Evaluation of Sustainable Utilization of Arable Land in Mountainous Areas of Yunnan Province Based on the Second National Land Survey

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Abstract: Research content: The intrinsic attributes of mountainous areas, namely vulnerable ecology and highly sensitive environment, are highly restricting sustainable utilization of arable land in mountain areas. At present, the research is more detailed on the evaluation of sustainable utilization of arable land in mountainous areas in borderland, and evaluation of sustainable utilization of arable land in mountainous areas is one of the important bases for ensuring food security, maintaining border stability, and promoting sustainable economic and social development. With Yunnan Province as an example, on the basis that the special connotations of sustainable utilization of arable land in mountainous areas are explained, in combination with the Second National Land Survey, the index system is constructed from 3 perspectives, eco-friendliness, economic feasibility, and social acceptability, and variation coefficient method and comprehensive index method are used to calculate the level of sustainable utilization of arable land and for grading. Research method: Progress in research on evaluation of sustainable utilization of arable land is learnt by literature review, and the research area is empirically analyzed by method of comparative analysis and qualitative-quantitative combined method. Conclusions: The arable land in the mountainous areas of Yunnan Province is generally in a state of sustainable utilization. Moderately sustainable and unsustainable cities and prefectures are almost equal, but there is no sustainable city or prefecture. In terms of spatial distribution, the level of sustainable utilization of arable land in mountainous areas is lower especially in mountains and highlands of the northeast Yunnan, and high mountains, highlands and canyons of the northwest Yunnan. Most of those areas are subject to a level of unsustainable utilization. The level of sustainable utilization of arable land in mountainous areas is higher in middle and eastern Yunnan.

1 Introduction

Sustainable utilization of arable land is an important measure to protect the ecological environment of arable land, guarantee national food security, safeguard national long-term stability, and realize a harmonious society. It is also an important part of sustainable socio-economic development and has been highly valued and widely implemented in China. In order to fully and systematically promote the sustainable utilization of arable land, many experts and scholars in China have performed theoretical discussions and empirical researches on the evaluation of sustainable utilization of arable land, which mainly focuses on building of the index system [1-6], empirical research on areas based on model and theory [7-10], and etc. For example, Shi Shufen [11] made a general review of evaluation index system of arable land intensification.

Wang Shuhua [12] made an in-depth exploration for the regulatory mechanism of sustainable utilization of arable land in China. Niu Haipeng [13] evaluated sustainable utilization of arable land in Jiaozuo City from the perspective of niche fitness. Sun Qi[14] studied sustainable utilization of eco-economic system of arable land in Henan Province on the basis of energy theory. However, in terms of existing literature, the evaluation and development of sustainable utilization of arable land in China is not systematic enough, and a complete and comprehensive evaluation index system has not yet been formed. The scale selected in most empirical researches conducted covers economically developed administrative regions in east and middle China. Arable land in these regions is more stable and utilized at a higher level. The research is weaker on the typical mountainous areas with vulnerable ecology and highly sensitive environment in the borders of southwest China. However, the level of

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sustainable utilization of arable land in the mountainous areas southwestern border areas is of great importance to the national economy and people's livelihood. It is an important issue for the prosperity and stability of the border areas.

Yunnan is a typical province in mountainous border areas of southwest China. Its arable land is of both resource attributes and ecological attributes. It is of great practical significance to make a reasonable evaluation for sustainable utilization of arable land in Yunnan. Thus, on the basis of results of the Second National Land Survey, evaluation index system of sustainable utilization of arable land in mountainous areas is constructed from 3 perspectives, eco-friendliness, economic feasibility, and social acceptability, and weight is confirmed by coefficient of variation so as to evaluate and analyze sustainable utilization of arable land in mountainous areas in Yunnan[15]. Several countermeasures and suggestions are proposed on sustainable utilization of arable land in mountainous areas in Yunnan in the end, which aims at providing reference for evaluation of sustainable utilization of similar arable land in mountainous areas.

