Advances in Engineering Research : Possibilities and Challenges
ISSN Print: 3079-5192
ISSN Online: 3079-5206
https://doi.org/10.63313/AERpc.9065

The potential power of ecological value visualization for the sustainable development to industrialized cities by combing ArcGIS and GeoSOS-FLUS: A case study in Jingmen

Longfei Wang[1]. Hongna Mu[1.a.*] and lei Liu[2.b]
[1]College of Horticulture and Gardening College, Yangtze University, Jingzhou 434025, China
[2]College of Architecture and Design, College of Arts and Sciences, Yangtze University, Jingzhou 434020, China
Email: [a.*]hongnamu@yangtzeu.edu.cn. [b]baryll@wlxy.edu.cn.

How to cite this paper: Wang, L. F., Mu, H. N., & Liu, L. (2025). The potential power of ecological value visualization for the sustainable development to industrialized cities by combing ArcGIS and GeoSOS-FLUS: A case study in Jingmen. *Advances in Engineering Research: Possibilities and Challenges*, 3(1), 42-54. ISSN Print: 3079-5192; ISSN Online: 3079-5206.
https://doi.org/10.63313/AERpc.9065
Published: 2025-12-31

Abstract

Land-use change has an impact on the value of ecosystem services. To uncover the relationship that has guiding significance for achieving ecological protection and coordinated socio-economic development in industrialized City. Based on the interpretation results of land use data from 2000 to 2020, the land use transfer matrix was established to analyze the characteristics of land-use changes in Jingmen. The ecosystem service values (ESV) was estimated using the equivalent factor method, in order to illustrating the spatiotemporal characteristics of land use change and ESV, ArcGIS software and the natural break-point method were employed. Results showed that: (1) From 2000 to 2020, the amount of cultivated land, forest land and grass land decreased following the construction land increased. The conversion of cultivated land to construction land is the most important way of land-use transfer. (2) The change of ESV showed a slow upward trend to a gradual downward trend. Among the single ecosystem services, regulation services held the main position. The spatial distribution of ESV did present the scattered distribution in low, medium, and high ecological value service area, and high value areas mainly distributed in areas of river and lake. (3) The simulating results of the land use pattern by GeoSOS-FLUS model showed the ecological service system rises 9.85% compared to 2020.

Keywords

Land-Use change; Ecosystem service Value; Equivalent Factor method; GeoSOS-FLUS; Jingmen

Introduction

As the primary resource for human survival, land resources are the main space for the survival of organisms in nature, which have natural and social attributes, the former is composed of land cover status, and the social attribute mainly indicates the state of land use (He, 2020). In order to meet the needs of human beings' survival and development, a variety of production and construction activities have been carried out by using land resources (Tang, et al., 2009), which lead to great changes in land use structure and function, and the residential living space in cities and towns have been deteriorating, so that land use cover/change (LUCC) has become an important part of global environmental change (Veldkamp&Verburg, 2004). In response to global climate change, the Chinese government has put up the "Dual Carbon" strategic goal, which aims to peak carbon emissions by 2030 and achieve carbon neutrality by 2060 (Li, et al., 2021). Previous studies have shown that optimizing land use structure can improve the carbon sequestration capacity of ecosystems (Xu, et al., 2023) and effectively promote the development of the global carbon cycle.

In such context, to explore the ecosystem service via its composition, process and function to get life-supporting goods and services that safeguard the necessities and life quality for people (Costanza, et al.,1997). After the article "The value of the world's ecosystem services and natural capital" released in journal NATURE, the quantitative assessment of ecosystem service value have been up to the most popularized field in international sustainable development research, and triggered many scholars at home and abroad to study the theory, evaluation, accounting methods, and application of ecosystem service value (Min, 2006). There are complicated relationships between the change of land use and the ecosystem services value. Land use structure inevitably leads to the transformation of the ecosystem structure and function, and promote the change of service value. Conversely, the change of ecosystem services affects the mode and efficiency of land use, leading to the change of land use structure (Zhu & Zhong, 2019). Jingmen City is an important node of the urban agglomeration in the middle reaches of the Yangtze River and the Hanjiang River Ecological and Economic Belt, and an important component city of the "YiJingJing Metropolitan Area". As a traditional industrial city and the main grain producing area of Hubei Province, it has been currently facing problems such as tight supply of land resources, serious environmental pollution, and ecosystem imbalance. So this paper ArcGIS 10.8 was utilized to analyze the land use situation during the 20 years (from 2000 to 2020) based on the land use data and social statistics of Jingmen. The Equivalent Value Method was used to calculate the value of ecosystem services, to analyze the temporal and spatial dynamics of land use and ecosystem service value, and which had potential power to provide a scientific basis for sustainable development and land use planning in future.

