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Evaluation on Land Use Planning Based on Ecosystem Services Value Change: A Case of Dujiangyan City

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Abstract
This paper aims at evaluating the implementation performance of the LUP of Dujiangyan city based on the total ESV change. The finding is that the total ESV increased only 192.76 million yuan over the period of the LUP implementation. The results show that the LUP achieve a good performance in maintaining ESV.

Key words: Land use change; Ecosystem services value; Dujiangyan city

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INTRODUCTION
There is a growing concern regarding evaluating on land use planning (LUP) in term of its failure to control urban sprawl in China. China has gained noteworthy achievements in social and economical domains since the reform and opening up policy was taken. The statistics from National Bureau of Statistics of China shows that GDP increased by 80 times over the period 1978-2009. And at the same time the urbanization rate increased from 17.92% to 48.34%. To some extent, the above-mentioned achievements are at the cost of environmental degradation, excessive farmland acquisition and land resources inefficiency use. LUP is to be made to change this situation every ten years. The LUP has played an important role in allocating land resources among different uses, but it seemed as if it was weak in protecting farmland. For instance, the data from Ministry of Land and Resources of China demonstrates that the farmland area decreased fiercely from 1.95 billion in 1996 to 1.83 billion in 2008. However, the built-up area in China increased from 21525 km^2 in 1999 to 40058km^2 in 2010; it almost increased by one time. This change not only causes the argument about Chinese food security but also leads to the concern Chinese ecological security seeing as farmland is of importance to either food security or ecological security. So, determining how to evaluate on the LUP is curial for maintaining sustainable land use and sustainable development for China.

Objectively speaking, there are several frameworks have been proposed to evaluate the LUP. For example, MA (2009) established the indictors of evaluating the LUP from economy, efficiency, effectiveness and equity 4 prospects based on the approach of Entropy. Yichun city was selected to example the evaluation result. It was found the LUP of Yichun city have a good performance over the period of 1996-2005. HE, *et al*. (2010) established a coordination degree model which integrated land intensive use degree, ecosystem services value and land use performance. Chengdu city was selected to test the availability of the model. The results showed that this model is available to evaluate the implementation performance of the LUP. TONG, *et al*. (2011) introduced the concept of performance evaluation into the evaluation on the LUP implementation. To realize this goal, they established the evaluation indicators based on analytic hierarchy process and fuzzy comprehensive evaluation. And Yilan county of Heilongjiang province was chosen to test its validity. The results shows that the LUP perform excellently over the period 1996-2010.

However, ESV has been always neglected in the process of evaluating the implementation performance of the LUP although land use poses a great effect to ecological system. Moreover, ESV has widely employed

into studying on land use or land cover change. So, chosen Dujiangyan city as an example, this study aims at evaluating implementation performance of the LUP by comparing the change of ESV before and after the implementation of LUP. This paper unfolds as follows: the next section introduces evaluation model and data collecting. The third section is the results and the last section concludes.

METHODOLOGY

Model

In term of the importance of ESV in policy decision, Costanza, *et al*. (1997) estimated the current economic value based on classifying the global biosphere into 16 ecosystem types and 17 service function (see Table 1).

Table 1
Ecosystem Services and Functions

Ecosystem services	Ecosystem function
Gas regulation	Regulation of atmospheric chemical composition.
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels
Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations
Water regulation	Regulation of hydrological flows.
Water supply	Storage and retention of water.
Erosion control and sediment retention	Retention of soil within an ecosystem
Soil formation	Soil formation processes
Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients
Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.
Pollination	Movement of floral gametes
Biological control	Trophic-dynamic regulations of populations
Refugia	Habitat for resident and transient populations
Food production	That portion of gross primary production extractable as food
Raw materials	That portion of gross primary production extractable as raw materials
Genetic resources	Sources of unique biological materials and products
Recreation	Providing opportunities for recreational activities
Cultural	Providing opportunities for non-commercial uses

In view of the approach of Costanza's evaluation of ESV, Xie *et al*. (2003) extracted the equivalent weight factor of ecosystem service per hectare of terrestrial ecosystems in China and modified the value coefficient of Chinese ecosystem based on surveying 200 Chinese ecologists. Xie's methods integrate ESV into Chinese reality, so it can be applied to different regions across China by localizing the average natural food production (see Table 2).

Table 2
Ecosystem Services Value Unit Area of Chinese Terrestrial Ecosystem

	Forest	Grassland	Cropland	Wet land	Water body	Barren land
Gas regulation	3.5	0.8	0.5	1.8	0	0
Climate regulation	2.7	0.9	0.89	17.1	0.46	0
Water supply	3.2	0.8	0.6	15.5	20.38	0.03
Soil formation and retention	3.9	1.95	1.46	1.71	0.01	0.02
Waste treatment	1.31	1.31	1.64	18.18	18.18	0.01
Biodiversity protection	3.26	1.09	0.71	2.5	2.49	0.34
Food produce	0.1	0.3	1	0.3	0.1	0.01
Raw material	2.6	0.05	0.1	0.07	0.01	0
Recreation and culture	1.28	0.04	0.01	5.55	4.34	0.01

XIE, *et al*. (2003) further definite the economic value of different types of ecosystem as 1/7 of the actual natural food production then proposed Chinese terrestrial ESV unit area of different ecosystem types (see Table 3).

