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Rice Pricing during Organic Conversion of the Honghe Hani Rice Terrace System in China

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Abstract: In 2002, the United Nations Food and Agriculture Organization initiated the Globally Important Agriculture Heritage Systems conservation program. Agricultural organic certification, based on traditional environmentally friendly technology, increases farmer income and encourages traditional agricultural heritage. However, during the organic conversion period, farmer income cannot be guaranteed; this period is also a bottleneck for heritage conservation via organic certification. Based on experiences at the Honghe Hani rice terrace system in Yunnan, China, we calculated and compared inputs and outputs of traditional and modern systems during organic conversion and developed a calculation method for determining opportunity costs of agricultural production. We found that the stability of farmer income during conversion can be guaranteed by setting the protective purchasing price at 6.93 CNY/kg, thereby achieving the goal of dynamic conservation of agricultural heritage systems.

Keywords: GIAHS; dynamic conservation; organic conversion period; agricultural products pricing; Hani terraces

1. Introduction

With progress in science, technology and land intensification, agricultural development resulted in both vast achievements and numerous ecological and environmental problems [1–3]. Further, some traditional agricultural systems of scientific, social, and cultural value are rapidly disappearing. Thus, the United Nations Food and Agriculture Organization initiated the Globally Important Agricultural Heritage Systems (GIAHS) dynamic conservation and adaptive management program to protect systems under threat [4,5]. To date there are 49 GIAHS across 19 countries.

There are several methods for GIAHS dynamic conservation, including adopting strict protection policy; assessing the ecosystem service values of GIAHS [6] and compensating farmers [7]; and applying for GIAHS branding to increase the price of GIAHS products [8].

There are many successful experiences in Japan for obtaining better prices by GIAHS branding, based on origin and production methods [9], such as Crested Ibis Rice. However, in China, the GIAHS logo in the market is not well recognized as organic certification, and very few consumers are willing to pay the extra price for products produced under a GIAHS. Organic certification is considered as the operable market mechanism for GIAHS conservation [10,11]. When GIAHS becomes mainstream in China, the GIAHS logo will be a better and more suitable market method for GIAHS conservation.

However, a conversion period of 1–3 years is involved to gain organic certification. Farmers may need to modify certain practices to receive organic certification that may be costly or have negative impacts on yield. During this period there is no organic certificate, yields do not attract higher prices and farmer income declines. Thus, the stability of farmers' income during conversion can be guaranteed by setting the protective purchasing price. The policy of protected purchase

pricing could be implemented via direct payments. During organic conversion, if farmers cultivate according to organic criteria and GIAHS, the government will give them direct payments based on yield. For example, the purchase price is A CNY/kg and the national grain purchase price is B CNY/kg, so the direct payments to farmers could be (A–B) CNY/kg.

Sonja et al. [12] divided the price of GIAHS products into four parts: the value of natural environment and resources, the cost of organic certification, and green packaging. These authors also discuss about product pricing mechanisms. Margaret et al. [13] proposed the beneficiary payment method on the basis of production costs whereby the price of organic agricultural products is divided into three parts: the value of natural resources and environmental, consumer welfare, and social welfare.

Studies of organic agricultural product pricing from the perspective of increasing farmer income and encouraging the inheritance of traditional agriculture systems or GIAHS are limited. Here, we use the Hani Rice Terraces System in China as an example and use input-output analysis, to (1) calculate and compare the economic income of traditional and modern non-organic agricultural production modes, and (2) determine how to price GIAHS products to identify break-even prices during conversion.

2. The Study Area

Honghe County, in southern China's Yunnan province, covers an area of 2057 km^2. The altitude is 1000–2000 m and 96% of the area is mountainous, with distinct vertical climate changes. The Hani Rice Terraces System is a GIAHS and covers 40,000 ha; the core area is 13,000 ha. Varieties of rice include hybrid rice, waxy rice and red rice [14].

The Hani Rice Terrace System is spatially characterized by the vertical distribution of ecological landscapes of forest-village-fields-river and the formation of unique energy and material flows within the system (Figure 1): natural precipitation falls to the ground and forms surface runoff flowing along slopes, through the forest, villages and terraces. Since the terraces are fixed into a horizontal plane with ridges higher than the water surface, surface runoff, sediment, soil nutrients and domestic sewage and waste manure are intercepted by terraced fields and are precipitated step by step. Terraced fields are fertile, and only a small amount of water flows without sediment and few pollutants enter valley rivers [15,16]. The Hani terraces save a great deal of costs regarding chemical inputs and lend themselves to developing organic agriculture.

