1) From 2010 to 2020, Jishishan County was deeply affected by urbanization, resulting in a continuous decrease in arable land and forest land. (2) The Ecosystem Service Value (ESV) of Jishishan County showed a trend of decreasing firstily and then increasing over the past 10 years; Grassland is the main contributor to ESV.(3) The spatial differentiation of ESV is obvious, showing a pattern of low in the middle and high in the periphery. (4) The growth of ESV during the research period comes from the increase of grassland and water area, and the loss of ESV and the impact of urbanization expansion are related to the reduction of forest area.

Keywords: Ecosystem service value, Land use change, Spatial pattern.

1. Introduction

Ecosystem Service(ESs),the products and services directly or indirectly obtained through the structure, processes, and functions of an ecosystem, providing a link between human socio-economic activities and natural ecological processes [2-3]. Land Use Change(LUCC)is an important way for human activities to intervene in ecosystems [4], directly affecting ESs functions by changing ecosystem types, patterns,and ecological processes[5],Ecosystem value Service(ESV) is its quantification.According to the MEA report released by the United Nations, the trend of gradual degradation of ESs is still intensifying. Against the backdrop of continuous urbanization, how to protect ecosystems and improve the supply of ESs has become a common challenge facing the world[7].Therefore, quantitative assessment of the impact of regional LUCC on the ESV can provide support for sustainable development[8].

LUCC mainly affects ESs through three ways: area change, mode change, and spatial pattern change. At present, research on the impact of LUCC on the ESV mainly includes two aspects: quantity and space. In terms of quantity, it mainly includes the spatiotemporal evolution characteristics of land use and ESV[10-12], the response of ESV to LUCC[13-14], and the impact of LUCC on ESV[15-16]. However, such studies only focus on the role of land area change and ignore the spatial relationship between LUCC and ecosystem service value. The spatial distribution characteristics of ESV and the role of LUCC in ESV were explored using simple correlation and regression analysis in space [18-19], but the impact of land use type transformation on ESV was not deeply analyzed. The current research on ESs in the agricultural pastoral ecotone mainly focuses on spatiotemporal changes and interrelationships. For example, Zhou Jianing et al. [20] studied the impact of LUCC on ESV and ecological environment quality; Zhang Jianning et al. [21] studied the impact of cultivated land changes on the ESV; Xu Wenbin et al. [9] studied the impact of land use and climate change on ESs ; At present, few people explore the impact of LUCC on ESs in the agricultural pastoral ecotone based on grid scale. Therefore, in order to develop reasonable and efficient land use strategies and ecosystem management, it is urgent to study and explore the impact of land use on the ecosystem of the agricultural pastoral ecotone at the micro scale.

The northern agricultural pastoral ecotone supports the survival and development of a considerable density of population [22]. It is a complex of industrial and ecological interfaces [23]. Located in the ecological barrier of the upper reaches of the Yellow River in China, Jishishan County is a typical ecotone between agriculture and animal husbandry, a strongly influenced area by human activities[24]. It is an important agricultural space with important theoretical and research value. Based on this, this study utilizes three phases of land use data from Jishishan County from 2010 to 2020 is used to calculate the ESV using the grain revision method, exploring the spatiotemporal evolution of ESV at the grid scale and the impact of land use changes on ecosystem service value, in order to provide theoretical and scientific references for improving the regional ecological environment and promoting sustainable land use.

2. Materials and Study Methods

2.1. Study area

Jishishan County is located between 120°41′E ~ 103°05′ E and 35°34′N-35°52′ N.The terrain is high in the southwest and low in the northeast. Due to the complex terrain and the comprehensive climate characteristics of mountains and high mountains, there are significant differences in the climate within the territory.The county has jurisdiction over 4 towns and 13 townships. At the end of 2020, the gross domestic product reached 2.636 billion yuan, with a permanent population of 239400 in the county and an urbanization rate of 21.88%. The overall level of economic development is

poor, with the primary industry being the main industry, and the main crops include spring wheat, corn, rapeseed.