1. Study Area and Data

1.1. Study area

Jingmen is located in the central part of Hubei Province, northwest of the Jianghan

Plain. In the implementation of the "One Belt, Two Circles" regional development strategy in Hubei, Jingmen is the intersection of the ecological and cultural tourism circle in western Hubei and the Wuhan city circle, and the fulcrum city of the Hanjiang River ecological and economic belt in Hubei Province. The climate is mild, the rainfall is abundant, the average annual temperature is between 15.6-16.3 °C, and the average annual precipitation is about 1000 mm in Jingmen City. Its GDP output value was 212.086 billion RMB, the permanent population was 2.5969 million, and the urbanization rate was 58.73% in 2021.

1.2. Data

The required land use data of the five periods of 2000, 2005, 2010, 2015 and 2020 were from the Data Center of Resources and Environmental Sciences of the Chinese Academy of Sciences (http://www.resdc.cn), and the above land use data were reclassified into six categories: cultivated land, forest land, grassland, water area, construction land and unused land. The land use vector data of Jingmen City were cut out from the administrative division of Jingmen, which were downloaded from Tiantu Hubei (https://hubei.tianditu.gov.cn/).2 Methods2.1 Land use dynamics
Land use dynamics is used to evaluate the rate of change of a certain land type in a certain period of time, and the formula is expressed as equation 1:

$$K=\frac{U_b-U_a}{U_a} \times \frac{1}{T} \times 100\% \qquad \text{(Equation 1)}$$

K is the land use dynamics, Ub is the area at the end of the land use period, Ua is the area at the beginning of the land use period, and T is the land use cycle. The K value of a certain land type indicates the more drastic change of the land type in the specific period.

1.3. Land use transition matrix

The land use transfer matrix can accurately reveal the direction and area of land use transfer in a certain period of time（Xu, et al., 2017), systematically and quantitatively describe land use change（Xu& Zhao., 1993), intuitively reveal the direction and quantity of land use transfer, and is conducive to visually displaying the characteristics of land use change in the study area （Qi, et al., 2023).

$$B_{ij}=\begin{bmatrix} B_{11} & B_{12} & \dots & B_{1n} \\ B_{21} & B_{22} & \dots & B_{2n} \\ \dots & \dots & \dots & \dots \\ B_{n1} & B_{n2} & \dots & B_{nn} \end{bmatrix} \qquad \text{(Equation 2)}$$

Bij represents the land area from class i to j at the beginning and end of the study, and n is the land use type. Using the intersection function in the overlay analysis of ArcGIS , the intersection analysis of the early raster and late vector data were carried out after the intersection operation, after the data processing with excel, the land use transfer matrix of Jingmen was obtained.

1.4. Calculation of the value of ecosystem services

Xie et al (2015) proposed that the equivalent factor was defined the economic value of the annual natural grain yield of farmland with an average yield of $1hm^2$ as 1equivalence, and its equivalent factor of other ecosystem service value refers to the contribution of the ecological service to the farmland food production service. The economic value provided by the natural ecosystem is 1/7 of the value of the food production service provided by the existing unit area of farmland without human input. The calculation formula is as follows:

$$E_a = \frac{1}{7}\sum_{i=1}^{n}\frac{m_i p_i q_i}{M} \qquad \text{(Equation 3)}$$

Among them, the economic value of Ea as a unit of farmland ecosystem to provide food production services (yuan/ha); i is the main crop species in Jingmen, including rice, wheat, corn, and so on; pi is the average price of the study area of i crops in a certain year; qi is the yield per unit area of i crops (kg/ha); mi is the planting area (hectares) of i crops; M is the area (hectares) of all crops.

By consulting the Jingmen Statistical Yearbook and the National Compilation of Agricultural Product Cost and Benefit Data, the ecosystem service value of one equivalent factor in Jingmen was calculated to be 1484.22 yuan/hm^2 by using Formula 3, and the ecosystem service value coefficient of Jingmen was calculated based on the ecosystem service value equivalent scale per unit area revised by Xie Gaodi in 2015 (Xu & Zhao,1993) (Table 1).

