Study on sustainable utilization of cultivated land eco-economic system in Yunnan province based on energy value analysis

Zhong Wen[1,*], Zhong Changbiao[2]

[1]School of Economics, Yunnan University of Finance & Economics, Kunming 650221
[2]School of Business, Yunnan University of Finance & Economics, Kunming 650221

Abstract. The research on sustainable utilization of cultivated land eco-economic system has important practical significance for understanding cultivated land status and promoting sustainable utilization of cultivated land. Based on energy value theory and analysis method, this paper establishes the evaluation Index system of cultivated land eco-economic system in Yunnan Province, and chooses 5 main indexes, such as net energy output rate, environmental bearing ratio, system production dominance, system stability index and sustainable development performance index, etc. The energy input-output structure and sustainable development status of cultivated land eco-economic system were evaluated. The results show that the net energy yield of cultivated land system in Yunnan province is 0.29, lower than the national average, and the competitiveness of agricultural products is not enough; the system production dominance and system stability index are 0.51 and 0.68 respectively, which indicates that the system self-control, adjustment and feedback need to be strengthened, the environmental carrying capacity and sustainable development performance index were 0.66, 4.21, reflecting the province's arable land system in the sub-sustainable state. Therefore, the current agricultural development mode should be adjusted to optimize the input structure, and we should actively introduce external energy value, make full use of external resources, and relieve resource pressure. On the basis of applying agricultural science and technology, strengthening the utilization intensity of renewable auxiliary energy, developing green industry, reducing the environmental pressure on cultivated land system, realizing the sustainable utilization of cultivated land system.

1 Introduction

The cultivated land ecosystem is a kind of special ecological form between natural ecosystem and artificial ecosystem, which is cultivated under the artificial cultivation system [1]. Many scholars have made a great deal of theoretical and empirical research on the evaluation of sustainable utilization of cultivated land, but they have neglected the contribution of natural resources to social and economic development, and urgently need to comprehensively consider the relationship between ecological environment system and human social economic system under the situation of energy and ecological crisis. In order to evaluate the sustainable development ability of cultivated land eco-economic system rationally and effectively. The theory and method of energy value analysis (h.t.odum) is a method of evaluating the degree of sustainable development based on the research of the power system in the late the 1980s, which transforms the energy and material of different classes of flow and storage into the energy value of the unified standard, and carries on the quantitative analysis, which provides a heavy for the rational utilization and evaluation of cultivated land resources. The standard of measurement is measured. The research on energy value theory in China is mainly focused on urban eco-economic system, industrial eco-economic system and agro-ecological economic system [2-5], but the systematic study of cultivated land eco-economic system is still insufficient. Based on this, the paper uses energy value theory and analysis method to evaluate the cultivated land eco-economic system in Yunnan Province, in order to provide reference for the sustainable use of cultivated land in Yunnan province, and to provide references for government decision-making.

2 Research Area Overview and Research methods

2.1 Study Area Overview

Yunnan Province is located in the Southwest frontier of China, between the east longitude 97°31′~106°11′, north latitude 21°8′~29°15′, is our country adjacent neighboring countries most, the border longest province one. The total land area of the province is about 394,000 km^2 (4.11% of

*Corresponding author: 15908854450@163.com.

the total area of the country), with a total population of 47.705 million people in the end of 2016. It is located in the low latitude plateau, belongs to the plateau monsoon climate, the province is rich and diverse climatic types, the annual temperature difference between the 10~15℃; the seasons are full of light and abundant in plants and animals. At the end of 2016, the total arable land area of Yunnan province was 6.2078 million hm^2 and the main grain crops were paddy, maize, wheat and so on, with peanut, rapeseed, sugarcane, flue-cured tobacco and tea.

2.2 Research methods and main indicators description

2.2.1 Research Methods

Energy value is the amount of energy that flows or is stored in another category, which is the amount of an effective energy that is directly or indirectly applied in the process of product or service formation [6]. The unit of energy is solar joule (erajoules; abbreviated to SEJ). The conversion rate of solar energy indicates how much energy (or matter) of a unit is equivalent to the amount of energy of a solar joule.

The energy conversion rate is a measure of energy quality, and the higher the conversion rate of some energy, the higher the energetic quality, and the higher the class level in the energy system [4].

The basic formula for calculating solar energy is: Solar value (sej) = Energy (J) [or substance (g) or value (yuan)] x Energy conversion rate (SEJ/J) (or sej/yuan or sej/g).

