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Evaluation of Land Use Efficiency Based on Eco-economic Value Accounting——Take Suichuan County, Jiangxi Province as an example

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Abstract: This paper uses the ecosystem service value as the evaluation index to conduct an environmental impact assessment on the overall land use planning of Suichuan County, Jiangxi Province (2006-2020). The results show that: (1) During the planning period, the ecosystem of Suichuan County was removed from cultivated land. In addition to the decline in service value, the value of ecological services in other land use types has shown an upward trend. Among them, garden plots have the largest increase, 37.878%;(2) The implementation of the new round of land use master plan will make the total value of the ecosystem service function of Suichuan County rise slightly, from 55.211×10^8 yuan in 2006 to 56.306×10^8 yuan in 2020, an increase of 1.095×10^8 yuan; (3) The per capita value of ecosystem services has dropped from RMB 10,303.68 in 2006 to RMB 9,851.64 in 2020, indicating that as the population continues to grow, the value of ecosystem services per person has shown a downward trend relative to the total value of ecosystem services, if the per capita value of ecosystem services is not lower than the status quo, it is recommended that the original plan be further revised and improved.

1. Introduction

Land use is the closest link between man and nature, and changes in land use/cover will inevitably cause changes in the structure and function of natural ecosystems [1]. Unreasonable land use will damage healthy ecosystems and reduce human welfare. Scientific and reasonable land use planning is the control and guidance of future land use. As a general term for various terrestrial ecosystems, land use structure changes cause changes in the types, areas and spatial distribution patterns of various ecosystems [2]. The adjustment of the land use structure for the purpose of economic benefits has led to a smaller and smaller proportion of the natural ecosystem area in the land use structure, while the proportion of industrial and mining, transportation and construction land in the artificial system has continued to increase. The deterioration of the natural environment has restricted economic development and caused a double lag in economic ecology. Therefore, strategic environmental assessment (SEA) should be carried out in the formulation of land use

planning to ensure the scientific nature of the planning.

The contribution of ecosystems to human beings can be evaluated by economic value. By monetizing the functions and benefits of ecosystem services, the economic price label of such services can be given. American ecologist Costanza et al. proposed a method for estimating the value of global ecosystem services [3]. His research made the principles and methods for estimating the value of ecosystem services more clear in a scientific sense. The economic value accounting of ecosystem services can quantify the impact of land use on the ecological environment. Land use planning affects the ecological environment by affecting land use, so it will have an impact on the ecological functions of the ecosystem including forests, grasslands and cultivated land. Therefore, the use of ecological economic value accounting methods to calculate the value and composition of ecosystem services under different land use structures in a region can reflect the value of services provided by the regional ecosystem and the focus of land use structure changes caused by different land use structures. To provide countermeasures and suggestions for the adjustment direction of the land use structure in the planning scheme is a good supplement and auxiliary to the multi-index comprehensive evaluation method.

The advantages of the ecological service value method are that it is simple and practical, and the data is easy to obtain. The calculation results can not only reflect the current situation of environmental impacts, but also reflect the changing trend of environmental impact assessment. The disadvantage is that the calculation results often reflect the ideal value of the ecological service value, without considering the significant impact of the changes in human social and economic activities on the ecological service function, and the calculation results are not in good agreement with the actual value. In order to improve the practicability of the ecological service value method in the environmental impact assessment of land use planning, the ecological service value loss caused by external disturbance and damage should be taken into account in consideration of the actual situation, and used after appropriate corrections. The GDP accounting system is used jointly [4, 5].