2.2. Data sources

The data used in this study main includes land use data, and statistical data. Land use data of 2010, 2015 and 2020 are from the Resource and Environmental Science and Data Center of the Chinese Academy of Sciences. The interpretation accuracy is more than 90% and The spatial resolution shall be 30 m.The grain crop yield and planting area data used to calculate the ESV are sourced from the corresponding year's "Linxia Prefecture Statistical Yearbook", and the grain price data is sourced from the Gansu Provincial Grain and Material Reserve Bureau.

2.3. Analysis of land use change

2.3.1. Land use dynamics

The dynamic degree of single land use can reflect the severity of changes in land use types within the region [25].The calculation formula is:

$$K = \frac{U_b - U_a}{U_a} \times \frac{1}{t} \times 100\% \quad (1)$$

Where: K is the dynamic degree of a certain type of land use (%); U_a and U_b represent the area of a certain type of land in the late and early stages, respectively; T is the year of change.

2.3.2. LUCC map

Perform pairwise intersection operations on three phases of land use data in ArcGIS map processing tools to obtain a land use transfer map, which can reflect the land area transferred in and out of different land use types during the research period and the location of the conversion [8].

2.3.3. Ecological service value

Adopting the evaluation system proposed by Costanza [26]:

$$ESV = \sum A_k \cdot VC_k \quad (2)$$

Where A_k is the k-th type of land use area (hm^2)) ; V_{ck} is the ecological service value equivalent of the k-th land type [yuan/(hm^2)]· a)];

Ecosystem equivalent is a key factor in evaluating the value of ecological services. The ecosystem service equivalent proposed by Xie Gaodi et al. [27] is based on national scale research, and direct use can cause significant deviation. Therefore, this article is revised based on food prices and actual situations: ①Based on the statistical yearbook and food price statistics of Gansu province the average grain yield and purchase price during the research base period are obtained to eliminate the impact of price fluctuations, Calculate the ESV of unit farmland production in Jishishan County from 2010 to 2020 as 1535.10 yuan Referring to the latest research by Xie Gaodi et al. [28], the biomass factors of various services provided by farmland ecosystems were revised.

Table 1. ESV coefficient of Jishishan County

Second category	Cropland	Forestland	Grassland	Water land	Unused land	Built land
Food production	548.03	383.77	353.07	1228.08	0	0
Raw material production	258.06	890.94	522.27	353.3	0	0
Water supply	548.74	461.13	292.05	12742.52	0	0
gas regulation	432.82	2937.76	1861.1	1184.33	30.76	0
climatic regulation	549.46	8788.24	4909.72	3524.53	0	0
Purify the environment	64.68	2571.96	1617.1	8547.53	154.01	0
Hydrologic regulation	550.17	5763.7	3606.16	157561.63	46.23	0
soil conservation	667.11	3577.66	2266.88	1434.15	30.84	0
Maintain nutrient cycle	550.89	277.76	169.74	108.02	0	0
biodiversity	84.31	3273.48	2069.09	3937.44	30.88	0
Provide aesthetic landscape	551.6	1436.94	911.61	2920.23	15.45	0

2.3.4. ESV flow to profit and loss model

The model based on the land transfer matrix can quantify the ESV loss-gain and the spatial and temporal transfer pattern caused by the interconversion between different land types.The calculation equation is as follows [29]:

$$PL_{ij} = (VC_j - VC_i) \times A_{ij} \quad (3)$$

Where PL_{ij} is the ESV profit and loss caused by the conversion of i to j; VC_i and VC_j are the ESV coefficient of i and j respectively; and A_{ij} is the area of i to j.

2.3.5. Hot spot analysis

Hot spot analysis is used to identify whether there are high value clusters (hot spots) or low value clusters (cold spots) in space for ESV, as well as the locations where cold spots and hot spots cluster. The above analysis operations were completed on ArcGis10.4.

3. Results

3.1. Characteristics of dynamic changes in land use

The main land types in Jishishan County are grassland and arable land (Table 2). The proportion of forest land and construction land is 9.6% and 3.3% respectively, while the proportion of water and unused land is the smallest (1.12% and 0.83%). From the perspective of land use changes, the water area has been increasing year by year, while cultivated land and forest land have been decreasing year by year; Construction land and unused land increase first and then decrease, while grassland is the opposite.

