Evaluation of Urban Ecosystem Service Value under New Urbanization—A Case Study of Chengdu City

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Abstract: In order to evaluate the change of ecosystem service value in Chengdu, GIS technology was used to obtain the land use type data of Chengdu from 2009 to 2018. The equivalent factor method was used as the core evaluation method, and an ecosystem value evaluation model was established to explore the impact of various land use types on ecosystem service value. The results show that: (1) the trend of land use change is that both the area and the proportion of land use change in different degrees. The area of cultivated land, water area and unused land are greatly reduced, and the area of construction land expands rapidly, mainly through the occupation of cultivated land and unused land. (2) The intensity of land use in Chengdu is greater and continues to increase, and the contribution rate of construction land is larger, which indicates that the land use structure is developing towards the structural direction of mainly construction land. (3) Changes in ecosystem service value are not only related to land use structure, but also to the economic development, willingness to pay and ability of the whole society. (4) Ecosystem service value is negatively correlated with construction land and unused land; it is positively correlated with cultivated land, forest land and grassland. Generally speaking, Chengdu's land use change has not caused obvious damage to the ecosystem, but the impact of human lifestyle on the environment in the process of economic development cannot be ignored. The growth of construction land area should be appropriately controlled, ecological land should be protected, and the sustainable development of social-economic-ecological benefits should be realized.

1 FOREWORD

Ecosystem is a complex ecosystem composed of nature, people and society. Ecosystem services refer to all the benefits that human beings derive from ecosystems, including supply services, regulatory services, cultural services and support services^[1]. In recent years, with the expansion of population and urbanization, people's demand for land development is increasing, and the original natural ecosystem of cities in the world is constantly being invaded, which leads to the degradation of many urban ecosystem services (Bojie Fu et al, 2014)^[2]. The value of ecosystem services, as all human benefits from ecosystems, is closely linked to human well-being and regional sustainable development and is an important consideration in regional land use planning (Ziwen Liu et al, 2019)^[3]. If urban ecosystem services are not effectively planned and protected, cities may no longer be livable and their sustainable development may be threatened. "Ecological prosperity is civilization, ecological decline is civilization decline" is a concentrated embodiment of Xi Jinping's ecological

civilization construction ideology and humanistic value, Chengdu will also consider ecological value in land planning, urban construction, adhere to the concept of green development, green water green mountain into Jinshan Silver Mountain. Taking Chengdu as an example, through the coupling study of land use change and ecosystem service value change, the influence of land use type change on ecosystem service value is discussed^[4]. The specific research implications are as follows: (1) As far as the government is concerned, according to the land use situation, the analysis of the changes in the value of ecosystem services in Chengdu during the period of rapid development aims at providing decision support for the rational utilization of land resources and the protection of the urban ecological environment, which is of great theoretical significance and application value to the protection and reconstruction of the ecological environment and the sustainable development of the region. (2) As far as the regional economy is concerned, it provides a new thinking direction for the regional economy to realize the green transformation and green leapfrogging from the perspective of ecosystem

service value assessment, and has important reference value for the formulation of the long-term development strategy of the regional economy. (3) As far as follow-up researchers are concerned, the study combines land-use change with ecosystem service value, which provides a new idea for ecosystem service value research, which is beneficial to enrich the impact of land-use change on ecosystem service value research, and provides a reference for follow-up related research.