2. Overview and research methods of the research area

2.1 Overview of the study area

Suichuan County is located between 113°56′51″~114°45′45″E, 25°28′32″~26°42′55″N, with an area of 3,144 km^2. It is located at the eastern foot of the southern section of the Luoxiao Mountains, the southwest border of Jiangxi Province, and the southwest of Ji'an City. The overall topography of Suichuan County is mountainous and less land. The overall terrain is like a dustpan that opens to the northeast. From southwest to northeast, there are Zhongshan, low mountains, hills and valley plains. It belongs to the mid-subtropical humid monsoon climate zone. The annual average temperature is between 15.1-18.1℃, the annual average precipitation is 1,421.2mm, and the annual average frost-free period is 284 days. This area is located in the mid-subtropical evergreen broad-leaved forest bioclimatic zone. The parent rocks mainly include Quaternary red clay, sand shale, granite, and phyllite. The main soil type is red soil, but due to the complicated soil-forming conditions such as topography and parent material, in addition to red soil, there are also yellow soil, purple soil and other soil types.

2.2 Data sources

The basic data of this article comes from Suichuan County Statistical Yearbook, Suichuan County Land Use Statistical Yearbook, Suichuan County Land Use Master Plan and Implementation Evaluation, Suichuan County Land Use Master Plan from 2006 to 2020, etc.

2.3 Ecosystem service value calculation algorithm

Ecosystem service value refers to the natural environmental conditions and utility that human beings rely on formed and maintained by the ecosystem and its ecological process. It is the products and services obtained directly or indirectly through the functions of the ecosystem [3]. At present, the most commonly used methods for evaluating ecosystem service value include ecosystem service value coefficient estimation method, direct market evaluation method, and non-market evaluation method based on conditioned value evaluation method [6]. This paper uses the ecosystem service value formula of Costanza et al. (Formula 1), and adjusts the ecological service value coefficients per unit area of different types of land in Fujian Province estimated by Yao Chengsheng et al. [7] to calculate the ecosystem service value of Suichuan County.

$$V_j = \sum_{i=1}^{n} (A_i \cdot VC_i) \tag{1}$$

Where: Vj is the annual total economic value of ecosystem service functions in the study area in year j; Ai is the area of the i-th land use type, hm^2; VCi is the ecological value coefficient of the i-th land type (see Table 1), Yuan/(hm^2•a).

Table 1 Coefficient of the ecosystem services value Yuan/(hm^2·a)

Land use type	arable land	Garden	woodland	Construction land	Waters	Unused land
Value coefficient	6831	6831	21599	0	53715	415

The total economic value of the ecosystem service function of the specific land use type in each year and the economic value increase of the ecosystem service function of the planned target year relative to the base year. The calculation formula is as follows:

$$\Delta V_j = V_j - V_0 \tag{2}$$

In the formula, Vj is the annual total economic value of ecosystem services in the study area in year j; V0 is the annual total economic value of ecosystem services in the study area in the base year; ⊿Vj is the increase or decrease in the economic value of the ecosystem service function in year j relative to the base year.

3. Results and analysis

3.1 Changes in the area of various land use ecosystems during the planning period

Land use planning affects the ecological environment by influencing land use, so the types of ecosystems are divided according to the different ways of land use. With reference to previous studies, the ecosystem of Suichuan County is divided into cultivated land, garden land, forest land, grassland, construction land, water bodies and other land. According to the area and changes of various land use types in the land use planning plan of Suichuan County from 2006 to 2020, the corresponding areas and changes of various land use ecosystems are obtained (Table 2).

Table 2 Change of area of each land use ecosystem of Suichuan from 2006 to 2020 (hm2, %)

		arable land	Garden	woodland	grassland	water	Construction land	Other land
area	2006	29996.56	3040.86	235155.56	4.07	4026.61	10213.24	18610.17
	2010	29866.67	3461.33	239310.67	4.07	4026.61	10360.00	14076.47
	2020	29666.67	4192.67	239965.33	4.07	4026.61	10793.33	12418.91
2006~2020	Change area	-329.89	1151.81	4809.77	0	0	580.09	-6191.26
	Rate of change	-1.10	37.88	2.05	\	\	5.68	-33.27
2006~2010	Change area	-129.89	420.47	4155.11	0	0	146.76	-4533.70
	Rate of change	-0.43	13.83	1.77	\	\	1.44	-24.36
2010~2020	Change area	-200.00	731.34	654.66	0	0	433.33	-1657.56
	Rate of change	-0.67	21.13	0.27	\	\	4.18	-11.78