Table 2. Area change of Land use types 0f Jishishan County from 2010 to 2020

2010		2015		2020	
Area/km²	Proportion/%	Area/km²	Proportion/%	Area/km²	Proportion/%
364.95	39.98	363.31	39.80	360.42	39.48
87.64	9.60	87.59	9.59	87.28	9.56
412.32	45.17	411.04	45.03	415.16	45.47
10.18	1.12	10.19	1.12	11.60	1.27
30.19	3.31	32.16	3.52	29.86	3.27
7.57	0.83	8.57	0.94	8.60	0.94

Table 3. Land Use types Transfer Matrix of Jishishan County during 2010-2020

	2010						
2020	Cropland	Forestland	Grassland	Water land	Built land	Unused land	Total
Cropland	-	131.37	1881.43	26.47	873.84	55.2	2968.31
Forestland	155.96	-	447.62	2.85	8.42	1.91	616.76
Grassland	2385.89	459.84	-	43.98	39.67	43.68	2973.05
Water land	98.34	19.5	74.17	-	4.27	43.04	239.32
Built land	749.07	33.26	101.15	15.09	-	0.00	898.57
Unused land	33.03	9.78	188.19	7.52	6.00	-	244.51
Total	3422.28	653.74	2692.56	95.9	932.2	143.83	15881.03

From 2010 to 2020, various land use types underwent mutual transformation , with a total area of 15881.03 hm ² (Table 3). Among them, grasslands are still the main contributors to the transfer in and out of various types of land. The transfer in area of water and unused land is greater than the transfer out area. The increase in forest land mainly depends on the supply of arable land and grasslands, but the total amount of transfer in is less than the total amount of transfer out, indicating that the construction efforts of the "Returning farmland to forest" is limited.The overall land use transfer in Jishishan County is mainly due to mutual transformation between arable land and grassland.

3.2. ESV variation characteristics

3.2.1. Characteristics of ESV temporal evolution

From 2010 to 2020, the overall value of ESV showed a trend of first decreasing and then increasing, with an increase of 295.2 million yuan over the past 10 years, with a change rate of 2.1% (Table 4).From 2010 to 2020, ESVs in various regions were relatively stable, with grassland producing the highest ecological value, accounting for 55% of the total value, followed by forest land (accounting for 18%).

Table 4. Changes of land use types of ESV 0f Jishishan County during 2010-2020

Land Use types	2010	2015	2020	2010-2015	2015-2020	2010-2020
Cropland	17.54	17.46	17.32	-0.08	-0.14	-0.22
Forestland	26.61	26.60	26.50	-0.02	-0.09	-0.11
Grassland	76.60	76.37	77.13	-0.24	0.77	0.53
Water land	19.70	19.72	22.45	0.02	2.73	2.75
Unused land	0.02	0.03	0.03	0.00	0.00	0.00
Built land	0.00	0.00	0.00	0.00	0.00	0.00
Total	140.48	140.17	143.43	-0.31	3.26	2.95

