A Tale of Two Land - The True Economic Costs of Land Use Projects

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Abstract:Land use is an important part of the human-land system, which can provide huge ecosystem services. Land use changes also lead to changes in the value of ecosystem services. Considering primary production, maintaining carbon dioxide and oxygen balance, nutrient cycling, water conservation, soil erosion and other main services functions, this study establishes a land use ecosystem services value (ESV) estimation method based on the terrestrial ecosystem simulator (TESim) implemented for regional scales (TESim-R model) coupled with the Land Use and Land Cover Change (LUCC) model (the TES-LUC model). This ESV estimation model facilitates understanding the true economic costs of land use projects as it considers ecosystem services. This model can be utilized to calculate the ecosystem data of different types of land use by substituting in data of meteorology, vegetation, soil, and control attribute, and then evaluate the ESVs of land use according to different ecosystems. Following Constanza et al. (2007), this study classifies the ESV of an area into five categories: primary production, climate regulation, nutrient cycling, water conservation, and erosion control. Using the net primary productivity (NPP) output value simulated by the TES-LUC model as the basis, the ESVs of five categories can be calculated, respectively. The sum of the five ESVs yields the total ESV. This study introduces the model through the example of China. To test the model, two cost benefit analysis, one on a land use development project of a small community, and the other one on a large national project, are conducted. The effectiveness of the model is evaluated for both projects.

This study first investigates the "Grain-for-Green" Project in Long County, Sha'anxi Province, China based on the remote sensing image of the county and the data published by the local bureau of statistics from 2000 to 2015. Using the model, this study calculates and analyzes the change of ESV in Long County during the study period. The results demonstrate that the area of woodland, construction land, and grassland increased in different proportion, among which the area of grassland increased the most at 15.15%. The increase in land area mainly came from the decrease in farmland, the reduced area of which is up to 6,055.40hm2. During the study period, the total ESV increased by 1.670×107 yuan, an increase of 0.52%. This is mainly attributed to the increase in the ESV of woodland and grassland. However, due to the sharp decrease in the area of farmland and water body, the NPP and the nutrient cycling function of Long County were affected, exhibiting decreasing ESVs during the period. Therefore, based on the model and results, this study puts forward policy implications for land use projects from perspectives of water resources, land allocation, and sustainability.

The model is further tested by evaluating the environmental costs of a large national land use project, the "Rapid Urbanization" Project of Yangtze River Delta, which is in the Outline of China's National Land Planning. Using data of land use gathered from six terms of remote sensing image interpretation data of Resource and Environmental Science Data Center of the Chinese Academy of Sciences from 1990 to 2015, the results derived from the model find that rapid urbanization leaded to unbalanced transition among different types of land, which caused a significant loss of ESV. From 1990 to 2015, the ESV of Yangtze River Delta decreased from 171.701 billion yuan to 168.267 billion yuan. Moreover,

among five ESV components, the loss in the ESV of soil erosion was the highest, which decreased by 1.518 billion yuan due to the violent transformation between farmland and construction land. As a concluding remark, this study proposes a series of implications for large land use projects from the perspective of planning, implementation, and management.

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Introduction

Ecosystem services refer to the direct or indirect access to life support products and services through the structure, process, and function of the ecosystem per se(Costanza et al., 1997; Repetto, 1992). According to the classification of ecosystem services function proposed in previous research, the functions of ecosystem services can be classified into supply function, regulation function, life support function, cultural entertainment functionetc.(De Groot et al., 2002; De Groot, 2006). Among them, the functions that can be commercialized, such as providing food and industrial raw materials, are called direct value functions, while the functions that are difficult to commercialize, such as climate conditions and water conservation, are called indirect value functions. Although the indirect value of ecosystem services is not reflected in the national accounting system, their value may greatly exceed the direct value. Costanza et al. (1997) first carried out a systematic assessment of the value of global ecosystem services. They defined the evaluation principles and scientific significance of the ecosystem services value (ESV). Ever since then the study of ESV has become a hotspot in the study of ecosystem sustainability.

Land use change is an important aspect of research on human-earth system, and its role in the environment and ecology has been attached great importance to in the field of research on global environmental change. The ESV of land use is firstly manifested in that it is not only an important material basis for the development of agriculture and animal husbandry, but also it has important ecological functions such as biodiversity protection, water conservation, windbreak, and sand fixation (Chen et al., 2016). At the same time, land use is the most basic economic activity of human beings, and its continuous change will also cause changes in the structure and function of ecosystems, leading to changes in ESV (Haddad, 2015). Therefore, it is of great significance to study ESV under land use change.

A great deal of previous research pertains to the change of ESV driven by land use. One trend expounded the concept, connotation, and value evaluation method of ecosystem services. Another trend evaluated the ESV of various types of land, such as grassland and plateau. Xieet al.(2010) modified Constanza et al. (1997) and established an Equivalence Factor Table of Ecosystem Services Value in China by using expert scoring method. Thereafter, based on the Equivalence Factor Table of Ecosystem Services Value in China, evaluation of ESVs of landusechange in different research areas has been carried out in large quantities (Zhang, Li, and Xie,2010). In addition, based on remote sensing and GIS technology, researchonchanges in regional ESV under the background of land use and land cover change has gradually increased, and the ESVs of grassland, forest, and water body have been evaluated. These studies mainly focus on the static analysis of the ESV of a year, and rely on economic theory, but lack the analysis of the laws of the ecosystem per se. Quantitative studies on the intrinsic relationship between land use structure/pattern and the ESV are scanty. Because ecosystem services function is related to the structure and the process of ecosystem itself, and is easily affected by different regional geography and climate, it can be used to analyze the relationship between land use change, ecosystem structure, ecological process, and services function, which can further provide a relatively reliable ecological basis for the evaluation of ecosystem services function.

Based on the terrestrial ecosystem simulator (TESim) implemented for regional scales (TESim-R model) and Land Use and Land Cover Change (LUCC) model, this study presents a modeling framework, TES–LUC, which couples the TESim model and land use model (LUCC). This model helps to understand the true economic costs of land use projects when ecosystem services are considered. This model calculates the ecological process data of different land use modes by substituting in data of meteorology, vegetation, soil, and control attributesetc., and then evaluates the ESVs of land use according to different ecological types. The model is tested by performing a cost benefit analysis of land use development projects of a small community-based project and a large national project. The effectiveness of the model is also evaluated.

This study develops the evaluation method of ESV with the example of China. Afterwards the model is applied to investigate two land use projects in China. This study focuses on China for the following reason. First of all, China has the second largest economy in the world. Meanwhile, it has one of the richest biodiversity on earth. With the rapid development of its economy, a massive amount of land in China has been explored, which inevitably undermines the ecosystem services. Like China, a large number of developing countries are going through the same process, i.e., developing the economy at the sacrifice of ecosystem services. Therefore, China provides a good case in point of the impact of land use on ESV.

