A Study on the Value Change of Land Ecosystem Services in Huangguoshu Scenic Area

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Abstract Land use and ecological service influence and constrain each other and the quantitative research on the value change of ecosystem services and land use in Huangguoshu scenic area can help to provide a scientific basis for the harmonious development of special ecology, society and economy in Huangguoshu scenic area. This paper analyzes the value change of land ecosystem services in Huangguoshu scenic area during 2009 - 2012, and explores important issues and focus in the land planning and development of Huangguoshu scenic area. The results show that the value of woodland ecosystem services is highest in Huangguoshu scenic area, accounting for nearly 70% of the total value, and there was a slight decline in the total value of ecosystem services in Huangguoshu scenic area during the four years, mainly due to the internal restructuring of agriculture and expansion of construction land. In the future development of Huangguoshu scenic area, it is necessary to economically and intensively use construction land, pay attention to the maintenance and improvement of land ecological environment, and focus on the protection of woodland, pasture land and other types of ecological land, so as to improve the overall regional land ecosystem services.

Key words Land use, Value of ecosystem services, Huangguoshu scenic area

1 Introduction

With the gradual deepening of sustainable development idea, the people in modern society have increasingly attached importance to the ecological environment. As for the current measurement of ecological environment, it mainly conducts quantitative assessment of the ecosystem service value. The value of ecosystem services means the life support product or service directly or indirectly obtained through the structure, processes and function of ecosystem and it is currently mature method to assess the ecological value. As the spatial carrier of ecological civilization construction, land is the basis of sustainable development. Land and ecological service influence and constrain each other[1]. Rational land use planning can scientifically guide the regional ecological civilization construction. Therefore, this paper combines land use change with the value of ecosystem services to explore the influence of land use structure change on the value of ecosystem services, analyze reasons for the changes, and discuss the relations between land use and the value of ecosystem services in Huangguoshu scenic area, in order to provide a reference for the land use planning and ecological civilization construction in Huangguoshu scenic area.

2 Overview of the study area and data sources

2.1 Overview of the study area Huangguoshu scenic area (105°35′50″ - 105°41′25″ E, 25°53′45″ - 26°31′50″N), is located in the upper reaches of Dabang River of Beipan River tributaries, between Zhenning County and Guanling County, Anshun City, Guizhou Province. It is 18.7 km long from north to south, and 148 km wide from east to west. It covers an area of 144.63 km^2, and it is 128 km away from Guiyang City, 45 km away from Anshun City, 390 km away from Kunming City, and 527 km away from Chongqing City. The highest elevation of this region is 1420 m and the lowest elevation is 650 m, with the elevation difference of 770 m. Huangguoshu Waterfall, is one of the largest waterfalls in China and East Asia located on the Baishui River in Anshun. It is 77.8 m high and 101 m wide. The main waterfall is 67 m high and 83.3 m wide. The karst features are clear in the scenic area where various kinds of landscape gather, such as karst stone forests, monadnock, isolated peak, karst cave and sinkhole, with karst area accounting for 80%. Huangguoshu scenic area administers Huangguoshu Town and Baishui Town, and has 1 neighborhood committee, 36 villages, and 189 villagers groups. There is a total population of 40728, and it is inhabited by Han, Buyi, Li, Miao and other ethnic groups. The ethnic minorities account for 84% of the total population. Roads and electricity are available for the villages in the area, and 85% of the villages have solved the difficulty in drinking water.

2.2 Data sources Huangguoshu scenic area is constituted by Huangguoshu Town and Baishui Town. Huangguoshu scenic area has no administrative division code in *Administrative Division Code of People's Republic of China* (GB/T2260 - 1999), so Huangguoshu Town is still under the jurisdiction of Zhenning Buyei and Miao Autonomous County, and Baishui Town is administered by Guanling Buyei and Miao Autonomous County. Therefore, based on land survey database management system of Zhenning Buyei and Miao Autonomous County and Guanling Buyei and Miao Autonomous County, using ArcGIS9.2 and Microsoft Office Excel 2010, the summary data table of land use classification area in Huangguoshu scenic area during 2009 - 2012, is formed by overlapping land use classification data of Huangguoshu Town and

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Baishui Town. Based on the land statistics in Huangguoshu scenic area during 2009 – 2012, for the analysis on the value of land ecosystem services, according to land use and operation characteristics, coverage characteristics and other factors, we study the actual land use in Huangguoshu scenic area, and divide the existing land use types into eight categories (cultivated land, garden plot, woodland, pasture land, construction land, waters, marshes and tidal flats, and other land types).