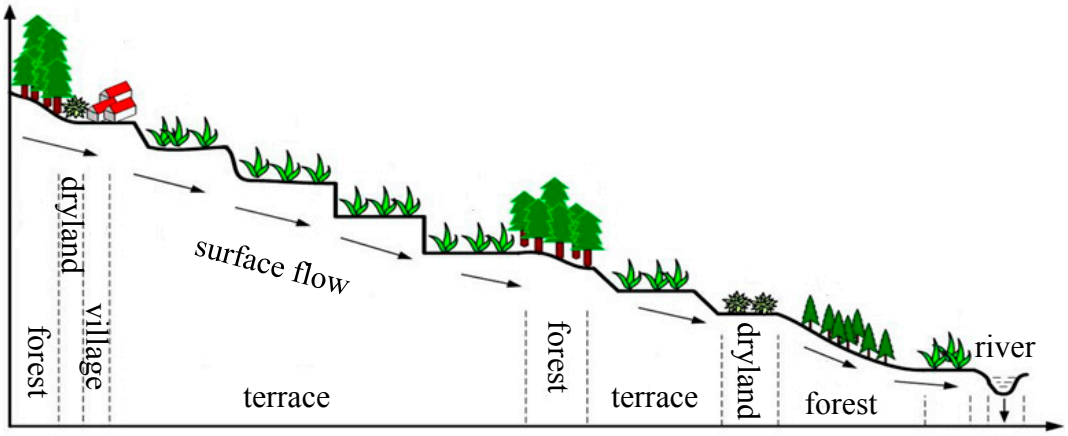

Figure 1. The landscape pattern of Hani rice terraces.

Because of the lower comparative effectiveness of traditional cultivation methods, land has been increasingly abandoned. Pesticide, fertilizer and other chemical usage has increased, destroying local ecosystems and pushing traditional agricultural culture to the verge of disappearance. Thus,

we compared the input and output of traditional and modern non-organic cultivation methods in the Hani Rice Terrace System.

3. Methodology and Data Sources

3.1. Methodology

In economics, prices are the result of supply and demand forces in the market. However, the protective purchasing price, setting by the government to guarantee the stability of farmers' income during organic conversion, needs to cover production and circulation costs (including distribution and processing costs), and remain a profit in line with alternative endeavors [17].

In many developing countries, especially China, many young people go outside or do other business for more income. Thus, the opportunity cost of labor and labor preferences should also be taken into consideration during the pricing analysis of GIAHS products. When they want to go outside and work in cities or do not like cultivating farmland the higher the opportunity cost. Thus, we put forward a parameter θ, the preference coefficient, to describe farmer willingness to do other business.

Based on this, the protective pricing of GIAHS products can be expressed as:

$$P = C_P + C_C + \theta \cdot C_0 + I. \quad (1)$$

wherein, P represents the protective price, C_P the cost of production, C_C the cost of circulation, θ the preference coefficient, C_0 the opportunity cost, and I the profit from the agricultural activity.

The commodity prices in the market are usually greatly affected by the costs of circulation, since the transport distance, the means of transport as well as handling times in circulation will impact terminal market prices from different degrees. In the research area, farmers mainly sell their harvest as primary food products, so we focus on the income of farmers and discuss the pricing of primary products. Therefore, the selling price of primary products can be expressed as:

$$P = C_P + \theta \cdot C_0 + I. \quad (2)$$

wherein P is the protective price, C_P the costs of production, θ the preference coefficient, C_0 the opportunity cost, and I the profit.

That means, when we want farmers to stay in their hometown to inherit and protect agricultural heritage systems, we should pay them the product cost, the opportunity cost and their preference (encouraging them to stay in agriculture), and finally, equal profit with modern agriculture (encouraging them to cultivate using traditional methods).

3.2. Price Accounting Method

The costs of agricultural products are mainly composed of input factors including fertilizer, seeds, labor, animal husbandry, pesticides, herbicides, irrigation and field management. The costs of production C_P can be expressed as:

$$C_P = \sum_{i=1}^{n} F_i. \quad (3)$$

wherein F_i refers to the costs of various input factors of agricultural production.