In summary, special connotations of sustainable utilization of arable land in mountainous areas are understood as: Ecology is not degraded, or water and soil loss and ecological degradation can be relieved by artificial reforming, and sufficient effective soil layers can be maintained for a long time to meet the growing need for food crops in a way that maintains innate ecological and productive functions, available performances and long-term sustainable utilization of arable land, so that output level can be maintained and enhanced, sufficient diversified food products can be provided continuously for people in most mountainous areas, the demand for survival and growth of generations can be met[16].

2 Special connotations of sustainable utilization of arable land in mountainous areas

The sustainable utilization of arable land arises in response to a series of catastrophic factors, such as gradually less quantity and lower quality of arable land resources. It aims to ease the hot-button issues of arable land utilization and promote the efficient and harmonious development and utilization of arable land resources. Mountainous areas are a unique areal type with innate vulnerable environment. Sustainable utilization of arable land in mountainous areas plays a major role in improving regional people's livelihood and bears double tasks of maintaining regional ecological balance and promoting harmonious development between man and land [9]. It is not difficult to find that arable land in mountainous areas shows a "pathological" side in the flood of economic and social development. For example, arable land is largely occupied for a purpose of construction, and unreasonable farming in arable land gives rise to declined fertility and water and soil loss. Besides, the artificial destruction of arable land in mountain areas is irreversible. Once arable land is impacted, its recovery cycle is infinitely long. Therefore, arable land in mountainous areas particularly

needs to be utilized sustainably so as to ensure harmony between its benign development and utilization. In addition, sustainable utilization of arable land in mountainous areas is a view which expresses sustainability of nature, economy and society. Sustainable utilization of nature is basis, sustainable utilization of economy is extension, and sustainable utilization of society is responsibility. So-called sustainable utilization of nature means level of affordability shall be fully considered and both long-term and short-term benefits considered when arable land in mountainous areas is developed and utilization. Sustainable utilization of economy means that benefits from arable land resources are explored at a high efficiency on the premise that quality of arable land resources in mountainous areas is not degraded. Sustainable utilization of society means that an increasing number of humans can be fostered with limited resources, delivers level of social acceptability and social affordability, and reflects a measure of intergenerational equity.

3 Research area overview and research methods

3.1 Research area overview

Yunnan Province is located at the southwestern border of China and belongs to the low-latitude plateau. Its geographical location is relatively special and topography and landform are complicated. The overall terrain is generally characterized by high northwest and low southeast. The land area of whole Yunnan is 394,000 square kilometers, ranking the eighth in China and accounting for 4.1% of China's total land area and about 84% of mountainous areas [15]. In 2010, Yunnan's GDP reached 618.975 billion Yuan, accounting for 19% of China's GDP, with an increase by 107.76 billion Yuan in the primary industry, 257.253 billion Yuan in the secondary industry, and 252.962 billion Yuan in the tertiary industry. In 2010, permanent population was 45.81 million in Yunnan.

According to the summary of the Second National Land Survey at the unified time point on December 31, 2009, there was 6.2439 million hectares of arable land in Yunnan Province, accounting for 16.29% of total land area. There was 925,800 hectares of arable land with 0° to 2°gradient which accounted for 14.83%, 699,500 hectares of arable land with 2° to 6°gradient which accounted for 11.20%, 1.814 million hectares of arable land with 6° to 15°gradient which accounted for 29.05%, 1.897 million hectares of arable land with 15° to 25°gradient which accounted for 30.38%, and 907,600 hectares of arable land with gradient＞25°which accounted for 14.54%.

3.2 Data sources

Data in the Paper come from *Yunnan Statistical Yearbook* (2010), *Yunnan Land Resources* (monograph for results of the Second National Land Survey in Yunnan Province) and Yunnan Bulletin of Provincial Economic and Social

Statistics (2010). Some data are acquired directly from statistical yearbook. A large part of data is required to be obtained through calculation.