3 Research methods

3.1 Dynamic degree of land use Dynamic degree of land use can be used to characterize the changes in the amount of land resources, quantitatively describe regional land use change speed, and find out the hot spots of land use change in different space. It plays a positive role in comparing the regional differences in land use change. Formula is as follows:

$$S = [(U_b - U_a)/(U_a)] \times T^{-1} \times 100\% \quad (1)$$

where S is the dynamic degree of one land use type within the study period; U_a and U_b are the amount of one land use type at the beginning and end of the study period, respectively; T is the length of study period, and when T is set as year, S is the annual rate of change in one land use type.

3.2 Value of ecosystem services Based on Costanza study, combined with China's actual situation, the Chinese scholars obtain the value of China's terrestrial ecosystem services by correction[2]. On this basis, by drawing on existing research, we perform quantitative estimation of the value of land ecosystem services in Huangguoshu scenic area, and the formula is as follows

$$ESV = \sum A_k VC_k \quad (2)$$

where ESV is the total value of ecosystem services (yuan); A_k is the area of land use type k in the scenic area (ha); VC_k is the value of ecosystem services per unit area of this land type (yuan/ha · a).

3.3 Coefficient of sensitivity Coefficient of sensitivity (CS) is used to determine the sensitivity of ESV to VC, in order to test whether the the value of China's terrestrial ecosystem services is suitable for Huangguoshu scenic area. The value index of various land use types is adjusted by 50%, to measure the change in the total value of ecosystem services. CS means the change in ESV caused by 1% of change in VC. If $CS > 1$, it indicates that ESV is sensitive and flexible to VC; if $CS < 1$, ESV is not flexible to VC. The larger the ratio, the more critical the accuracy of VC to estimated ESV[3]. It is calculated as follows:

$$CS = \frac{(ESV_j - ESV_i)/ESV_i}{(VC_{jk} - VC_{ik})/VC_{ik}} \quad (3)$$

where C_S is sensitivity; ESV is the total value of ecosystem services (yuan); VC is the value of ecosystem services per unit area of land (yuan/ha · a); i is the initial state; j is the adjusted state; k is the land use type.

4 Results and analysis

4.1 Land use change Through information technology, we obtain the land use data from the dynamic land use database in Huangguoshu scenic area during 2009 – 2012 (Table 1). It is found that during 2009 – 2012, the area of cultivated land and construction land in Huangguoshu scenic area showed a growing trend, an increase of 32.81 ha and 33.88 ha, respectively; the annual rate of change in the area of marshes and tidal flats was lowest, and they were the relatively stable land use types in the scenic area; the area of garden plot and woodland showed a downward trend, a decrease of 2.99 ha and 21.54 ha, respectively; the area of pasture land declined most in the scenic area, a total reduction of 43.86 ha, but due to the large absolute amount, the dynamic variation in land use is less than 2%.

Table 1 Dynamic change in land use in Huangguoshu scenic area during 2009 – 2012

	The amount of change//ha	Dynamic degree of land use//%
Cultivated land	32.81	0.93
Garden plot	-2.99	-0.70
Woodland	-21.54	-0.37
Pasture land	-43.86	-1.83
Construction land	33.88	4.69
Waters	-0.18	-0.09
Marshes and tidal flats	0.00	0.00
Other land types	1.88	0.15