In this paper, the Constanza ecosystem service value model is used to calculate the ecosystem service value, and the calculation formula is as follows:

$$ESV = \sum (A_k \, x \, VC_k) \qquad \text{(Equation 4)}$$

$$ESV_f = \sum (A_{fk} \, x \, VC_{fk}) \qquad \text{(Equation 5)}$$

ESV is the value of land ecosystem services in the study area, yuan/a; Ak is the area of the kth land use type, hm2; VCk is the ecosystem service value coefficient of the kth land use type, yuan/(hm2·a); ESVf is the value of ecosystem services of type f, yuan/a; Afk is the area of the F type ecosystem and the K land use type, hm2; VCfk is the ecological service value coefficient of the k land use type, yuan/(hm2·a).

Table 1. Coefficient of ecosystem service value per unit area for each land use type of Jingmen

Level service	Secondary services			Land types			
		Cultivated	Woodland	Grass	Water	Construction	Unused
POS	FP	1640.1	374.77	346.32	994.43	0	0
	RMP	363.63	860.85	509.58	549.16	0	0
	WS	-1937	445.27	282	8074.16	0	0
RS	GC	1321	2831.1	1791	1981.43	0	29.684

	CR	690.16	8471.2	4734.7	4371.03	0	0
	PE	200.37	2482.4	1563.4	6790.31	-3651.2	148.4 2
	HR	2218.9	5543.6	3468.1	93854.6 5	-11206	44.52 7
SS	SC	771.79	3447.1	2181.8	2404.44	0	29.68 4
	MNC	230.05	263.45	168.21	185.53	0	0
	Bio.	252.32	3139.1	1983.9	7732.79	0	29.68 4
CS	AL	111.32	1376.6	875.69	4912.77	356.213	14.84 2
	Total	5862.7	29235	17905	131850. 68	-14501	296.8 4

Notes: CL, Cultivated land; POS, Provision of services; RS, Reconciliation services; SS, Support Services; CS, Support Services; FP, Food production; RMP, Raw material production; WS,Water supply; GC, Gas conditioning; CR, Climate regulation; PE, Purify environment; HR, Hydrological regulation; SC, soil conservation; MNC, Maintain nutrient cycling; Bio, Biodiversity; AL, Aesthetic landscape.

1.5. Land use projections

To predict future land use changes, the change and spatial distribution characteristics of land use structure in the study area were simulated by the software GeoSOS-FLUS, and the FLUS model was employed based on one concrete land use data and land use drivers and then based on Markon chain (Markov chain, a mathematical model algorithm), the prediction results were obtained. Due to the wide scope of this study, the random sampling method was used to sample land use data and driving factors.

Taking the land use data of Jingmen in 2010 and 2015 as the initial data, the normalized driving factors were input into the BP-ANN model, and 20 raster data were extracted as samples by random sampling method to obtain regional land use types. The land use data of Jingmen in 2020 was obtained by substituting it into the CA model, and the Kappa coefficient and Fom coefficient were verified.

2. Results

2.1. Land use change in Jingmen

2.1.1. Overall change in land use

The land use status map at five time points (2000, 2005, 2010, 2015 and 2020) was obtained by mask extraction and reclassification based on the first-level land use classification during the past 20 years in Jingmen (Fig. 1).

