

# Effect of Land Use Change on Ecosystem Service Value in Dujiangyan City

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**Abstract:** In order to evaluate the impact of land use change on ecosystem service value in Dujiangyan City, through equivalent factor method, qualitative and quantitative analysis is carried out on the dynamic change of land use change and its caused ecosystem service value in Dujiangyan City from 2010 to 2016. The results show that: (1) Dujiangyan city land use changes a large extent, with the extension of construction land expansion as the main increase part, and at the cost of the reduction of arable land and grassland area. (2) Over the past 7 years, the total value of ecosystem services in Dujiangyan city followed a law of first rising and then falling, showing an overall rising trend, with a total increase of 19.2244 million yuan. (3) The accuracy of the ecological value coefficient of woodland and grassland will greatly affect the value assessment of ecosystem services in Dujiangyan city. (4) From the relationship between land use type and ecosystem service value, cultivated land and construction land are negatively correlated with ecosystem service value, on the contrary, forest land, grassland, water area and construction land are positively correlated with ecosystem service value. In general, the land use of Dujiangyan City did not cause obvious damage to the ecological environment, but also cannot ignore the impact of land use changes on the environment in the process of economic development. It is necessary to control the growth of construction land area, promote the conservation and rational development of Eco-tourism area in Dujiangyan City, maintain the stability of ecosystem services in Dujiangyan City, and realize the strategy of sustainable development of Social-Economic-Ecological benefits.

## 1 Introduction

Ecosystem services refer to all the benefits that mankind obtains from the ecosystem, including supply services, regulatory services, cultural services and support services [1]. Land use refers to a series of biological and technological means adopted by human beings to carry out long-term or periodic management, governance and transformation of land, according to the natural characteristics of land and for certain economic and social purposes [2]. Although land use will bring great economic benefits to human beings, the unreasonable artificial changes of land use and landscape pattern will greatly affect the value of ecosystem services. The sustainable development of man and nature will be threatened if man unilaterally pursues economic benefits and ignores the potential utility of ecosystem in the process of utilizing and transforming ecosystem. On the basis of Costanza et al. 's study, Chinese scholar Gaodi Xie et al. [3] obtained the scale of ecosystem service value in China, which is the basis for studying the value of land ecosystem service. Therefore, using the data of land use data in 2010 ~ 2016 Dujiangyan city, using the equivalent factor method, the dynamic change of land use and ecosystem services value in qualitative and

quantitative analysis, and reference and scientific basis for the decision of land use in Dujiangyan, help to promote ecological protection and reasonable development of the tourist area in Dujiangyan, maintain the stability of the Dujiangyan city ecosystem services, and realize the social, economic, ecological sustainable development strategy.

## 2 Research Area Profile

Dujiangyan city is located on the northwestern edge of the Chengdu plain, the Minjiang mountain pass, because of the world famous water conservancy project Dujiangyan and the Chinese Taoist birthplace of Mount Qingcheng has long been well-known; the city border east with Pengzhou, Pidu district, Wenjiang district, west and north with Wenchuan county, south of Chongzhou city; 48 kilometers from Chengdu. In 2018, the city covers an area of 1208 square kilometers; it has jurisdiction over 5 sub-district offices, 13 towns, 1 township, 1 economic development zone; the household registration population is 622200, the resident population is 696900, the urbanization rate is 60.2%; the birth population is 5965, the death toll is 4625, and the natural population growth rate was 2.09‰. Dujiangyan city is a

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city with a history of more than 2000 years, because of the weir, because of the water and prosperity of the city; in the Neolithic period is the ancient Shu ancestors live in the area, is one of the birthplaces of ancient Shu. Dujiangyan city this city to mountain, water, forest, weir, bridge integrated, fully reflect the city has water, water in the city, " irrigation city water color half city mountain "layout characteristics, this has a" worship water Dujiangyan, ask Qingcheng Mountain " reputation. May 8, 2007, Qingchengshan-Dujiangyan scenic spots were rated as the national AAAAA class tourist attractions. In 2012, the city's GDP exceeded 20.818 billion yuan. Dujiangyan City's 1996 GDP was 4.93 billion yuan, and by 2009 its GDP had reached 11.66 billion yuan. In 2012, Dujiangyan's gross regional product (GDP) was 20.818 billion yuan, up 13.6 percent from its 2011 GDP. Dujiangyan City achieved an increase of 2.199 billion yuan in the primary industry, 4.5 percent over 2011, and an increase of 7.617 billion yuan in the secondary industry, 17.8 percent over 2011. The three industries increased by 11.002 billion yuan, up 12.6 percent from 2011. The proportion of the first, second and third industries is 10.6:36.6:52.8, and the contribution rate of the three industries to economic growth is 3.6%,47.6% and 48.8%, respectively. The added value of the private economy in Dujiangyan City was 13.086 billion yuan, an increase of 16 percent over 2011.