2 OVERVIEW OF RESEARCH AREA

Chengdu is located on the western edge of Sichuan Basin, with a terrain sloping from northwest to southeast. The city is 192 kilometers long from east to west, 166 kilometers wide from north to south, and a total area of 12,390 square kilometers. Chengdu is rich in soil resources and has various types of soil. Land resources have the following characteristics: First, there are various types of land, which can be divided into 8 categories according to the current land use types, such as cultivated land, garden land and grassland. Second, the plain area ratio is significant, reaching 4,971.4 square kilometers, accounting for 40.1% of the city's total land area. Third, the land reclamation index is high, the land is fertile, the soil layer is deep, the climate is mild, irrigation is convenient, the proportion of usable area can reach 94.2%, the city's average land reclamation index reaches 38.22%, of which the plain area is as high as over 60%. Chengdu's population grew steadily. By 2018, Chengdu's resident population was 16.33 million, of which 11.9405 million were urban residents and the urbanization rate of the resident population was 73.12%. In 2018, the per capita disposable income of all residents in Chengdu was 36,142 yuan, up 8.8% year on year. Among them, the per capita disposable income of urban residents was 42128 yuan, up 8.2% year-on-year, 0.1 percentage point higher than that of the whole province. Per capita disposable income of rural residents was 22,135 yuan, up 9.0% year on year, the same as that of the whole province. In recent years, Chengdu has advocated the development of a green economy and vigorously promoted the construction of ecological civilization. As a new first-tier city, its total economic volume has reached a new level. In 2018, Chengdu's economic operation will be generally stable, with steady progress. The GDP of the region reached 1534.277 billion yuan, an increase of 8.0% over the same period of the previous year at comparable prices. The growth rate was 1.4 percentage points higher than that of the whole country, which was the same as that of the whole province. Among them, the added value of the primary industry reached 52.259 billion yuan, up 3.6%. The added value of the secondary industry reached 651.619 billion yuan, up 7.0%. The added value of the tertiary

industry reached 830399 million yuan, up 9.0%. The three industrial structures are 3.4: 42.5: 54.1.

3 DATA AND METHODS

3.1 The data source

The land use data from the chengdu city bureau of land and resources to carry out the second national land survey of statistical survey data of land use change, land use classification in accordance with national standards and the geological features of chengdu, chengdu city land use types can be divided into farmland, forest land, garden land, grassland, water area and wetland, construction land and unused land six grade class. The socio-economic data are from chengdu statistical yearbook and China statistical yearbook.

3.2 The research methods

3.2.1 Analysis of land use change in chengdu city

(1) Analysis of land use intensity and structure change. The change of land use is mainly reflected by the change of land use intensity and use mode. The comprehensive index of annual land use intensity and the intensity contribution rate of a single land use type during the 10 years from 2009 to 2018 were studied to analyze the change mode of land use in chengdu during the 10 years.

(2) Land use intensity analysis

Comprehensive land use intensity index, reflecting the overall change of all land types:

$$I = \sum (L_i \times P_i) \times 100\% \quad (1)$$

I represents the comprehensive index of land use intensity, L_i represents the grade of land use intensity of class i land use types, and P_i represents the proportion of class i land use types in the total land area.

The contribution rate of the utilization intensity of a single land type reflects the influence of a single land use type on the change of the comprehensive index of land use intensity.

$$R_i = \frac{I_{ib} - I_{ia}}{I_{ia}} = \frac{L_i \times (P_{ib} - P_{ia})}{L_i \times P_{ia}} \quad (2)$$

R_i is the contribution rate of the comprehensive index of land use intensity of class i in chengdu from year a to year b ; I_{ib} and I_{ia} are the land use intensity indexes of type i land use types in year b and year a in chengdu. P_{ib} and P_{ia} are the ratio of class i land use types to the total land area in year b and year a in chengdu. L_i represents the grade of land use intensity of class i land use types [5][6].

Table 1. Evaluation table of chengdu land use intensity grade.

	Unutilized stage	Light utilization grade	Low utilization level	Strong utilization level	Strong utilization level
Land use type	Unutilized land	waters	Woodland, grassland	Cultivated land and other agricultural land	Construction land
Intensity rating	1	2	3	4	5

Table 2. Comprehensive index of land use intensity in chengdu.

