

Original Research

Selecting Counties to Participate in Agricultural Carbon Compensation in China

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Abstract

Agriculture has the dual attributes of being a carbon source and a carbon sink. The agricultural carbon compensation mechanism is important for increasing agricultural carbon sink and reducing agricultural carbon emissions. However, there is no specific entry threshold for the implementation of agricultural carbon compensation in China. Taking the two indicators of agricultural carbon sink level and agricultural carbon emission intensity as the basic indicators, and taking the regional average agricultural carbon sink level and the regional average agricultural carbon emission intensity as the baseline, we established the agricultural carbon compensation area selection process. According to the agricultural carbon compensation area selection process, the results obtained in Hotan Prefecture were reasonable. The result of selection accorded with the actual situation of agricultural carbon emission and agricultural carbon sinks in Hotan Prefecture.

Keywords: agricultural carbon compensation mechanism, entry threshold, agricultural carbon sink level, agricultural carbon emission intensity, area selection process

Introduction

Climate change caused by greenhouse gas emissions has greatly affected the world. It has become the common goal of countries worldwide to address climate change, reduce GHG (greenhouse gases) emissions, and implement sustainable development strategies. China has proposed that by 2030, its CO₂ emissions per unit of GDP will have decreased by 60-65% compared with emissions in 2005.

In addition to the second and third industries, agriculture is also an important source of GHG emissions

[1-3]. Approximately 17% of China's GHG emissions are from agriculture emissions [4], which is responsible for >20% of global agricultural GHG [5]. Agricultural GHG emissions of CH₄ and N₂O account for 50% and 92% of China's total CH₄ and N₂O emissions, respectively [6].

Although agriculture is one of the main sources of anthropogenic greenhouse gases on earth, it also has a strong carbon sink function, which has great potential for greenhouse gas absorption. On the one hand, forests are the first recognized ones with carbon sinks. On the other hand, crops absorb much CO₂ through photosynthesis, and the carbon content can reach 43-58% of total biomass [7]. Moreover, the potential of carbon sequestration in cultivated land is huge,

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the carbon sequestration of arable land in the world was 0.75-1.0 Pg/a, and the world's carbon sequestration of farmland will be 20-30 Pg in the next 50-100 years [7-9].

With the achievements in energy-related GHG emissions, renewables, and the plan to form a nationwide carbon-trading scheme, China can and will lead on climate change after the United States' exit from the 2015 Paris Agreement [10]. However, China does not do well in agricultural GHG emissions reduction [11]. Although China's agricultural GHG emissions intensity has declined [4], the total amount of agricultural GHG emissions still grew and had not yet reached the inflection point. A large amount of the rural labor force has flowed to the city [12], and the excessive dependence on agricultural machinery has increased. The development of agricultural S&T (science and technology) level has been low and agriculture-related R&D investment has been little. Farmers usually planted crops, raised livestock, and used the agrochemical inputs in an inefficient way just because they lacked knowledge and experience [2]. China lacked incentives, tax mechanisms, and compensation mechanisms on agricultural GHG emissions reduction [2]. 94% of the world's countries had integrated agricultural GHG emissions into the GHG emission reduction system [13], and many countries had begun to implement relevant plans and policies to reduce agricultural GHG emissions, such as the United States, Japan, and India [14, 15]. As a large agricultural country, China should implement effective policies to reduce agricultural GHG emissions, and the agricultural carbon compensation mechanism especially needs to be established and improved, which is an effective mechanism to reduce agricultural GHG emissions [7, 16-21].