Firstly, based on the energy input-output data of the 2016-year cultivated land eco-economic system in Yunnan Province, the energy value input-output analysis table of cultivated land system is established by the conversion coefficient and the ability value. Then, the energy flow of the computing system and the establishment of an energy index system are used to analyze and evaluate the sustainable performance of cultivated land eco-economic system in Yunnan Province according to the dynamics of the flow and quantity of the material flow and the quantity relationship between them.

Among them, the original data and solar values are based on the 2017 Yunnan Provincial Statistical Yearbook and the China Rural Statistical Yearbook 2017 and some of the survey data, respectively, by the energy conversion coefficient and the value of solar energy transfer rate calculation (table 1).

2.2.2 Main indicator description

(1) Net energy yield (EYR)

The net energy yield is the ratio of the system energy value to the economic input energy value. Input energy value comes from the human socioeconomic, including fuel and various means of production and human Services, it is a measure of the efficiency of the system is a standard.

(2) Environmental load-carrying rate (ELR)

The environmental load-carrying rate is the ratio of the total amount of energy input and auxiliary energy value of the system to the total value of renewable energies. It is used to evaluate the pressure of cultivated land utilization to the environment system, the higher the ratio indicates that the higher the utilization of the renewable environment resources, the stronger the utilization degree of the system energy.

(3) System production Advantage degree

The system production superiority degree is the index which reflects the rationality and the superiority difference of each industrial structure of the system. The superiority degree of the system is close to 0, which shows that the difference of superiority degree of each industry is very small, and the closer to 1 of the system production superiority, the more the industry structure is in an absolute dominant position. This paper uses the system production superiority index to appraise the cultivated land system, and the formula of the superiority degree of the production of the compound system:

$C = \Sigma(E_m Y_i / E_m Y)\ (i = 1, 2, \cdots n)$, where in $E_m Y_i$ represents the energy output of subsystem I in the system, $E_m Y$ indicates the total value of the system energy.

(4) System Stability Index

The System stability Index indicates the stability of the system, the System Stability Index is high, then the system's material flow, energy flow Connection network developed, the system of self-control, regulation, feedback strong, has a great self-stability. The calculation formula of system Stability Index:

$S = -\Sigma[(E_m Y_i / E_m Y)\ln(E_m Y_i / E_m Y)]\ (i = 1,2,\cdots n)$, wherein $E_m Y_i$ represents the energy output of the subsystem in the system, $E_m Y$ indicates the total value of the system energy.

(5) System Sustainability Performance Index (EISD)

The system sustainable Development performance index mainly illustrates the system's sustainability capability, the larger the index means that the higher the social and economic benefits of the unit environmental pressure, the better the system's sustainable development performance.Its mathematical expression is:

$$EISD = EYR \times EER / ELR$$

Among them, EYR represents the system energy yield, EER is the system Energy exchange rate (Eer=emt/emy), ELR is the environmental load-carrying rate.

3 Research results and analysis

3.1 Energy input-output analysis of cultivated land eco-economic system in Yunnan Province

The total energy value of arable land eco-economic system in Yunnan Province is 9.57×10^{22} sej (table 1), which can update the energy value of environmental resources to 7.43×10^{22}sej, which is mainly the value of 5 of rainwater chemical energy 5.93×10^{22}sej, which accounts for 79.81% of the energy value of renewable environmental resources. Most of Yunnan's annual rainfall in 1100mm, the southern part of the region can reach more than 1600mm, the rainfall is rich, the rainfall reached 1201mm in 2016, and so renewable

environmental resources can be a large amount of rainwater input. The energy loss of non-updatable environmental resources is mainly the loss of organic matter in the topsoil, its energy value is 8.44×10^{21}sej, accounting for 8.82% of the total input energy, which indicates that the soil fertility is poor in the system. The non-renewable industrial auxiliary energy value is 1.3×10^{22}sej, in which electricity and fertilizer accounted for a large proportion, respectively 36.31%, 59.33%, indicating that the system crops absorbed mainly from fertilizer, electricity in agricultural production as the main force of mechanical energy. The Renewable Organic Auxiliary energy is 4.79×10^{17}sej, which mainly comes from the input of manpower, organic fertilizer and seed, and the proportion of organic fertilizer is 94.15%, which indicates that organic fertilizer is the main way of agricultural production in Yunnan, and it is comparatively ecological. In 2016, the energy value of cultivated land eco-economic system in Henan Province was 1.17×10^{18}sej, the main food crops and economic crops were 6.8×10^{17}sej and 4.87×10^{17}sej, which showed that the proportion of grain crops was slightly larger than that of cash crops. It is indicated that the cropping structure in Yunnan province is dominated by food crops, but there is a tendency to change gradually to cash crops.