3.2.2. Spatial evolution characteristics of ESV

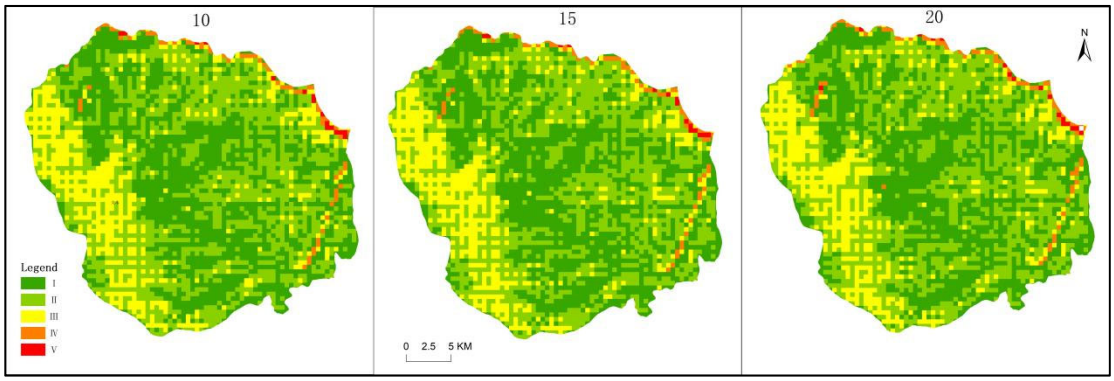

Figure 2. Space division map of ESVof Jishishan County during 2010-2020

Figure 2 shows that the spatial differentiation of ESV is significant, with a differentiation pattern of low in the middle and high in the surrounding areas. The agricultural areas with flat terrain and dense population and residential areas in the central region are strongly affected by human activities, resulting in low ESV. However, the surrounding pastoral

areas with high altitude and cool climate have high ESV due to the high value equivalent of grasslands and weak human activity interference.

3.3. Impact of LUCCon the ESV

3.3.1. ESV flow direction characteristics

Using the land transfer matrix to obtain the 2010-2020 ESV profit and loss flow statement in Jishishan County (Table 5), it is possible to intuitively analyze the impact of changes in land use quantity on ESV in Jishishan County. The results showed that the conversion of arable land to grassland and arable land to water were the main ecological service value-added methods.The mutual transformation of forest and grassland also contributed to the growth of ESV.The conversion of grassland to farmland and the conversion of water bodies to grassland are the main types of ecological service impairment. The conversion of forest land to cultivated land and the conversion of cultivated land to construction land are also the main and highly concerned types of ecological service impairment.Through in-depth analysis, it can be seen that returning farmland to grassland and water conservation are the main reasons for the increase in ESV value, playing a decisive role in improving ecosystem service functions. The transfer of water bodies to other land use types is the main reason for the decrease in ESV in the study area.

Table 5. Flow direction of ESV of Jishishan County during 2010-2020

2020	2010					
	Cropland	Forestland	Grassland	Water land	Built land	Unused land
Cropland	-	-0.34	-2.59	-0.50	0.42	0.02
Forestland	0.40	-	0.53	-0.05	0.03	0.01
Grassland	3.29	0.63	-	-0.77	0.07	0.08
Water land	1.86	0.32	1.30	-	0.08	0.83
Built land	-0.36	-0.10	-0.19	-0.29	-	0.00
Unused land	-0.01	-0.03	-0.34	-0.15	0.00	-