### 3 Data and Methods

#### 3.1. Sources of data

The land-use data used are from the survey of land-use change statistics carried out by the Land and Resources Bureau of Dujiangyan City from the second national land survey in 2007. According to the national land use classification standard, combined with the geological and geomorphological characteristics of Dujiangyan City, the land use type of Dujiangyan City is divided into six first-class land types, such as cultivated land, woodland, grassland, water area, construction land and unused land. Socio-economic data for the period 2010-2016 are derived from the Chengdu Statistical Yearbook and the China Statistical Yearbook.

#### 3.2. Research Methods

##### 3.2.1. Land use change in Dujiangyan City

This paper uses land use dynamics to study the land use change in Dujiangyan City, the research period is 2010-2016. In order to study the quantitative changes of various land use types in Dujiangyan, K is set as the quantitative changes of certain land use dynamics in the study period in Dujiangyan City.  $U_a$  and  $U_b$  indicate the number of certain land use types at the beginning and end of the study period, then the land use dynamics of Dujiangyan City can be expressed as:

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

The formula can be intuitively reflected in the period 2010-2016, Dujiangyan City land use changes.

##### 3.2.2. Value Evaluation of Ecosystem Services in Dujiangyan City

(1) Modelling. In this paper, we will adopt the method based on the value equivalent factor per unit area, that is, the equivalent factor method [4] [5]. And the current equivalent factor method is a static method, which cannot reflect the dynamic change of ecosystem service value in time and space. Therefore, based on the equivalent factor method of Xie Gaodi et al, according to the preliminary investigation of the team and the collection of all kinds of literature and data, the equivalent factor correction was carried out to determine the corresponding ecosystem service value equivalent factor table in Dujiangyan City (Table 1), thus establishing the ecosystem service value evaluation model of Dujiangyan City. In this paper, the ecosystem service value (yuan) of Dujiangyan city is set as  $ESV$ ; the area of the k-type land use area ( $hm^2$ ) in Dujiangyan city is  $A_k$ ; the value coefficient (yuan/ $hm^2$ ) is  $VC_k$ , indicating the service value of the unit area of the k-type land use area in Dujiangyan city;  $S_k$  represents the biomass factor adjustment coefficient, and  $S_n$  represents the social economic factor adjustment coefficient based on the residents' willingness to pay and the ability to pay. Represents the following:

$$ESV = \sum (A_k \times VC_k \times S_k \times S_n) \quad (2)$$

##### (2) Equivalent Factor Correction

① Value of food production service per unit area of farmland ecosystem. The economic value of grain provided by  $E_n$  for per unit area of farmland in Dujiangyan City is set;  $P$  means the average price of grain crops in the nth year of Dujiangyan City,  $Q_n$  is the total yield of all grain crops in the nth year of Dujiangyan City;  $M_n$  is the cultivated land area in the nth year of Dujiangyan City, as follows:

$$E_n = (P \times Q_n / M_n) \times \frac{1}{7} \quad (3)$$

② Biomass factor. The adjustment of biomass factor in this paper assumes that the biomass of Dujiangyan city is linearly related to the value of ecosystem service. Set  $S_k$  to represent the biomass factor coefficient of Dujiangyan city,  $NPP_s$  to represent the net first sex productivity of vegetation in Dujiangyan city,  $NPP_g$  to indicate the net first sex productivity of vegetation in the whole country, then it is expressed as:

$$S_k = \frac{NPP_s}{NPP_g} \quad (4)$$

③ Socio-economic factors. The adjustment of the social and economic situation of Dujiangyan is mainly to consider the two factors of willingness to pay and ability to pay, set  $S_n$  as the n-year social and economic factor coefficient of Dujiangyan City,  $P_n$  as the willingness

coefficient of residents of Dujiangyan City, and  $R_n$  as the capacity coefficient of residents of Dujiangyan City.

$$S_n = P_n \times R_n \tag{5}$$

**Table 1.** Value Equivalent Scale of Ecological Service Unit Area in Dujiangyan City

Level 1 type	Type II	plough	forest land	meadow	waters	Construction land	Unused land
Supply services	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
Regulating services	gas regulation	0.72	4.32	1.5	0.51	0	0.75
	climatic 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
Support Services	waste disposal	1.39	1.72	1.32	14.85	-2.46	0.66
	Soil conservation	1.47	4.02	2.24	0.41	0.02	1.12
Cultural services	Maintenance of biodiversity	1.02	4.51	1.87	3.43	0.34	0.935
	Providing an aesthetic landscape	0.17	2.08	0.87	4.44	0.01	0.435
	amount to	7.9	28.12	11.67	45.35	-9.59	5.835

(3) Determine the value of ecosystem services in Dujiangyan City. From the above model, the value of ecosystem services in Dujiangyan City (Table 2) is obtained.