The remaining part of this study is organized as follows. Section 2 introduces the model of ESV evaluation. Section 3 is devoted to the cost benefit analysis of the "Grain-for-Green" project in Long County, Sha'anxi Province, China. Section 4 presents the cost benefit analysis of the "Rapid Urbanization" project in Yangtze River Delta, China.Section 5discusses the implications of the TES-LUC model onland use project planners and managers based on the evaluation of Section 3 and Section 4. How might the model need to change over time is also discussed.

Development of the ESI Evaluation Model

The Sample Data

Land use data are derived from the 1:4 million land use spatial distribution map issued by Institute of Geography and Resources, Chinese Academy of Sciences in 2012. In addition,the data of five years(2013-2017) are derived from the interpretation results of TM remote sensing images between 2013 and 2017. Land use data derived from land use spatial distribution map are corrected by land use data derived from TM remote sensing images by taking the geometric mean.

Meteorological and topographic data are derived from the 1:4 million digital map published by the Institute of Geographic Sciences, Chinese Academy of Sciences in 2012, and the 1:250,000 topographic elevation database compiled by the State Bureau of Surveying and Mapping of the People's Republic of China in 2015. Climate data are collected from meteorological stations of China Meteorological Administration. 348 stations are selected for the period from 2013 to 2017.

Statistical data are gathered from the National Statistical Yearbook and the Annual Forestry Statistical Yearbook from 2013 to 2017. Price data are gathered from China Statistical Yearbook and actual survey data.

The TES-LUC Model

The TES-LUC model includes several modules, such as land use dynamic process module, net primary productivity module, water movement module, soil erosion module, carbon and nitrogen cycling module. It is driven by meteorology, vegetation, soil, geospatial attributes and related physiological parameters of different vegetation. Using different input data, the ecosystem process data under different land use spatial patterns can be obtained. According to the actual situation of land use in China, using the actual meteorological data as the driving force, various spatial attributes, vegetation, soil, and other related parameters, as well as the initial values of relevant variables as input data, the TES-LUC model can be established. After several iterations of the model, four different stages of land use status in an area can be obtained. The simulation results of net primary productivity (NPP(x)), average soil erosion (E(x)), average soil water content (Q(x)), and average soil organic matter content (U(x)) at grid points, and the simulation results of regional average net primary productivity (NPP(x)), average soil erosion (E(x)), average soil water content (Q(x)) and, average soil organic matter content (U(x)) are obtained. After that, the value of each grid point and the whole ESV of an area can be calculated.

Evaluation Method of ESV

According to the classification method of Costanzaet al. (2007), taking into account of the geomorphological characteristics and vegetation and soil types of an area, the ESV of an areacan beclassified into five categories: primary production, climate regulation, nutrient cycling, water conservation, and erosion control. Using the net primary productivity (NPP) output value simulated by the TES-LUC modelas the basis, five categories of ESVcan be calculated, respectively. The evaluation methods of ESV of each category are as follows.

Net Primary Productivity

Net primary productivity (NPP) and biomass are two important indicators of the production of organic matters. Biomass reflects the storage of organic matters, while NPP reflects the quantity of organic matters produced in a certain period of time (such as one year). NPP simulated by the TES-LUC model is converted into the value of ecosystem primary production in an area according to the unit mass value of organic matters. The formula specification is as follows:

$$V_n = \sum\sum NPP(x) \times P_n(x), \quad (1)$$

in which V_n is the ESV of primary production, NPP(x) is the simulated mean of NPP in each grid, and $P_n(x)$ is the value of unit organic matters.

Climate Adjustment Value

When assessing the ecosystem services functions of fixed CO_2 and released O_2, according to the reaction function of photosynthesis and respiration, the amount of CO_2 required for each 1g of dry matter formation (generally 1.62g) and the amount of O_2 released (generally 1.2g) can be calculated. Then the functional value of CO_2 absorption is estimated by carbon tax method, and the functional value of O_2 release is estimated by industrial oxygen production method. The formula is:

$$V_r = \sum\sum 1.62 \times NPP(x) \times P_r, \quad (2)$$

$$V_o = \sum\sum 1.2 \times NPP(x) \times P_o, \quad (3)$$

in which NPP(x) is the NPP in each grid simulated by the TES-LUC model. P_r and P_o are the unit mass value of CO_2 in carbon tax method and the industrial oxygen price in industrial oxygen production method, respectively. The unit mass value of CO_2 is calculated by utilizing Swedish carbon tax rate of US\$0.15/kg (C), which is converted into the tax rate of absorbing CO_2 of US $\$3.36 \times 10^{-4}$ /g (CO_2), and the industrial oxygen price of O_2 is 4×10^{-4} yuan/g (O_2).

Nutrient Cycling Value

Vegetation in ecosystems can fix other nutrients in the process of growth. These nutrients are recycled through complex food webs and become an indispensable part of the global biogeochemical cycle (Gao et al., 2007). When assessing the role of ecosystems in nutrient cycling, the annual uptake of nitrogen, phosphorus, and potassium in ecosystems estimated based on the NPP simulated by the TES-LUC model. According to statistical data, the average price of nitrogen, phosphorus and potassium fertilizers is 400,350, and 350 yuan per ton, respectively, and the corresponding conversion rates of pure nitrogen, phosphorus and potassium are 79/14, 506/62, and 174/78, respectively. The formulas are as follows.

$$V_u = V_{un} + V_{up} + V_{uk} \quad (4)$$

$$V_{un} = \sum\sum NPP(x) \times R_{n1} \times R_{n2} \times P_n \quad (5)$$

$$V_{up} = \sum\sum NPP(x) \times R_{p1} \times R_{p2} \times P_p \quad (6)$$

$$V_{uk} = \sum\sum NPP(x) \times R_{k1} \times R_{k2} \times P_k \quad (7)$$

in which V_u is the nutrient value absorbed by regional ecosystem in a period of time. V_{un}, V_{up}, and $V_{uk}$are the value of nitrogen, phosphorus, and potassium absorbed, respectively. R_{n1}, R_{p1}, and R_{k1} are the distribution rates of nitrogen, phosphorus, and potassium in organic mattersin different ecosystems (Table 1). R_{n2}, R_{p2}, and R_{k2} are the proportion of pure nitrogen, pure phosphorus, and pure potassium converted into nitrogen, phosphorus, and potassium fertilizers, respectively.P_n, P_p, and $P_k$are the average prices of nitrogen, phosphorus, and potassium fertilizers in the area in a period of time.

Table 1 Nutrient Distribution Rate of Chinese Ecosystem ($g \cdot g^{-1}$)

Element	Woodland	Grassland	Farmland	Construction Land	UnusableLand	Water Body
Nitrogen	0.00418	0.013289	0.013288	0.013203	0.013273	0.004204
Phosphorus	0.00089	0.000093	0.000090	0.000087	0.000091	0.000901
Potassium	0.00181	0.008908	0.008915	0.008874	0.008909	0.001802

Water Conservation Value

Conservation of water resources is an important function of ecosystem. The indirect economic value of ecosystem for conservation of water resources can be evaluated by referring to the research methods of Li (2010). The TES-LUC model is used to simulate the vertical movement of water to obtain soil volumetric water content in different soil layers. Soil conservation water source is similar to reservoir water storage. Therefore, the value of conservation water source is estimated by the cost of building a reservoir with water requirement of 1t. According to the cost of construction cost, the average cost of building 1m^3 reservoir capacity in China is 0.67 yuan (He, 2010).

$$V_w = \sum\sum Q(x) \times P_w(x) \times S(x) \quad (8)$$

in which Q(x) is the soil water content simulated by the TES-LUC model, $P_w(x)$ is the cost of building unit storage capacity, and S(x) is the corresponding area.

