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Study on Sustainable Development of Agriculture in Dabieshan Pilot Site Based on the Model of Ecological Footprint[1]

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Abstract: Quantitative evaluation and monitor the status and the degree of sustainable development is a hot and difficult problem. Among the existed evaluation methods and models, ecological footprint is a comprehensive and practical method. Since it was introduced into China in 1999, it has been widely used in the study of regional ecological sustainable development. The authors take Dabieshan Pilot Site as the research object, based on the introduction of basic principle and method of ecological footprint, calculate the ecological footprint of Dabieshan Pilot Site in 2008.The results show that, the ago-ecological footprint of Dabieshan Pilot Site is 1.379042hm^2/person, while the available ecological capacity is 1.094089hm^2/person, per capita ecological deficit is 0.284953hm^2/person. The agriculture development in Dabieshan Pilot Site is in the state of unsustainable. We analyze the reasons and put forward the issues which we would focus on in the next stage.

Keywords: Agriculture, Sustainable Development, Ecological Footprint, Dabieshan Pilot Site

1. Introduction

Since the 1990s, the international community raised a lot of indicators of sustainable development system and its quantitative evaluation methods of calculation model. Among these ways, due to the ecological footprint model which adopted specific bio-physical measure has the advantages of operable, has been widely used in regional study on ecological sustainable development, relevant scholars also try to make the model more perfect and try to amend the relevant factors. In February 2011, Hubei provincial government put forward the strategic initiatives of constructing Dabieshan Pilot Site,Hubei province take the overall objective of "red Dabieshan, develop Dabieshan, green Dabieshan, rich Dabieshan" plan to make the Dabieshan Pilot Site become the important ecological region and ecological civilization education demonstration bases. Due to the initial start regions of Dabieshan Pilot Site are all key agricultural countries, so measure the ago-ecological footprint of Pilot Site is essential to the research on agricultural sustainable. Based on this, the authors try to use the model of ecological footprint to calculate the ecological footprint of Dabieshan Pilot Site, in order to provide some reference and basis for the relevant departments.

2. The Related Researches on Agro-Ecological Footprint

There are a lot of researches on the ecological footprint, but when speaks to agriculture, there are very few. Jinzhigeng (2008),took Shenyang as the research object and analyzed the ecological footprint of agriculture, concluded that the agro-ecological footprint in Shenyang is 1.6797hm^2/person, the available ecological capacity is 0.20289hm^2/person, the per capita deficit reach 1.47689hm^2/person,this showed that Shenyang is in the state of unsustainable development. Sunwei (2008) took Shigatse as the research object and drawn the conclusion that the comprehensive ago-ecological footprint is 334153.27hm^2.Bi'anping (2010) took Fujian province as the research object, based on the regional production measured the ago-ecological footprint. Yangping (2011) took Chuxiong as the research object and calculated the agro-ecological footprint which came to the conclusion that agro-ecological footprint is 1.521hm^2/person.The available ecological carrying is 0.888hm^2/person; per capita deficit is 0.633hm^2/person. Tangchong (2007) took Shangyi as the research object and used the method of ecological

footprint to draw that agricultural per capita ecological deficit is 0.36hm^2; agriculture in Shangyi is in a serious unsustainable state.

3. Introduction to the Research Object

Dabieshan Pilot Site was founded in February 2011, the initial regions include eight countries which covering Hong'an, Macheng, Yingshan, Luotian, Tuanfeng, Qichun, Dawu and Xiaochang. The Dabieshan Pilot Site located in the eastern of Hubei Province, South of Dabieshan, and the north shore of the middle reaches of the Yangtze River, the middle of the Beijing-Kowloon Railway.

The land area of these eight countries is 2.0642 million square kilometers, the total population is 8.6562million in 2008,the sown area is 624.16 thousand hectares, the forest area is 3103 hectares, the pasture area is 2874.47 thousand hectares and the aquaculture area is 86.739 thousand hectares.