**Table 2.** Value of land-use ecosystem services in Dujiangyan City from 2010 to 2016

	plough	forest land	meadow	waters	Construction land	Unused land	total value
2010	2660.36	7609.98	604.76	793.98	-1337.3	16.63	10348.41
2011	2075.62	7352.56	482.31	973.77	-1130.91	12.73	9766.08
2012	3233.56	10122.23	757.81	1045.85	-1881.13	18.51	13296.83
2013	3084.66	10094.81	737.35	1043.48	-1934.73	15.26	13040.83
2014	3058.87	10367.93	677.45	1028.5	-2353.81	15.43	12894.37
2015	2864.42	10662.08	618.31	1118.43	-2690.48	15.62	12788.3
2016	2889.41	10260.16	640.13	1250.3	-2784.48	15.33	12270.85

Unit: 10,000 yuan

Overall, the total value of ecosystem services in Dujiangyan between 2010 and 2016 is more than 90 million yuan, and the trend is rising. According to the results, in the seven years from 2010 to 2016, the total value of ecosystem services in Dujiangyan City was the lowest in 2011, at 97.6608 million yuan, and 2012 was the year with the highest total value in the period, while after 2012, the total value showed a downward trend, which was due to the extension expansion of construction land in Dujiangyan City, which led to the decline of the total value of ecosystem services in Dujiangyan City. Therefore, The total value of ecosystem services in Dujiangyan City is a rule of rising before falling. In particular, the increase in woodland area from the perspective of land-use mode changes has contributed to a substantial increase in ecosystem service value of 26.5018 million yuan, while the value of ecosystem services has been slightly increased by 2.2905 million yuan, 353700 yuan and 4.5632 million yuan, respectively, from cultivated land, grassland and water areas.

### 3.2.3. Sensitivity and correlation analysis

Different types of land use will make the ecological value coefficient different. Therefore, to verify that the evaluation of ecosystem service function is correct, sensitivity index (CS) and correlation coefficient (r) are introduced to study the sensitivity and correlation of the total value of ecosystem services with the coefficient of ecological value in the process of land use change.

#### (1) Sensitivity analysis

The formula for calculating the sensitivity index is as follows:

$$CS = \frac{(ESV_b - ESV_a) / ESV_a}{(VC_{bi} - VC_{ai}) / VC_{ai}} \tag{6}$$

In the formula, CS is the sensitivity index, ESV, VC is the total value of ecological services and the coefficient of ecological value, a and b represent the initial and adjusted values, respectively, and i is some land use type [6] (i=1,2,...,6). CS means that the change of the ecological value coefficient by one percent will

cause the corresponding change of the total value of the ecological service. If  $CS > 1$ , the VC change will only cause fewer changes in the ESV, indicating that the result obtained is inaccurate and less credible. The greater the sensitivity, indicating that the accuracy of ecological value coefficient is more important to the evaluation of ecosystem service value [7].

(2) Correlation analysis

Correlation analysis starts with two or more variable factors and quantitatively analyzes the correlation degree

of the two variable factors [8]. The value of ecosystem service is related to the area of each local class, in order to judge its correlation degree, it can be analyzed by SPSS software. The value of  $r$  is in the range of  $(-1, 1)$ . when  $r > 0$ , it is called positive correlation; the larger the absolute value of the relation number  $r$  (closer to 1), the higher the degree of linear correlation between these variables; and vice versa; when  $r = 0$ , it is called zero correlation [8].

**Table 3.** Sensitivity index and correlation coefficient of Dujiangyan from 2010 to 2016

Land use type	Sensitivity index		Sensitivity index change value	Correlation coefficient
	2010	2016		
plough	0.0734	0.0714	0.0020	-0.757**
forest land	0.3143	0.3122	0.0021	0.826**
meadow	0.6379	0.6399	-0.0020	0.869**
waters	0.0694	0.0628	0.0066	0.807**
Construction land	0	0	0	-0.789*
Unused land	0.0147	0.0189	-0.0042	0.814**

Note: "\*" means significant difference at  $P < 0.05$  level; "\*\*" means significant difference at  $P < 0.01$  level.