Year	Chengdu Land Use Intensity Composite Index (%)
2009	445.18
2010	444.24
2011	444.02
2012	441.08
2013	440.12
2014	448.2
2015	450.2
2016	451.02
2017	452.29
2018	453.87

Table 3. Chengdu land use area statistical unit: square kilometers.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
arable land	4285.53	4284.46	4109.54	4038.90	3894.18	3723.29	3598.27	3423.21	3376.29	3179.24
woodland	3533.51	3533.58	3549.15	3564.71	3580.28	3595.85	3611.41	3606.84	3602.26	4544.94
Grassland	659.43	659.31	649.57	639.83	630.09	620.35	610.61	610.42	610.24	674.09
waters	222.75	222.75	224.99	227.24	229.48	231.72	233.96	233.77	233.58	164.50
Construction land	1774.17	1774.16	1853.45	1932.75	2012.04	2091.33	2170.62	2285.11	2399.57	2050.42
Unutilized land	40.28	36.27	34.29	31.28	26.09	24.64	23.28	22.29	22.18	21.99

As can be seen from the table, the comprehensive index of land use intensity of chengdu fluctuates between 445 and 453, indicating that the city is in the transition from low to strong use, indicating that chengdu is in the development period of land use, and the potential of land development and use in the later period is still large. Land use intensity index of chengdu changes appear to fall after a rise in volatility, but since 2013, the overall

rise, and since 2016, rising amplitude increase, accelerating urbanization and industrialization process of chengdu, the land use intensity level to develop in the direction of higher level and later as the industrialization and urbanization speed, the intensity of land development and utilization of chengdu will continue to increase.

Table 4. Contribution Rate of Various Land Use Types to Comprehensive Land Use Index in Chengdu.

	arable land	woodland	Grassland	waters	Construction land	Unutilized land
Contribution Rate of Land Use Intensity (%)	-0.2570	0.2861	0.0226	-0.2611	0.1557	-0.4849

Can be seen from the table, in the 10 years from 2009 to 2018 of chengdu, arable land, water area, the contribution rate of unused land is negative, the value of construction land and forest land, meadow and is positive, but the general land use intensity index is rising, forest land and its contribution is the largest, the second is to use construction land, that land use structure is to the main direction of ecological priority, followed by the shift in the direction of construction land for the time.

Note that the contribution rate of unused land is large and negative, indicating that a large number of unused land is reclaimed for forestland and construction land, which also confirms that the land use structure of chengdu is developing towards green development, ecological priority and construction land.

3.2.2 Systematic evaluation of ecosystem service value in chengdu

(1) The construction of service value evaluation model of ecosystem. Based on existing studies, this paper defines the economic value equivalent of natural grain output of 1 hectare of farmland with national average yield in a year as 1, and the corresponding ecosystem services are farmland food production services^[7]. Furthermore, according to the contribution of other ecosystem services to farmland food production services, their respective equivalent factors were determined, and the scale of ecological service value per unit area of China's terrestrial ecosystem was drawn. On the basis of the above work, adjust the corresponding impact factors according to the actual situation of chengdu, and construct the value evaluation model of ecosystem services:

$$ESV = \sum (A_k \times VC_k \times S_k \times S_n) \quad (3)$$

ESV is the value of ecosystem services (yuan); A_k is the area of class k land use type (hm²); VC_k is the value coefficient, representing the service value per unit area of the land use type k (yuan /hm²); S_k is the adjustment coefficient of biomass factor, while S_n is the adjustment coefficient of social and economic factors calculated based on residents' willingness to pay and ability to pay^[8].

Value of food production service in farmland ecosystem per unit area. With reference to existing studies, the value of food production services in the farmland ecosystem was taken as equivalent 1, and then the value of other ecosystems was calculated based on the equivalent factor table^[9]:

$$E_n = (P \times Q_n / M_n) \times \frac{1}{7} \quad (4)$$

E_n is the economic value of food provided per unit area of farmland in chengdu; P is the average price of grain crops in year n in chengdu, and Q_n is the total output of all grain crops in chengdu in year n . M_n is the cultivated land area of chengdu in the NTH year. To eliminate the factors of price changes in each year, P is the average price of grain crops in 2017.

