The Evaluation Principles, Indicator System and Methods for Environment-friendly Utilization of County-level Land Resources

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Abstract From the perspective of environmental issues concerning land use and importance of county, we analyze the great significance of environment-friendly use of county land resources. On the basis of discussing the concept and connotation of environment-friendly utilization of land resources, we build the basic framework for the evaluation of environment-friendly utilization of land resources from environment, economy and society, and propose the evaluation methods combining composite index method and multi-angle single indicator evaluation method. At the same time, we establish the grading system and grading standards for environment-friendly county land use, to promote the qualitative and quantitative evaluation of environment-friendly county land use.

Key words County scale, Land use, Environment-friendly

Land is the material basis of human survival and development. Special attributes of land resources have made the land resources occupy the basic position in the three elements of population, resources and environment[1-2]. Whether the land resources are rationally used is directly related to the sustainable development of human society[3]. For the limited land use, the sustainable development of the traditional model has many limitations, ignoring the value and sustainable development of the spatial environment. There is an urgent need for the environment-based land use pattern which can promote harmonious development of environment, natural resources, human production and life. The unique characteristics of China's county economy determine that its development will inevitably have a direct or indirect impact on the composition and dynamic changes of regional land use, thus determining the degree of the environment-friendly land resources utilization[5-6].

At present, China's socialist new rural construction has entered a period of full implementation. The environment-friendly land use and socialist new rural construction complement each other, and the county plays a connecting role in China's socialist new rural construction. Therefore, it is important to research the studies of county-level environment-friendly utilization of land resources. The county scale is the optimal scale for the environment-friendly use, management and planning of China's land resources[7-8]. There is an urgent need to carry out in – depth study of evaluation, planning and management of county-level environment-friendly utilization, to ensure the building of county and national environmental-friendly society and successful implementation of sustainable land use strategy.

From the researches at home and abroad, the current study on the assessment of sustainable land use has not yet established the evaluation indicator system and methods for achieving the organic combination of ecological sustainability, economic sustainability and social sustainability, and coordinating the dialectical relationship among production development, affluent life and good ecology[9]. Since the mid – 1900s, the environment-friendly land use thinking has emerged in the world, but there are few special studies on the environment-friendly land use patterns. Especially for the "environmental friendly land use model" in China, there are basically a handful of qualitative descriptive studies on it[10-11].

In this paper, taking the study of county-level environment-friendly land utilization as the goal, we discuss the concept, connotation, evaluation indicator system, environment friendliness calculation and other methods for the county-level environment-friendly utilization of land resources, aimed at using new concept of ecological civilization development to regulate and restrain people's behavior and way of land development and utilization, achieve the fundamental change from "environmentally unfriendliness" to "environmentally friendliness"; providing a basis for establishing the evaluation indicator framework for county-level environment-friendly utilization of land resources, and further building the environment-friendly land use pattern, to ensure the construction of environment-friendly society and new rural construction, improve environment and resource protection and ultimately achieve sound and rapid development of county economy.

1 Principles and methods

1.1 Evaluation concepts and connotation of county-level environment-friendly utilization of land resources

1.1.1 The concept of county-level environment-friendly utilization of land resources. Based on some studies[4, 9, 12], this paper believes that environment-friendly land use is a land use pattern in pursuit of harmony between man and nature, without generating negative externalities or with the smallest negative externalities under existing conditions.

Environment-friendly land use is a friendly land use pattern

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using the eco-friendly development and use modes and measures to maintain the ecological, economic and social sustainability of land use, and achieve the human development, rational use of natural resources, and harmonious development of environment.