The goal of the plan is to gradually transform the land use mode to intensification under the premise of protecting the ecological environment, and to further improve the land use structure and layout. Strive to maintain the dynamic balance of the total arable land, and the economic, social, and ecological benefits of land use have been significantly improved. During the planning period, the area of the garden ecosystem will increase significantly, from 3040.86 hm^2 in 2006 to 4192.67 hm^2 in 2020. The area of forest ecosystem has also increased significantly, from 235155.56 hm^2 in 2006 to 239965.33 hm^2 in 2020.

3.2 Dynamic changes in the total value of ecosystem services during the planning period

Use formula (1) and the ecosystem ecological value coefficient in Table 1 to calculate the ecosystem service value of each land use type. The results are shown in Table 3.

Table 3 Change of ecosystem services values for each landuse category and total ecosystem services values in Suichuan County

		arable land	garden	woodland	grassland	water	Unused land	total
Ecosystem service value	2006	2.049	0.208	50.791	0	2.163	0	55.211
	2010	2.040	0.236	51.689	0	2.163	0	56.128
	2020	2.027	0.286	51.830	0	2.163	0	56.306
2006~2020	Variation	-0.023	0.079	1.039	0	0	0	1.095
	Rate of change	-1.10	37.88	2.05	\	\	\	38.82
2006~2010	Variation	-0.009	0.029	0.897	0	0	0	0.917
	Rate of change	-0.43	13.83	1.77	\	\	\	15.16
2010~2020	Variation	-0.014	0.050	0.141	0	0	0	0.178
	Rate of change	-0.67	21.13	0.27	\	\	\	20.73

It can be seen from Table 3 that the implementation of the new round of land use planning in Suichuan County will slightly increase the total value of Suichuan County's ecosystem services. From 55.211×10^8 yuan in 2006 to 56.306×10^8 yuan in 2020, an increase of 1.095×10^8 yuan. The changes in the ecosystem service value of each land use type in Suichuan County during the three analysis periods are all positive. Except for the decline in the ecosystem service value of cultivated land and the unchanged ecosystem service value of water bodies, the ecosystem service value of other land types are all on the rise. Among them, garden land has the largest increase of 37.88%; forest land has an increase of 2.05%. The absolute value of forest land service value increase was the largest, about 1.039×10^8 yuan, and the absolute value of cultivated land service value decrease was the largest, about 0.023×10^8 yuan. This shows that the increase in the value of forest ecosystem

services is the main factor for the increase in the value of total ecosystem services in Suichuan County. From the analysis results, judging from the perspective of ecosystem service value, the plan is reasonable and can effectively increase ecological benefits.

3.3 Dynamic changes in the value of ecosystem services per capita during the planning period

Ecosystem services are for humans, and the ultimate beneficiaries are humans. Therefore, it is necessary to calculate the per capita value of ecosystem services in the analysis process. The per capita value takes into account the factors of population growth. Compared with the overall value, it can better reflect the impact of changes in the ecological environment on humans. The per capita value of ecosystem services for each land use type in Suichuan County is shown in Table 4. The population data for 2006 and 2010 are from the Suichuan County Statistical Yearbook, and the population for 2020 is calculated based on the average natural population growth rate in the past 10 years.

Table 4 Change of ecosystem services values per capita in Suichuan county (Yuan / person,%)

		arable land	garden	woodland	grassland	water	Unused land	total
Ecosystem service value	2006	382.40	38.77	9478.86	0	403.65	0	10303.68
	2010	368.44	42.70	9334.59	0	390.60	0	10136.34
	2020	354.57	50.11	9068.52	0	378.43	0	9851.64
2006~2020	Variation	-27.83	11.34	-410.34	0	-25.21	0	-452.04
	Rate of change	-7.28	29.27	-4.33	\	-6.25	\	-11.41
2006~2010	Variation	-13.96	3.93	-144.27	0	-13.05	0	-167.34
	Rate of change	-3.65	10.15	-1.52	\	-3.23	\	-1.74
2010~2020	Variation	-13.87	7.41	-266.07	0	-12.17	0	-284.70
	Rate of change	-3.76	17.36	-2.85	\	-3.12	\	-7.63