Biomass factor adjustment. Assuming a linear relationship between biomass and ecosystem service value, the biomass factor is adjusted by comparing the net primary productivity of vegetation in different regions.

$$S_k = \frac{NPP_s}{NPP_g} \quad (5)$$

NPP_s is the net primary productivity of vegetation in chengdu. NPP_g is the net primary productivity of national vegetation; S_k is the adjusting coefficient of biomass factor.

$$NPP = 3000[1 - e^{-0.0009695V - 20}] \quad (6)$$

$$V = \frac{1.05 Pre}{\sqrt{1 + (1 + 1.05 Pre / L)^2}} \quad (7)$$

$$L = 3000 + 25Tmp + 0.05Tmp^3 \quad (8)$$

NPP is the net primary productivity of vegetation in the study area. V is the actual annual evapotranspiration; Pre is annual precipitation; L is the average annual evapotranspiration; Tmp is the average annual temperature. $NPP_g = 376g/m^2$, $NPP_s = 663g/m^2$ in chengdu, and $S_k = 1.76$ in chengdu. According to the adjusted coefficient of biomass factor, the scale is as follows:

Table 5. Chengdu Ecological Service Value Scale Adjusted by Biomass Factors.

Primary type	Secondary type	arable land	woodland	Grassland	waters	Construction land	Unutilized land
Supply service	Food production	1	0.19	0.24	0.30	0.006	0.122
	Raw material production	0.22	1.69	0.20	0.20	0	0.10
Adjustment service	gas regulation	0.41	2.45	0.85	0.29	0	0.43
	Climate regulation	0.55	2.31	0.89	1.17	0	0.44
	Hydrological regulation	0.44	2.32	0.86	10.66	-4.27	0.43
	waste disposal	0.79	0.98	0.75	8.44	-1.40	0.375
Support services	Maintain soil	0.84	2.28	1.27	0.23	0.011	0.64
	Maintaining biodiversity	0.58	2.56	1.06	1.95	0.19	0.53
Cultural services	Provide aesthetic landscape	0.10	1.18	0.49	2.52	0.006	0.25
Total		4.93	15.96	6.61	25.76	-5.46	3.317

(3) Adjustment of socio-economic factors. Considering the influence of social and economic conditions on willingness to pay and ability to pay, the calculation model of adjustment coefficient of social and economic factors in chengdu is as follows:

$$S_n = P_n \times R_n \quad (9)$$

S_n is the adjustment coefficient of social and economic factors in the NTH year of chengdu, while P_n is the coefficient of willingness to pay of chengdu. R_n is chengdu's capacity to pay coefficient.

The calculation formula of willingness to pay coefficient is as follows:

$$P_n = \frac{W_{qn}}{W_{gn}} \quad (10)$$

$$W = \frac{2}{(1 + ae^{-bm})} \quad (11)$$

$$m = \frac{1}{EL_n} - 2.5 \quad (12)$$

$$EL_n = ELC_n \times Pec_n \times ELr_n \times Per_n \quad (13)$$

P_n is the willingness to pay coefficient of chengdu in n years; W_{qn} is the willingness to pay parameter of chengdu in year n; W_{gn} is the national average willingness to pay in n years; Parameter m is the coefficient of social development stage; b in chengdu is 1; EL_n is the total engel coefficient of the research area in the NTH year; ELC_n represents the rural engel coefficient of the study area; Pec_n is the proportion of rural population in the total population; ELr_n represents the engel coefficient of the cities in the study area; Per_n refers to the proportion of urban population in the total population.

Table 6. Calculation Results of Chengdu Willingness to Pay Coefficient.