China's carbon compensation research focuses on the realization path of agricultural carbon sink values and researching the carbon trading market [7, 22-26]. In practice, agricultural carbon compensation has been mentioned in agricultural ecological compensation, such as grain subsidies, returning farmland to forests, returning farmland to grassland, and the construction of the three North Shelterbelt, etc., but only the subsidiary of the agricultural ecological compensation in the government compensation. In terms of market compensation, carbon market compensation develops slowly and focuses on forest resources. At present, most of the CDM projects in China are forest projects, and the domestic carbon trading pilot market is mainly aimed at forest carbon sinks in agriculture. In China, Sichuan and Shaanxi provinces and Xinjiang Uygur Autonomous Region have also carried out voluntary trading projects on agricultural greenhouse gas emissions reduction, such as formula fertilization by soil testing and drip irrigation [27]. However, these studies and projects have not given specific entry threshold for the implementation of agricultural carbon compensation. After fully understanding the basic situation of agricultural carbon

compensation in China, we set up a simple threshold for participation in agricultural carbon compensation that can provide reference for regional participation in agricultural carbon compensation, at the same time making due the contribution to reduce agricultural GHG emissions.

Material and Methods

Agricultural Carbon Emissions and Carbon Sink Calculations

Agricultural carbon emissions are mainly considered to be the use of agricultural land, paddy fields, and livestock farming [4, 6, 28-30]. Carbon sinks mainly come from soil carbon sequestration of cultivated land throughout the life cycle of crop growth and carbon absorption in the economic forest [7, 31-33].

The formula for calculating agricultural carbon emissions is:

$$E = \sum E_i = \sum T_i \mu_i \quad (1)$$

...where E is the total agricultural carbon emissions, E_i is the agricultural carbon emissions of agricultural carbon source i , T_i is the amount of agricultural carbon source i , and μ_i is the agricultural carbon emission coefficient of agricultural carbon source i . Three types of carbon emissions (C , CH_4 , and N_2O) have been calculated in this paper and we convert CH_4 and N_2O to standard carbon according to IPCC [34]. All of the carbon sources and coefficients in this paper are from the research of Xiong et al. [6].

The formula for calculating agricultural carbon sinks is:

$$C = CS + CP + CF \quad (2)$$

...where C is total agricultural carbon sinks, CS is the total soil carbon sequestration of cultivated land, CP is the total carbon absorption in planting industry, and CF is total carbon absorption in the economic forest. Concrete calculation methods of carbon sinks in this paper are from the research of Xiong et al. [7].

Determining Entry Threshold Index

In accordance with the existing studies about energy, GHG emissions, agricultural carbon emissions, and agricultural carbon sinks [2, 7, 35-44], we found that ACEI (agricultural carbon emission intensity) and ACSL (agricultural carbon sink level) were the core of these studies, so we determined that they were the threshold index.

$$ACEI = \frac{E}{AGDP} \quad (3)$$

$$ACSL = \frac{C-E}{E} \quad (4)$$

... where *AGDP* is agricultural gross output value.

Area Selection Process through Threshold Index

The reason for the area selection through threshold index is that the current project is limited, the purpose is to make the project implementation obvious, the demonstration effect good, and farmers' incomes high. The area selection process through the threshold index is as follows (Fig. 1): the first step, choose the priority area to participate in agricultural net carbon sinks compensation through the comparison of ASCL (the ASCL values of the national, provincial, and prefecture level cities can be selected here); the second step, choose the priority area to participate in compensation of agricultural carbon sinks in low carbon mode through the comparison of ACEI (the ACEI values of the national, provincial, and prefecture level cities can be selected here), then make the determination of low carbon mode of agricultural carbon sinks compensation through analysis of agricultural carbon emissions structure in the selected area. The rest of the areas are waiting for opportunity.

Agricultural net carbon sinks compensation refers to the compensation for the net carbon sinks of agriculture, which belongs to the total factor carbon compensation, and the participating counties and cities were no longer involved in the compensation of agricultural carbon sinks in low carbon mode. Compensation of agricultural carbon sinks in low carbon mode refers to compensation for reduced agricultural carbon emissions in a low-carbon model. Reduction of agricultural chemicals, low carbon cultivation, and low carbon breeding refers to specific low carbon modes. "Waiting for opportunity" means that the areas that fail to be elected wait for other agricultural carbon compensation opportunities.