3.3.2. Spatial Association Features

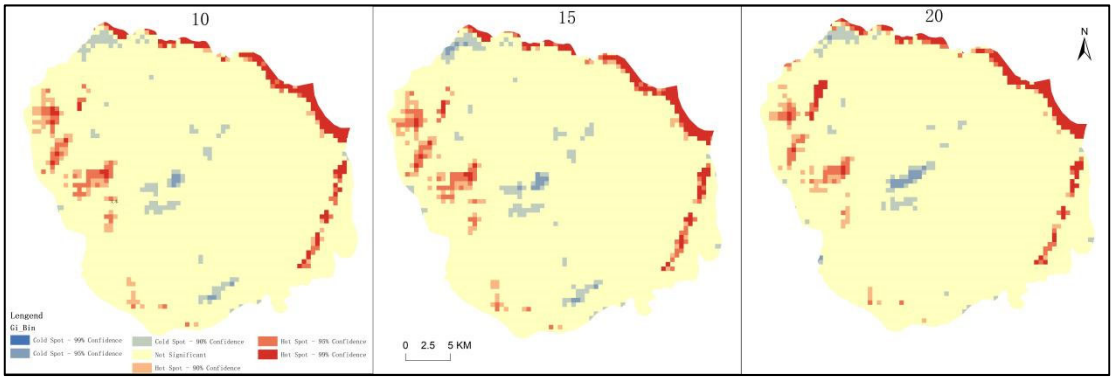

Figure 2. Hot spot analysis diagram of Jishishan County

From Fig. 2 , ESV hot spots were mainly distributed in river valleys (such as the Yellow River and its tributaries Yinchuan River), Gaixinping Forest Farm, and other areas in 2010. Except for the river valleys, they were basically pastoral areas. The fundamental forces leading to spatial differentiation are the types of landforms and changes in terrain, as well as the resulting land use patterns. Cold point areas are mainly distributed in relatively flat terrain, large population and residential areas. Construction land is mostly concentrated and contiguous, and it is also a major agricultural area. Between 2010 and 2015, both cold and hot spots experienced diffusion: only Gaixinping Forest Farm showed an eastward trend in the hot spot area.The expansion of hot spots is mainly attributed to the impact of ecological water replenishment policies in Yinchuan River around 2010, while cold spots are mostly related to the expansion of urban construction land.

4. Conclusions

This paper analyses the impact of land use change on ecosystem services in Jishiyama County at the grid scale, based on land use data from Jishiyama County for the 3 periods 2010-2020. The conclusions are as follows:

(1) Between 2010 and 2020, coand forest land in Jishiyama County continued to decline, water area continued to increase, building land and unused land increased before decreasing, and grassland was the opposite.

(2) ESV decreases and then increases during the 10 a period generally. The land type with the highest ESV is grassland, followed by forest land;

(3) The spatial differentiation of ESV is obvious: low in the middle and high in the periphery, with the hot spots all mainly distributed in the distribution of the river valley and Gaixinping Forestry; the cold spots are mainly distributed in the township of Bumatan, Zhaizigou Township and Banzang Township.

(4) Grassland to cropland and watershed to grassland are the most important types of ecological service impairment. The return of cropland to grassland and water containment are the main reasons for the increase in ESV .But the transfer of watershed to other land use types is the main reason for the decrease in ESV in the study area.

References

[1] Wei H, Zhao W, Zhang X, et al.Regional ESVevaluation based on land use changes: A case study in Dezhou, Shandong

Provience, China.Acta Ecologica Sinica,2017,37(11):3830-3839.

[2] Costanza R , Arge, Groot R D , et al. The value of the world's ESs and natural capital.Nature, 1997, 387(15):253-260.

[3] Ouyang , Wang x k , Miao H.A primary study on Chinese terrestrial ESs and their ecological-economic values.Acta Ecologica Sinica,1999(05):19-25.

[4] Guo CY, Noble, Zhou Boyan, et al. Effects of LUCCon ESVin Funiu Mountain based upon a grid square.Acta Ecologica Sinica,2019, 39(10): 3482-3493.

[5] Li Y F, LYC ,LG, et al.Effects of LUCCon ESs: a case study in Miyun reservoir watershed.Acta Ecologica Sinica,2013,33(03):726-736.

[6] Schneider A, Logan KE ,Kucharik C J . Impacts of Urbanization on Ecosystem Goods and Services in the U.S. Corn Belt. Ecosystems, 2012, 15(4):519-541.

[7] SHI L Y, CUI S H, YIN K, LIU J. The Impact of Land Use/Cover Change on Ecosystem Service in Xiamen. Acta Geographica Sinica. 2010, 65(06):708-714.

[8] SUN M H，NIU W H ，ZHANG BB，GENG Q L，YU Q，Spatial-temporal evolution and responses of ESVunder LUCCin the Yellow River Basin: A case study of Shaanxi-Gansu-Ningxia region Northwest China.Chinese Journal of Applied Ecology, 2021, 32(11):3913-3922

[9] Xu W B, R LY.Impacts of Land Use and Climate Change on ESs in Agro-pastoral Ecotone Environmental Science1-14 [2023- 03-27].

[10] Lei J R, Chen Z Z, Chen X H, et al .Spatio-temporal changes of land use and ESs value in Hainan Island from 1980 to 2018.Acta Ecologica Sinica,2020, 40(14):4760-4773.

[11] Wang Dayu, Wei Haiyan, He Min, et al.Temporal and Spatial Patterns of ESs Value in the Three Gorges Reservoir Area Based on Land Use. Resources and Environment in the Yangtze Basin, 2020, 29(01):90-100.