Internationally, in accordance with the concept of environmental services or ecosystem services to pay, in order to further protect the ecological environment and promote sustainable development of agriculture, the United States, Japan, the European Union and the Germany respectively introduced a series of policies and regulations to strengthen the agriculture ecological compensation. Among the agricultural policy of environmental protection, agro-ecological compensation has become an important means which can change the farmers' production methods, the use of environmentally friendly agricultural production technologies, and the protection of agricultural product quality safety and protection of agricultural ecological environment. Drawing on the international experience, it can promote to establish the agro-ecological compensation mechanism in China and protect the agricultural ecological environment, safeguard the quality and safety of agricultural products and improve their international competitiveness. The implementation of agro-environmental laws and the policy of agro-ecological compensation make the agro-ecological environment have been significantly improved. Such as to link the price subsidies and environmental measures, adjust the structure of agriculture, reduce the pressure of environment, and change the mode of agricultural production, forestation and so on.

The united states always attention the agricultural production and the development-related resources, ecology, environmental protection, formulate a series of environment regulations and long-term plans about protecting arable land, water and other natural resources and ecological environment which can promote the sustainable development of agriculture. In Japan, there are agricultural improvement funds to enhance the natural circulation function of utility projects and the transformation of green manure and compost soil continued to dry farming projects in an integrated response to the cause of the agricultural production. The point of departure on international is to pay compensation for the improvement of specific beneficiaries, boils down to help pay and service both. The logic is to meet the environmental needs of those who pay for personal ecological improvement. 15

About the start time on the Chinese eco-compensation practice, scholars have a little controversy, one view believe the ecological compensation started in the 1970s, 16Due to the lack of forest protection funds, Sichuan Qingcheng mountain forest hack rampant deforestation which made it was faced with the ecological crisis, later, the Chengdu Municipal Government decided to take 30% of ticket sales of Qingcheng Mountain on forest protection, and established as a system which creating a forest ecological benefit compensation. The other views believe that began in 1983 in Yunnan Province of phosphate rock mining collection of vegetation and other ecological damage to the environment restoration costs. In 1984, the levy of resource compensation officially opened the prelude to China's eco-compensation practice. From the 1990s, the Chinese government set up a pilot ecological compensation in Guangxi, Fujian and other places to have initiated the Grain for Green Project in 2002, grazing-for-grass works, protecting natural forests and other major ecological construction projects and then to the 2006 China Environment and Development International Cooperation Committee completed a study of ecological compensation mechanism and policy issues, the initial establishment of the theoretical framework of ecological compensation. In recent years, different countries and scholars in different regions of the agro-ecological compensation has launched a large number of studies and achieved good results, such as carried out in Latin American countries of PES, project initiated by the World Bank, Europe's agricultural economy project, Chinese Grain for Green project.

In addition to the large national ecological construction projects outside the project such as returning farmland to forest and grazing for grass, the existing researches reflected the agricultural ecological compensation areas are Gansu, Loess Plateau, and Erhai and so on. Relative to the Promotion of the goal of sustainable development of green agriculture, the pilots are still very few; this research is still in its infancy.

Laws and regulations are not complete. Although China has launched some pilots' demonstration of returning farmland to forests, conservation tillage and has achieved some success, but for the farmers to take to reduce the use of chemical fertilizers, pesticides, organic manure, environmentally friendly and resource-saving production measures there are not compensation policy, it is difficult to mobilize the enthusiasm of farmers for environmental protection. The lack of relevant legislation will directly affect the implementation of green agro-ecological compensation. In the construction of ecological compensation laws and regulations, the scholars also expand the initial study: Feng Zhang (2010) explore the design of mechanism and legal protection in her monograph, and take Shandong province as an example discussed the legalization of countermeasures.

4. Data Sources and Research Methods

The data involved in this paper about land use types and other information all from the 《Hubei Provincial Rural

Statistical Yearbook》.

In the process of calculating the ecological footprint, it is needed to consider six types of bio-productive areas: Fossil energy land, arable land, woodland, grassland, construction land and waters. Due to the biologically productive of different bio-productive lands are different, so it is needed to convert the resource consumption and the waste intake into biologically productive area when using average productivity of the world. Equivalence factor needed to be introduced, because it can convert bio-productive land into equivalent ecological productivity land, and calculate the total overall ecological footprint. In the process of calculating carrying capacity, the production factors needed to be introduced, because it can convert the similar ecological productivity land of different countries and regions into comparable area. The formula is:

$$E_f = \sum_{j=1}^{6}(r_j \times \sum_{i=1}^{n}(aa_i)) = \sum_{j=1}^{6}(r_j \times \sum_{i=1}^{n} c_i / p_i) \quad (1)$$