Soil Erosion Value

According to the Soil Erosion Classification Criteria issued by the Ministry of Water Resources (Yang, 2009), soil erosion includes the value of reduced land loss area, reduced soil fertility loss, and reduced sediment deposition, which can be calculated by soil erosion and soil organic matters simulated by the TES-LUC model. The detailed process is as follows.

Land area reduction. Based on the amount of soil erosion and the average thickness of soil tillage layer, and taking the average thickness of soil tillage layer (0.3m) as the thickness of soil layer in China, the economic value of reduced land area is estimated by the opportunity cost method of land. The formula is

$$V_{ss}(x) = [E(x) + 0.3] \times OC(x) \quad (9)$$

in which $V_{ss}(x)$ is the value of land area loss reduced by each grid over a period of time, E(x) is the amount of soil erosion simulated by the TES-LUC model, and OC(x) is the opportunity cost of soil production (yuan/m^2). The values are determined according to different ecosystem types, as shown in Table 2.

Table 2 Opportunity Cost of Soil Production in Terrestrial Ecosystem of China (yuan/hm^2/year)

Ecosystem Types	Woodland	Grassland	Farmland	Construction Land	Unusable Land	Water Body
Opportunity Cost of Soil Production	160.30	335.00	2324.500	3819.8	2.08	6.94

Note: Based on the Statistical Data of China in 2017. The average value is reported.

Soil fertility loss. Maintaining soil fertility mainly includes reducing the loss of organic matters, nitrogen, phosphorus, and potassium, which are calculated by the following formulas:

$$\mathrm{Vfec(x)} = \mathrm{E(x)} \times \mathrm{U(x)} \times \mathrm{Pfc}, \quad (10)$$

$$\mathrm{Vfen(x)} = \mathrm{E(x)} \times \mathrm{N(x)} \times \mathrm{Pfn}, \quad (11)$$

$$\mathrm{Vfep(x)} = \mathrm{E(x)} \times \mathrm{Cp(x)} \times \mathrm{Pfp}, \quad (12)$$

$$\mathrm{Vfek(x)} = \mathrm{E(x)} \times \mathrm{Ck(x)} \times \mathrm{Pfk}, \quad (13)$$

$$\mathrm{Vfe(x)} = \mathrm{Vfec(x)} \times \mathrm{Vfen(x)} \times \mathrm{Vfep(x)} \times \mathrm{Vfek(x)}, \quad (14)$$

in whichVfec(x), Vfen(x), Vfep(x) and Vfek(x) are the functional values of reducing N, P, and K losses, respectively. E(x) is the soil erosion simulated by the TES model, U(x) is the organic matter content simulated by the TESim model, N(x), Cp(x), Ck(x) are the pure N fertilizer equivalent, P fertilizer equivalent and pure K fertilizer equivalent of soil. Pfc, Pfn,Pfp, and Pfk are the average prices of firewood, nitrogen, phosphorus and potassium fertilizers, respectively. The content of nitrogen, phosphorus, and potassium in soil are based on the average data of China. Table 3 lists the content of nutrient elements in soil.

Table 3 Content of Nutrient Elements in Soil (g/kg)

Type	Total Nitrogen	Total Phosphorus	Total Potassium
Cultivated Land	4.74	0.36	13.74
Grassland	4.56	0.42	14.42

Sediment deposition value. Usually, soil erosion will lead to the deposition of some sediment in reservoirs, rivers, lakes, and other places. It directly causes the decline of water storage requirements, which to some extent aggravates the occurrence of drought, flood, and other disasters. The value of this loss in ecosystem reduction can be calculated approximately on the basis of water storage costs:

$$V_{st}(x) = E(x) \times L_{tr}(x) \times P_{re}(x), \quad (15)$$

in which $V_{st}(x)$ is the value of ecosystem's reduced silt loss in a period of time. E(x) is the amount of soil erosion simulated by the TES model.$L_{tr}(x)$ is the proportion of sediment that causes siltation in the total amount of erosion.$P_{re}(x)$ is the average engineering cost of storage capacity.

Based on the above three factors, the value of soil erosion function can be obtained as follows:

$$U_{sr} = V_{ss} + V_{fe} + V_{st}. \quad (16)$$

Processing of Price Parameters

The price level has a significant upward trend during the simulation period of 2013-2017. Because the evaluation of ecological benefits involves the comparison of ESVs between different years, and according to the characteristics of regional ecological assets calculation, it is necessary to convert and discount the price variables of different years. In this study, GDP deflator is used to approximate the price data obtained in different years with 2010 as the monetary base year, so as to incorporate into a unified evaluation framework.

The model is tested by performing a cost benefit analysis of land use development projects of a small community-based project, i.e., the "Grain-for-Green" Project in Long County,and a large national project, i.e., the "Rapid Urbanization" Project in Yangtze River Delta. The model is also evaluated in terms of effectiveness.

Cost Benefit Analysis of the "Grain-for-Green" Project in Long County

Institutional Background

Long County is in Baoji City, Sha'anxi Province. Its longitude ranges from 106°26'E to 107°8'E, and its latitude ranges from 34°35'N to 35°6'N. The county has an altitude of 800.2m - 2,466m, and it has a sub-humid warm temperate continental monsoon climate with an average annual temperature of 10.7℃ and an average annual rainfall of 600.1mm. It lies on the Weibei arid plateau with a typical loess erosion landform and fragile ecological environment.

Long County is rich in biodiversity. It is the base of dairy farming of Sha'anxi Province. Since the 1990s, Long County has been actively engaged in the construction of economic zones. After more than 20 years of development, Long County's economic condition has significantly improved. However, some problems have also gradually begun to appear, such as severe destruction of forest and grass, deterioration of ecological environment, and aggravation of water loss and soil erosion. To change this situation, since 2000, Long County has been eagerly responding to the call of the country and intensively promoting the "Grain-for-Green" Project. It has made great achievements so far. The success of Long County is a classic example of the impact of dynamic changes in land use on ESV in China. Therefore, this study investigates the "Grain-for-Green" Project in Long County as the land use development project of a small community. It evaluates the impact of Long County's changes of land use on ESV in 2000, 2005, 2010 and 2015.

Changes in Land Use

The data are gathered from Landsat images and Statistics Bureau of Baoji. Through multiple processing of Landsat images with ENVI software, data of Long County's various land use area from 2000 to 2015 are obtained. Other relevant data are gathered from Baoji Statistical Yearbook andLong County Annual Economic Development Bulletin from 2000 to 2015. Table 4 summarizes the changes in land use of Long County in 2000-2015.