3.3 Construction of evaluation index system

Whether evaluation index system is constructed scientifically and accurately is directly related to authenticity of evaluation results. On the basis of sustainable development theory and characteristics of arable land utilization in mountainous areas, with the principles [18], systematization, science, independence, dynamics and operability, followed, the evaluation index system owhich covers 3 principle levels, eco-friendliness, economic feasibility and social acceptability, and 13 indexes is constructed for sustainable utilization of arable land in mountainous areas (Table 1).

Table 1 Evaluation Index System of Sustainable Utilization of Arable Land in Mountainous Areas

Objective level	Principle level (weight)	Index level (weight)	Calculation method	Data source
Evaluation of sustainable utilization of arable land in mountainous areas	Eco-friendliness（0.61）	Effective irrigation rate of arable land //% (0.11)	(paddy area + irrigable land)/total area of arable land	Land Change Survey
		Terraced level of slope //% (0.07)	Area of terrace and terrace land/area of arable land /≥2°	Land Change Survey
		Proportion of arable land in slope higher than 25°(0.2)	Area of arable land in slope ＞25°/ area of arable land	Land Change Survey
		Over-reclamation rate//% (0.13)	Area not suitable for farming (arable land in slope)/total area of arable land	Land Change Survey
	Economic feasibility（0.21）	Area where stable output is ensured despite drought or flood hm^2 (0.1)	Arable land where normal output is ensured despite drought or flood	*Yunnan Statistical Yearbook*
		Average unit grain output //kg/ hm^2 (0.06)	Total grain output/ seeded area of food crop	*Yunnan Statistical Yearbook*
		Output of plantation per unit arable land//Yuan/ hm^2 (0.09)	Output of plantation/ total area of arable land	*Yunnan Statistical Yearbook*
		Per capita annual net income of farmers // Yuan (0.06)	——	*Yunnan Statistical Yearbook*
		Natural population growth rate //% (0.04)	——	*Yunnan Statistical Yearbook*
	Social acceptability（0.18）	Per capita arable land area // hm^2/person (0.06)	Area of arable land/total population	*Yunnan Statistical Yearbook*
		Per capita grain output//kg/ person (0.05)	Total grain output/ total population	*Yunnan Statistical Yearbook*
		Grain sown proportion//% (0.03)	Grain sown area/total sown area	*Yunnan Statistical Yearbook*

3.3.1 Description of general indexes

General indexes are applicable to evaluation of sustainable utilization of arable land in most areas, such as over-reclamation rate, area where stable output is ensured despite drought or flood, average unit grain output, per capita annual net income of farmers, per capita arable land area, and per capita grain output [16-17]. Some general indexes (not detailed introduction here) were quoted appropriately in the Paper. And their specific meanings and measurement & calculation methods are not changed in the Paper.

3.3.2 Description of special indexes

(1) Terraced level of slope

Terraced level of slope is a proportion which terrace and terrace land accounts for in total area of arable land.

Arable land in slope is vulnerable to water and soil loss and ecological degradation. Terrace transformed from slope can turn arable land in slope where soil, water and fertility are drained into the terrace and terrace land where soil, water and fertility are conserved. Arable land in slope with gradient 8^0 to 25^0 is transformed into terrace so as to control water and soil loss, which is an effective means to prevent ecology of arable land from being degraded and quality becoming lower [18]. Thus, terraced level of slope is an important index which reflects eco-friendliness of sustainable utilization of arable land in mountainous areas.

(2) Proportion of area of arable land in slope $>25°$

Arable land in slope mainly refers to a geomorphic type of which gradient is between $6°$ and $25°$. It is of a high gradient and a low capacity of water source conservation. It is not only an important part of arable land resources in mountainous areas and but also the greatest threat to ecological security of arable land in mountainous areas. Undoubtedly, arable land in slope with gradient higher than $25°$ shall be de-farmed and recovered ecologically so as to improve vegetation coverage.

