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Research Article

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The impact of land use/cover change on the ecological carrying capacity in Loess Hilly region

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ABSTRACT

Based on the theory of ecological footprint, and as land use/cover change the breakthrough point in Loess hilly area, the ecological carrying capacity analysis method was used to calculate the ecological carrying capacity of Shanghuang experimental area. The results showed that the total ecological carrying capacity in 1982, 2000 and 2010 were 242.47、750.53、929.68 hm^2. Meanwhile the per capita ecological carrying capacity in 1982, 2000 and 2010 respectively were 0.67、1.47、1.86 hm^2, the ecological carrying capacity was growing up year after year, which shows that the ecological carrying capacity of the study area steadily increased. Expanding the productive land area and continuous improvement of the land ecological production capacity were the reasons; in particular, the latter is the key. This paper provides a feasible method of quantitative evaluation of land use impact on the ecological environment.

Keywords: land use/cover change; ecological footprint; ecological carrying capacity; Loess hilly region

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INTRODUCTION

Land cover refers to the physical and biological cover the surface of land, including water, vegetable, bare soil, and/or artificial structures. Land use is a more complicated term, which is synthesis of human activities such as agriculture, forestry and building construction that alter land surface processes, including biogeochemistry, hydrology and biodiversity. Land use/land cover change (LUCC) is one of the key topics in the global change research[1-5].

Most of the research on LUCC has been focused on the dynamic mechanism of land use change, the regional and global mode of LUCC, the application of remote technology in LUCC research and the sustainable research. In China, the research on LUCC mainly has been focused on the change pattern, driving mechanism and environmental effect of the land use from a regional perspective. The selected areas involve mainly two types. One type is the “hot spot area,” which is the area with intense human activities and natural drivers; the other is the “fragile area” with fragile ecological environment. Study on land use in fragile areas is beneficial in increasing the awareness of fragility and revealing the formation and evolution mechanism in those areas.

Severe soil erosion in Loess Plateau has been regarded as a major environmental problem, which exerts pressures on the environment and changes its quality and quantity of natural resources. This problem is related to both natural factors and human activities. The natural factors include intensive rainstorms, looses soil, unique topography, while the excessive reclamation on the sloping land for long time was the human factor. Hazards such as land degradation and ecological deterioration caused by soil erosion had threatened the people life and the ecology environment of the whole Yellow River basin. As a result, it is important to study the problems of soil erosion and understanding the natural and social factors which cause the land degradation and ecological deterioration in this region.

Ecological footprint method is one of quantitative methods of evaluating regional sustainable development capacity[6-15]. Although there were many evaluation methods, ecological footprint method was accepted by many scholars because of its intuitive results, regional comparability and being easier to reveal the relationship between natural capital and economic development[16-21]. This article analyzes the ecological supply and ecological demand of regional land, use the ecological footprint model which was take the national average yield as its calculate standard to applied to the regional land sustainable use study.

EXPERIMENTAL SECTION

Study area

The Shanghuang study area (35°59′-36°02′N, 106°26′-106°30′E), with an area of 7.61 km^2, is located in Loess hilly and gully region of south Ningxia(Fig.1), China., This region has a temperate semi-arid climate. The annual average temperature arranges between 5 ℃ and 7℃, while the annual cumulative sunlight reaches up to 2200-2700 hours. The average precipitation is between 260 mm and 820 mm. The elevation varies from 1534.3 m to 1822.0 m. In 2005 year, its population was 519, and the net annual income per farmer was 2093.2 Yuan(RMB), the soil loss intension is 1000 $t•km^{-2}•yr^{-1}$.

Data source and land use classification system

Shanghuang experimental area was selected as a study area by Chinese Academy of Science and Ministry of Water resources to carry out long-term research in 1982. Since that time, investigation of the effects of eco-environmental change on agricultural economics was carried out continuously. The land use and land cover change is an important field for scientific research, the researches protracted land use maps in 1982 year according to the investigations and the relief map with scale of 1:10000 which was mapped by NingXia Bureau of Surveying and Mapping in 1982 year. The researches investigated the land use change in different period from 1982 to 2005 year, and the researches compiled the digital Orthophotoquad map based on the technical of 3S(GPS, GIS, RS) and with the information sources of color infrared aerial photography photograph of the study area with scale of 1∶5000 in 2004 year.