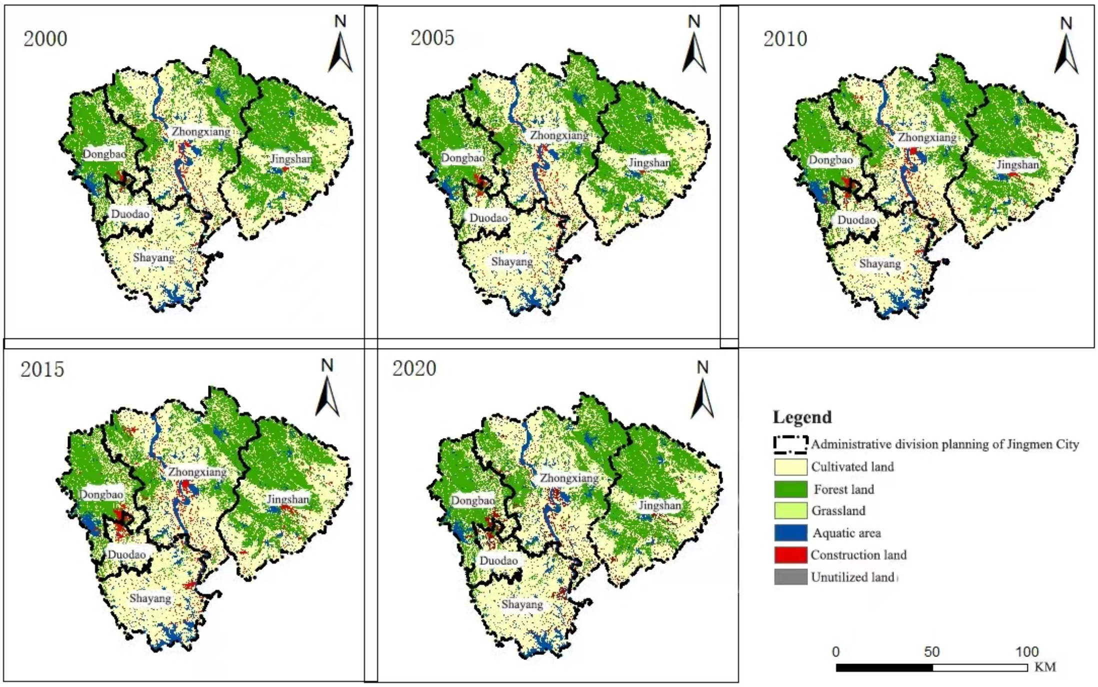

Fig 1. Land use status of Jingmen from 2000-2020

From 2000 to 2020, the land use types in Jingmen were mainly cultivated land and forest land, which accounted for nearly 90% of the total land. The cultivated land was mainly distributing in the southern Jianghan Plain, the woodlands were in the Dahong Mountains and Jingshan Mountains. The water area was mainly composed of many lakes such as the Han River and Zhanghe River reservoirs and Changhu Lake; Construction land was located in plain terrain and close to water sources.

In the past 20 years, the land use of Jingmen has changed with varying degrees, and the overall trend was that cultivated land, forest land and grassland have been decreasing. Firstly, among which cultivated land has decreased the most, with a decrease of 151.34 km^2 (reduction rate 2.293%), followed by forest land, with a decrease of 38.41 km^2. Secondly, the meadows have decreased by 0.31 km^2. The land types of water, construction land and unused land were increasing, among which the increase range of construction land was the biggest, with an increase of 172.23 km^2 and an increase rate of 49.512%, which was followed by water and unused land, with an increase of 17.82 km^2 and 0.15 km^2, respectively.

2.1.2. Analysis of land use dynamics

The dynamics of land use reflect the rate of change of a certain land use type in a certain time range, illustrating the change of each land use type. From 2000 to 2020, the comprehensive dynamic degree of land use was 0.62% in Jingmen, indicated that the land use was in a very slow change state during the past 20 years, and showed a trend of first increasing and then decreasing (Table 2).

As the comprehensive dynamic rate as be concerned, the highest was 0.31% in the spell of 2005-2010, and the lowest was at 0.07% in the following 5years (from 2015 to 2020). As for dynamic rates of land use types, the construction was the largest one from 2015 to 2020, which was 9.9%. From the analysis of the single dynamic degree of land use types, it could be concluded that the increase ranking was construction land > unused land > cultivated land > water area > grassland > forest land, which indicated that the urbanization process has been accelerating accompanied with the development of social and economic in Jingmen in the past 2 decades.

2.1.3. Land use transition matrix analysis

Table 2. Land use transfer matrix of Jingmen (2000-2020)

	Land use types in 2020						Transfer in	Transfer out
	Cultivated	Woodland	Grass	Waters	Construction	Unused		
CL		108.17	0.62	50.79	141.62	0.06	149.87	301.18
WL	100.07		1.29	14.23	46.44	0.02	123.58	162.03
GL	0.52	1.16		0.87	0.21		2.45	2.76
W	27.41	11.24	0.50		10.54	0.14	67.65	49.70
Con.L	21.81	2.99	0.04	1.76		0.00	198.80	26.61
UL	0.05	0.02		0.01			0.22	0.08
Surplus/deficit	151.32	38.45	0.31	-17.95	-172.20	-0.15		

Notes: CL, Cultivated land; WL, Woodland; GL,grassland;W, Waters; Con.L, Construction land; UL, Unused land.

