Compensation and Quantification of Cultivated Land Ecological Value and its Countermeasure Study——A Case Study of Xuzhou County Region

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Abstract. Arable land provides material sources for human beings, meanwhile it provides a variety of ecological and social services value. The paper has quantified ecological value of cultivated land in Xuzhou City based on the ecological footprint comprehensive calculation method of equivalent factors, and has combined with the ecological overload index and the correction coefficient of social economy to determine the final ecological value compensation dosage of cultivated land at the county level in Xuzhou City. Through quantitative analysis, it is concluded that the ecological value of cultivated land in the other six county-level units is surplus except that the cultivated land in the city area cannot meet the ecological consumption needs to compensate for other areas. Due to the ecological value surplus of arable land, the city can get 2 billion 6 million yuan of arable land ecological value compensation. This paper also has put forward three countermeasures for the ecological value compensation of cultivated land from the government and the public, so as to help the improvement of the later ecological value compensation mechanism of cultivated land.

1. Introduction

Cultivated land is the material source of human life, which not only has the function of grain, but also a variety of ecological services. People's demand for ecological health and safety has also increased with the increase of living standards, so the ecological service function of cultivated land has gradually been paid attentions to. Scholars at home and abroad have studied the correlation theory of ecological value compensation from different angles, such as environmental ecology and social economics. In recent years, the role and responsibility of the region in the issue of ecological compensation has attracted the attentions of scholars at home and abroad, and balanced the interests of all parties from the perspective of coordinating regional relations, so as to promote regional coordinated and sustainable development. Compensation and quantification is the core and difficulty in ecological compensation. At present, the generally accepted method is the comprehensive measurement algorithm, which is mainly based on the ecological value calculation, and supplemented by other methods. Therefore, the determination of ecological value is the premise and basis of compensation and quantification. Daily et al. discussed ecosystem service and its value from the based on the perspective of ecology[1]. Costanza.R et al. divided the global ecosystem services into 17 categories, then estimated the monetary value of ecosystem services from the point of view of economics[2]. In China, Chinese ecosystem service value equivalent factor table and value scale developed on the basis of the evaluation model of global ecosystem service function by Xie Gaodi and other scholars is the most widely used[3-5]. This method can more accurately reflect the process of production, consumption and value realization of Chinese ecosystem services. Although the confirmation of ecological value provides a reasonable basis for ecological compensation, but there is no unified approach to determine the specific compensation value[6]. Based on the ecological footprint model, this paper has calculated the external effects of the

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ecological service value of cultivated land in Xuzhou county region, and then estimated the ecological compensation of cultivated land in the county. From the angle of fairness principle of sustainable development, it has constructed ecological value compensation mechanism of cultivated land in the county, coordinated the relationship between farmland protectors and beneficiaries, and promoted the coordinated development of the county units of Xuzhou City, the reasonable allocation of land resource value and income, and urban and rural integration development.

2. Data sources and construction ideas

2.1 Data sources

Taken the economic and social development data and cultivated land production and consumption data of all county-level units in Xuzhou in 2015 were as the source data, this paper has estimated the ecological compensation value of cultivated land in Xuzhou city and county. The data was from the "2015 economic and social development statistical bulletin of Xuzhou city", "2015 statistical yearbook of Xuzhou city", "2015 economic and social development statistical bulletin of Feng county", "2015 economic and social development statistical bulletin of Pei county", "2015 economic and social development statistical bulletin of Suining City", "2015 economic and social development statistical bulletin of Xinyi City" and " 2015 economic and social development statistical bulletin of Pizhou City".

2.2 Construction ideas

The main idea on ecological value compensation calculation of cultivated land in Xuzhou County region is as follows: (1) calculate total ecosystem service value in the county; (2) calculate ecological footprint EF, bearing capacity EC and ecological overloading index EF_i of cultivated land of all units at the county level; (3) determine the floe direction of ecological external benefits of each county, divide compensation payments area and acquisition area according to the ecological overloading index; (4) considering the social ability to pay, use the social and economic development factors to correct it, finally calculate the specific amount of ecological value compensation of cultivated land of Xuzhou city in the actual operation, compensation payments area should pay the ecological compensation expenses of cultivated land to the compensation benefit area[7].