3.4 Dimensionless data

Due to different data sources, there is no unified dimension for index data. Indexes are required to be standardized by z-score standardization and 0-1 standardization so that indexes of different dimensions can be compared. The specific calculation equation is:

$$x^* = \frac{x - \mu}{\sigma}$$

Where: μ is average of all sample data and σ is standard deviation of all sample data.

$$x^* = \frac{x - min}{max - min}$$

Where: max is maximum of sample data and min is minimum of sample data.

3.5 Weight confirmation

Variation coefficient method is to directly use the information contained in indicators to obtain weight of indicators through calculation. It is a method of objective empowerment. The basic approach of this method is: In the evaluation index system, the greater difference between values of index will be more able to reflect the gap between the evaluated units. Since there is no uniform dimension for indexes in the evaluation index system, it is impossible to directly compare the degree of difference. The coefficient of variation of indexes needs to be used to measure the degree of difference between values of indexes [19]. The equation of coefficient of variation of indexes is as follows:

$$V_i = \frac{\sigma_i}{\overline{x}_i} \qquad (i = 1, 2, \cdots, n)$$

Where: V_i is coefficient of variation of the i th index

and also called coefficient of standard deviation, σ_i is standard deviation of the i th index, and $\overline{x}_i$ is average of the i th index.

Weight of indexes is:

$$W_i = \frac{V_i}{\sum\limits_{i=1}^{n} V_i}$$

3.6 Comprehensive evaluation method

In accordance with standardized value and weight of indexes, comprehensive index method is used to calculate comprehensive evaluated value of sustainable utilization of arable land. The specific equation is as follows:

$$Y = \sum\limits_{j=1}^{m} P_j W_j$$

Where: P_j is standardized value of the jth evaluation index and W_j is weight of the jth evaluation index.

3.7 Division of evaluated level of sustainable utilization of arable land in mountainous areas

With Zhou Guofu and other scholars' criterion on level of sustainable utilization of land for reference and existing literature integrated, the east part is unsustainable when its comprehensive evaluated value is ≤0.500 and the middle part is unsustainable when its comprehensive evaluated value is ≤0.450. In combination with practical conditions of sustainable utilization of arable land in mountainous areas in Yunnan, an area is unsustainable when its comprehensive evaluated value is ≤0.350. And sustainable utilization of arable land is divided into four levels, unsustainable, generally sustainable, moderately sustainable and sustainable[20-21]. (Table 2)

Table 2 Criterion on Evaluated Level of Sustainable Utilization of Land

Comprehensive evaluated value	Evaluation criterion
≤0.350	Unsustainable
0.351—0.500	Generally sustainable
0.501—0.750	Moderately sustainable
>0.750	Sustainable

4 Evaluation results and analysis

It can be seen from the evaluation results (Table 3 and Fig.1) that there is a certain gap between the sustainable utilization of arable land resources in the mountainous areas of cities and prefectures in Yunnan Province. And the level of sustainable utilization of arable land resources is higher in some cities and prefectures, such as Kunming City, Qujing City, Yuxi City, Honghe Prefecture and Wenshan Prefecture. Comprehensive evaluated values of those cities and prefectures are higher than 0.5, which is a moderately sustainable level. The level of sustainable