Table 4 Changes in Land Use of Long County in 2000—2015

	2000		2005		2010		2015	
Types	Area/hm2	Proportion/%	Area/hm2	Proportion/%	Area/hm2	Proportion/%	Area/hm2	Proportion/%
Grassland	27,565.70	12.2	30,569.00	13.53	31,725.30	14.04	31,749.00	14.05
Farmland	71,057.50	31.45	66,599.10	29.48	65,389.10	28.94	65,002.10	28.77
Construction Land	3,476.53	1.54	3,534.13	1.56	3,584.10	1.59	3,822.16	1.69
Woodland	########	54.4	########	55.03	########	55.09	########	55.15
Water Body	792.7	0.35	795.81	0.35	660.58	0.29	668.07	0.3

UnusableLand	126.79	0.06	110.16	0.05	97.92	0.04	93.69	0.04

As can be seen in Table 4, the structure of land use of Long County has changed significantly from 2000 to 2015.The change in farmland use exhibits a large and continuous decline. The reduced area is 6055.4hm2, a decrease of 8.50% and accounting for 2.68% of the total land area.The change in unusable land also exhibits a downward trend, decreasing by 33.10hm2 and accounting for 0.01% of the total land area. Changes in land use of woodland, construction land, and grassland all demonstratea continuous upward trend. The increase in grassland area is 4183.30 hm2, increasing by 15.18% and accounting for 1.85% of the total land area. Woodland area increases by 1,684.18hm2,an increase of 0.01% and accounting for 0.75% of the total land area. Construction land area increases by 345.63hm2, increasing by 9.95% and accounting for 0.15% of the total land area. The change in waterbody is relatively unstable, with an increase in the early stage, a decrease in the interim stage, and an increase again in the late stage.Water body area decreases by 124.62 hm2 in the study period. This is a decrease of 15.72%, accounting for 0.06% of the total land area.

Changes in ESV

Table 5 summarizes the ESVs of different land types in 2000-2015.

Table 5 ESV of various land types in 2000-2015

Types of Land	ESV/106 Yuan			
	2000	2005	2010	2015
Grassland	177.74	197.79	205.36	205.38
Farmland	439.78	411.18	403.53	400.94
Construction Land	52.70	52.83	52.90	53.14
Woodland	2465.34	2492.57	2495.64	2498.11
Water Body	33.70	33.83	28.05	28.37
UnusableLand	0.049	0.043	0.038	0.037
Total	3169.31	3188.24	3185.52	3185.98

As can be seen in Table 5,woodland has the largest increase in ESV, showing a continuous upward trend, with a total growth of 3.277×107 yuan. The largest growth was witness from 2000 to 204 with an increase of 2.720×107 yuan, accounting for 83.07% of the total growth of ESV ofwoodland.Farmland has the second highest ESV. However, the ESV of farmland has been in a decreasing trend during the 15 years, with a total decrease of 3.884×107 yuan. In the first 5 years alone, the decreasedESV accounts for 73.64% of the total decreasedESV of farmland.The ESV of grassland is lower than that of woodland and farmland. Nevertheless, it shows an upward trend, with a total increase of 2.764×107 yuan. In the first five years, ESVgrew the most, accounting for 72.54% of the total growth value of grassland. The ESV of construction land has an ordinary growth rate and experiences a total increase of 0.44×106 yuan. The area of waterbody accounts for only about 0.30% of the total area, and its ESV accounts for a small proportion of the total ESV, which is only about 1.00%. It decreases by 5.33×106 yuan during the study period.

Regardingthe total ESV, it increased rapidly in 2000-2005 and remained stable after that. This is mainly due to the fact that while pursuing rapid economic development through exploring land, most of increase in land use is concentrated in the first five years. After that, the area of land use decreased. Therefore, the change in land use is consistent with the change in ESV in the sample period.

The Impact of Changes in Land Use on ESV

Changes in land use have a significant impact on ESV. From 2000 to 2015, the total ESV increased by 1.670×107, an increase of 0.52%. This is due to the increase in woodland area and the decrease in farm land area. The ESV of per unit area by land type is ranked as water body >woodland > grassland > farmland. Although the area of waterbody has reduced, the reduction is very small. Therefore, the total ESV still increases. Table 6 summarizes the changes in ESV structure in 2000-2015.

Table 6 Changes in ESV Structure in 2000-2015

Types of Functions	ESV/106 Yuan			
	2000	2005	2010	2015
Net Primary Productivity	389.83	389.61	389.11	389.03
Climate Adjustment Value	843.31	850.02	851.09	851.33
Nutrient Cycling Value	304.64	303.18	300.65	300.36
Water Conservation Value	591.37	596.84	594.57	595.05
Soil Erosion Value	1040.16	1048.59	1050.1	1050.21
Total	3169.31	3188.24	3185.52	3185.98

As shown in Table 6, among five different ecosystem services, the ESVs of NPP and nutrient cycling decrease, and the ESVs of others increase. The reason is that the “Grain-for-Green” Project in Long County converted farmland into woodland and grassland. Figure 1 depicts changes in land use and ESV in 2000-2015.

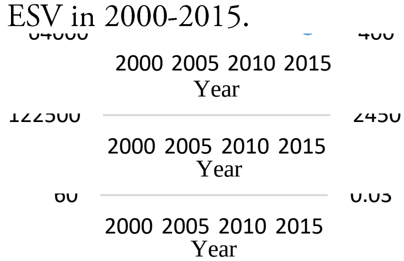

Figure 1 Changes in Land Use and ESV in 2000-2015

As can be seen in Figure 1, for each land use, the trend of land area (in orange) and ESV (in blue) over time is roughly the same. Compared with woodland, farmland has stronger productive capacity, higher content of nitrogen, phosphorus and potassium. Meanwhile, the decrease in farmland area is greater than the increase in woodland area. Thus, the ESVs of NPP and nutrient cycling decrease.

Evaluation of the Model

The model proposed in Section 2 is applied to assess the benefit and cost of the “Grain-for-Green” Project in Long County from 2000 to 2015 in terms of ESV.The purpose is to verify the effectiveness of the ESV evaluation model through evaluating the changes in ESV of the “Grain-for-Green” Project. The result demonstrates that in 2015, the total ESV of Long County is 3185.98×106 yuan, which includes both the benefit and the opportunity cost brought by the project. This study calculates the ESV of Long County by utilizing the coefficients of ESVof Constanza et al. (1997) modified by Xie (2010), as most existing research on Chinese regional ESV does.It calculates the ESV of Long County by the following formula:

$$\mathrm{ESV} = (A_k \times VC_{kf}) \quad , \quad (17)$$

in whichA_k is the area of land use type k, and VC_{kf} is the ESV coefficient of the ecosystem function onland use type k. Using the data on land area obtained frommultiple processing of Landsat images with ENVI software and the modified ESV coefficient by Xie (2010), the ESV of Long County is calculated to be3324.62×10^6 yuan, which is 4.35% higher than the ESV calculated by the modelproposed in Section 2. Hence, the model provides an effective estimation.