From 2000 to 2020, the six types of land use were transferred out and transferred into different degrees in its corresponding periods. The main type was the transfer of cultivated land to forest land, water area and construction land, the transfer total area was of 301.18 km^2, accounting for 55.53%. The area of construction land, transferred from cultivated land and forest land, was higher than the area transferred out, and the net area transferred in was 172.2 km^2. Since 2015, it has been implemented that the policy impact of the ecological city strategy and the promotion of the comprehensive land improvement project in the whole region of Jingmen. The transfer center has been changing from 2015 to 2020, the forest land, water area and construction land have been converted to cultivated land, and then cultivated land has become the largest one, and the amount of change in unused land was minimal.

2.2. The value of ecosystem services in different categories

The ESV data analysis in Jingmen showed a slow increase and then a gradual downward trend, of which the highest ESV was 28.166 billion RMB in 2010, and the lowest total in 2020 was 27.692 billion (table 3). In 2020, it will decrease by 89 million compared with 2000, with a change rate of -2.29%. The ESV changes were consistent with the area changes of land use types, and the ESV of cultivated land, forest land and grassland decreased slowly from 2000 to 2015, and increased from 2015 to 2020. After reaching the highest value in 2010, the ESV of the water area declined gradually, with a decrease of 104 million and 227 million in 2010-2015 and

2015-2020, respectively.

Construction land has a negative effect on ecosystem services, which may be the main reason for the total ESV decrease in Jingmen. Due to the small area of unused land, it has little impact on the negative functions of ecosystem services. The ESV of regulation services was much higher than the other three types in the last 2 decades, with an average value of 20.349 billion yuan, followed by support services (average value of 4.812 billion yuan) and supply services (1.647 billion yuan) (Table 3), and the lowest was cultural services (average value, 1.141 billion yuan); the service value order was as follow, regulation services> support services> supply services > Cultural services.

Table 3. Values and rates of change of different ecosystem service types in Jingmen (2000 to 2020)

First service	Second service	Ecosystem service value					ESV Change	ESV change rate
		2000	2005	2010	2015	2020		
Supply service	FP	13.38	13.34	13.25	13.14	13.14	-0.24	-1.83%
	RMP	6.77	6.77	6.73	6.69	6.69	-0.08	-1.16%
	WS	-3.85	-3.61	-3.34	-3.29	-3.43	0.42	-10.89%
subtotal		16.30	16.49	16.64	16.53	16.40	0.10	0.59%
Regulate service	GC	23.25	23.23	23.10	22.96	22.98	-0.27	-1.18%
	GC	46.69	46.71	46.48	46.27	46.34	-0.35	-0.76%
	PE	17.12	17.16	16.95	16.54	16.49	-0.63	-3.70%
	HR	116.24	117.83	118.77	116.88	115.43	-0.81	-0.69%
subtotal		203.31	204.93	205.30	202.65	201.24	-2.07	-1.02%
Support service	SC	22.78	22.79	22.68	22.56	22.58	-0.21	-0.91%
	MNC	2.87	2.87	2.85	2.83	2.83	-0.04	-1.45%
	Bio.	22.52	22.66	22.70	22.58	22.50	-0.02	-0.10%
subtotal		48.18	48.31	48.23	47.96	47.91	-0.27	-0.56%
Culture service	AL	11.31	11.41	11.49	11.45	11.39	0.08	0.70%

Notes: CL, Cultivated land; POS, Provision of services; RS, Reconciliation services; SS, Support Services; CS, Support Services; FP, Food production; RMP, Raw material production; WS,Water supply; GC, Gas conditioning; CR, Climate regulation; PE, Purify environment; HR, Hydrological regulation; SC, soil conservation; MNC, Maintain nutrient cycling; Bio, Biodiversity; AL, Aesthetic landscape.

2.3. Spatial variation in the value of ecosystem services

The ecosystem service value was divided into three levels: low, medium and high ecological service value area. Illustrated by table 3, the high ecological value service areas were distributed in the Dahong Mountains of northeast, the low mountains and wolds in the tail areas of Jingshan Mountains in the northwest, and the lake area of the Jianghan Plain in the central, were mainly woodland and water. The low ecosystem service areas were mainly distributed in the southwest, southeast and central plains, were included the cultivated land and urban areas. Based on the perspective of the spatial distribution of ESV, Zhongxiang had the highest ESV value, followed by Jingshan, Dongbao District and Shayang, and the lowest was in Duodao District. In the past decades, the ESV value showed a downward trend in Dongbao District, Duodao District, Jingshan, and Shayang. The largest decrease happened in Duodao District decreasing of 1.0464 million yuan, and the change rate up to 11.3%. As to Zhongxiang, an upward trend was presented, with an increase of 448.600 thousand yuan(change rate,0.44%).