3. Ecological value compensation model of cultivated land in Xuzhou County

3.1 Calculation model

Based on the study of Xie Gaodi, this paper calculated the ecological value quantity by the equivalent factor and its value quantity[3-5]. Through finding the data of per unit area yield of grain crop, sown area and the national average price of grain crops, it is calculated according to the following formula[8]:

$$Ea = \frac{1}{7}\sum_{i=1}^{n}\frac{m_i p_i q_i}{M} \qquad \text{（Formula 1）}$$

In the formula 1, Ea is equivalent factor value quantity of one unit (yuan/hm^2); i is the grain crop species; P_i is the national average price of the i-st grain crops (yuan/kg); q_i is per unit yield of the i-st grain crop (kg/hm^2); m_i is the sown area of the i-st grain crops (hm^2); M is the sown total area of the i-st grain crop(hm^2); 1/7 refers to the economic value provided by natural ecosystem without human input, is one seventh of the food production service economic value provided by

cultivated land per unit area.

The total ecosystem service value of cultivated land in each county can be calculated by this formula:

$$Ae = 6.91 \times Ea \times S \qquad \text{（Formula 2）}$$

In the formula 2, Ae is the total ecosystem service value of regional land (yuan /year); Ea is equivalent factor value quantity of one unit (yuan/hm^2); S is the grain sowing total area (hm^2); 6.91 refers to that the total ecological value quantity of farmland ecosystem is equivalent to value quantity of 6.91 equivalent factor.

3.2 Calculation model of Judgment on regional acquisition or payment compensation and compensation ratio

3.2.1 Ecological footprint model of cultivated land

$$EF = N \times \mathrm{ef} \qquad \text{（Formula 3）}$$

$$\mathrm{ef} = \sum_{i=1}^{n} rA_i = \sum_{i=1}^{n} r\frac{C_i}{P_i} \qquad \text{（Formula 4）}$$

In the formula 3, EF is the total ecological footprint of farmland in the county area (hm^2); N is the county total population (million), ef is the ecological footprint of county per capita cultivated land (hm^2/a person); in the formula 4, n is consumer items type; i is specific consumer items; r is balance factor of cultivated land, for 2.17; A_i the yielding ability cultivated area of the i-st consumption project of county per capita (hm^2/a person); C_i is the consumption per capita in the county area of the i-st consumption project (kg/a person), P_i for the global average productivity of the i-st consumption project.

3.2.2 Ecological carrying capacity model of cultivated land

$$EC = N \times \mathrm{ec} \qquad \text{（Formula 5）}$$

$$ec = a \times r \times y \qquad \text{（Formula 6）}$$

In the formula 5, EC is the total ecological carrying capacity of cultivated land in the county area (hm^2); ec is the ecological carrying capacity of cropland of the county per capita (hm^2/a person); in the formula 6, a is biological yielding ability cultivated area of per capita arable land(hm^2/a person); y is yield factor for cultivated land ecological productive land , for 1.66.

3.2.3 Ecological overloading index of cultivated land

After determining whether the cultivated land ecological capacity is surplus or deficit, it also need to calculate the ecological overloading index of cultivated land in the region. Combining the ecological service value and ecological footprint can realize the reallocation of the ecosystem services value between the regions. The concrete formula is as follows:

$$EFI = \frac{(EC - EF)}{EC} \qquad \text{（Formula 7）}$$

In the formula 7, EFI is the ecological overloading index of cultivated land; EF is the ecological footprint of regional cultivated land (hm^2); EC is the ecological carrying capacity of regional cultivated land (hm^2).