Besides, to further verify the effectiveness of the model, the calculated ESV is compared with the results of Xu (2017), which estimates the ESV of Baoji City by the conventional method, as most existing research on Chinese region does. The ESV of Long County isassumed to be proportional to the area of Baoji City. Using Engel coefficient, the ESV of a smaller area can be deduced by the following formula:

$$\frac{1}{E_n} = t + 3 \quad (18)$$

$$W_C = \frac{1}{1+e^{-t}} \quad (19)$$

$$ESV_{corrected} = ESV_{original} \times (1 - W_C) \quad (20)$$

in which$E_n$is the Engel Coefficient, and $W_C$is the willingness to pay for ecosystem. It can be calculated that$W_C$of Baoji City is 0.487. After correction, the ESVs of Baoji City and Long County are 1.06×10^6yuan and1.63×10^6yuan, respectively. The land area of Baoji City and Long County are shown in Table 7.

Table 7 Land Area and Proportion

	Land Area/km^2	Proportion /%
Baoji City	18116.93	100%
Long County	2657.75	14.67%

Long County occupies 14.67% of the land area of Baoji City. Hence,based on the proportion of land area, the estimated ESV of Long County can be calculated. The estimated ESV is 1.56×10^5 yuan, which is 4.5% lower than the ESV calculated by the model proposed in Section 2. Again, the model provides an effective estimation.

Summary

Thestructure of land use of Long County changed significantly from 2000 to 2015. The area of woodland, construction land, and grassland increased in different proportion, among which the area of grassland increased the most. The increase inland area mainly came from the decrease in farmland, whose reduced area is up to 6,055.40 hm2.In terms of ESV, woodland has the highest ESV, followed by farmland and grassland, while the ESVs of construction land, water body, and unusable land are lower. Due to the schedule of the project and the rapid exploration of land, the total ESV increased rapidly in the early stage, and then remained stable. Compared with the total ESV of 2000, the total ESV of 2015 increased by 1.670×107 yuan, an increase of 0.52%, which is mainly attributed to the increase in ESV of woodland and grassland.The result verifies the positive role that the “Grain-for-Green” Project has played in improving the local ecological environment.

Cost Benefit Analysis of the “Rapid Urbanization” Project in YRD

As a key area of China’s strategic development, the Yangtze River Delta is identified as the test field of the “Rapid Urbanization” Project in the Outline of National Land Planning. As a typical economically developed and densely populated area, the excessive urban construction and land use development has brought up degradation of ecosystem.How to coordinate the relationship between land use and ecological protection, effectively improve the ecosystem services function, and obtain the comprehensive benefits of land use has become a major issue for the construction of ecological civilization. Based on the remote sensing monitoring data of land use from 1990 to 2015, this section analyzes the process of land use transition and ESV in the “Rapid Urbanization” Project in Yangtze River Delta, in order to understand the costs and benefits of a large national project when ecosystem services are considered.

Institutional Background

The “Rapid Urbanization” Project in Yangtze River Delta involves 26 cities in three provinces and one autonomous city (Jiangsu Province, Zhejiang Province, Anhui Province, and Shanghai). Yangtze River Delta is located at longitude 32°34N’-29°20N’ and latitude 115°46E’-123°25E’. Itis the intersection of the “Belt and Road” and The

Yangtze River Economic Belt. As the most developed area of China, Yangtze River Delta plays a pivotal strategic position in the overall development of China's national modernization and all-round opening. Yangtze River Delta has exhibited a slowdown in economic growth in recent years. Since Yangtze River Delta can no longer sustain rapid economic growth by enhancing factors in conventional economic growth model, it resorts to enhancing factors in neoclassical economic growth model, with urbanization as the key driving force. The "Rapid Urbaization" Project has a special significance for sustainable development in China. Nevertheless, the "Rapid Urbanization" Project occupies ecological resources. Overload excavation and utilization of ecosystems inevitably damage the ecosystem services function.

Changes in Land Use

Spatial and Temporal Changes in Land Use

The data of land use aregathered from six terms of remote sensing image interpretation data of Resource and Environmental Science Data Center of the Chinese Academy of Sciencesfrom 1990 to 2015. The grid unit size is 1km×1km. Socioeconomic data are gathered from Jiangsu Statistical Yearbook, Zhejiang Statistical Yearbook, Anhui Statistical Yearbook, Shanghai Statistical Yearbook, and China Agricultural Product Price Survey Yearbook. According to the land use coverage classification system of the Chinese Academy of Sciences, land use types can be classified into six categories: farmland, woodland, grassland, water body, construction land and unusable land. Ecosystem types are classified into farmland ecosystem, woodland ecosystem, grassland ecosystem, construction ecosystem, water body ecosystem, and unusable land ecosystem.

The impact of the "Rapid Urbanization" Projectin the Yangtze River Delta on land use from 1990 to 2015 has significant characteristics of temporal variation. In terms of the number of changes, the decrease in farmland area, woodland area, and grassland area was 9.83%, 0.77%, and 2.71%, respectively. While the increase in water body area, construction land area, and unusable land area was 4.23%, 87.81%, and 34.65%, respectively. Among them, the deceleration of farmland from 1995 to 2000 was slower than that in other periods, but the scale of reduction was still huge, with a net decrease of 857.00km^2. The scale of construction land continued to expand, with a net increase of 11168.07km^2 in 25 years, mainly occupying the farmland around cities and towns. Both the area of woodland and grassland increased from 1990 to 1995, and monotonously decreased after 1995. Besides, both the area of water body and unusable land decreased first and then increased. The decrease in 1990 and 1995 was 0.59% and 30.95%, respectively.Due to the fact that the area of unusable land is small in the first place, the area change was minimal. Nevertheless, the change rate of unusable land was very large.

From 1990 to 2015, the "Rapid Urbanization" Project in Yangtze River Delta has brought up intensive transformationamong different types of land. Up to 28.16% of the farmland was transformed, mainly into construction land, woodland, and water body, which were 16,800.86km^2, 9,333.34km^2, and 4,664.80km^2, respectively.The transformation mainly occurred in Taihu Basin. Meanwhile, 23.09% of woodland, 33.99% of water body, and64.05% of construction land were transformed,mainly into farmland. The transformation of woodland into farmland mainly occurred in the mountainous areas of Anhui Province and the hilly areas of East Zhejiang Province and West Zhejiang Province. The transformation of water bodyinto farmland mainly occurred around rivers and lakes, such as the Yangtze River, Taihu Lake and Chaohu Lake. The transformation of construction land into farmland mainly occurred in the Chaohu Basin and Taihu Basin. Grassland and unusable land are mainly transformed into woodland and farmland. Table 8 provides a detailed summary of transformations and changes in land use in Yangtze River Delta from

1990 to 2015. The transformation and changes are presented in the form of a matrix, in which different types of land transformed from and into.