Empirical Results: County Selection of Agricultural Carbon Compensation in Hotan Prefecture

Study Area

Hotan Prefecture is located in the southernmost tip of the Xinjiang Uygur Autonomous Region. It covers an area of approximately 248,100 km². Mountains in the prefecture account for 33.3%, deserts account for 63%, and the oasis accounts for 3.7%. The oasis is divided

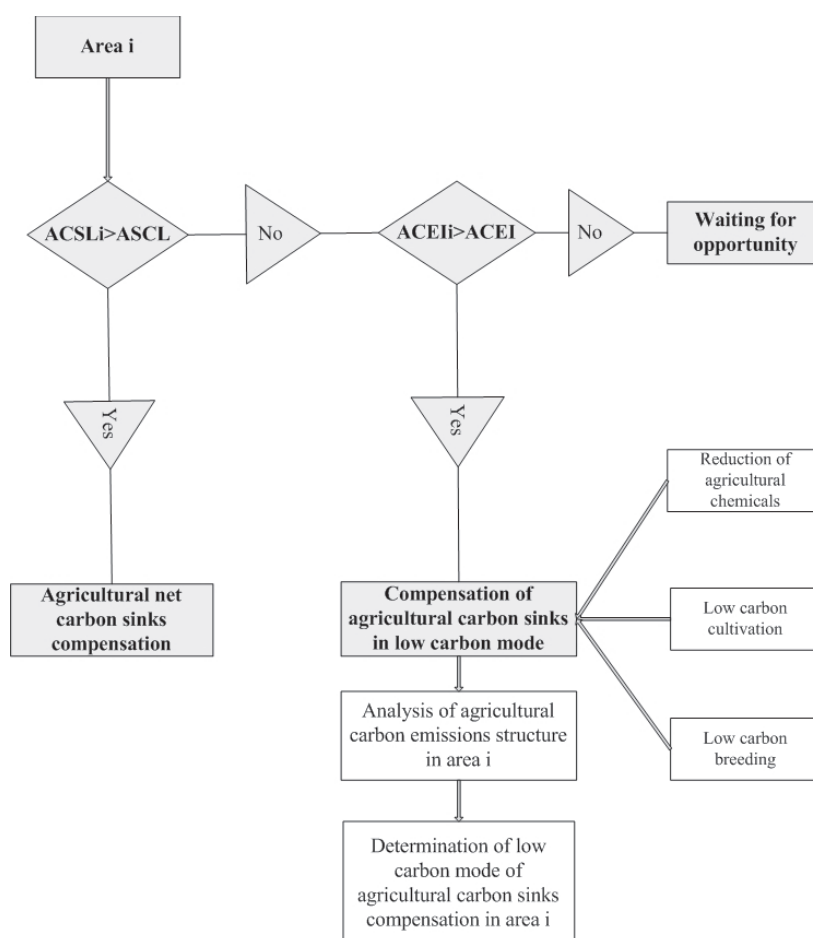


Fig. 1. Agricultural carbon compensation area selection process.

Table 1. Agricultural carbon sinks of one city and 7 counties in Hotan Prefecture in 2014 (10⁴ tons).

Counties and cities	Commercial forest	Soil	Planting industry	Total carbon emissions	Net carbon sinks	Carbon sink level
Hotan Prefecture	195.70	237.56	155.61	78.10	510.76	6.54
Hotan City	11.43	14.58	11.67	5.24	32.44	6.19
Hotan County	35.42	33.40	19.24	12.34	75.72	6.14
Moyu County	38.99	48.52	37.24	20.16	104.59	5.19
Pishan County	27.66	39.92	21.54	8.44	80.68	9.56
Luopu County	26.21	30.80	24.98	8.99	73.01	8.12
Cele County	23.02	23.84	15.27	7.25	54.88	7.57
Yutian County	26.31	42.33	23.19	11.90	79.93	6.72
Minfeng County	6.65	4.16	2.49	3.87	9.43	2.44

into more than 300 subsections by the desert and Gobi [6].