4.2 Equivalence factor of the value of ecosystem services On the basis of global ecosystem service evaluation model, Xie Gaodi *et al.* sum up 9 ecosystem services (air regulation; climate regulation; water conservation; soil formation and protection; waste disposal; biodiversity maintenance; food production; raw material production; leisure and entertainment). Based on China's soil types and topographical features, the value of ecosystem is corrected to get the value of ecosystem service suitable for China's terrestrial ecosystem (Table 2)[4]. This table defines the economic value of annual natural food production for 1 ha of farmland with national average yield as 1. The equivalence factor of the value of other ecosystem services refers to the contribution of the ecological service produced by ecosystem relative to farmland's food production and services. The value table is corrected in accordance with the actual situation in Huangguoshu scenic area. Through comprehensive comparative analysis, it is found that the economic value of one ecosystem service value equivalence factor is equal to one seventh of average grain yield market value in Huangguoshu scenic area[5]. Therefore, based on the average grain yield in Huangguoshu scenic area in recent years, the economic value of annual natural grain yield per unit area of farmland in Huangguoshu scenic area is calculated at 522.96 yuan/ha · a. On this basis, we get the corresponding ecosystem types and ecological value coefficients of various land use types in Huangguoshu scenic area (Table 3).

4.3 Calculation of ecosystem service value Using the above estimation formula for the ecosystem service value, combined with

the land use change data, we calculate the value and amount of change in ecosystem services in Huangguoshu scenic area during 2009 – 2012 (Table 4). As can be seen from Table 4, the woodland has the highest ecosystem service value in Huangguoshu scenic area, accounting for nearly 70% of total value, followed by the cultivated land, waters and garden plot; other land types have the lowest ecosystem service value, only 3% of total value. In nearly four years, the total ecosystem service value in Huangguoshu scenic area declined slightly, from 98432219.55 yuan in 2009 to 98111933.4 yuan in 2012, mainly due to the reduction of woodland and pasture land. Although cultivated land increased and the ecosystem service value also increased during this period, the growth rate was less than reduction rate of ecosystem service value caused by the decline in the area of woodland and pasture land, so it decreased by about 0.32% overall. Woodland had the largest amount of reduction in ecosystem service value (246130.6), accounting for more than 50% of the total amount of reduction, followed by pasture land; the ecosystem service value of garden plot showed a decreasing trend, with total amount of reduction of 22743.3 yuan; the ecosystem service value of cultivated land first increased and then decreased, with total increase of 118563.97 yuan, making the largest contribution to ecosystem service value increase; due to small total area and little change, there was little change in the overall ecosystem service value of marshes and tidal flats.

Table 2 Ecosystem service value equivalence for China's terrestrial ecosystems

	Forest	Grassland	Farmland	Wetland	Waters	The land difficult to use
Air regulation	3.50	0.80	0.50	1.80	0.00	0.00
Climate regulation	2.70	0.90	0.89	17.10	0.46	0.00
Water conservation	3.20	0.80	0.60	15.50	20.38	0.03
Soil formation and protection	3.90	1.95	1.46	1.71	0.01	0.02
Waste disposal	1.31	1.31	1.64	18.18	18.18	0.01
Biodiversity maintenance	3.26	1.09	0.71	2.50	2.49	0.34
Food production	0.10	0.30	1.00	0.30	0.10	0.01
Raw material production	2.60	0.05	0.10	0.07	0.01	0.00
Leisure and entertainment	1.28	0.04	0.01	5.55	4.34	0.01
Total	21.85	7.24	6.91	62.71	46.01	0.42

Table 3 The per unit area of ecosystem service value for various land types in Huangguoshu scenic area Unit: yuan/ha · a

	Cultivated land	Garden plot	Woodland	Pasture l and	Marshes and tidal flats	Waters	Other land types
Corresponding ecosystems	Farmland	Forest and grassland	Forest	Grassland	Wetland	Waters	The land difficult to use
Per unit area of ecological value	3613.65	7606.45	11426.68	3786.23	32794.82	24040.47	219.64

Note: According to research results of Costanza and Ran Shenghong[6-7], the ecosystem service value of construction land is small, so we do not estimate the economic value of its ecosystem services.