1.1.2 The connotation of county-level environment-friendly utilization of land resources. China's environmental friendly land use is an important part of building environment-friendly society, and a part of environment-friendly society. The connotation of environmental friendly land use is as follows: (i) Environment-friendly land use is the space – time extension of sustainable land use, posing higher requirement on land us and laying more emphasis on the natural environment. (ii) The environment-friendly land use is coordinated with the carrying capacity of resources and environment, and takes following the laws of nature as a criterion. (iii) The environment-friendly land use and construction of new socialist countryside complement each other, having historic limitations. The characteristics of the Chinese environment-friendly land use pattern[12] are as follows: pursuit of unification of ecological and economic benefits; combination of modern science and traditional experience of Chinese agriculture; combination of natural regulation and artificial regulation; combination of comprehensiveness and regionality; emphasis on building model based on regional characteristics and land types. (iv) The environment-friendly land use pattern and intensive use of land or land saving complement each other[10, 12]. Environment-friendly land use is the unification of utilization objective and connotation. By saving land, we can free up more land for ecological construction, thus creating excellent environmental conditions for land use; by intensive use of land, we can not only obtain good economic returns, but also improve the efficiency of resource use, reduce the emission of pollutants, thereby maintaining good land ecological conditions.

1.1.3 Evaluation of county-level environment-friendly utilization of land resources. The evaluation of environment-friendly land use borrow ideas from the studies of sustainable land use[8], and the basic content can be summarized as three aspects: (i) Ecological sustainability (ie, ecological friendliness); (ii) Economic feasibility (reflecting economic sustainability); (iii) Social acceptability (characterizing social sustainability). The eco-friendly evaluation plays an important role in environment-friendly utilization of land, and is the basis for the evaluation of environment-friendly land use[13]. The core of evaluation of environment-friendly land use lies in the comprehensive assessment of degree of environmental friendliness of land use.

1.1.4 The evaluation indicator system framework for the county-level environment-friendly utilization of land resources. Based on the connotation of county-level environment-friendly utilization of land resources and the characteristics of county land use, this article builds the evaluation indicator system framework for county-level environment-friendly land use (Table 1).

Due to the different concepts and models for "multi-indicator collective measurement method", there are great differences in the selected indicators. In the specific application, different counties (cities) can choose the appropriate indicators to build the indicator system suitable for sustainable land use strategies of the land resources, according to land use characteristics in different types of regions as well as the actual situation of natural, social, and economic conditions[8].

Table 1 The indicator system framework for county-level environment-friendly utilization of land resources and data acquisition approach

Goal	Criterion	Evaluation indicators	Composite indicators	Data acquisition approach
Environment-friendly utilization of land resources	Eco-friendliness	Land productivity index	Crop yield per unit area//kg/hm^2	Rural economic statistics
			Basic fertility index	Soil survey
		Land transformation index	The proportion of effective irrigated area//%	Ground field survey, remote sensing
			The proportion of low – yielding fields //%	Rural economic statistics
			The proportion of farmland shelterbelts area //%	Ground field survey, remote sensing
		Resources and environmental protection index	Forest coverage//%	Forest survey and remote sensing
			Application rate of chemical fertilizer per hectare//kg	Rural economic statistics
			Application rate of pesticide per hectare//kg	Rural economic statistics
			Energy consumption per unit of land //t standard coal	Socio-economic statistics
			The emission of three industrial wastes per 10^4 yuan of industrial output value//t	Socio-economic statistics
			The proportion of natural disaster affected area//%	Annual disaster survey, remote sensing

(Table 1)

Goal	Criterion	Evaluation indicators	Composite indicators	Data acquisition approach
			The proportion of soil erosion area //%	Located observation in monitoring sites, remote sensing
			The proportion of basic farmland area //%	Ground field survey or soil survey
		Land use intensity index	Multiple cropping index//%	Rural economic statistics
			New output value per unit area // yuan/hm^2	Socio-economic statistics
			Per capita arable land area/hm^2	Cadastral survey, land change survey
	Economic feasibility	Economic level	Per capita GDP //yuan	Socio-economic statistics
			Per capita food production//kg	Socio-economic statistics
			Input – output ratio per unit area of agricultural land	Socio-economic statistics
		Land use diversity	Land management diversity index	Rural socio-economic statistics
			Land use structure diversity index	Land change survey
	Social acceptability	Life quality	Per capita disposable income of urban residents//yuan	Socio-economic statistics
			Per capita net income of rural residents//yuan	Socio-economic statistics
		Population quality	The proportion of non-agricultural population//%	Socio-economic statistics
			National quality (proportion of population with junior high school education or higher) //%	Questionnaire survey or census