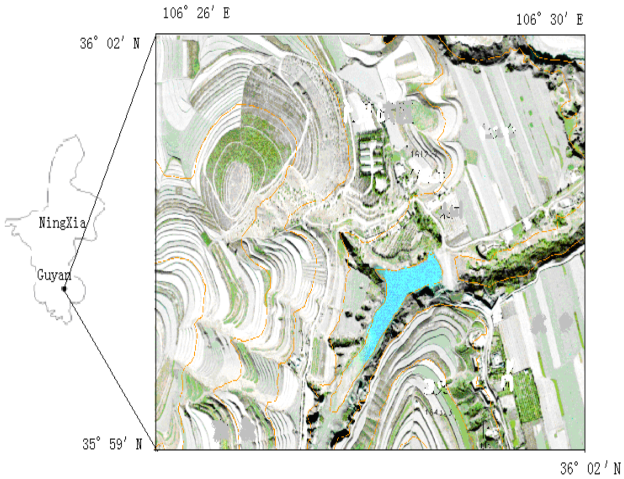

Fig.1 Location of the study area

According to the land classification system, in this paper, cropland refers to the land for cereals which include terrace, sloping cropland and flat or basic cropland; forest land includes timber forest, ecological forest and nursery; grassland means natural of artificial grass for pasturing; and other types of land are non-agriculture

The model of ecological footprint

Ecological footprint(EF), is earliest proposed by William Rees, a Canadian eco-economist.

In 1992, It represents the amount of biologically productive land and sea area necessary to Supply the resources a human population consumes，and to assimilate associated waste．It is a standardized measure to explore consumption space of natural capital from biologically physical quantity.．The EF method is a quantitative measure of sustainable development．Detailedly，resource and energy in a region are converted into corresponding biologically productive land necessary to supply the resources and are contrasted with biologically productive area of the region with ability to provide the resources and energies；thus，it would be easier to determine whether an area's development is within ecological caring capacity (EC). Ecological carrying capacity is a standard to measure sustainable capacity of a region and it is of significance for prediction of future advancement of a region．

The equivalence factor is from EF reports in 2004 from WWF[14]. The equation of per capita EC was as follows:

$$EC = \sum a_j \times r_j \times y_j \qquad (1)$$

where the EC represents per capita ecological carrying capacity (hm^2)； a_j represents per capita biologically productive area； r_j represents equivalence factors； y_j represents production factors.

Table 1: The land use change from1982~2010 year in Shang Huang experimental area hm^2

Land use type		1982	2000	2010	1982-2000	2000-2010
Copland	Subtotal	279.7	228.4	79.4	-51.3	-149
	Sloping land	239.0	155.6	13.3	-83.4	-142.3
	Terrace	0.0	39.0	39.0	39.0	0
	Basic land	40.7	33.8	27.1	-6.9	-6.7
Forestland		9.4	158.3	238.3	148.9	80
Grassland	Subtotal	374.6	275.3	326.4	-99.3	51.1
	Natural grassland	369.6	229.0	219.3	-140.6	-9.7
	Artificial grassland	5.0	46.3	107.1	41.3	60.8
Building site		3.9	9.2	9.6	5.3	0.4
Traffic land		10.1	20.3	31.5	10.2	11.2
Water area		5.6	12.6	12.6	7	0
Orchard land		0.4	4.8	11.1	4.4	6.3
Unused land		77.3	52.1	10.2	-25.2	-41.9