From Table 3, it can be seen that the local class CS is less than 1, indicating that ESV is inelastic to VC. Judging from the sensitivity of land use type and ecosystem service value, the sensitivity index of woodland and grassland is large, among which the grassland is the largest, which indicates that the evaluation of ecosystem service value in Dujiangyan city requires higher accuracy of ecological value coefficient of woodland and grassland. From the relationship between land use type and ecosystem service value, cultivated land and construction land are negatively correlated with ecosystem service value. On the contrary, woodland, grassland, water area and unused land are positively correlated with ecosystem service value.

## 4 Conclusions and discussions

### 4.1. conclusion

Based on the analysis of land use dynamic change, ecosystem service value estimation and impact of land use on ecosystem service value change in Dujiangyan City from 2010 to 2016, we can see that:

(1) The change of land use in Dujiangyan city is large, the extension expansion of construction land is the main increasing part, the forest land is the second, the rest are reduced, which indicates that Dujiangyan city is in the stage of rapid urbanization and has the trend of the over-developing tourist area. The overall land use intensity is low, indicating that the potential benefits of land resources in Dujiangyan City have not been brought into full play, the land use efficiency still needs to be improved, and the land use mode needs to be changed. In addition, Dujiangyan City's land use comprehensive index shows a continuous rise, but the increase is small, with the rapid development of new urbanization and development requirements, urban and rural land use

mode is changing, land use potential, but its potential has not been realized effectively, it is necessary to further study the land use work, perfect the deficiency of the existing utilization mode, and realize the maximum utilization.

(2) During the seven years, the total value of ecosystem services in Dujiangyan city follows a law of rising first and then falling, but the overall trend is rising, with a total increase of 19.2244 million yuan, indicating that the ecological environment has not been damaged, and the potential of ecological value development is great. However, if we ignore the impact of the increase of construction land occupied part of the ecological land, it will pose a threat to the sustainable development of Dujiangyan City.

(3) Land use type will affect the ecological value coefficient, and the difference of the latter will affect the evaluation of ecosystem service value. The sensitivity analysis shows that the accuracy of ecological value coefficient of woodland and grassland will greatly affect the value evaluation of ecosystem services in Dujiangyan City.

(4) In general, the land use of Dujiangyan City does not cause obvious damage to the ecological environment, but also cannot ignore the impact of land use changes on the environment in the process of pursuing economic benefits. The economy of Dujiangyan City is mainly driven by the extension of construction land. In this process, Dujiangyan City needs to continue to change the land use mode, improve the social, economic and ecological efficiency of land use, strive to form a new pattern of urbanization, consider the impact of the increase of construction land area, promote the protection and rational development of the ecological tourism area of Dujiangyan City, maintain the stability of ecological services in Dujiangyan City, and realize the Social- Economic-Ecological benefits of the three sustainable development strategy.

## 4.2. Discuss

Based on the research of Xie Gaodi and others, this paper studies the ecosystem service value of Dujiangyan in the last seven years by using the equivalent factor method in view of the change of land use mode in Dujiangyan City from 2010 to 2016. Although this paper can expound the dynamic evolution of ecosystem service value in Dujiangyan City in the last seven years, there are still some shortcomings, which need to be further discussed and studied. In the process of evaluating the value of ecosystem service in Dujiangyan City, combined with the actual situation of Dujiangyan City, the biomass factor and the socio-economic factor were adjusted, and the results obtained have certain reference significance. Getting the ecology by calculation, the data of system service value is very intuitive, but it does not take into account the influence of other factors on the ecological service function, so there is a certain difference between the assessed data and the real value. At the same time, the research content of ecosystem services is single, which is too limited to the value evaluation of ecosystem services [9]. But the debate over whether value assessment is applicable to ecosystem services and how to represent the value of ecosystem services has continued. Research on the value of ecosystem services and products encourages policymakers to focus on what can be measured and quantified, especially in terms of money, but does not reflect social justice and environmental appeal service, natural assets, or the true value of human health [10]. But realistically, these real values are also difficult to measure, and the most rigorous way is to adjust the ecosystem service value scale for these factors to bring them closer to real value. In recent years, scholars have gradually recognized the limitations of the value quantity assessment method, so at present, ecosystem service assessment is more inclined to the material quality assessment method, such as the RUSLE model for assessing soil conservation services [11], the CASA model for net primary productivity [12]. In the future, more attention will be paid to the measurement of ecosystem services quality, taking ecosystem services into account oil Land use planning proposals.

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