The Real Cost of Land Use Project

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Abstract

As we all know, biosphere provides a plenty of natural processes which is called ecosystem services functions to maintain humans' healthy and sustainable living environment. And humans inevitably have an impact on ecosystems when implementing land development projects, which has the potential to limit or remove ecosystem services. However, we generally neglect the environment impact of projects when we evaluate project costs. So in this paper, we take into account the environment costs to calculate the cost of land-use project.

Keywords

Environment services value, real cost, land use.

1. Introduction

Most of the serious ecological problems faced by countries are related to the use of land, because the change of land use has an important impact on global environmental change, so the environmental effects brought about by land use change are taken as one of the important research topics in the world in recent years. And the goal of "sustainable development" also is set out by the United Nations agenda 21st century, aimed to leading every country in the world to take corresponding measures to coordinate human resources, the environment, the economy and other aspects of coordinated development, so as to achieve sustainable development of mankind as a whole.

As we all know, biosphere provides a plenty of natural processes to maintain humans' healthy and sustainable living environment, such as turn CO_2 into O_2. However, when humans change ecosystems, it is possible for us to limit ecosystem services. And some small projects that seems trivial, such as building roads, sewers, bridges, houses or factories, but if add up to them and accompany with some big projects, they will have an impact on a region, country, even world.

Traditionally, most land-use projects don't take into count the impact on the ecosystem and the changes to it. With the further increase of urbanization, the development and utilization of land is becoming more and more frequent. If we just exploit land without the goal of "sustainable development", the problem of environment will get worse and worse. So how to stimulate the cost of land use development projects and how to consider environmental degradation in the cost of these projects has become a problem that needs to be addressed now.

So it's our job to build a model to stimulate the cost of land use with environmental degradation, and give advices to the developer.

2. Assumption

(1) The value of ecosystem services identified for different land types per unit area is reliable and will not change in recent years.

(2) The land-use of highway building is based on the parts of meadow, garden land, woodland and plow land and the proportion of land types to the area of highway building is similar to the proportion of land types to the nation's area.

(3) The value of ecological service in land after the construction of Expressway is zero.

3. Symbol Description

Table 1 All the symbols mentioned in the article indicate

Symbol	Meaning	Symbol	Meaning
EnC	Environmental cost	AtC	Atmospheric conditions
Fun	Funding(environment is not included)	ClC	Climate control
LaC	Real land cost	DiR	Disturbance control
ESV	Ecosystem services value	HuC	Humidity control
VC	Ecosystem services value of unit area	WaS	Water supply
FoS	Food supply	ErC	Erosion control
RaM	Raw material	SoF	Soil forming
GeR	Genetic resources	NuC	Nutrient cycle
Ent	Entertainment	WaT	Waste treatment
Cul	Culture	Pol	Pollination
A	Area	BiC	Biological control
ExL	The increase in highway length(kilometers)	Hab	Habitat

4. Model

Because any land-use planning affects environment, it's important to consider the value of ecosystem services for different types of land when calculating the real economic costs of land-use development projects [1], to classify ecosystem services functions into 17 categories in [1], and to quantify them as prices, forming the value of ecosystem services (ESV).

Because of the different functions of ecosystem services produced by different land types, Chinese scholars have calculated the value of ecosystem services in different types of land use units(VC) in China based on the methods provided in this article [1] combined with the actual situation in China in the [2].By multiplying the different types of land area by the value of ecosystem services corresponding to the unit area, the value of ecosystem services under a certain area of this type of land is obtained. And the result as follows:

$$ESV^i = VC^i \times A^i = (AtC^i + ClC^i + DiR^i + HuC^i + WaS^i + ErC^i + SoF^i + NuC^i + WaT^i + Pol^i + BiC^i + Hab^i + FoS^i + RaM^i + GeR^i + Ent^i + Cul^i) \times A^i \quad (1)$$ [3]

VC^imeans the VC of the type of land i. And the value of i equals P, G, W, M, and L. (P ,G, W, M are plow land,garden land, wood land, meadow and Land for residents and urban construction.)

Land use development projects is the transformation between land types, before and after the conversion of the land area unchanged, the value of ecosystem services of this land changes, so the environmental cost of land use development projects EnC is the reduction of the value of the land ecosystem services before and after the implementation of the project. The result as follows:

$$EnC = ESV^i - ESV^j \quad (2)$$

Based on the result [1], and the [2], accompany with the experts who are in the same field and our discussion, the Ecological value table of various land use Type unit area in China is finally obtained. The table as follows:

Table 2. Unit ecosystem service value of each land use type/Yuan $\cdot (\mathrm{hm}^2 \cdot \mathrm{a})^{-1}$

Land type	P	G	W	M	L
AtC	12.39	61.24	82.6	39.87	0
ClC	0	363.85	726.88	0.83	0
DiR	41.3	344.03	413	275.06	0
HuC	0	19.64	24.78	14.51	0

WaS	0	115.15	0	230.3	0
ErC	0	86.62	41.3	131.94	0
SoF	4.13	43.52	82.6	4.44	0
NuC	4.13	8.67	16.52	0.83	0
WaT	0	683.7	718.62	648.77	0
Pol	115.64	139.46	165.2	113.71	0
BiC	198.24	68.79	33.04	104.55	0
Hab	0	91.82	165.2	18.45	0
FoS	446.04	366.61	413	320.22	0
RaM	4.13	106.48	206.5	6.47	0
GeR	4.13	7.85	14.87	0.83	0
Ent	0	170.61	297.36	43.87	82.6
Cul	0	34.97	16.52	53.43	82.6
summation	210.63	1041.08	3417.99	2008.08	165.2

When we calculate the cost of project development, we should take the part of the value of ecosystem services that is transformed into account. The sum of real capital investment and environmental cost of different land types development projects is the real economic cost of land use planning. And the formula as following:

$$LaC = Fun + EnC \tag{3}$$

5. Solution

In order to illustrate the true economic costs of land development projects in large countries, we use the example of calculating the cost of building highways in China every year. We get China's increase in highway length (ExL) per year from 2013 to 2017, as well as China's arable land, garden, woodland, grassland and the residential land as a percentage of China's total land area from [4]. But as we all know, the residential land isn't used to build highway, so the data we gathered doesn't include. All data is included in Table 3.