RESULTS AND DISCUSSION

Analyses of land use change

Tab.1 shows that the land use and land cover of Shanghuang experimental area changed greatly within 28years. Cropland decreased from 279.7 hm^2 in 1982 to 79.4 hm^2 in 2010 year while forest land increased form 9.4 hm^2 in 1982 year to 238.3 hm^2 in 2011year. Of the lost cropland, 62.9% was converted to forestland, 30.9% was converted to grassland, and 5.3% was converted to orchard. The unused land decreased by 33.6% during the total period, the orchard and the artificial grassland increased separately form 0.4 hm^2 and 5.0 hm^2 in 1982 year to 11.1 hm^2 and 107.1 hm^2 in 2010 year while the natural grassland decreased form 369.6 hm^2 in 1982 to 219.3 hm^2 in 2005 year. The reason that the sloping cropland converted to terrace or artificial grassland is to increase ecological benefit while that the basic cropland converted to orchard is to increase economic benefit. From 2000 to 2010 year, the main driving force of land use was the factor of policy, 91.5% of the sloping cropland was converted into grassland and forestland, which accelerated the improvement of ecological environment.

Analyses of ecological carrying capacity

Due to differences of resources in varied countries and regions，the practical area of biologically productive area in countries or regions can not be made use of directly, instead, The area in different types should be standardized．The production factors can be used to represent local yield and world—average yield of a biologically productive area．What is more．１２％ of protection area for biologically diversity should be deducted in related calculation.

As shown in Table 2, the ecological carrying capacity in 1982, 2000 and 2010 year respectively are 242.47, 750.53 and 929.68 hm^2. Form the per capita ecological carrying capacity point of view, in 1982 year, the total population is 363 in Shuanghuang experimental area, and the per capita ecological carrying capacity is 0.67 hm^2, the population were 512 and 501 in 2000 and 2010, while the per capita ecological carrying capacity respectively are 1.47 and 1.86 hm^2. Even in the case of population growth, the total ecological carrying capacity in 2010 year is 2.8 times to the beginning of the study in Shanghuang experimental area, while the per capita ecological carrying capacity is 1.8

times. Compared with the per ecological carrying capacity in 1993 in China, the per ecological carrying capacity is 0.8 hm^2, the per ecological carrying capacity in Shanghunag experimental area is higher than the national average ecological capacity, and compared with other countries in the world, such as Canada, the ecological carrying capacity is 9.6 hm^2, the level of per ecological carrying capacity is far below this.

CONCLUSION

(1)This paper analyzed sustainable development capacity based on ecological footprint method in Loess hilly region form 1982, 2000 and 2010 year, the results were shown that the ecological carrying and per capita were still increasing year by year, and the total ecological carrying increased form 242.47 hm^2 in 1982 to 929.68 hm^2.

(2)As to the view of land use and land cover change, as to the exploitation of unused land, it could increase the area of ecological production. The area of unused land decreased from 77.3 hm^2 to 10.2hm^2.and at the same time, through the land structure and adjustment of the policy of returning farmland to forest, the ecological capacity of different land use type increased.

Table 2: Natural ecological carrying capacity of study area in different period hm^2

Land use type	1982			2000			2010		
	area	Equalization factor	Production factor	area	Equalization factor	Production facto	area	Equalization factor	Production facto
Farmland	284	2.8	0.24	241.4	2.8	0.82	100.1	2.8	1.64
Grassland	374.6	0.5	0.37	275.3	0.5	0.9	326.4	0.5	1.2
Forest land	9.4	1.1	0.47	158.3	1.1	0.6	238.3	1.1	0.8
Water area	5.6	0.2	1	12.6	0.2	1	12.6	0.2	1
Building site	14.0	2.8	0.24	29.5	2.8	0.82	41.1	2.8	1.64
Absorption of CO_2	0	0	0	0	0	0	0	0	0
Total supply area	275.54			852.87			1056.45		
Bio-diversity protect（12%）	33.07			102.34			126.77		
Total ecological carrying capacity	242.47			750.53			929.68		
Per capita enological carrying capacity	0.67			1.47			1.86		

(3)In order to improve the comparability between different districts，a uniform standard should be developed so that the ecologic*l footprint can be used as a decision-making too1． Although it may be useful to utilize an equivalence factor． it is still a fixture value. If both an equivalence factor and various weight can be integrated，the ecological footprint will be more practica1. In addition，recent resource depreciation research and a ”satisfaction barometer” index should be considered． In this way the ecological footprint model can be developed that considers intergenerational justice as a new sustainable evaluate system．

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