Table 3
Ecosystem Services Value Unit Area of Chinese Terrestrial Ecosystem Unit: *yuan/ha*

	Forest	Grassland	Cropland	Wet land	Water body	Barren land
Gas regulation	3097.0	707.9	442.4	1592.7	0.0	0.0
Climate regulation	2389.1	796.4	787.5	15130.9	407.0	0.0
Water supply	2831.5	707.9	530.9	13715.2	18033.2	26.5
Soil formation and retention	3450.9	1725.5	1291.9	1513.1	8.8	17.7
Waste treatment	1159.2	1159.2	1451.2	16086.6	16086.6	8.8
Biodiversity protection	2884.6	964.5	628.2	2212.2	2203.3	300.8
Food produce	88.5	265.5	884.9	265.5	88.5	8.8
Raw material	2300.6	44.2	88.5	61.9	8.8	0.0
Recreation and culture	1132.6	35.4	8.8	4910.9	3840.2	8.8

Followed by the abovementioned methods, we can evaluate the LUP according to the change of the ESV. Suppose there are k types of land use, each type has f kinds of ecological function and the corresponding ESV coefficient is VC_{kf}, then the total ESV before and after implementation of the LUP can be calculated by the following equations:

$$ESV_k = \sum_f A_k^i \times VC_{kf} \ (i = 1,2) \quad (1)$$

$$ESV_f = \sum_k A_k^i \times VC_{kf} \ (i = 1,2) \quad (2)$$

$$ESV = \sum_k \sum_f A_k^i \times VC_{kf} \ (i = 1,2) \quad (3)$$

Where A_k^1 denotes the area for land use types k before the LUP implementation and A_k^2 denotes the area for land use types k after the LUP implementation. Finally, whether the LUP is feasible or not can be decided by the change of ESV. If the ESV after the implementation of LUP is greater than before the implementation of LUP, the LUP is feasible. Otherwise, it is not.

Data Collecting

On one hand, Dujiangyan city is famous for its scenery such as Qingcheng Mountain, Dujiangyan; On the other hand, Dujiangyan city experienced a big earthquake on May 12, 2008. It is vital to pose ecological function on land use. The implementation of the LUP should help to improve the ESV. So Dujiangyan city is chosen as an example. The data for the land use change is listed as Table 4.

Table 4
The Land Use Change in Dujiangyan City Unit: *ha*

	Before the LUP	**After the LUP**	**Change**
Cropland	39000.4	35997.3	-3003.1
Frost	58933.2	59001.1	67.9
Grassland	0	4920	4920
Wetland	145.5	162.6	17.1
Water body	2022.8	2024.9	2.1
Barren land	7019.7	2655.1	-4364.6
Construct land	13892.2	16082.8	2190.6

From Table 3, it seems that during the LUP implementation period, the barren land decreased the most, then the cropland. However, the construct land increased the most although it has zero ESV. And the change of the ESV before and after the implementation of the LUP could be obtained according the above equations.

RESULTS

By calculation employing the equations (1), (2) and (3), the total ESV change over the period of the implementation of the LUP of Dujiangyan city can be obtained. Table 5 lists the result of ESV change.

Table 5
The Total ESV Change over the Covered Period of Dujiangyan City Unit: *million yuan*

	Before the LUP	After the LUP	Change
Cropland	1647.76	1520.88	-126.88
Frost	24896.21	24924.89	28.68
Grassland	0.00	228.20	228.20
Wetland	506.30	565.80	59.50
Water body	3782.42	3786.35	3.93
Barren land	1.09	0.41	-0.68
Total	30833.78	31026.54	192.76

The results show that during the period of the implementation of the LUP of Dujiangyan city the total of ESV increased 192.76 million yuan. It demonstrates that the LUP achieve a good performance from the ESV change perspective. Different land use changes have different effect on the ESV. The cropland decreased from 39000.4 *ha* to 35997.3*ha,* which lead to the ESV decreased 126.88 million *yuan*. This is the main reason that gives rise to reduce of the ESV of Dujiangyan city over the period of the LUP implementation. Meanwhile the grassland increased 4920 *ha,* which cause to the ESV increased 228.20 million *yuan*. This is the main reason that brings out the rising of the ESV of Dujiangyan city over the period of the LUP implementation. However, the results also shows that the ESV change is small. So, the LUP should restraint the croplands, frost, grassland, wetland, water body and barren land from transforming into construct land in order to improve the function of the ecological system.

CONCLUSION AND DISCUSSION

The results show that the LUP achieve a good performance over the covered period but the local government should pose extra importance on the LUP because the rising is small. So, the policy implication is that: (1) LUP is a feasible tool to maintain the ecological functions by control the land use change; and (2) to satisfy the land demand for economical growth; the local government should take comprehensive measures such as economical, legal and administrative to encourage use the stock land. However, land use is a complicated process, which leads to ecological benefits, economical benefits and social benefits simultaneously. So, the further study should pay more attention to integrate the above benefits into evaluate the LUP implementation performance.

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