When $EFI = 0$, the ecological service value of cultivated land in this area just meets the use of this region, and the ecological environment is in a balance state. If $EFI > 0$, then there is a surplus

in the ecological service value cultivated land in this area. The greater the EFi value is , the more the surplus is, the larger ecological service value output outward is; similarly, if $EFi<0$, it indicates that the ecological of the area is overload , the ecological service value of cultivated land loss. The smaller the EFi value is, the more serious the degree of the overload is, and the more the ecosystem service value quantity which it accepts the other parts is[9].

3.3 Calculation model of compensation coefficient

If the compensation is simply based on the ecological services value, it may exceed the payment capacity in some areas, so it needs to be corrected by certain social and economic coefficients. The ecological compensation coefficient r of cultivated land is determined by taking the regional GDP as the basic reference and combining Engel coefficient. The specific expression formula is as follows[10]:

$$r = \frac{1}{1+e^{-t}} \qquad \text{（Formula 8）}$$

There into， $t = En = Ea \cdot \theta + Eb \cdot (1-\theta)$

In the formula 8, r is the social and economic coefficient, $r \in (0, 1)$; 1 is the maximum value, showing the maximum of cultivated land ecological capacity to pay; En is the comprehensive Engel coefficient; Ea is Engel coefficient for the urban; Eb is Engel coefficient for the rural; θ is the level of urbanization.

3.4 Comprehensive calculation model

There is a direct relationship between ecological service value and ecological value compensation. After determining the ecosystem service value of each county, combined with the actual ability to pay compensation and other factors of compensated region, a comprehensive calculation model is established, which is as follows[11]:

$$AEC = Ae \times EFi \times r = Ae \times \frac{EC - EF}{EC} \times r \qquad \text{（Formula 9）}$$

In the formula 9, AEC is the payed/ obtained ecological compensation dosage of cultivated land in the area (yuan/year); Ae is the regional ecosystem service value of cultivated land (yuan/year); EF is the regional ecological footprint of cultivated land (hm^2); EC for regional ecological carrying capacity of cropland (hm^2); r is correction coefficient.

4. Calculation results and analysis

According to the comprehensive calculation model of ecological value compensation, the ecological value compensation amount of cultivated land in each county level unit in Xuzhou is calculated, in which positive value means to obtain compensation and negative value indicates to pay compensation. Specific calculation results are shown in table 1.

Table 1 Ecological value compensation of cultivated land in counties (cities, districts) of Xuzhou City in 2015

County（district）	Ecological service value（a hundred million）	Ecological overloading index	Compensation factor	Compensation amount（a hundred million）
Jurisdiction	5.71	-0.45	0.5768	-1.48
Tongshan District	13.49	0.50	0.5839	3.97
Feng County	11.32	0.45	0.5847	3.01
Pei County	11.77	0.40	0.5856	2.76
Suining County	13.87	0.63	0.5854	5.14
Xinyi City	9.58	0.55	0.5830	3.09
Pizhou City	14.34	0.43	0.5824	3.58
Total	80.08			20.06

4.1 Calculation results analysis of cultivated land ecological service value

In 2015, the total ecological service value of cultivated land in Xuzhou reached 8 billion 8 million yuan. The ecosystem service value of Pizhou, Suining and Tongshan District was all above 1 billion 300 million yuan, among which the highest is in Pizhou, for 1 billion 434 million yuan. The ecological service value of Feng County, Pei County and Xinyi City was all between 900 million yuan and 1 billion 200 million yuan, while the ecological service value of the Jurisdiction is the lowest, only 571 million yuan. Therefore, there is a great difference between the ecosystem service value of different regions.

In 2015, the regional GDP of Xuzhou Jurisdiction accounted for 60% of the total GDP in the city, and the sum of regional GDP of each county unit accounted for only 40%. Therefore, the county units with relatively low economic development level have undertaken more farmland protection tasks, thus losing some opportunities for economic development. However, the economically developed areas have less responsibility for cultivated land protection and have more opportunities for economic construction and development. Therefore, in order to promote the sustainable development among regions, balance the distribution of interests among different regions, and solve the regional contradictions, the implementation of ecological compensation of cultivated land is an important means.