utilization of arable land resources is lower in some cities and prefectures, such as Zhaotong City, Diqing Prefecture and Nujiang Prefecture. Comprehensive evaluated values of those cities and prefectures are lower than 0.35, which is an unsustainable level. On the whole, there are characteristics as follows: (1) During "the Second National Land Survey", sustainable utilization of arable land in mountainous areas in Yunnan Province is at a generally sustainable level with a large difference between areas and a trend that the southern and northern parts are of a lower level, the middle part is of a higher level, and level in the eastern part is higher than that in the western part, which is closely related to economic development level, geographical conditions and indexes selection of area; (2) Focus is placed on eco-friendliness evaluation, value of eco-friendliness index is higher than that of economic feasibility and of social acceptability; eco-friendliness index selected is practically consistent with characteristics of arable land utilization in mountainous areas; results of evaluation are distinguished between the important and the lesser one; (3) Yunnan is at a generally sustainable level on the whole. Moderately sustainable and unsustainable cities and prefectures are almost equal, but there is no sustainable city or prefecture. The level of sustainable utilization of arable land in mountainous areas is lower especially in mountains and highlands of the northeast Yunnan, and high mountains, highlands and canyons of the northwest Yunnan. Those areas are subject to a level of unsustainable utilization.

Table 3 Results of Evaluation of Sustainable Utilization of Arable Land in Mountainous Areas of Yunnan Province during "the Second National Land Survey"

| Cities and prefectures	Eco-friendliness	Economic feasibility	Social acceptability	Comprehensive evaluation	Results of evaluation
Kunming City	0.346	0.175	0.04	0.561	Moderately sustainable
Qujing City	0.286	0.11	0.113	0.509	Moderately sustainable
Yuxi City	0.311	0.183	0.047	0.541	Moderately sustainable
Baoshan City	0.231	0.123	0.064	0.418	Basic sustainable
Zhaotong City	0.176	0.042	0.089	0.307	Unsustainable
Lijiang City	0.156	0.04	0.102	0.298	Unsustainable
Pu'er City	0.31	0.022	0.109	0.441	Basic sustainable
Lincang City	0.317	0.022	0.102	0.441	Basic sustainable
Chuxiong Prefecture	0.286	0.106	0.044	0.436	Basic sustainable
Honghe Prefecture	0.451	0.071	0.068	0.590	Moderately sustainable
Wenshan Prefecture	0.363	0.029	0.133	0.525	Moderately sustainable
Xishuangbanna Prefecture	0.174	0.093	0.054	0.321	Unsustainable
Dali Prefecture	0.213	0.17	0.046	0.429	Generally sustainable
Dehong Prefecture	0.171	0.091	0.1	0.388	Generally sustainable
Nujiang Prefecture	0.16	0.013	0.118	0.291	Unsustainable
Diqing Prefecture	0.108	0.055	0.115	0.278	Unsustainable
Yunnan Province	0.254	0.084	0.084	0.422	Basic sustainable
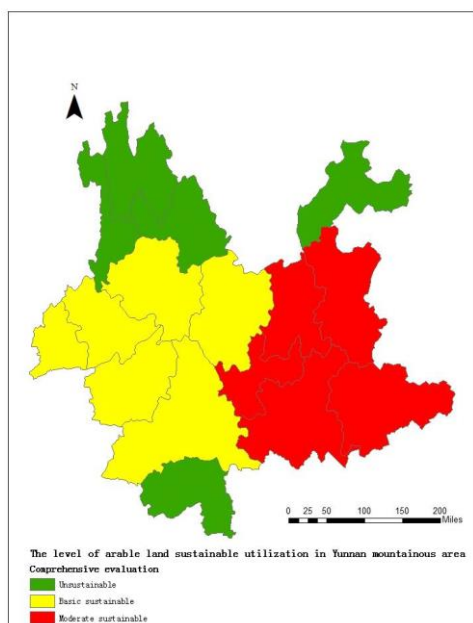
Fig.1 Spatial Distribution for Evaluated Level of Sustainable Utilization of Arable Land in Mountainous Areas of Yunnan Province

5 Countermeasures for sustainable utilization of arable land in mountainous areas in Yunnan Province

It can be seen from the analysis for cities and prefectures in Yunnan Province that there is still large room for development in terms the level of sustainable utilization of arable land resources in mountainous areas in cities and prefectures. It is necessary to add efforts to appropriately develop arable land resources in mountainous areas in a way that enhances level of sustainable utilization of arable land.