The opportunity cost C_0 refers to the average annual net income per unit of labor in other industries in the research area, which can be expressed as:

$$C_0 = \frac{1}{n} \sum_{i=1}^{n} C_i. \quad (4)$$

wherein C_i is the annual net income of the labor force in other industries engaged in the survey sample.

The preference coefficient θ refers to local preferences to cultivate as farmers or to engage in other business, which can be expressed as:

$$\theta = E/W \tag{5}$$

wherein E refers to farmers' intention of income to maintain the GIAHS, when they have the opportunity to get the income of W from other business.

When $\theta < 1$, farmers prefer to cultivate in traditional ways; when $\theta = 1$, farmers do not have obvious preferences; and when $\theta > 1$, farmers prefer to do other business. The higher the θ, the higher the willingness of farmers to engage other business.

Profit I represents the average profit of per unit farmland from modern non-organic production, which can be calculated as:

$$I = P_m - C_P \tag{6}$$

In the formula, P_m is the income per unit farmland of farmers to sell their non-organic agricultural products, and C_P is the average cost per unit farmland in modern non-organic production.

3.3. Sources of Data

From the middle of July to the middle of August 2016 we surveyed eight administrative villages (Figure 2) of Jiayin Township and Baohua Township in Honghe County in the Hani Rice Terraces System. Through questionnaires and interviews we obtained the input–output status of rice cultivation of local farmers and their willingness to engage in crop production or work in cities as migrant workers.

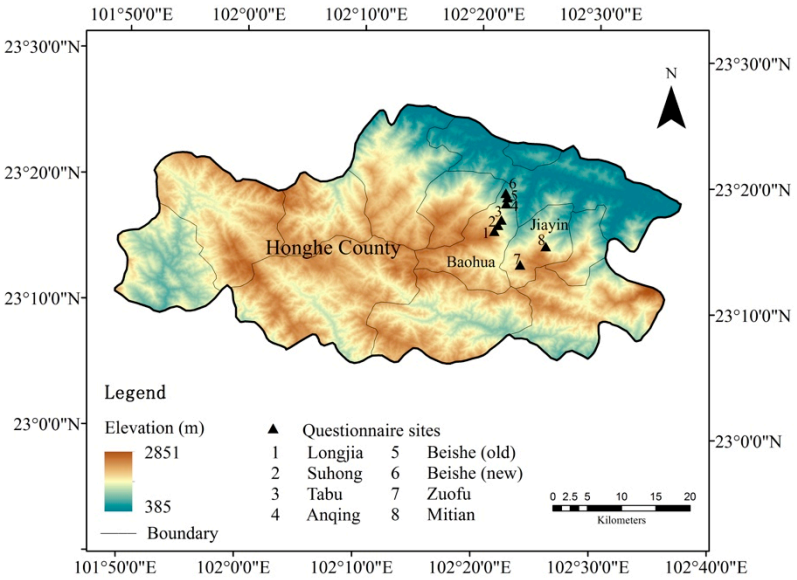

Figure 2. The study area and questionnaire sites.

The survey included the cultivate mode (modern non-organic production and traditional production in Honghe Hani Rice Terraces System), application amount of fertilizer (chemical fertilizer and manure), the use of pesticide, the costs of seeds, irrigation and weeding, labor, the amounts of animals in use, the use of agricultural machinery, the willingness of farmers to farm, their willingness to engage the next generation in farming and the expected income if they continue farming.

Respondents were selected using random sampling and 272 valid completed questionnaires were collected, accounting for 90.67% of the total number of farmers in the areas surveyed. The majority of respondents were male, accounting for 65.2% of the sample. Regarding age structure, the labor forces are mainly middle-aged, and those aged 60 and above accounted for 13.4%; from 40 to 60, 60.3%; and

40 and below 40.3%. The certification of pollution-free, green and organic agro-product in the survey area is very rare, the ratio is 4%, 6% and 15%. And 69% products have no certification (Table 1).

The statistical average of the survey data is taken as the input–output value per unit.

Table 1. Descriptive statistics from the household survey.