4.2 Ecological overloading index of cultivated land

The ecological overloading index of cultivated land reflects the gap between the demand for ecological services of cultivated land from human beings and the ecological services provided by regional cultivated land. The results showed that the ecological overloading index of other counties (cities, districts) was positive except for Jurisdiction, which was between 0.4~0.7, and the ecological condition was good. It accounted for that, in addition to that the ecological service provided by land of Jurisdiction cannot meet itself needs, which needed to accept the ecosystem service value of arable land from the other regions, other counties (cities, districts) had surplus ecological land, then the compensation can be obtained.

4.3 Analysis of ecological compensation amount of cultivated land

From the calculation results, we can see that the ecological value compensation amount of other counties is all positive in Xuzhou City, in addition to Jurisdiction, and the compensation can be obtained. On the whole, Xuzhou can get 2 billion 6 million yuan of ecological value compensation of cultivated land, which shows that the ecological services provided by Xuzhou's arable land are enough to meet the ecological consumption of the city and have surplus.

5. Conclusions and recommendations

5.1 Conclusion

Taking Xuzhou municipal districts and six county-level units as units, this paper used the ecological footprint calculation method based on comprehensive equivalent factor, quantified the ecological value of cultivated land of Jurisdiction, Tongshan District, Feng County, Peixian, Suining County, Xinyi City, Pizhou City the seven areas in Xuzhou City, and determined the final ecological value compensation amount of cultivated land of all units at the county level in Xuzhou City combined with the ecological overloading index and the social and economic correction coefficient. Among them, in addition to that the arable land of municipal district can not meet the ecological consumption itself, and need to pay compensation to the other regions, the ecological value the land produced of the other six units at the county level can meet their own needs, and have surplus. Overall, the ecological value of cultivated land in Xuzhou City is surplus , and the city can get 2 billion 6 million yuan of arable land ecological value compensation.

5.2 Recommendations

5.2.1 Formulate and improve laws and regulations on the ecological value compensation of cultivated land

At present, the state has definite regulations on the protection of forest and water resources, and has promulgated “regulations of returning farmland to forests” and “water pollution control law”, but there are no specific laws and regulations for the ecological value compensation of cultivated land. The amount of cultivated land directly affects the food security, so from a national perspective, it should increase corresponding content of cultivated land compensation, gradually form perfect laws and regulations , to ensure the effective implementation of the compensation system of cultivated land.

5.2.2 Improve public protection awareness on cultivated land and expedite supervision feedback channels

The government should strengthen the propaganda of ecological value of cultivated land, popularize cultivated land ecological service value knowledge with the Internet, new media and other forms, let the masses to establish protection consciousness of cultivated land, and make the concept about the value compensation of cultivated land be formed gradually. Therefore, stimulate the public to actively participate in the protection of cultivated land, and ensure the establishment and implementation of the compensation mechanism of cultivated land value. At the same time, with the increase of public awareness of the value of cultivated land compensation, protecting cultivated land will become a spontaneous and conscious behavior, which will also play a supervisory role in the establishment of the compensation mechanism of cultivated land value. Meanwhile, it should guarantee the unimpeded supervision and feedback channels, timely

communicate with the masses, and encourage people to report the destruction of farmland and other acts, and does not condone the destruction acts of the ecological environment and held responsible for punishment according to laws, to correctly guide public awareness of ecological protection of cultivated land.

5.2.3 Broaden the sources of compensation and implement reasonable compensation methods

Diversified sources of compensation funds can not only reduce the burden on the government, but also ensure fairness, so that the government and society will pay for the ecological compensation together. Our country can establish diversified financing channels through credit, securities and other channels, and encourage more enterprises and non-governmental organizations to invest in the fund-raising work. Rational compensation can promote the benign interaction between the supply side and demand side. When determining the compensation way, it should take into account the specific circumstances of the local area, according to the proper time and the local conditions. We should organically combine monetary compensation, physical compensation, technical compensation and policy compensation to protect the legitimate rights and interests of cultivated land protectors, stimulate the enthusiasm of cultivated land protectors, and perfect the compensation framework of ecological value of cultivated land.

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