Table 4 Total service value of land ecosystem in Huangguoshu scenic area Unit: yuan

	2009	2010	2011	2012	2009 – 2012
Cultivated land	12689127.80	12748391.72	12825254.13	12807691.77	118563.97
Garden plot	3237686.80	3235252.74	3227950.54	3214943.51	-22743.30
Woodland	67342315.14	67131264.43	67176057.00	67096184.54	-246130.60
Pasture land	9056284.49	8996197.02	8902828.58	8890220.43	-166064.07
Marshes and tidal flats	796914.16	796914.16	801177.49	796914.16	0.00
Waters	5027583.74	5027824.14	4673708.00	5023256.45	-4327.28
Other land types	282307.40	282652.24	283748.26	282722.53	415.13
Total	98432219.55	98218496.46	97890724.01	98111933.40	-320286.14

4.4 Sensitivity analysis The ecosystem service value coefficient of various land use types is adjusted up or down 50%, respectively, and we calculate the adjusted ecosystem service value and coefficient of sensitivity of ecosystem service value for various land use types (Table 5). As can be seen from the data in the table, the coefficient of sensitivity of various land use types' ESV to VC in Huangguoshu scenic area is less than 1, and it is in the descending order of woodland > cultivated land > pasture land > waters > garden plot > marshes and tidal flats > other land types. Woodland has the largest coefficient of sensitivity (0.68), that

is, for each additional 1% of woodland's VC, ESV will increase by 0.68%, followed by the coefficient of sensitivity of cultivated land (0.13); marshes and tidal flats have the smallest coefficient of sensitivity (not more than 0.01); the coefficient of sensitivity of other land types is 0.03 – 0.1. Overall, there is a small change in the coefficient of sensitivity of different land use types' ecosystem service value to ecosystem service value index in different years, and it is less than 1, indicating that the ecosystem service value lacks elasticity to the change in ecosystem service value coefficient, so the results of this study are credible.

4.5 Analysis of reasons for change Through the analysis of changes in land use and ecosystem service value in Huangguoshu scenic area in recent years, it can be found that the land use change in Huangguoshu scenic area has changed the ecosystem service function, and the ecosystem service value shows an overall decreasing trend. There are mainly two reasons. One the one hand, the structure is adjusted within agriculture in Huangguoshu scenic area, for example, the reclamation of woodland into new arable land will make the land with high ecosystem service value change to the land with low ecosystem service value, thereby reducing the total ecosystem service value. On the other hand, the expansion of construction land in Huangguoshu scenic area needs to occupy cultivated land, woodland and grassland, resulting in reduction of total ecosystem service value.

Table 5 Coefficient of sensitivity of ecosystem service value for various land use types in Huangguoshu scenic area

	2009	2010	2011	2012
Cultivated land VC ±50%	0.12850	0.12938	0.13059	0.13013
Garden plot VC ±50%	0.03279	0.03283	0.03287	0.03266
Woodland VC ±50%	0.68198	0.68132	0.68399	0.68170
Pasture land VC ±50%	0.09171	0.09130	0.09065	0.09033
Marshes and tidal flats VC ±50%	0.00807	0.00809	0.00816	0.00810
Waters VC ±50%	0.05107	0.05119	0.04774	0.05199
Other land types VC ±50%	0.00286	0.00287	0.00289	0.00287

5 Conclusions and recommendations

5.1 Conclusions Land use and ecological service influence and constrain each other and the quantitative research on the value change of ecosystem services and land use in Huangguoshu scenic area can help to provide a scientific basis for the harmonious development of special ecology, society and economy in Huangguoshu scenic area. This paper analyzes the value change of land ecosystem services in Huangguoshu scenic area during 2009 – 2012, and explores important issues and focus in the land planning and development of Huangguoshu scenic area. The results show that the value of woodland ecosystem services is highest in Huangguoshu scenic area, accounting for nearly 70% of the total value, and there was a slight decline in the total value of ecosystem services in Huangguoshu scenic area during the four years, mainly due to the internal restructuring of agriculture and expansion of construction land. In the future development of Huangguoshu scenic area, it is necessary to economically and intensively use construction land, pay attention to the maintenance and improvement of land ecological environment, and focus on the protection of woodland, pasture land and other types of ecological land, so as to improve the overall regional land ecosystem services.