Table 3. The proportion of type i land in total area

Year	$\boldsymbol{Pro^P}$	$\boldsymbol{Pro^G}$	$\boldsymbol{Pro^W}$	$\boldsymbol{Pro^M}$	$\boldsymbol{ExL}$**(km)**
2013	0.128	0.0124	0.2483	0.2754	8060
2014	0.128	0.0124	0.2483	0.2754	7394
2015	0.140625	0.014583	0.263542	0.228125	11265
2016	0.142435	0.015088	0.266934	0.231483	6745
2017	0.197136	0.020897	0.369575	0.32062	6796

As we all know, the standard length of highway lane in China is 3.75 meters wide, plus the emergency parking belt which is 2.5 meters wide and the central isolation zone which is 1 meter wide. If we consider that the way is 8-lane highway, so we can get the whole length is 36 meters easily. Other ancillary facilities (guardrails, etc.) can be counted at 40 meters. And we learn about the cost of building highway is range from 60 to 80 million per kilometre by looking for data [5] and asking experts. So the real money invested in building highways is:

$$max\ Fun = 8000 * ExL \tag{4}$$

$$min\ Fun = 6000 * ExL \tag{5}$$

Based on assumption (2), the area of the land type before building highway is:

$$A^i = Pro^i * ExL * 40 \quad (6)$$

Combined the formula (1) (2) (6) and assumption (3), we can get the environmental cost of highway building in China is:

$$EnC = \sum_i EnC^i = \sum_i (ESV^i - 0) = \sum_i VC^i \times A^i \quad , \quad i = P, G, W, M \quad (7)$$

And with the formula (3)(4)(5)(7), we obtain the range of the real cost of highway building in China:

$$[6000 * ExL \ + EnC, 8000 * ExL + EnC]$$

And the changeable trend of minimum total cost and maximum cost is described in the following Fig.1.

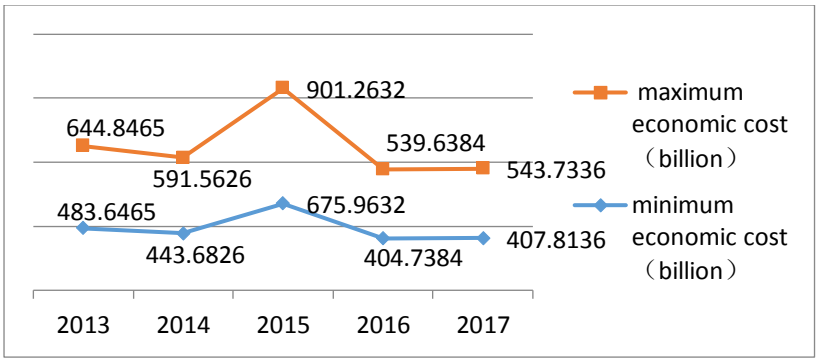

Fig.1 The trend of minimum total and maximum cost

6. Analysis

In order to analyze and evaluate the validity of the model, the relationship between the increase of expressway in China and the total economic cost is investigated. We gathered the data [4] of the increase of China's expressway every year from 2013 to 2017 as an independent variable, and the minimum and maximum total economic cost of the year calculated by our model as the dependent variable respectively. Because the total economic cost should be linearly related to the increase of expressway, we use MATLAB mathematical software to use linear model for least squares fitting of expressway increase and total economic cost. And we obtain:

$$min\ LaC = 0.015663620348664 + 0.060004122749584 * ExL \quad (7)$$

$$max\ LaC = 0.015663620350403 + 0.080004122749584 * ExL \quad (8)$$

The error squares calculated by using the linear model are: 1.43596e-04, 1.43596e-04.The error squares is smaller. The scatter points obtained by MATLAB drawing are roughly on the fitting line. This shows that the linear model constructed is authentic and reliable, and the model passes the test.

We get the information that the increase in the highway length in China in 2012 was 10600 kilometers. And the range of total LaC of building the highway in 2012 is between 636.059 and 848.059 billion yuan that calculated by using our formula (7) and (8). And China's total investment in building highways is 723.81 billion yuan. It also shows that using our model can calculate the total economic cost of building highways when knowing to increase the amount of highways in China for one year.

7. Conclusion

Through the large country project models that we have specifically enumerated, it is known that when land-use planning is carried out, real cost of different projects increase or decrease when

environmental costs are taken into account. And it is because the type of the land would change after the project planning. In the one hand, some projects have had a positive impact on ecosystems after planning, improving the original environment and increasing the service value of the region's ecosystems, so the LaC of the project will be reduced. On the other hand, some projects have had a negative impact on ecosystems after planning, and the original environment has become worse, reducing the service value of the region's ecosystems, so the real economic cost of the project will increase.

So, we suggest that the project planners and managers should take environmental costs into account and minimize the final real economic cost, rather than capital investment in the planning of land use. If every project is considered by this way, the damage on our environment will be greatly reduced. What's more, the Government should strongly support land development projects with negative environmental costs, which is beneficial to our ecological environment.

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