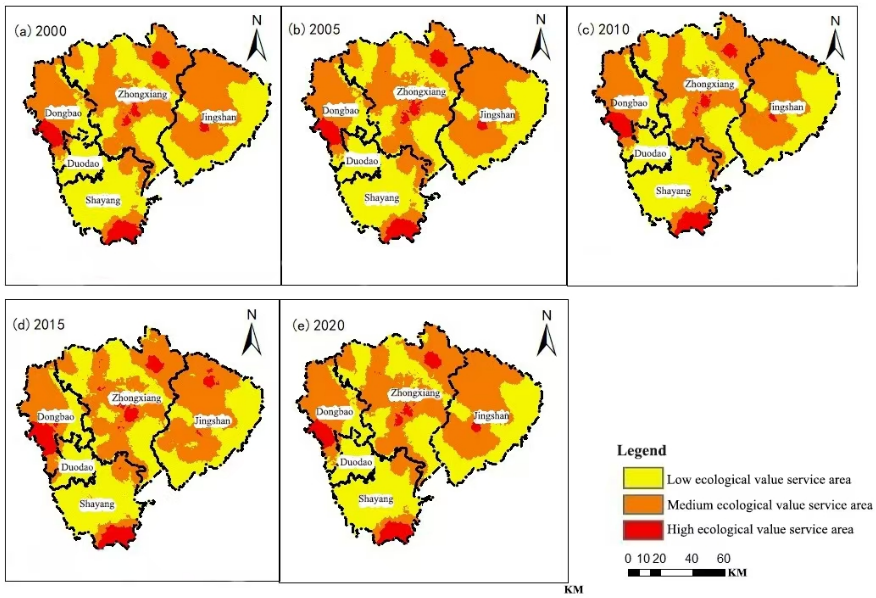

Fig 2. Evolution of spatial pattern of ecosystem service value in Jingmen (2000-2020)

2.4. Simulation results of the FLUS model

The simulation results are credible, and can be used for the simulation prediction of land use in 2025 and 2030 (Table 4), according to the verification of Markov chain and FOM coefficient basing on FLUSH model.

Table 4. KAPPA coefficients, FOM coefficients for 2010 and 2015

Initial data	Forecast data	KAPPA coefficient	FOM coefficient
2010 Year	2020 年	0.823	0.046
2015 Year	2020 年	0.798	0.045

Fig 3. Evolution of land use pattern in Jingmen from 2025 to 2030

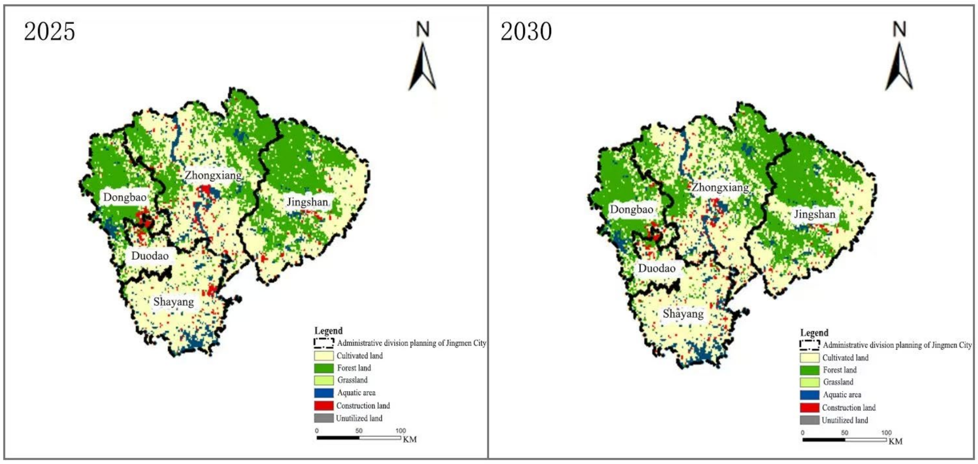

Table 5. Changes of ESV in Jingmen(2020 -2030)