5.1 Scientifically verifying for amount of arable land in slope with gradient ＞25° scientifically and performing orderly ecological de-farming

Ecological de-farming is a measure to recover reclaimed arable land in slope (especially in steep slope) to woodland before reclamation, in order to protect and improve ecological environment of land. It is found from study on water and soil loss in arable land of Yunnan Province that arable land in slope is a land type with the severest water and soil loss, especially in the slope with gradient＞25°. Thus, it is necessary to formulate stringent laws and regulations on verification so as to scientifically verify the amount of arable land in slope with gradient ＞25° in a way that provides a solid foundation for ecological de-farming.

5.2 Vigorously promoting comprehensive renovation of arable land in mountainous areas

where "transforming slop into terrace" plays a dominant role

Arable land in slope is a main part of arable land in mountainous areas. Thus, it is urgently needed to build basic farmlands in mountainous areas by taking comprehensive measure on water and soil conservation where "transforming slop into terrace" plays a dominant role, and to control water and soil loss in arable land, improve agricultural production conditions of mountainous areas and improve quality and rate of output of arable land in mountainous areas by enhancing terraced level of arable land in mountainous areas[22].

5.3 Reinforcing construction of water conservancy project in mountainous areas and enhancing effective irrigation rate of arable land

Arable land in the mountainous areas is of a high proportion and scattered. The construction of large and medium-sized water conservancy projects is characterized by difficulties in construction and water diversion. As a result, the focus shall be placed on further improving small-scale water conservancy projects in line with local conditions and increasing government's investment and mass labor, so as to build a more complete water conservancy project system of mountainous areas, and highly improve effective irrigation rate, grain production capacity and rate of output of arable land in mountainous areas.

6 Conclusions

Yunnan is a unique mountainous province in the borders of southwest China. To study on evaluation of sustainable utilization of arable land in mountainous areas in Yunnan is of great practical significance. On the one hand, such study is an enrichment and expansion of items of study on sustainable utilization of arable land in China, providing beneficial reference for land research. On the other hand, it practically provides scientific basis for sustainable utilization of arable land in mountainous areas and reference for stability and sustainable economic and social development of the borders of southwest China. However, the Paper also has some deficiencies. Only year-end data from the Second National Land Survey in Yunnan Province are selected. the Paper is not convincing enough and needs to be further improved.

References

1. Zhao Kai, Niu Gang. Discussion on the Evaluation Index System of Sustainable Utilization of Arable Land [J]. On Economic Problems, 2001, (6):45-47.

2. Wang Hongying, Zhai Ruichang, Cai Deli. Construction of Evaluation Index System for Sustainable Utilization of Arable Land under PSR Model[J].Heilongjiang Agricultural Sciences, 2010, (2):33-35.

3. Duan Yuhu, Li Chunhe, Li Qingli. A Preliminary Study on the Evaluation of Sustainable Utilization of Arable Land [J]. Real Estate Valuation, 2008, (6):29-31.

4. Du Qingyun, Gong Lifang. A Preliminary Study on the Evaluation Index of Sustainable Utilization of Arable Land[J].Scientific and Technological Management of Land and Resources, 2002, (5):30-33.

5. Liu Guangcheng, Dong Jie, Tian Xinwei. A Preliminary Study on Evaluation of Sustainable Land Utilization[J]. Chinese Journal of Agricultural Resources and Regional Planning, 2002, 23(2):23-27.

6. Fan Hui, Zhou Jin. Evaluation of Sustainable Utilization of Arable Land Resources in Henan Province Based on Fuzzy Matter-element Model[J].Scientific and Technological Management of Land and Resources, 2010, (4):82-87.

7. Shu Bangrong, Liu Youzhao, Lu Xiaoping, et al. Study on the Application of Energy Analysis Theory to the Evaluation of Sustainable Utilization of Arable Land——A Case Study of Nanjing City[J].Journal of Natural Resources, 2008, 23(5):876-885.