Variable	Mean	Max	Min	SD
Family Number	5.58	11.00	1.00	1.79
Gender of Head (male = 1, female = 2)	1.39	2.00	1.00	0.49
Age of Head	40.99	82.00	13.00	14.79
Family Income CNY/a	41,111.51	509,000.00	5546.00	60,151.38
Income from GIAHS CNY/a	7779.45	73,200.00	5546.00	2959.5
Percentage of Agricultural Income/%	36.15	100.00	0.48	34.03
Other Income CNY/a	33,881.67	500,000.00	0.00	57,756.43
Percentage of Other Income/%	65.13	100.00	0.00	34.69
Cultivated Area/hm^2	0.27	6.25	0.01	0.53
Modern non-organic production/hm^2	0.091	0.50	0.00	0.10
Traditional production (GIAHS)/hm^2	0.053	0.46	0.00	0.02
Certification of Agricultural Product [a]	1.17	5.00	1.00	0.53

Note: [a] common agro-product = 1, local special agro-product = 2, pollution-free agro-product = 3, Green agro-product = 4, organic agro-product = 5.

4. Results and Analysis

4.1. Analysis of the Inputs of the Two Cropping Systems

According to our survey, the unit price of fertilizers, pesticides, seeds and herbicides was calculated using prices in 2016. The cost of manure is 0 because in the Hani terraces system, the manure is made by farmers from animal and human excrement with no additional cost; the costs of animal power were calculated on the basis of costs of raising one cow for one year (1095 CNY annually and 3 CNY per day). Irrigation costs were calculated on the basis of a government subsidy standard 750 CNY/hm^2 as the reference standard, and considering farmers' self-investment, this article took 900 CNY/hm^2. Modern non-organic cultivation uses small machinery to save labor costs, and the agricultural machinery costs were calculated using the average price of tillage, transculturation and harvesting in 2016. Traditional cultivation mostly depends on labor to farm, it is need to employ the extra labor besides the family labor and labor costs in the Honghe Hani terraced area are 80 CNY/d.

According to Formula (3), in the Hani terraced fields, the direct input costs of traditional rice during organic conversion were 15,476.5 CNY/hm^2 and 6470 CNY/hm^2 for modern non-organic production (Table 2). There was a significant difference between the traditional method during organic conversion and modern non-organic production.

Table 2. Differences for inputs of rice cultivation between two methods of production.

Input Factors		Traditional Production during Organic Conversion			Modern Non-Organic Production	
Categories		Unit Price (CNY)	Unit Input (/hm^2)	Unit Cost (CNY/hm^2)	Unit Input (/hm^2)	Unit Cost (CNY/hm^2)
Seeds (kg)		15	22	330	15	225
Fertilizer (kg)	Calcium	0.65	1200	780	0	2520
	Nitrogen	4.8	0		525	
Manure [a]		0	0	0	0	0
Pesticides (300 g/bottle)		5	0	0	15	75
Herbicides (bags)		4	0	0	150	600

Table 2. *Cont.*

Input Factors			Traditional Production during Organic Conversion		Modern Non-Organic Production	
Categories		Unit Price (CNY)	Unit Input (/hm^2)	Unit Cost (CNY/hm^2)	Unit Input (/hm^2)	Unit Cost (CNY/hm^2)
Animal power costs (head)		1095	0.7	766.5	0	0
Irrigation costs (CNY)		900	0	0	1	900
Agricultural machinery costs (hm^2) [b]	Tillage	1050	0	0	1050	3050
	Transplanting	900	0		900	
	Harvest	1200	0		1200	
Amount of extra labor (day/person) [c]	Planting, harvesting	80	45 + 15	13,600	0	0
	Manual weeding	80	30		0	
	Ridge dressing	80	20		0	
	Tillage	80	60		0	
Total			15,476.5		6470	

Note: [a] manure is made by farmers themselves and it is free in the Hani terraces system; [b] modern non-organic cultivation uses some small machinery and pesticides to save labor costs; [c] traditional cultivation mostly depends on labor to farm.

4.2. Output Analysis of the Two Cultivation Methods

The paddy fields in this study use mono-cropping for rice cultivation, so the output of paddy fields are only rice and rice stalks. Harvested rice stalks are mainly used to feed cattle or left in the field to be burned. In the calculation process, this part is not directly converted into money, but is offset with part of the input in terms of costs of farm fertilizer and animal power, and the final output is based only on rice production.