Land type	2020		2025		2030		2020-2030	
	ESV value	Rates	ESV value	Rates	ESV value	Rates	Trend	Change rates
CL	37.81	13.66	37.80	13.04	36.97	12.15	D	-1.51
WL	130.87	47.26	133.88	46.20	139.58	45.88	D	-1.38
GL	0.55	0.20	0.45	0.16	0.44	0.14	D	-0.06
W	115.23	41.61	122.95	42.43	130.88	43.02	A	1.41
Con.L	-7.54	-2.72	-5.31	-1.56	-3.67	-1.19	A	1.53
UL	0	0	0	0	0	0	UN	0
Total	276.92	100	289.77	100	304.2	100	A	9.85

Notes: CL, Cultivated land; WL, Woodland; GL,grassland;W, Waters; Con.L, Construction land; UL, Unused land; D, Descent; A, ascend; UN,unchanged. ESV value, ESV value / 100 million yuan; Rates, Contribution Rate (%).

In 2025 and 2030, the dominated land types in Jingmen will still be cultivated land and forest

land, with 52.2% and 51.07%, respectively. The area of unused land is the least (less than 0.01%). By 2030, all of the cultivated land, forest land, grassland, construction land, and unused land will be reduced in Jingmen. The calculations showed the ESV can reach 28.977 billion yuan in 2025 and 30.42 billion yuan in 2030, of which the highest proportion will be forest land still, accounting for 46.2% and 45.88% respectively. In the future development, there should be actively implemented ecological and environmental protection policies, to practice the concept of the 20th National Congress of the Communist Party of China, to provide scientific and rational layout guidance, to improve the ecological efficiency of unused land, to limit the flooding and expansion of construction land, to restore effectively cultivated land, forests and grasslands, and reconstruct land use types, so as to improve ecosystem service functions.

3. Discussions

The development plans of provinces and cities have a certain impact on the changes of land use types in administrative areas. From 2010 to 2015, the reduction rates of forest land and grassland have been suppressed to some extent, and the expansion of construction land has been decreased. This is likely to be related to the "Twelfth Five-Year Plan for Land Use in Jingmen City" (hereinafter referred to as the "Plan") issued by the Jingmen Municipal Land and Resources Bureau, which clearly requires "strengthening land ecological construction, controlling the total amount of construction land, improving the ecological conservation function of urban green space, and initially establishing an environment-friendly land use model to provide land use guarantee for the national modern forestry demonstration city". In order to facilitate the successful realization of the goals of the 12th Five-Year Plan, the protect actions for cultivated land and forest land have carried out vigorously in Jingmen , which was probably the main reason for the lowest comprehensive dynamic degree from 2015 to 2020.

Considering the time span in this study, Zhongxiang had the highest ESV in each span. The main reason possibly relate to its wide cover and very rich natural resources, "Five Points of Pastoral and Three Points of forest, One Point of Urban and Rural Areas and One Point of Water", there have been abundant cultivated land resources in the central part, mountains, forests and lakes densely packed in the eastern. On April 11, 2023, the Zhongxiang Municipal Bureau of Natural Resources completed the "Zhongxiang City Land and Space Master Plan (2021-2035)", deepening the implementation of land use from the institutional perspective and laying the foundation for Zhongxiang's Dual Carbon pattern.

It was speculated the main influencing factor was the area that has been relating to the development of industry. During the "13th Five-Year Plan" period, the total output value of large-scale industries in the region was 65.87 billion yuan, increase of 7.53% yearly. The growth rate of the added value of large-scale industry was 9.3%. It can be seen that in the future development, in the face of the implementation of high-quality ecological service value, the task of the Duodao district will be more arduous.

There is the correlation between land use structure and ecosystem service value. The future land use pattern can be predicted through the GeoSOS-PLUS model, so as to predict the value of ecosystem service system in the region in advance. The ESV model used in this study was based on the theory proposed by Xie Gaodi, and the analysis of the model was more comprehensive and credible, which can provide a certain reference value for local provinces and cities for land use planning. However, there were some limitations and shortcomings in this paper, such as whether there are new factors in ESV that are worth to explore. In addition, the data was limited, and few driving factors were used. In the light of precise simulation and prediction for sustainable municipal developmental planning to administrative agents, more socio-economic driving factors should be used in the future model analysis and calculation, and more refined multi-scenario prediction and simulation could be carried out in the future.