	Chengdu Willingness to Pay Parameters	National Willingness to Pay Parameter	Chengdu Willingness to Pay Coefficient
2009	0.969	1.036	0.935
2010	1.005	1.032	0.974
2011	1.007	1.025	0.982
2012	0.994	0.914	1.087
2013	1.025	0.938	1.092
2014	1.039	0.893	1.116
2015	1.042	0.876	1.189
2016	1.057	0.760	1.390
2017	1.068	0.592	1.804
2018	1.063	0.542	1.961

The calculation formula of capacity to pay coefficient is as follows:

$$R_n = \frac{gdp_n / cpo_n}{GDP_n / NPO_n} \quad (14)$$

R_n represents the capacity to pay coefficient of chengdu in n years; cpo_n represents the total population of chengdu in n years; gdp_n represents the GDP of chengdu in n year ; GDP_n represents the total gross domestic product of the country in n years. NPO_n is the total population of the country in the NTH year.

Table 7. Calculation Results of Chengdu's Capacity to Pay Coefficient.

	Per capita GDP of Chengdu (yuan/person)	National GDP Per Capita (Yuan/Person)	Coefficient of capacity to pay
2009	20110.93	26179.54	0.768
2010	39208.82	30807.93	1.272
2011	39518.42	36301.56	1.088
2012	57609.83	39874.28	1.444
2013	63476.59	43684.39	1.453
2014	70611.37	47005.40	1.502
2015	74273.52	50027.93	1.484
2016	77470.47	53679.52	1.443
2017	87260.21	59200.61	1.473
2018	96033.67	64643.50	1.481

Table 8. Calculation Results of Adjustment Coefficient of Chengdu's Social and Economic Factors.

	Willingness to Pay Coefficient	Coefficient of capacity to pay	Adjustment coefficient of social and economic factors
2009	0.935	0.768	0.718
2010	0.974	1.272	1.238
2011	0.982	1.088	0.989
2012	1.087	1.444	1.569
2013	1.092	1.453	1.586
2014	1.116	1.502	1.676
2015	1.189	1.484	1.764
2016	1.390	1.443	2.005
2017	1.804	1.473	2.657
2018	1.961	1.481	2.902

Valuation of ecosystem services. According to the existing Chinese land ecosystem unit area ecosystem service value when scale, adjust the corresponding biomass factors and social economic factors, formulated in accordance with the actual situation of chengdu chengdu ecosystem ecological service value per unit area yield, then respectively the area multiplied by the value of the ecosystem when scale to calculate the unit value, finally it is concluded that the ecosystem service value.

$$ESV = \sum (A_k \times VC_k \times S_k \times S_n) \quad (15)$$

Table 9. Ecological Service Value per Unit Area of Chengdu Ecosystem..

Primary type	Secondary type	arable land	woodland	Grassland	waters	Construction land	Unutilized land
Supply service	Food production	1	0.33	0.43	0.53	0.01	0.215
	Raw material production	0.39	2.98	0.36	0.35	0	0.18
Adjustment service	gas regulation	0.72	4.32	1.5	0.51	0	0.75
	Climate regulation	0.97	4.07	1.56	2.06	0	0.78
	Hydrological regulation	0.77	4.09	1.52	18.77	-7.51	0.76
	waste disposal	1.39	1.72	1.32	14.85	-2.46	0.66
Support services	Maintain soil	1.47	4.02	2.24	0.41	0.02	1.12
	Maintaining biodiversity	1.02	4.51	1.87	3.43	0.34	0.935
Cultural services	Provide aesthetic landscape	0.17	2.08	0.87	4.44	0.01	0.435
Total		7.9	28.12	11.67	45.35	-9.59	5.835

Table 10. Total Value of Ecological Services of Various Land Types in Chengdu: RMB 10,000 Yuan.