There were significant differences in the yield of rice between traditional cultivation methods and modern non-organic production. During organic conversion, soil fertility in the short-term and pest control rate was relatively low and yield was low. According to the survey, the average yield per unit area of traditional cultivation in the organic conversion period in the Hani rice terraces was only 5250 kg/hm^2, significantly lower than that for modern non-organic production, an average of 8250 kg/hm^2.

By 2016, as the national grain purchase price 2.7 CNY/kg, the income from modern non-organic production is 22,275 CNY/hm^2, and according to Formula (6), the profit of this production mode is 15,805 CNY/hm^2.

Rice cannot be sold as organic during organic conversion, and the purchase price is still 2.7 CNY/kg. Thus, the income from traditional cultivation is 14,175 CNY/kg, and the profit is −1301.5 CNY/hm^2. When we evaluated labor costs in input-output analyses, the traditional GIAHS is a losing production activity. For this reason, governmental support is required to protect GIAHS, given their significant social, cultural and ecological value. As labor is free for farmers themselves, when the labor cost is not included in the calculations to estimate the production cost, the profit of traditional cultivation is 12,298.5 CNY/hm^2 but still lower than that for modern non-organic production.

4.3. Accounting of the Opportunity Cost and Preference Coefficient θ

Due to unbalanced economic development in China and a dual structure between urban and rural areas, the rural labor force, driven by the 'push and pull' force [18] between rural and urban areas, has been driven away from rural areas to seek higher wages. Therefore, we should consider the opportunity cost of the labor force in the Hani terraced area caused by regional and urban-rural wage differences.

In addition, even under the same net income conditions, many labor force members, especially young people, tend to leave the land and work in cities. A preference coefficient θ must be

added to correctly and accurately reflect reality, and ultimately to retain labor to protect traditional cultivation methods.

The survey results show that 29.3% of respondents are willing to farm at home and 70.7% of respondents are not willing to farm at home (Figure 3); 11.3% of respondents hope their children stay in their hometown to farm and 88.7% do not (Figure 4). When asked about the reasons to farm at home, the majority expressed their concerns of their age and fear to have their children in the city unable to survive.

Supposing the income of farming at home is the same as working in cities, 90.8% of respondents under the age of 60 choose to live in the city; and only when annual net income in cities is 10,000 CNY and in the field it is 12,600 CNY, are those under 60 willing to farm at home. Young workers in the Hani terraced area clearly prefer to work in the city. This may be because their focus on quality, comfort of living and work environment. According to Formula (5), the preference coefficient θ is 1.26.

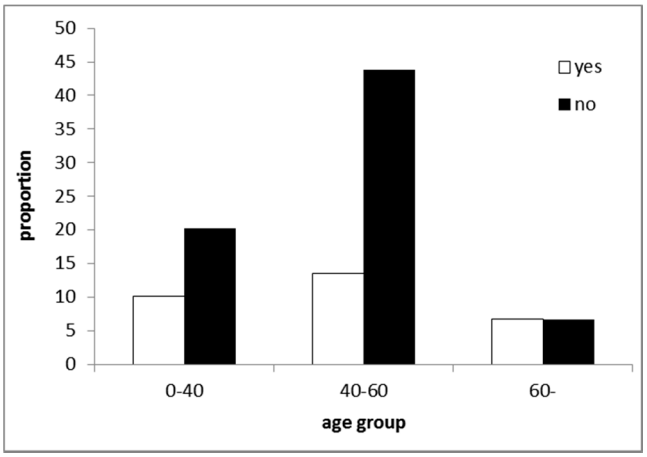

Figure 3. Willingness for farming in different age groups.

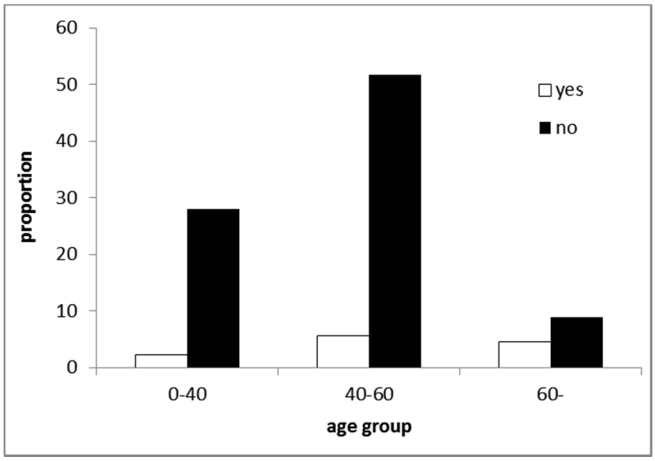

Figure 4. Willingness of farmers for the next generation to farm at home.