Ef represents the total ecological footprint (hm2), i is the input type of consumer goods, Pi is average production capacity of the item of i consumer goods, c_i is i consumer consumption, aa_i is the bio-productivity area which is converted by the i-th items. R_j is the equivalence factor, because the biological production capacity per unit area of arable land, fossil energy land, grassland, woodland, etc. In order to make the results of calculation convert into a comparable item, it is necessary to multiply an equivalence factor before the various types of biologically productive area. In this way, it could be converted to unified and comparable bio-productivity area; j is the type of biologically productive land. According to the necessary of actual accounting and corresponding classification in Hubei Rural Statistical Yearbook. In this paper, the consumption part of the biological resources are adjusted into the following categories: food crops (including the summer and autumn harvest crop), cotton, oilseeds, fiber crops, sugar, vegetables (including melon), the main forest products(including lacquer, tea seed oil, turpentine, chestnut, etc),tea, garden fruits, aquatic products, beef, pork, lamb, poultry, milk, eggs. Because all of the above resources are produced by these four categories of biologically productive land from arable land, forest land, waters and pasture, so it is needed to convert them into arable land footprint, woodland footprint, water footprint and pasture footprint.

$$EC = N \bullet ec = N \bullet \sum a_j \bullet r_j \bullet y_j (j = 1,2,\ldots 6) \quad (2)$$

Among this formula, the EC is the region's total carrying capacity, the ec is per capita carrying capacity, the N is the total population, and the a_j is the per capita area of biologically productive. The r_j is the equivalence factor, y_j is the yield factor.

We handle the area of biological resources productive with the data of the world average yield from the UN Food and Agriculture in 1993.The agricultural land in Dabieshan Pilot Site is classified as arable land, grassland, woodland and the waters. According to the recommendations of the world Environment and Development Commission (WCED), it is needed to deduct 12% of the biodiversity conservation area.

The producers generally bear the cost of production, while no or only bear part of the costs and external costs. The essence what caused the eco-social of external diseconomies is the socialization of private costs. Therefore, make the external economic internalization caused by external economic consequences borne by the perpetrator which is to establish the economics basis of the ecological compensation mechanism.8The production of green agriculture has the typical external characteristics, the services function which provided by the green agro-ecosystems, especially the life function and ecological function are public production to some large extent. Due to its non-competitive often leads to over-development of using agriculture resources, and ultimately the interests of all members are damaged. Its non-exclusive would engender a "free rider" mentality, no one is willing to provide public goods, and the result is no one can enjoy the public goods. To solve this problem, government regulation and government foot the bill is one of the mechanisms that effectively solve the public goods

5. Agro-Ecological Footprint Calculations in Dabieshan Pilot Site

After pooled analysis of the equivalence factor which is commonly used by the world, the results show that there are great differences of the equivalence factor which come from different source. In order to minimum the errors, this study take the average of the five equivalence factor commonly used in international as the equivalence factor of the Dabieshan Pilot Site. That is arable land is 2.49, pasture is 0.47, woodland is 1.40, waters is 0.27, construction land is 2.49 and fossil energy land is 1.4. When calculating the ecological carrying capacity, due to the resources of different countries and regions are different, not only the production capacity per unit is quite different, but also the same type of unit area is quite different. Therefore, the actual area of the same type biologically productive land in different countries and regions couldn't be directly comparable. Ecological construction need to adjust the economic structure, cropping patterns, consumption patterns, involving a large number of economic loss, this will enviably reduce the speed of development and people's living standards temporarily, and also lead to temporary loss of the ecological construction and environmental governance, economic efficiency and development speed. If there are a lot of financial compensation and financial assistance, make the economic losses withstand the range of eco-builders and then they are willing to actively carry out ecological construction.It is needed to be adjusted. The difference of local production between some biologically productive area in different countries or regions and the world average yield could be represented by yield factor. The yield factor of some country

or region is the ratio of its average productivity and the same land's average productivity in the world.