5.2 Recommendations

5.2.1 Protecting the existing forest vegetation and the forest ecology in the river basin. It is necessary to implement the project of returning farmland to forest, and strictly prohibit deforestation, especially for the sloping land with gradient of more than 25°. The key is to build bank and tourism trunk roads, and strengthen the greening of roads in the main scenic area, to constitute a green corridor linking various scenic areas. The greening trees and flowers should fully reflect the geographical characteristics, and there is a need to plant arbor, shrub, grass and flower in different section, to form different types of forest landscape.

5.2.2 Strengthening the greening and characteristics of tourist reception centers and tourist attractions at all levels. The greening of Huangguoshu new town and second-level tourist reception center should be based on the relevant requirements of ecological garden city and tourist city greening, to increase coverage rate and standards of green space. The greening of Shitouzhai and Langgongcun should be based on economic forest to form the ethnic economic garden integrating rural environment and ethnic customs. For the greening of scenic spots and roads in Great Fall scenic area, Tianxingqiao scenic area, Dishuitan scenic area and Balinghe scenic area, it is mainly based on ornamental flowers to highlight the artistic and functional landscape effect, and combine sightseeing, shelter and economic benefit.

5.2.3 Including the land ecosystem service value accounting in national economic accounting. Huangguoshu scenic area is located in the central part of South China Karst region with the world's most typical karst landform, and it is still by far one of the constantly evolving rare "living" karst areas in the world. It is one of the first national scenic spots and national AAAAA level scenic spots. The value of scenic resources lies in not only the sightseeing, and the scenic resources also have values of environmental regulation, scientific research and education. Therefore, it is necessary to include the land ecosystem service value accounting of Huangguoshu scenic area in the national economic accounting, and implement real "green GDP". And according to the characteristics of Huangguoshu scenic area, it is necessary to build long-term service value evaluation mechanism, in order to provide reli-

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pulsory education, vocational education and skills training to enhance farmers' cross-regional employment capacity, and encourage population to transfer to other provinces or the key development areas in the province.

Table 5 The factors that affect human-land linking policy

Factors	Content
Policy characteristics	Top-level institutional design, employment information guidance, social security and continuation, child's equal right to education, household registration system reform, and housing security policy coverage
Personal and family characteristics	Personal characteristics (sex, age, health status, education level, vocational skills, marital status, *etc.*), household composition
Domicile environmental characteristics	Local economic development, social network, village's geographic characteristics, land transfer, local vocational training capacity
Level of urban development	Urban scale (population size, built-up area, GDP), number of city jobs and number of jobs per capita, matching of industrial demand and labor transfer, level of public services, level of urban management
Differences in folk customs and life habits	Differences in language, culture and life habits, discrimination against strangers

5.3 Making joint efforts to integrate into the city On the one hand, the level of urbanization in northern Anhui is improved by significantly cutting agricultural population, accelerating construction of beautiful countryside, and promoting agricultural land transfer, so as to promote the development of modern agriculture. On the other hand, it is necessary to encourage the urbanization away from home in the province, and promote moderate flow of labor from northern Anhui to Wanjiang, in order to provide employed population support for the industrial development in the industrial transfer demonstration areas of Wanjiang city belt, and improve the quality of urbanization. Meanwhile, it is necessary to accelerate the equalization of public services, and achieve full coverage of basic public services for the transferred agricultural population.

5.4 Guiding the rural voluntary exit It is necessary to implement homestead system reform. From the incentive mechanism, we have to explore reasonable compensation standards for homestead exit. The design of compensation standards should be based on the construction land benefits in the unified urban-rural land market, to provide housing subsidies for the rural residents settling in the city. It is also necessary to establish paid homestead use system and increase the tax burden to make the cost of holding homestead higher than benefits, and prompt farmers to actively withdraw from the homestead.

5.5 Promoting common urban-rural development It is necessary to establish a unified urban-rural land market system, and a set of rules to implement establishment of unified urban-rural land market, so that the governments and the public have rules to follow. There is a need to establish identity files for each plot of rural land, including arable land, collective construction land and homestead; register the land and issue certificate from door to door to clearly define ownership relations; improve transfer payment system, and establish a link between provincial transfer payment and agricultural population transfer.

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able data support for the forecasting of regional ecological security.

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