The survey results show that, on a daily basis, the average daily wage for migrant workers is 110 CNY/d, higher than that of local farmers, which is 30 CNY. Thus, according to Formula (4), the opportunity cost of the labor force using traditional modes during organic conversion in the Hani terraces is 4047.62 CNY/hm^2.

4.4. The Product Pricing of Traditional Cultivation

When pricing agricultural products in the organic conversion period we should guarantee that the profits per hm^2 are equal to the profits of fields under non-organic cultivation, so profit I is 15,805 CNY/hm^2.

According to Formula (2),

$$P = C_p + \theta \cdot C_0 + I = 15476.5 + 4047.62 \times 1.26 + 15805 = 36381.5 \text{ CNY/hm}^2$$

the rice price of traditional cultivation in the organic conversion period of the Hani terraces should be 36,381 CNY/hm^2. As the average yield per unit area of rice during organic conversion is only 5250 kg/hm^2, the price is 6.93 CNY/kg.

This means that only when the purchase price of traditional agricultural production during organic conversion is set at 6.93 CNY/kg, will it be possible to retain local farmer interest in GIAHS production and protect this terrace system and cultivation method.

5. Conclusions and Discussion

The direct input of traditional cultivation in the organic conversion period in the Hani terraces system was significantly higher than that of modern non-organic production. Of the total cost of inputs, labor costs account for the largest proportion, while the yield per unit area was significantly lower than that of modern non-organic production. Young migrant workers in the Hani terraces system prefer to live and work in cities where there is higher income, making the agricultural opportunity cost high. The rice protected purchase price of traditional cultivation during organic conversion should be set at 6.93 CNY/kg to guarantee income stability of farmers, protection of the Hani terraced fields and inheritance of traditional culture and skills.

5.1. The Purpose and Relativity of Pricing

The subsidy of fixing protective prices for agricultural products encourages farmer enthusiasm for production, which is fair, reasonable and operable. The purpose of this study was to try to develop a protective price for the purpose of protecting heritage landscapes and traditional production methods. Pricing is based on the income and willingness of farmers as well as the average profits of modern non-organic production and is different from the method and meaning of the pricing of market commodity. In essence it is a method of compensation. Therefore, it is not feasible for the pricing of organic conversion products with no agricultural protection purposes.

5.2. Pricing Farmers' Purchase Price of Rice Based on Their Way of Disposing of Primary Agricultural Products

The price of agricultural products is affected by many factors. Due to price fluctuation in space and time, it is very difficult to price products. Existing studies on commodity pricing mainly focus on theoretical analysis of product price structure [19,20], product pricing methods [21] and factors influencing prices [22]. However, there are limited quantitative studies of cases of commodity pricing in China and abroad.

Taking into account the actual interests of farmers, that they often sell rice directly and the profits of hybrid rice (the most popular type under modern non-organic production), we focused only on protective price determination for rice during the organic conversion period. Mechanized scale cultivation is not feasible in this region, while population loss is mainly due to the economic gap between regions. The average purchase price and average production input of hybrid rice in the plain areas of China were used here. Pricing accuracy still needs to improve, but basically our work reflects the basic requirements for purchase prices of hybrid rice during organic conversion.

5.3. Dynamic and Regional Nature of the Protective Prices of Agricultural Products during Organic Conversion

Commodity prices are influenced by costs, profit margins of production and circulation of the profit margins, imbalance between supply and demand, inflation, consumer preferences and the information they master.

Prices involved in this paper are based on prices in 2016 for input and output calculations, so the calculated results have a low time effectiveness. There are also huge differences in the mode of agricultural production, production costs and agricultural opportunity costs between different regions, so the protective prices during conversion in different regions are different.

We calculated the price according to the input and output of the yield per unit area. The scale merit can also affect farmers' total income and their willingness towards cultivation. It is an important issue that needs further discussion. The significance of this study lies in providing a new method of agricultural compensation during organic conversion and a new method for protective pricing.

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Conflicts of Interest: The authors declare no conflict of interest.

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