1.1.5 Evaluation methods for county-level environment-friendly utilization of land resources. Based on the previous studies[8], this article proposes a both quantitative and qualitative composite index method and a multi-angle single indicator evaluation method. The ultimate goal of the evaluation is to identify unfriendly factors in the process of land use[13], propose solutions to the problem, and put forth the improved model for environment-friendly utilization of land resources.

(i) Composite index method. Composite index evaluation method, namely, the effects of dimension are eliminated so that all indicators have the same utility, and different weights are given to different indicators, to finally get a composite evaluation index value:

$$X_i = \sum_{i=1}^{n} W_i \cdot U_i \ (i \text{ is the number of indicators})$$

where X_i is the comprehensive evaluation value; U_i is the score of evaluation indicator i; W_i is the weight of evaluation indicator i.

There are some methods for determining the indicator weight, such as Delphi method and hierarchical analysis method. Composite index method is to evaluate the three individual indicators of eco-friendliness, economic feasibility and social acceptability of land use (including composite indicators), focused on the evaluation of changes in the environment-friendly utilization of land resources. However, the composite index method is not easy to expose the specific problems.

(ii) Multi-angle single indicator evaluation method[8]. Although using composite index method, we can get the general situation of environment-friendliness of county-level land resources, some specific problems are covered up in the land use. In order to identify the obstacle factors in the sustainable land use, we use the qualitative method for evaluation, namely the multi-angle single indicator evaluation method.

Multi-angle single indicator evaluation method is to evaluate various indicators concerning eco-friendliness, economic feasibility and social acceptability of land use one by one, namely to evaluate the individual indicators that can reflect the evaluation object (including composite indicators). From different aspects, different angles, it is to evaluate whether they meet the requirements of friendliness; if any one of the three aspects is unfriendly, then it is believed that this land use pattern is non-friendly.

2 Grading of environment-friendliness of county-level land use

At present, there has not yet any special study of the grading system and grading standards for environment-friendliness of land use at home and abroad. According to the development stage theory, we borrow the ideas from Rostow's theory of economic development stage, and at the same time, draw on previous researches on the land[9-14]. Finally by consulting experts, the environment-friendliness of county-level utilization of land resources is divided into four stages: non-environment-friendly, critically environment-friendly, basically environment-friendly and highly environment-friendly (Table 2).

Table 2 The grading standards for evaluation of county-level environment-friendly utilization of land resources and the basic meaning

Environmental friendliness grade	Environment-friendliness values	Basic meaning
Highly environment-friendly	≥0.90	The eco-friendliness of land use is high; the land development and utilization activities do not cause a significant impact on environment; it can ensure the environment-friendliness of land use.
Basically environment-friendly	0.70 – 0.90	The environment-friendliness of land use is good; the land development and utilization activities cause little impact on environment; if taking certain measures, the environment-friendliness of land use can be ensured.
Critically environment-friendly	0.50 – 0.70	The environment-friendliness of land use is low; unreasonable land development and utilization activities have caused a certain degree of influence and destruction on environment; only by taking effective measures can we ensure the environment-friendliness of land use.
Non-environment-friendly	≤0.50	The environment-friendliness of land use is very low, and the unfriendliness is particularly prominent; there is a need to fundamentally reverse the land use pattern and take significant measures to ensure the environment-friendliness of land use.

3 Conclusions

(i) Based on the seriousness of increasingly deteriorating environment and importance of importance, it is necessary to carry out the evaluation study on the county-level environment-friendly land use. Using new concept of ecological civilization to regulate and restrain people's land development and utilization behavior, we can promote the fundamental change of land use from "environmentally unfriendliness" to "environmentally friendliness", and provide a basis for establishing evaluation system for sustainable environment-friendly use of county land resources and further building the environment-friendly land use pattern, to ensure the construction of environment-friendly society and new rural construction, improve the capacity of resources and environment protection, and further achieve sound and rapid development of county economy.