In summary, in the context of rapid urbanization, the relationship between land use and ecosystem services has been very complex, and it is worth in-depth consideration and discussion in urban development planning to further clarify the ecological processes and interactions between various ecosystems in order to better promote urban sustainable development, and realize the coordinated development of ecological protection and social economy. For future development, it should adhere to the important concepts of "harmonious development" and "people-centered", focus on deepening the structural reform of the land supply side and improving the human-land linkage mechanism, scientifically and rationally plan the land use planning within its jurisdiction, build a green and harmonious urban space with high ecosystem service value for the people of Jingmen, and promote the realization of the "Double Carbon" strategic goal as scheduled.

4. Conclusions

From 2000 to 2020, the structure of land use types had not been changed much in Jingmen, the main land use types were cultivated land and forest land, and the land use was in a very slow state of change. The ESV showed a slow increase and then a gradual downward trend, and the changes of ESV were basically consistent with the changes in land use types, and the contribution of forest land and water areas to ESV was nearly 90%, and the single ESV was mainly regulation services. The simulation results show that in 2030, there will still be dominated by cultivated land and forest land. Compared with 2020, the ESV of Jingmen will increase by 5.85% in 2030, and the ESV of construction land and water area will increase.

References

[1] Aokang X, Mengjun H, Jing S, et al. Spatial and temporal variability of ecosystem carbon storages and multi-scenario simulation Based on the PLUS-InVEST model in the Shiyang River basin.China Environmental Science:1-11[2023-12-25].

[2] Costanza R d, Arge R, de Groot R, et al.The value of the world's ecosystem services and natural capital.Nature,1997,386:253-259 .

[3] Huajun T, Wenbin W, Peng Y, et al. Recent Progresses of Land Use and Land Cover Change (LUCC) Models. Acta Geographica Sinica,2009,64(4):456-468.

[4] Gaodi X, Caixia Z, Leiming Z, et al. Improvement of the Evaluation Method for Ecosystem Service Value Based on Per Unit Area. Journal of Natural Resources, 2015, 30(8):1243-1253.

[5] Jie M, Wei G, Xiaoyun L, Anlu Z. Analysis on Spatial-Temporal Changes of Land Use and Ecosystem Services Value in Wuhan City. Journal of Soil and Water Conservation. 2006,8（4）,170-174.

[6] Jingwen L, Suocheng D, Yu L, et al. The pattern and driving factors of land use change in the China-Mongolia-Russia economic corridor. Geographical Research,2021,40(11):3073-3091.

[7] Lan X, Yi Z. Forecast of land use pattern change in Dongling District of Shenyang: an application of Markov process Chinese. Journal of Applied Ecology, ,1993,4（3）：272-277.

[8] Liping Q, Zhaoqing L, et al. Spatial and temporal variations of ecosystem service values in Jiangsu Province based on land-use change. Journal of Nanjing Forestry University(Natural Sciences Edition),2023,47(4)：200-208

[9] Nan He. Study on the Evaluation of Ecosystem Service Value in Hubei Province Based on Land Use Change.. Central China Normal University, 2020.

[10] Su X, Yongming Z, Ming D, et al. Spatial distribution of land use change in the Yangtze River Basin and the impact on runoff. Progress in Geography,2017,36（4）：426-436.

[11] Turner B L I,Skole D,Sanderson S,et al. Land-use and land-cover change:science/research plan ICBP Report No 35/HDP Report No .7[R] Stockholm : IGBP,1995 .

[12] Veldkamp A, Verburg P H. Modelling land use change and environmental impact. Journal of Environmental Management,2004,72(1-2SI): 1-3.

[13] Wenyuan D, Fangqi J, Wanli H, et al. Study on Transition of Land Use Function and Ecosystem Service Value Based on the Conception of Production, Living and Ecological Space: A Case Study of the Fuzhou New Area. Journal of Natural Resources, 2018, 33 (12): 2098-2109.

[14] Yezhou Z,Yexi Z. Spatio-Temporal Evolution of Land Use and Ecosystem Service Value in Yangtze Ｒiver Delta Urban Agglomeration. Resources and Environment in the Yangtze Basin,2019，28(7):1520-1530.

[15] Yinglong H, Yinbiao C, Zihao Z, et al. Spatial Heterogeneity Change of Guangzhou Ecosystem Services Value. Tropical Geography, 2018,38(4):475-486.