3.2 Energy Index system and result analysis of constructing ecological economic system of cultivated land in Yunnan province

3.2.1 Net energy yield

In Yunnan Province, the net energy yield of 2016 years was 0.29, which was lower than the average net energy yield of national Agricultural system (1). 42) and the net energy yield of cultivated land system in Guangdong Province (0. 95).It is indicated that the overall function of farmland system in Yunnan Province is not ideal, the conversion rate of input energy is low, and with the same amount of input, the low energy output of cultivated land system in Yunnan Province can be obtained, and the product does not have price competitiveness.

3.2.2 Environmental carrying rate

The environmental carrying rate of cultivated land eco-economic system in Yunnan Province is 0.66, which is lower than the national average cultivated land environment. It is indicated that the development level of cultivated land system in Yunnan is relatively low, the environment pressure of system production is not big, and the agricultural environmental resources have potential for further development. Therefore, it is appropriate to increase the input of non-renewable industrial auxiliary energy in the future, especially to focus on renewable and functional inputs, so as to improve the productivity of cultivated land while maintaining its sustainability.

3.2.3 System production dominance and stability index

The production dominance index of cultivated land system in Yunnan province is 0.51, which indicates that the dominant position of grain crops is beginning to incline to cash crops, and the balance of the system is broken. This is related to the use of abundant natural resources such as Yunnan province to vigorously develop cash crops. The stability index of cultivated land system in Yunnan province is 0.68, which is much smaller than that of Sanshui agricultural eco-Economy Department (0.91), which indicates that the network of subsystems is poor, and its self-control, adjustment and feedback need to be strengthened.The results of the system dominance index show that the proportion of economic crops in Yunnan province is slowly catching up with grain crops, breaking the system balance, and also indicating that the farmland system stability is not good enough, and the structure of each production unit in the cultivated land system is constantly adjusting.

3.2.4 System Sustainability Performance Index (EISD)

According to the relevant research [7], EISD indicators in 2~18 show that the system is full of vitality and development potential, in a better state of sustainable development, EISD>18 explained that the development and utilization of system resources is insufficient; eisd<2 shows that the system's energy value is insufficient and the environment carrying pressure is too large, the system is not sustainable. After calculation, the sustainable development performance index of cultivated land eco-economic system in Yunnan province is 4.21, which is much higher than the sustainable Development performance index of national Agricultural System 0.30 (1998), which is slightly lower than 4.29 (2001) of the agricultural system in Jiangsu province. According to the comprehensive analysis of environmental load rate and system sustainable performance index, the farmland eco-economic system in Yunnan Province is in sub-sustainable development state, and the competitive advantage of agriculture is low.Yunnan Province, as the Southwest Frontier Province, food security is related to the national peace and stability, so we need to vigorously protect cultivated land resources, improve cultivated land productivity level.

Table 1 Energy value input and output of cultivated land eco-economic system in Yunnan Province (2016)

Category	Project	Code or expression	Solar value (SEJ)
Energy Value Input	Updatable Environment Resources	E_mR	7.43E+22
	Environment resources cannot be updated	E_mN	8.44E+21
	Total investment in Environmental resources	$E_mI = E_mR + E_mN$	8.27E+22
	Non-renewable industrial auxiliary energy	E_mF	1.30E+22
	Renewable Organic Auxiliary Energy	E_mR1	4.79E+17
	Purchase Energy Value input	$E_mU = E_mF + E_mR1$	4.03E+22
	Total Value Input	$E_mT = E_mI + E_mU$	9.57E+22
Energy value Output	Food crops	E_mY1	6.80E+17
	Cash crops	E_mY2	4.87E+17
	Total value Output	$E_mY = E_mY1 + E_mY2$	1.17E+18

Table 2 Energy Value Index system of cultivated land eco-economic system in Yunnan Province

Energy Value Indicator	An expression	Numerical
NET energy yield	EYR=EmY/EmU	0.29
Environmental load-carrying rate	ELR=(EmF+EmN+EmR1)/EmR	0.66
Advantages of System Production	C=Σ(EmYi ／ EmY)2(i=1，2，…，n)	0.51
System Stability Index	S=一 Σ[(EmYi ／ EmY)In(EmYi ／ EmY)]	0.68
System Sustainability Performance Index	EISD=EYR×EER/ELR	4.21

4 Conclusions and recommendations

Yunnan Province, as the Southwest Frontier Province, food security closely related to the country's long-term stability, in the economic construction of the erosion of arable land, the urgent need to study the sustainable use of arable land, and effectively protect scarce arable land resources, and actively for the food security in Yunnan to make suggestions.