Table8 Transformations and Changes in Land Use in Yangtze River Delta from 1990 to 2015 (km^2)

	Land Use Types	2015						
		Grassland	Construction Land	Farmland	Woodland	Water Body	Unusable Land	Total
1990	Grassland	3362.7	257.96	1539.32	2177.05	395.33	2.5	7734.86
	Construction Land	103.52	4572.69	6977.14	544.64	516.6	3.23	12717.82
	Farmland	1349.72	16800.86	82067.76	9333.34	4664.8	23.63	114240.11
	Woodland	2365.45	1284.94	8813.96	43672.34	630.27	15.14	56782.1
	Water Body	342.92	966.94	3605.51	598.31	10727.39	8.98	16250.05
	Unusable Land	1.29	2.5	11.5	21.21	2.68	2.09	41.27
	Total	7525.6	23885.89	103015.2	56346.89	16937.07	55.57	207766.21

Transition Pattern of Land Use

The mutual transformation betweenfarmland and construction land, and farmland and woodland,is an important pattern of changes in land use, with the importance index being 66.17%. The rapid urbanization of Yangtze River Delta attracts people and capital to gather swiftly. The construction land took up a large amount of farmland as urban area was excessively expanding to the suburb, resulting in a loss of farmland by 16800.86km^2. Thishappenedin the initial period of rapid urbanization from 1990 to 1995. The area of construction land was as high as 11081.19km^2, especially in Jiangsu Province, which accounts for 44.84% of the total land area. From 1995 to 2000, the speed of urban expansion was slightly slower, but thespeed in South Jiangsu Province, Central Zhejiang Province, and Anhui Province was still fast. After 2000, Yangtze River Delta entered a new stage of urbanization, and the number of new construction projects increased sharply. During the period, due to the policy of increasing the land use for urban construction and decreasing the land use for rural construction, a large amount of rural residential area was reclaimed and transformed into farmland. This phenomenon was particularly prevalent in Jiangsu Province and Anhui Province, in which 2503.23km^2 and 2542.99km^2 of land were transformed, respectively.

The mutual transformation between farmland and woodland mainly occurred in the south of Yangtze River Delta, which is consistent with the topographical distribution of woodland. Because of the topographical conditions, some hillsides with poor water conditions were transformed into woodland, and agricultural structure was adjusted accordingly. For example, land for food crops were transformed into land for economic crops. From 1990 to 1995 and from 1995 to 2000, 9413.66km^2 and 7692.25km^2 of farmland was transformed into woodland, respectively. At the same time, deforestation and reclamation were also common. From 1990 to 1995 and from 1995 to 2000, there were 8784.02$km^2$and 8009.45km^2 of woodland that was transformed into farmland, respectively, mainly in Zhejiang Province and Anhui Province. After 2000, the land use policies on farmland and woodland changed, and the mutual transformation among different types of land became extremely smooth. Only 73km^2 of farmland were transformed into woodland, and 72 km^2 of woodland were transformed into farmland, mainly in Zhejiang Province. Table 9 summarizes the important index of changes in land use in Yangtze River Delta from 1990 to 2015.

Table 9 Importance Index of Changes in Land Usein Yangtze River Delta from 1990to 2015

Types of Changes in Land Use	Area of Change/km^2	Importance Index/%
Farmland – Construction Land	16,800.86	26.52
Construction Land – Farmland	6,977.14	11.01
Farmland – Woodland	9,333.34	14.73
Woodland – Farmland	8,813.96	13.91
Farmland – Water Body	4,644.8	7.36
Water Body – Farmland	3,605.51	5.69
Cumulative	50,195.61	79.22
Other Types	13,165.6	20.78
Total	63,361.21	100

The Impact of Changes in Land Use on ESV

Distribution of ESV and Changes

The ESV of Yangtze River Delta has generally declined over the past 25 years, from 171.07 billion yuan in 1990 to 168.267 billion yuan in 2015. Table 10 summarizes ESV of Yangtze River Delta.

Table 10 ESV of Yangtze River Delta (10^8 Yuan)

Types	1990	1995	2000	2005	2010	2015
Farmland	459.56	448.78	445.34	432.02	422.83	414.61
Woodland	818.75	826.19	820.29	817.42	815.68	812.37
Grassland	74.13	74.86	69.74	63.38	61.78	60.11
Water Body	329.39	325.25	339.99	354.31	357.19	357.15
Construction Land	35.15	36.56	36.77	37.2	38.32	38.39
Unusable Land	0.03	0.02	0.02	0.02	0.02	0.04
Total	1,717.01	1,711.66	1,712.15	1,704.35	1,695.82	1,682.67

As can be seen in Table 10, from the perspective of composition, the ESVs of woodland, farmland, and water body are the mainstay of the total ESV. The sum of contribution rates reached 94.14% in 2015.

From 1990 to 1995, the ESV of Yangtze River Delta decreased by 535 million yuan, with a change rate of -0.31%. The decrease is mainly caused by the reduced ESVof farmland. From 1995 to 2000, the ESV of Yangtze River Delta increased by 49 million yuan, with a change rate of 0.03%. Compared with 1990-1995, the deceleration of farmland ecosystem services has slowed down. From 2000 to 2015, the change rate ofESV of Yangtze River Delta was -1.72%. The change rate of ESV of farmland, woodland, and grassland were all negative. Although the change rate of ESV of unusable land was 100.00%, it made the least contribution to ESV.

Changes in ESV Components in 1990-2015

As mentioned in previous sections, this study choosesfivecomponents to evaluate ESV, i.e.,net primary productivity, climate adjustment value, nutrient cycling value, water conservation value, and soil erosion value. Table 11 summarizes changes in ESV components of Yangtze River Delta.

Table 11 Changes in ESV Components of Yangtze River Delta (10^8 Yuan)

ESV Components	1990	1995	2000	2005	2010	2015	1990-2015
Net Primary Productivity	187.45	186.45	185.27	182.78	181	179.16	-8.29
Climate Adjustment Value	392.46	391.79	388.99	384.38	382.15	378.92	-13.54
Nutrient Cycling Value	260.34	258.27	261.03	261.7	260.73	258.59	-1.75
Water Conservation Value	432.65	432.23	436.47	439.67	439.33	437.07	4.42
Soil Erosion Value	444.11	442.92	440.39	435.82	432.61	428.93	-15.18
Total	1,717.01	1,711.66	1,712.15	1,704.35	1,695.82	1,682.67	-34.34

As can be seen in Table 11, the results show that almost all ESVcomponents decreased from 1990 to 2015, except water conservation value, because the area of water was increasing due to the development of aquaculture. The change in soil erosion value was the largest, which decreased by 1.518 billion yuan because of the continuous decline in farmland area.