Table 1. *Biological resource accounts.*

Items	Biomass and Productivity (t)	Yield Per Unit Area $kg \bullet hm^{-2}$	Per Capita Output $kg \bullet person^{-1}$	Per Capita Ecological Footprint（hm^2）	Land Type
Agricultural products					
Food crops	3613782	6400.379	417.479	0.065227	Arable land
Cotton	73271	1307.944	8.464569	0.006472	Arable land
Oil	507195	1998.247	58.59326	0.029322	Arable land
Hemp	7264	2977.049	0.839167	0.000282	Arable land
Sugars	29411	37229.11	3.39768	9.13E-05	Arable land
Vegetables(including dish with melon)	2681432	22735.56	309.7701	0.013625	Arable land
Forest products (including lacquer, teased oil,turpentine, chestnut)	3451059	1112169	398.6806	0.000358	Forestland
Tea	29200	861.2553	3.373305	0.003917	Forestland
Garden fruits	133445	5174.894	15.41612	0.002979	Forestland
Aquatic products	359180	4140.929	41.49396	0.01002	Waters
Livestock products					
Beef	40361	148.8594	4.66267	0.031323	Pasture
Pork	299457	73.52247	34.59451	0.47053	Pasture
Mutton	7508	14.78611	0.867355	0.05866	Pasture
Poultry	85078	175.2986	9.828562	0.056068	Pasture
Milk	24449	104.5244	2.82445	0.027022	Pasture
Eggs	245525	5.058908	8.36406	1.653333	Pasture

Table 2. *Demand of ecological footprint* $hm^2 \bullet person^{-1}$.

Land type	Total areas	Equivalence factor	Balanced area
Arable land	0.115109	2.49	0.286621
Forest land	0.007254	1.40	0.010156
Aquaculture	0.01002	0.27	0.002705
Pasture	2.296936	0.47	1.07956
Footprint of total demand			1.379042

Table 3. *The supply of ecological footprint Ecological Carrying capacity）* $hm^2 \bullet person^{-1}$.

Land type	Per capita ecological area	Equivalence factor	Per capita ecological capacity
Arable land	0.721055	2.49	1.184982
Forest land	0.000358	1.40	0.000456
Aquaculture	0.01002	0.27	0.000101
Pasture	0.332071	0.47	0.029654
Total			1.215192
Deduction of 12% of biodiversity conservation land			0.121103
The per capita utility of ecological carrying capacity			1.094089

6. Conclusions and Deficiencies

Using the model of ecological footprint, we calculate the agro-ecological footprint of Dabieshan Pilot Site in 2008 and come to the results as follows: per capita ecological footprint is 1.379042 hm^2/person, While the available ecological capacity is 1.094089 hm^2/person, per capita ecological deficit is 0.284953 hm^2/person.The agricultural development of Dabieshan Pilot Site is in the state of unsustainable. The ago-ecological deficit in Dabieshan Pilot Site that is in the state of relatively low level consumption and productivity show that the agriculture production directly limit the ecological carrying capacity, and finally cause the ecological supply capacity is not enough. The concept of agriculture multi-functional first appeared in Japan's "rice culture", "rice culture" is the culture which emphasis rice production has an important cultural function and value, rice production in the prevention of soil erosion, protect vegetation, water conservation, prevention of soil erosion and soil erosion, the treatment of organic waste, air purification, green and natural landscape, as well as traditional cultural inheritance multifaceted role. Multi-functional of agriculture refers to the agricultural sector in additional to the production of grain and other agricultural products, agriculture also bear an increasingly important and expanding economic, ecological, environmental, social stability and social functions. In other words, agriculture can not only ensure a stable supply of food, but also can bring a variety of social, ecological, cultural and other aspects of utility. The study on green agro-ecological compensation in China is still at the exploratory stage, it is needed to have a groundbreaking breakthrough both in breadth and depth. Study appropriate experience to learn from other countries, China need to launch researches according to the actual situation. Meanwhile, it is needed to select some relatively mature methods in other areas of eco-compensation and select a number of pilot lights of local conditions to conduct research and promote the improvement

of the ecological compensation mechanism of green agriculture. Therefore, in order to make the agricultural development of Dabieshan Pilot Site into the state of sustainable, it should be considered to transform the mode of agriculture production. In addition, due to the limited of the data sources, consumer items and yield factors are not precise enough; the authors plan to focus on the issues that yield factors and the research data next stage.

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