(1) We should adjust the input structure of farmland system and change the mode of economic development. The net energy yield and environmental carrying rate of cultivated land system in Yunnan province are at a lower level than that of other provinces. This indicates that the cultivated land system needs to be improved, but at the same time, it is important to control the energy value of non-renewable environmental resources, pay attention to agricultural ecological environment protection, lighten the pressure of system environment resources and promote the sustainable development of cultivated land system.Therefore, we must adjust the current investment structure of arable land, increase the input of renewable resources, increase the output rate of net energy, change the existing mode of economic growth, improve the management of agricultural environmental pollution, protect natural resources and environment, enhance the utilization of resources and enlarge the environmental

capacity of regional development.

(2) To improve the system opening rate, the introduction of foreign energy values is widely introduced. Cultivated land eco-economic system is a dissipative structure, in order to maintain the sustainable development of the system; the system must ensure the entry of external energy value. It can be seen from table one that the dominance and stability index of cultivated land system in Yunnan Province is not high, and the system self-control, regulation and feedback are weak. The scarcity of cultivated land resources in Yunnan Province, especially the area of high quality dam area, with the development of economy, environment and resources pressure will become more and more serious. Therefore, we should increase the openness of the system, introduce the external energy value to improve the energy feedback rate, make full use of external resources and alleviate the resource pressure in the region. Mainly includes two aspects: one aspect is to boldly introduce external funds and scientific and technological personnel, to absorb the external energy and information extensively, on the other hand, strengthen the communication and exchange between the teaching and the outside educational research units.Advanced technology and management experience, such as high energy conversion rate, is a special energy value and real wealth, these intangible scientific and technological value of the introduction, digestion and innovation, will effectively promote the rapid and sustainable development of the system economy and society.

(3) We should actively develop pollution-free industries to achieve sustainable development of the system. The sustainable performance index of cultivated land system in Yunnan province generally reflects the low level of the overall development of cultivated land system in Yunnan province. The sustainable performance index is slightly above the sustainable threshold, which indicates that the development of cultivated land system in Yunnan Province is in sub-sustainable state. If we neglect the healthy state of the system, the farmland ecosystem will develop slowly to unsustainable state. Therefore, we must adjust the current mode of development, play the role of market regulation, seize the resources in the region, on the basis of advanced agricultural technology, the development of green pollution-free products, increase product value-added, the creation of distinctive agricultural products brand, enhance market competitiveness; While increasing the input of industrial auxiliary energy value, we should strengthen the input of renewable function, improve the utilization rate of renewable environment resources, develop the compound ecological agriculture, lighten the environmental pressure of cultivated land system, and realize the sustainable development of cultivated land system.

References

1. Wu Ye, Yang Guishan Wan Rongrong. Research progress on the relationship between cultivated land change and social economic development [J]. Progress in Geography, 2008, 27 (1): 90,198.
2. Li Shuangcheng, Cai Yunlong. Study on land sustainable utilization situation based on energy analysis [J]. Economic Geography, 2002, 22 (3): 346-350.
3. Li Jianling, Chen Fei, Li Jianjie. Energy value analysis of urban ecosystem in Beijing [J]. Urban issues, 2005, (6): 25-29.
4. Zhang Yaohui. Analysis method of energy value of agro-ecosystem [J]. Chinese Journal of Eco-Agriculture, 2004, 12 (3): 181-183.
5. Hong ling, Gao Wangsheng, He Wenqing. Analysis on energy value of cropping system in semiarid region of northern agro-pastoral ecotone with Wuchuan County as an example [J].Agricultural research in arid areas, 2005,23 (1): 157-161.
6. Odum H T . Ecology and Economy ： “Emergy”Analysis and Public Policy in Texas [M] . Texas:1987.
7. Ulgiati S, Brown M T . Monitoring Paterns of Sustainability in Natural and Man—made Ecosystems[M] . Ecological Modelling， 1998， 108.