Evaluation of the Model

The model proposed in Section 2 is again compared with another study which adopted the method of Constanzaet al. (1997), in which the coefficients of ESV are modified by Xie (2010) for better estimation of ESV in China.In order to evaluate the effectiveness of the model,the ESV of Yangtze River Deltais compared with the result of the latest research on the ESV of Yangtze River Delta based on the conventional method. Liu, Zhang, and Zhang(2014) found that the ESVof Yangtze River Delta in 1980, 2005, and 2010 was 420.99, 415.31, and 402.47 (10^8 yuan), respectively. This translates into a finding that the ESVof Yangtze River Delta decreased by 4.40% from 1980 to 2010. However, the ESVsof Yangtze River Delta in 2005 and 2010 calculated in Section 4.3.1are 1,704.35 and 1695.82 (10^8 yuan), respectively. The difference between these two results is mainly due to different research areas and research methods. Liu, Zhang, and Zhang(2014) only investigated 16 cities in two provinces(Jiangsu Province andZhejiang Province) and one autonomous city (Shanghai), while this section investigated 26 cities in three provinces (Jiangsu Province, Zhejiang Province, and Anhui Province) and one autonomous city (Shanghai). Thus, the extra areacontributes a lot to the total ESV. In addition, Liu, Zhang, and Zhang(2014) measured ESV based on Constanza's method, which usually treats the ESV of construction land as 0, while the model proposed in this studytakes into account ofthe ESV of construction land. Therefore,calculating the ESV of Yangtze River Delta using the model proposed in this study gets a higher ESV. Based on the different ESVsof 2005 and 2010 in two studies, it can be found that the adjustment rate is about 4.2%. Consequently, the ESV of 1980 can be estimated to be 1,768.158 (10^8yuan). Therefore, the change rate of ESV from 1980 to 2010 calculated using the model proposed in this study is 4.09%, which is similar to 4.40%. Therefore, the model provides an effective estimation for a large project.

Summary

During the study period, the spatial and temporal pattern of land use in Yangtze River Delta changed significantly. The area of farmland showed a trend of "rapid decrease–slow decrease–rapid decrease". Farmland was mainly transformed into construction land, woodland and water body, especially in Taihu Basin. The area of construction land showed a trend of "rapid increase—slow increase—rapid increase". Construction land was mainly transformed from farmland, woodland and water body. The area of woodland increased first and then decreased. It was mainly transformed into farmland. The transformation of woodland mainly occurred in the mountainous areas of Anhui Province and the hilly areas of East Zhejiang Province and West Zhejiang Province. The area of water body decreased first and then increased. Water body was mainly transformed from farmland.

The ESV of Yangtze River Delta during the study period was generally on a downward trend. Except from 1995 to 2000, the ESV increased slightly, while it decreased in all other periods. Especially after 2000, the decline rate ofESV gradually accelerated. From 1990 to 2015, the ESV of Yangtze River Delta decreased by 3.434 billion yuan in total. The unbalanced mutual transformation among different types of land, for example, farmland, construction land, and woodland, was the main driving force of the decline in ESV, which reflected the conflict among urban construction, agriculture production, and ecological spatial structure.

Implications

Using the model proposed in this study, land use project planners and managers can easily calculate the true economic costs of the land use project. Thus, they can better plan and evaluate potential projects. However, they should also pay attention to the external costs that may come together with the benefits, and consider rational resource distribution of their projects so as to achieve sustainable ecological construction. Therefore, this study puts forward policy implications for land use projects based on the modelling and the results of the two cases analyzed above.

Implications for Small Land Use Projects

Taking into account of the opportunity cost of the land use project, the model proposed in this study cancalculate the true economic cost of land use projects. Hence, land use project planners and managers should pay more attention to the ecological costs of land use and the sustainability of projects. Taking the "Grain-for-Green" Project in Long County as an example, land use planners and managers are suggestedconsidering the following issues.

Water Resources Carry Capacity of Ecological Environment

The continuous increase in vegetation coverage affects the carrying capacity of water resources of the conceded land (Feng et al., 2003). Since the launch of the "Grain-for-Green"Project in Long County, the area of farmland has decreased and the area of woodland has increased. The increase in vegetation coverage creates greater demand for water resources, thus affecting the carrying capacity of water resources of the whole region. Competition among plants for water resources directly affect their growth, and adversely affect vegetation diversity (Cao, Chen, and Yu, 2009).Therefore, land use planners and managers should consider sustainable utilization of water resources, and do a thoroughinvestigation on the aquatic environment. Then, combined with the local water conservancy projects, land use planners and managers are suggested utilizing water resources rationally. Specific measures include:

Vigorously promote hightechnology and efficiently use the land and precipitation such as collecting rainwaterfor irrigation.

Increase the efficiency of utilizing groundwater and plant vegetation with high water carryingcapacity, such as sea-buckthorn, poplar, locust etc.(Sun, Yang, and Tuo, 2005).

When conceding farmland to woodland, the natural succession of vegetation should be encouraged (Tian and Liu, 2004), and appropriate intervention is needed when necessary. That is because natural forests have more advantages in spatial structure, biodiversity richness, and self-regulation ability. They have less impact on soil moisture status and therefore turn out to be more sustainable (Xu, 2001).

Rational Allocation of Land Resources

The "Grain-for-Green" Project has some impact on the food safety of Long County. In the early stage of the project, farmland with a slope greater than 25° was the main target of conceding, accounting for 27.82% of the total farmland in Long County with a total area of 0.985 million hm2 (Chen et al., 2015). However, by 2008, a total of 1.167 million hm2 of sloping farmland had been conceded and converted to woodland, largely exceeding the expectation. Due to the sharp decline in the area offarmland, the total amount of grain output reducedsignificantly.

Although a great deal of existing research argues that returning land for farming to forestry brings more ecological benefits than negative costs (Wang et al., 2013; Liu, 2015),based on the current situation of the continuously decreasing farmland in Long County, land use planners and managers are suggested optimizing the allocation of land resources and understanding the benefits and costs of land use from multiple perspectives. From the view of production efficiency, they can pursue technological improvements and advanced farming techniques, thereby increasing food production (Zhang, 2002). Moreover, they can improve soil quality and land productivity through rational fertilization (Tian and Liu, 2004). From the view of land use structure, all types of land use should be reasonably planned based on ecological values and economic values.Blind returning land for farming to forestry is discouraged. By implementing the policies proposed above can land use planners and managers promote a balanced development of ecology and agriculture.

Sustainability

Although the"Grain-for-Green" Project has made remarkable achievements, it lacks a detailed and long-term plan for future goals. Due to the lack of previous practical experience, the project has brought up a series of problems. For example, the substantial decrease in farmland area caused by blind conceding farmland and the large man-made forest are not conducive to the restoration of natural vegetation. What is more, unfair economic subsidy policy made reclamation frequently occur.

Land use project planners and managers can attempt to solve these problems from a policy perspective. On one side, they should provide more support for the project. They can increase the budget and expenditure on the project, and encourage farmers to develop alternative industries. On the other side, they should improve relevant policies and regulations, which is the basis of ensuringa smooth progress of the project. Strict laws and regulations can guarantee the efficiency of utilizing funds, truly benefiting project participants, thus enhancing the mutual trust between people and the government.

Implications for Large Land Use Projects

The model proposed in this studyshows that the excessive land use development, such as the "Rapid Urbanization" Project in Yangtze River Delta, often leads to frequent transformations among different types of land, for example, the mutual transformation between farmland and construction land, which causes reduction in ESV. Based on the empirical findings,this study proposes the following implications for large land use projects.