(ii) On the basis of discussing the necessity of carrying out evaluation study on county-level environment-friendly land use, this article proposes the concept and connotation of county-level environment-friendly utilization of land resources; points out that the key to evaluation of environment-friendly land use lies in the eco-friendliness evaluation; from the ecological, economic and social aspects, builds the basic framework for the evaluation of county-level environment-friendly utilization of land resources.

On the basis of previous studies, this article proposes the evaluation methods comprising composite index method and multi-angle single indicator evaluation method. According to the characteristics of environment-friendly land use, this article establishes the grading system and grading standards for the environment-friendliness of county-level land use. The environment-friendliness of county-level utilization of land resources is divided into four stages: non-environment-friendly, critically environment-friendly, basically environment-friendly and highly environment-friendly. And finally the basic meaning of each grade is determined.

References

[1] XIE JQ. Study on index evaluation and planning practice of land sustainable use system[D]. Beijing: College of Resources and Environment, China Agricultural University, 1999. (in Chinese).

[2] MA KW, ZHANG QL. Sustainable land use and sustainable social and economic development[J]. China Land Science, 2001, 15(2): 15 – 17. (in Chinese).

[3] HOU HP. Study on the evaluation of land sustainable use in counties—Taking the case of Dagu County, Shanxi Province D]. Taiyuan: College of Resources and Environment, Shanxi Agricultural University, 2003. (in Chinese).

[4] ZHAN S. A new mode of land utilization—friendly land utilization model study[J]. Journal of Guizhou University of Technology(Social Science Edition), 2007, 9(4): 84 – 87. (in Chinese).

[5] ZHANG FR, WANG J, CHEN BM. The indicator system and method to assess the sustainability of land use[M]. Beijing: China Agriculture Press, 2003. (in Chinese).

[6] WANG J, GUO XD. A study of scientific regulation of sustainable land use at county scale in China[J]. Progress in Geography, 2002, 11(3): 216 – 220. (in Chinese).

[7] WANG J, ZHANG FR, GUO XD, *et al*. Assessment methods of sustainable land use at county scale[J]. Geography and Geo-Information Science, 2004, 20(2): 53 – 56. (in Chinese).

[8] WANG J, PU LJ, ZHANG FR, *et al*. Sustainable land use indicators at county scale——A case study of Xishan City, Jiangsu Province[J]. Resources Science, 2003, 25(5): 40 – 45. (in Chinese).

[9] YANG ZS, LIU YS, HE YM, *et al*. The principles and methods of eco-friendliness evaluation of land use in mountainous areas at county level and its case study[J]. Journal of Natural Resources, 2008, 23(4): 600 – 611. (in Chinese).

[10] LIU GF, DIAO CT. Study on harmonizing land use and eco-environment construction in Jiangjin, Chongqing Municipality[J]. Research of Soil and Water Conservation, 2006, 13(6): 62 – 64. (in Chinese).

[11] ZHANG CY, Wahap HALIK, MA Y, *et al*. Environment externalities analyse of typical arid areas land use change ——Make Qira Oasis in Xinjiang Province for example[J]. Yunnan Geographic Environment Research, 2007, 19(1): 28 – 33. (in Chinese).

[12] MAO DH, CHEN QL, WANG ZY. On some basic problems in the patterns for environmental-friendly land utilization[J]. Resources Environment & Engineering, 2007, 21(1): 7 – 78. (in Chinese).

[13] FU BJ, CHEN LD, MA C. The indicator system and method to assess the sustainability of land use[J]. Journal of Natural Resources, 1997, 12(2): 45 – 48. (in Chinese).

[14] FENG J. Patterns of land use of large towns in southern Jiangsu Province and its spatial planning [J]. Resources Science, 2002 , 24(5) : 39 – 45. (in Chinese).