Hotan has a population of 2.15 million people, with 30 nationalities represented. Approximately 82.71% of the population works in agriculture. Its regional economy is dominated by agriculture, which can be divided into three main industries: planting, animal husbandry, and commercial forestry and fruit.

Data Description

Commercial forestry data are from the Bureau of forestry and other data in this study come from the Hotan Prefecture statistical yearbooks (2015).

Empirical Results

According to the agricultural carbon compensation area selection process (Fig. 1), Hotan's selection process is as follows:

(1) The agricultural carbon sink level in Hotan prefecture was selected as the standard, there were four counties (Pishan, Luopu, Cele, and Yutian) whose

agricultural carbon sink levels were higher than that of Hotan Prefecture (Table 1). These counties were given priority to participate in the agricultural net carbon sink compensation project. Agricultural net carbon sink compensation belongs to the total factor carbon compensation, and the participating counties and cities were no longer involved in the compensation of agricultural carbon sinks in low-carbon mode.

(2) The agricultural carbon emission intensity in Hotan Prefecture was selected as the standard, and four counties (Minfeng, Moyu, and Hotan, plus Hotan City) whose agricultural carbon emission intensities were higher than that of the prefecture (Table 1). These counties were given priority to participate in compensation of agricultural carbon sinks in low-carbon mode. Through the analysis of agricultural carbon emissions structure in Hotan Prefecture, we can see that carbon emissions from livestock breeding are dominant (Table 2). Therefore, these cities and counties gave priority to participation in low-carbon livestock breeding projects.

In this paper, the carbon emission intensity of the planting industry in Hotan Prefecture was chosen

Table 2. Agricultural carbon emissions of one city and 3 counties in Hotan Prefecture in 2014 (10⁴ tons).

Counties and cities	Carbon emissions from land use	Proportion	Carbon emissions from paddy field	Proportion	Carbon emissions from enteric fermentation	Proportion	Carbon emissions from manure emissions	Proportion	Total carbon emissions	Carbon emission intensity (kg/10 ⁴ AGDP)
Hotan Prefecture	24.66	0.3158	0.082	0.0010	26.36	0.3375	27.00	0.3457	78.10	1470.49
Hotan City	1.89	0.3598	0.005	0.0009	1.65	0.3154	1.70	0.3239	5.24	1486.98
Hotan County	3.42	0.2775	0.025	0.0020	4.55	0.3687	4.34	0.3518	12.34	1516.24
Moyu County	5.33	0.2645	0.022	0.0011	7.64	0.3790	7.17	0.3554	20.16	1670.92
Minfeng County	0.61	0.1564	0.000	0.0000	1.49	0.3836	1.78	0.4600	3.87	2873.51

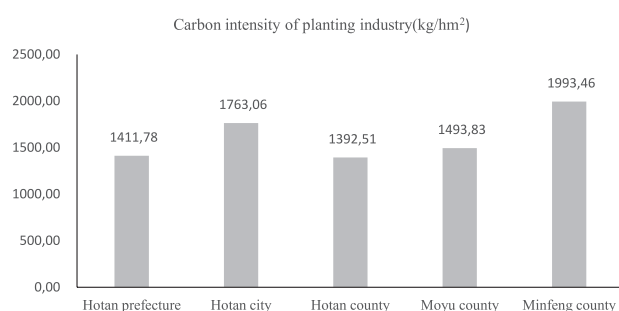


Fig. 2. Carbon intensity of planting industry of one city and 3 counties in Hotan Prefecture in 2014.

as the standard, and three entities (Minfeng County, Hotan City, and Moyu County) had agricultural carbon emission intensities of planting industry higher than that of Hotan Prefecture (Fig. 2). Through the analysis of carbon emission structure of the planting industry, carbon emissions mainly came from the use of chemical fertilizer (Table 3). Therefore, these counties and cities were given priority to participate in projects of the reduction of agricultural chemicals (reducing the use of chemical fertilizer).