First and foremost, in terms of planning a large land use project, planners should first consider the strategies and actual conditions of the target areas. Then, select the most appropriate land development methodsaccording to the characteristics of land, adjust the land use structure, and improve the land allocation efficiency and rationality, in order to achieve sustainable development of economy, society, and ecology (Food and Agriculture Organization, 1993). To be specific, urban areas are the main places where non-agricultural population reside. Urban area should first fulfill the needs of various activities of people. Land use projects in urban area should consider the strategy of development and potential of the city, control the expansion of construction land, and maintain a dynamic balance between construction land and farmland. Besides, saving existing urban construction land and old city reconstruction and unusable land canhelp increase urban land use rate and realize a reasonable urban land use structure.For rural area, large land use projects mainly focuson farmland. Land use planners should keep the quantity, quality, and safety of farmland by scientific methods and strict procedures. For ecological protection area, land use projects must protect biodiversity, special natural landscape, and ecological resources.

Besides, in terms of implementing a large land use project, land use project managers should strictly carry out land use regulation and control transformations among different types of land, which can ensure farmland safety and food supply security, and meet the demand of construction projects at the same time. Besides, complying with land use regulations can also protect the public interest from infringement and achieve sustainable use of land resources. In addition, it is essential to build an information system when implementing a large land use project because it can help control the progress of the project, reduce ongoing costs, and improve working efficiency.

Moreover, in terms of managing a large land use project, land use project managers should improve the financial management system of land use projects, which can ensure the liquidity and adequacy of funds, and realize rational utilization and effective supervision. Besides, clarifying the rights and duties of the government and investors can form a virtuous circle of investment and income, which can promote the industrialization and socialization of land use. In addition, it is also helpful to establish a public participation system, so that the public can clearly define their duties and rights. Meanwhile, land use project managers can understand social needs more accurately, reduce decision-making errors, and make land use projects meet the interests of both the public and the individuals.

Potential Modification of the Model

Referring to the previous research results and combining with the actual situation of China, this study proposes a new evaluation methodof ESV. Using the simulation data of the TES-LUCmodel as the basic data, the spatial and temporal pattern changes of ESV in China is studied by means of GIS. This study is based on the ecosystem process, and then introduces the direct and indirect market value into the ecosystem services evaluation system, so that the ecosystem process and socio-economic are closely linked, and the evaluation results are more objective and reliable. The two cases in Section 3 and Section 4 verify that the model is effective.

Nevertheless, because of the heterogeneity, complexity, and dynamic characteristics of ecosystems, their services functions also show obvious spatial scale differences. Under different scales, the same ecological services functions are given different values. Therefore, although the model proposed in this study provides feasible reference for ESV estimation of land use projects, there are still some limitations. Although this studyestablishes a model with five components, which provides a feasible way to explore the relationship between the ESV and land use, it is still necessary to study more scientific and accurate methods for estimating the ESV of each component,especially in terms of spatial transformation and scale effect of ESV.Besides, the bivariate spatial correlation between land use and ESV is not considered in the model. Therefore, future research may incorporate the spatial spillover effect into the model by using spatial econometric method.

Last but not the least, the model proposed in this study assumes equal weight of each of the five components that make up the ESV. Nevertheless, it cannot be neglected that as time goes, the influence of each component on the total ESV keeps evolving. Therefore, the weight of each component needs adjustment in the future according to practical situation of land investigated. Under the violent change of land use, predicting its impact on ESV can also be embedded in the model.

References

1. Chen, D., Jin, G., Zhang, Q. et al. (2016). Water ecological function zoning in Heihe River Basin, Northwest China,Physics and Chemistry of the Earth,96,74-83.
2. Costanza, R., D'Arge, R., and De Groot, R., et al. (1997). The value of the world's ecosystem services and natural capital. Nature, (386): 253-260.
3. Cao, S., Chen, L., and Yu, X. (2009). Impact of China's Grain for Green Project on the landscape of vulnerable raid and semi-arid agricultural regions: a case study in northern Shaanxi Province, Journal of Applied Ecology, 46(3), 536-543.
4. Chen, Y., Wang, K., and Lin, Y. (2015). Balancing green and grain trade, Nature Geoscience, 8(10), 739-741.
5. Food and Agriculture Organization of the United Nations. (1993). An International Framework for Evaluating Sustainable Land Management.
6. Feng, Y., Han, W., and Wang, H. (2003). Study on the sustainable development oriented optimal allocation to region water resources, System Engineering Theory and Practice, 23(2), 133-138.
7. Gao, Q., et al. (2007). Modeling interplay between regional net ecosystem carbon balance and soil erosion for a crop-pasture region, J. Geophys. Res., 112, 224-241.
8. Groot, R. (2006). Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes,Landscape and Urban Planning, 75, 175-186.
9. He, C., He, X., and Fu, L. (2010). China's South-to-North Water Transfer Project: Is it Needed?,Geography Compass, 49, 1312-1323.
10. Haddad, M., Brudvig, A., Clobert, J. et al. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems, Science advances, 1(2).
11. Jiang, Y. (2009). China's water scarcity, Journal of Environmental Management, 90(11), 3185-3196.
12. Liu, C. (2015). Estimating the effects of the sloping land conversion to forestland on grain production, Forestry Economics, (9).
13. Liu, G., Zhang, L. and Zhang, Q. (2014). Spatial and Temporal Dynamics of Land Use and Its Influence on Ecosystem Services Value in Yangtze River Delta,Acta EcologicaSinica, 34(12), 3311-3319.
14. Li, J., et al. (2010). Changes in ecosystem services values in Zoige Plateau, China, Article in Agriculture Ecosystems and Environment, 139(4), 766-770.
15. Notte, A., et al.(2017). Ecosystem services classification: A systems ecology perspective of the cascade framework.Ecological Indicators,74,392-402
16. Repetto, R. (1992). Accounting for environmental assets. Scientific American, 64-70.
17. Sun, B., Yang, K., andTuo, W. (2005). Balanced use of soil water resource and sustainable development of ecological vegetation in Hilly areas of the loess plateau, Acta AgriculturaeBoreali-occidentalis Sinica, 14(4),

92-96.
18. Tian, J., and Liu, G. (2004). Existing problems and suggestions on program for conversion of farmland to forestland or grassland in loess plateau, Bulletin of Soil and Water Conservation, 24(1), 63-65.
19. Wang, B. (2013). Effects of Grain for Green Project on food security on loess plateau, Bulletin of Soil and Water Conservation, 33(3), 241-245.
20. Wallace, K. (2007). Classification of ecosystem services: Problems and solutions,Biological Conservation, 139, 235-246.
21. Wang, X. (2014). Consideration on accelerating effective control of soil and water loss in loess plateau, Soil and Water Conservation in China, (6), 1-3.
22. Xie, G., Zhen, L., Lu, C., et al. (2010). Applying Value Transfer Method for Eco-Services Valuation in China, Journal of Resources and Ecology, 1(1), 51-59.
23. Xu, Y. (2017). Evaluation on ecological benefits of returning farmland to forest in Baoji City, Bulletin of Soil and Water Conservation.
24. Zhang, B., Li, W., andXie, G., (2010). Ecosystem services research in China: progress and perspective,Ecological Economics, 69(7), 1389 - 1395.
25. Zhang, X. (2002). Analysis and evaluation of energy elow of agroecosystems in Longdong loess plateau, Research of Agricultural Modernization, 23(6).