Year	arable land	woodland	Grassland	waters	Construction land	Unutilized land	total
2009	9233.2	27036.8	2098.8	2754.9	-4640.2	64.1	36547.6
2010	15962.2	46859.9	3628.6	4763.9	-8023.8	99.8	63290.6
2011	12393.7	44115.4	2893.9	3895.1	-6785.5	76.4	56589.0
2012	19429.8	60733.4	4546.9	6275.1	-11286.8	111.1	79809.5
2013	18508.0	60568.9	4423.8	6260.9	-11608.4	91.6	78244.8
2014	18952.8	65207.6	4664.7	6771.1	-12922.9	92.6	82765.9
2015	19586.5	69972.5	4909.9	7310.6	-14342.9	93.6	87530.2
2016	19136.5	73561.1	5040.8	7501.8	-15506.9	92.0	89825.3
2017	25465.4	96710.5	6799.2	10113.4	-21970.5	123.6	116994.4
2018	27217.9	120000	8525.0	8084.4	-21309.1	139.0	185275.4

4 CONCLUSION AND DISCUSSION

4.1 Conclusion

Based on the analysis of the dynamic change of land use in Chengdu from 2009 to 2018, the estimation of ecosystem service value and the research results of the impact of land use change on ecosystem service value, we know that:

(1)From 2009 to 2018, the area of cultivated land, water area and unused land in the research area decreased significantly, and the area of construction land expanded rapidly, mainly through the occupation of cultivated land and unused land. A small part of water area was converted into woodland and grassland. The trend of land use change is that both the area and the proportion of land use change to different degrees. The transfer among various land use types has to some extent resulted in the reduction of land structure order degree, the deterioration of equilibrium degree and the instability of land use system.

(2)Chengdu's land use intensity is relatively high and continues to increase: with the acceleration of urbanization and industrialization in Chengdu, the intensity level of land use is developing to a higher level and will continue to increase. the contribution rate of

construction land is relatively large, which indicates that Chengdu's land use structure is developing towards a structure dominated by construction land.

(3)The change trend of each land type and the total value of ecosystem services in the region is basically the same, especially in the water area, cultivated land and unused land, and there is a big difference in the change speed of other lands. This shows that the change of ecosystem service value is not only related to the structure of land use, but also to the economic development, willingness to pay and ability of the whole society.

(4)The ecosystem service value of land use in Chengdu increased from 2009 to 2018, but the increase rate was lower and lower. Cultivated land and forest land contributed the most to the total increase of ecosystem service value, while the value of ecosystem service value of construction land was negative. There is a negative correlation between construction land and ecosystem service value. The growth of construction land should be properly controlled to ensure that the grassland and farmland are not reduced. It is extremely important to protect ecological land and take the road of ecological-economic sustainable development to promote green development.

4.2 discussion

The evaluation of ecosystem service value is affected by many factors. If different methods are adopted, the absolute value of ecosystem service value will vary greatly, but it will not affect its temporal and spatial variation law. Based on the research of Xie Gaodi and others, and based on the change of land use pattern in Chengdu from 2009 to 2018, this paper uses the equivalent factor method to analyze and evaluate the ecosystem service value of Chengdu in the past ten years. Although this method can reveal the evolution of temporal and spatial distribution pattern of ecosystem service value in Chengdu in the past ten years to a certain extent, there are still some deficiencies, which need further discussion and research.

(1) The internal structure of the ecosystem is relatively complex, and the service value of the ecosystem is affected by various factors. In this paper, in the process of evaluating the ecosystem service value of Chengdu, the biomass factor and social economic factor were adjusted according to the actual situation of Chengdu. The results obtained have certain reference significance. However, this study only analyzes the temporal and spatial evolution of ecological service value in the study area from the perspective of land use change, and lacks comprehensive consideration of other influencing factors. (2) This paper evaluates the ecosystem service value of various land use types in Chengdu by referring to relevant documents. By comparing the ecosystem service value of various land use types in ten years, it is concluded that the increase of construction land is an important reason that affects the slow growth of ecosystem service value in the study area. However, due to the complex ecological service function of construction land and limited data acquisition, it is difficult to define the scope and extent of its impact. This paper has not made an in-depth analysis of this problem, and there are still some shortcomings, which need to be further discussed in the future.

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