Discussion

(1) According to the agricultural carbon compensation area selection process, the results obtained in Hotan Prefecture were reasonable. The result of selection was in accord with the actual situation of agricultural carbon emissions and agricultural carbon sink in Hetian Prefecture [6, 7].

(2) Because of the small scope in Hotan Prefecture, the index screening is relatively simple, and it will become complicated on the provincial and national scales.

(3) Agricultural greenhouse gas emissions without low carbon technologies are used as baseline, and carbon emission reductions in low-carbon models can be traded after certification by third-party certification bodies [27]. In this paper, the agricultural carbon sink mainly refers to the agricultural carbon reserves. The carbon sinks for trading mainly refer to the increase in carbon sinks due to the conversion of cultivated land into economic forests.

(4) The use of low-carbon technologies in any region can lead to the reduction of agricultural greenhouse gases, and any region can participate in agricultural carbon compensation. The reason for the area selection through threshold index is that the current project is limited, and the purpose is to make the project implementation obvious, have a good demonstration effect, and raise farmers' incomes. The ultimate goal is to reduce total agricultural greenhouse gas emissions.

(5) Entry threshold indexes and the agricultural carbon compensation area selection process are relatively simple. We need to increase judgment indicators so that the entry threshold is more systematic and scientific.

(6) Most of the studies on agricultural carbon emissions and agricultural carbon sinks are based on the unified coefficient [4, 6, 28-30]. Needless to say, this is not reasonable, because there is a big gap in agricultural greenhouse gas emission coefficients between different regions on a large scale, and so is the calculation of agricultural carbon sinks. Agricultural carbon compensation requires more scientific statistical coefficients.

Conclusions

Agriculture is an important carbon source, with 94% of the world's countries having integrated agricultural GHG emissions into the GHG emissions reduction system after the Paris Climate Conference [13]. At the same time, it also has a strong carbon sink function. Agricultural carbon compensation mechanism is an important mechanism for increasing agricultural carbon sink and reducing agricultural carbon emissions. However, there is no specific access threshold for implementing agricultural carbon compensation. We set up a simple threshold for participation in agricultural carbon compensation that can provide a reference for regional participation in agricultural carbon compensation.

Taking the two indicators of agricultural carbon sink level and agricultural carbon emission intensity as the basic indicators, and taking the regional average agricultural carbon sink level and the regional average agricultural carbon emission intensity as the baseline, we established the agricultural carbon compensation area selection process. According to the agricultural carbon compensation area selection process, the results

Table 3. Carbon emissions from planting industry in one city and 3 counties in 2014 (tons).

Counties and cities	Chemical fertilizer	Pesticides	Plastic sheeting	Diesel	Cultivated land	Irrigation	Paddy field	Total carbon emissions from planting industry
Hotan Prefecture	158977.06	2188.60	21854.42	17920.28	548.67	45138.37	817.32	247444.73
Hotan City	12239.27	45.66	1647.24	2121.27	34.34	2764.61	47.25	18852.39
Moyu County	37318.76	507.11	3890.18	2021.11	112.23	9471.71	224.00	53321.09
Minfeng County	4462.77	60.74	264.18	382.88	10.04	880.66	0.00	6061.28

obtained in Hotan Prefecture were reasonable. The result of selection accorded with the actual situation of agricultural carbon emission and agricultural carbon sink in Hotan Prefecture [6, 7].

Due to the limitations of the author's research, entry threshold indexes and the agricultural carbon compensation area selection process need to be improved and expanded upon, such as agricultural carbon compensation scale, scientific statistical coefficients, and so on. These research topics call for the author to make further studies in the future.

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Conflict of Interest

The authors declare no conflict of interest.

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