8. Xiong Changsheng, Hu Yueming, Cheng Jiachang, et al. Evaluation of Sustainable Utilization of Arable Land Based on Niche Theory[J].Guangdong Agricultural Sciences, 2013, (7):197-201.

9. Zhao Xi, He Guosong. Discussion on the Evaluation of Sustainable Utilization of Arable Land Resources-A Case Study of Xianning City, Hubei Province[J].Scientific and Technological Management of Land and Resources, 2004, 21(5):17-20.

10. Xu Erqi, Zhang Hongqi. A Study on Evaluation of Sustainable Land Utilization in Ecologically Fragile Areas in China[J].Chinese Journal of Agricultural Resources and Regional Planning, 2012, 33(3):1-6.

11. Shi Shuqin, Cao Yuqing, Wu Wenbin, Yang Peng, Cai Weimin, Chen Youqi. Research Progress on Evaluation Index System and Evaluation Method of Arable Land Intensification[J]. Chinese Journal of Agricultural Sciences, 2017, (07): 1210-1222.

12. Wang Shuhua, Wang Yuncai. Discussion on Regulatory Mechanism of Sustainable Utilization of Arable Land in China[J]. China Land Sciences, 2001, (02): 10-13.

13. Niu Haipeng, Zhao Tongqian, Zhang Anlu, et al. Evaluation of Sustainable Utilization of Arable Land Based on Niche Fitness[J].Acta Ecologica Sinica, 2009, (10):5535-5543.

14. Sun Qi, Sun Pengyuan, Gao Yongsheng, et al. A Study on Sustainable Utilization of Eco-economic System of Arable Land in Henan Province Based on Energy Analysis [J]. Chinese Journal of Agricultural Resources and Regional Planning, 2010, (03): 37-42.

15. Si Zhaoxia, Zhang Hebing, Chen Ningli. Evaluation of Sustainable Utilization of Arable Land in Henan Province Based on Variation Coefficient Method[J].Hubei Agricultural Sciences, 2015, (08):2028-2031.

16. Yang Zisheng, Liu Yansui. Research on Eco-Friendly Land Utilization in Mountainous Areas of China—Taking Yunnan Province as an Example[M]. China Science and Technology Press, 2007.

17. Wang Hongying, Cui Ruichang, Cai Deli. Construction of Evaluation Index System for Sustainable Utilization of Arable Land under PSR Model[J].Heilongjiang Agricultural Sciences, 2010(2):32-35.

18. Wang Ying, Yang Xiaoxiong, Xie Yi. A Study on Evaluation of Sustainable Land Utilization in Counties in Underdeveloped Areas: A Case Study of Ningming County in Guangxi[J].Hunan Agricultural Sciences,2013(17):76-83.

19. Yang Zisheng, Liu Yansui, He Yimei, et al. The Principles, Methods and Practices of Evaluation of Eco-Friendliness of Land Utilization in Counties in Mountainous Areas [J].Journal of Natural Resources, 2008, 23(4):600-611.

20. Zhou Zhixiang. Comprehensive Evaluation of Port Based on Variation Coefficient Method: A Case Study of Coastal Ports in Liaoning [J]. Manager's Journal, 2015, (05): 181.

21. Si Zhaoxia, Zhang Hebing, Chen Ningli. Evaluation of Sustainable Utilization of Arable Land in Henan Province Based on Variation Coefficient Method[J].Hubei Agricultural Sciences, 2015, 54(08):2028-2031.

22. Chen Baiming. Construction and Evaluation of Indicator System Framework of Sustainable Utilization of Regional Land [J].Progress in Geography, 2002, 21(3):204-215.

23. Zhao Qiaogui. Research on Arable Land Utilization and Protection Measure System Guaranteeing Food Security in Mountainous Provinces: A Case Study of Yunnan Province [A]. Specialized Committee of Land Resources Research under Chinese Society of Natural Resources: 2008:8.