It can be seen from Table 4 that during the planning period, the change in the value of ecosystem services per capita showed an opposite trend to the increase in overall service value during the three analysis periods. The per capita value of ecosystem services has dropped from RMB 10,303.68 in 2006 to RMB 9,851.64 in 2020. Except for the increase in the per capita ecosystem service value of garden plots, the service value of other land use types showed negative growth. It shows that although the plan has increased the total value of ecosystem services in Suichuan County, due to the increase in population, the per capita value of ecosystem services and the area of ecological land have decreased, and the rate of ecological environment construction in Suichuan County has lagged behind the rate of population growth. If the per capita ecosystem service value is not lower than the beginning of the planning period, the planning should be further improved and revised.

4. Environmental impact mitigation measures for land use planning

As a form of strategic environmental impact assessment, the ultimate goal of the environmental impact assessment of overall land use planning is to propose measures to mitigate adverse environmental impacts and increase favorable environmental impacts. Based on the results of the environmental impact assessment of the overall land use planning in Suichuan County, this paper proposes the following environmental impact mitigation measures.

(1) Ensure orderly land use structure, strict land use control, and reasonable arrangement of ecological land. Strict management of land use and giving play to the regulation and control role of land use are important ways to achieve coordinated development of land use and the ecological

environment. In terms of land use, it is necessary to strictly control construction land and agricultural land, and actively arrange ecological land; In terms of layout, it is necessary to focus on arranging ecological land for ecologically fragile areas. In urban construction, it is necessary to increase the proportion of ecological land and make a reasonable layout of land types.

(2) Strengthen the investigation and research of the ecological environment and grasp the changes in time. It is necessary to keep abreast of the changes in the ecological environment issues that have been initially grasped such as soil erosion and geological disasters. Strengthen monitoring, establish an early warning mechanism, and improve the ability to manage ecological problems and prevent disasters. Improve monitoring and early warning methods. Build a database for various ecological issues, use GIS and other means, scientifically manage, and reflect the changes in the ecological environment in a timely and accurate manner.

(3) Scientifically formulate and strictly implement relevant plans. Scientifically formulate spatial layout plans such as overall land use plans, town plans, and industrial layout plans, and plan economic development activities within a reasonable area. Strengthen special plans such as water and soil erosion prevention and control plans, geological disaster prevention plans, and returning farmland to forests, and actively formulate and highlight various ecological problems prevention and solutions. At the same time, it is necessary to strictly plan and implement various reasonable spatial layouts and correct policies and measures to achieve the coordinated development of economic development and ecological environment.

5. Conclusion

(1) During the planning period, except for the decline in the ecosystem service value of cultivated land in Suichuan County, the ecosystem service value of other land use types showed an upward trend. Among them, the garden area has the largest increase, which is 37.878%;

(2) The implementation of the new round of land use planning in Suichuan County will increase the total value of Suichuan County's ecosystem services. From 55.211×10^8 yuan in 2006 to 56.306×10^8 yuan in 2020, an increase of 1.095×10^8 yuan;

(3) The per capita value of ecosystem services has dropped from RMB 10,303.68 in 2006 to RMB 9,851.64 in 2020. It shows that as the population continues to grow, the value of ecosystem services per capita is showing a downward trend relative to the total value of ecosystem services.

(4) If the per capita ecosystem service value is not lower than the status quo, it is recommended to further modify and improve the planning scheme, and further rationally optimize and layout the regional land use structure. Strictly control the conversion of land with high ecosystem service value such as forest land, garden land, and cultivated land to land with low ecosystem service value such as construction land, so as to ensure the healthy operation of the ecosystem.

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