[12] Shan Y J, Yuan W L, Miao Y, et al.Spatiotemporal Variation of ESVin Datong City of Shanxi Province During 2000-2019.Bulletin of Soil and Water Conservation, 2021, 41(06): 310-317+344.

[13] Lei Y H, Ding G D, Li Z M, et al.Land use/cover change and its ESVresponse in the Beijing-Tianjin sandstorm source control project area.Journal of Desert Research, 2021, 41(06): 29-40.

[14] Ding L L, Wang Q, Chen X, et al.The responses of ESs to land-use change in Dianshan Lake area from 1984 to 2014.Acta Ecologica Sinica,2019, 39(08):2973-2985.

[15] Wang Y Q, Ma Junming.Effects of LUCCon ESs value in Guangxi section of the Pearl River-West River Economic Belt at the county scale.Acta Ecologica Sinica,2020, 40(21):7826-7839.

[16] Zhang J, LG, Qi L H,et ,al The landscape pattern and ecological service value in Danjiangkou City under LUCCfrom 2003 to 2018.Acta Ecologica Sinica, 2021, 41(04):1280-1290.

[17] ZHANG Y F, LI Y. ESV(ESV) and spatial-temporal difference of urban agglomeration in Guanzhong plain from 1995 to 2015. Journal of Zhejiang University（Science Edition）,2020, 47(05):615-623+629.

[18] YU Q R, XU N Y, SUN S Q, GUO L 1.The spatial-temporal variability of land use pattern and ESs value in the northwest of Hubei Province. Ecological Science, 2019, 38(04):119-128.

[19] Xiao J S, Qiao B, Chen G Q, et al.LUCCand evolution of ESVin Maduo County of source region of the Yellow River.Acta Ecologica Sinica, 2020, 40(02):510-521.

[20] Zhou J N, Qin F C, Zou W, et al.Response of Land use/cover to Ecosystem Service and Ecological Environment quality in Agro-pastral of Northern China —— Take Duolun County of Inner Mongolia Autonomous Region as a case study Bulletin of Soil and Water Conservation,2019,39(04):249-255+2.

[21] Zhang J N, Chen Y T, Wang Y, et al. Impact of Cultivated LUCCon ESVin the Northern zone Agro-pastral transitional zone—— Take Wuzhong City, Ningxia Hui Autonomous Region as an example Bulletin of Soil and Water Conservation, 2021, 28(06):283-291.

[22] CHENG X, Unique ecosystem c haracters and ecological principles for development in the ecotone between agriculture and pasture in north China. CHINESE JOURNAL OF APPLIED ECOLOGY, 2002(11):1503-1506.

[23] WANG Z W, WANG P, WANG X, HANG X T,CHEN Q T, Study on the cological safety assessment of farming-grazing transition zone in China.PRAT ACULT URAL SCIENCE, 2009, 26(04):64-73.

[24] Ni F, Zhou D M, Sun Lirong, Ma J, Zhu X Y, Zhang J, Study on Ecological Carrying Capacity Evaluation Based on Township Scale:A Case Study of Jishishan County. TERRITORY & NATURAL RESOURCES STUDY, 2022 (01): 42-48.

[25] Wang X L, Bao Y H, Study on The Methods Of Land use dynamic change reseach. PROGRESS IN GEOGRAPHY, 1999(01):83-89.

[26] XIE G D, LU C X, LEN Y F, ZHENG D, LI S C. Ecological assets valuation of the Tibetan Plateau. Journal of Natural Resources, 2003(02):189-196.

[27] XIE G D, ZHANG C X, ZHANG L M, CHEN W H, LI S M,Improvement of the Evaluation Method for ESV Based on Per Unit Area.JOURNAL OF NATURAL RESOURCES, 2015, 30(08):1243-1254.

[28] RAN Y J, LEI D M, LIU L, GAO L P. Impact of LUCC on ESV in Urban Agglomeration of Central Yunnan Province During2000－2020. Bulletin of soil and water Conservation .2021, 41(04):310-322+2.

[29] Deng C X, Zhong X L, Xie B G, et al.Spatial and temporal changes of land ESV in Dongting Lake area in 1995-2015. Geographical Research, 2019, 38(4): 844-855.