Journal of Architectural Research and Development, 2022, Volume 6, Issue 5
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Study on the Carbon Effect of Agricultural Land Remediation Based on the Carbon Peaking and Carbon Neutrality Goals

Hua Guo*, **Hongyun Li**, **Hangzhou Zhang**

Weinan Branch of Shaanxi Land Engineering Construction Group Co., Ltd., Weinan 714000, Shaanxi Province, China

Corresponding author: Hua Guo, 865702953@qq.com

Abstract: With the goal of achieving carbon peak and carbon neutrality, this paper studies the carbon effect of agricultural land remediation. In this paper, the carbon effect mechanism and calculation method of land consolidation, the proposed national carbon peaking and carbon neutrality goals, and the requirements put forward by agricultural land consolidation followed were analyzed. Then, the application research on the carbon effect accounting of agricultural land consolidation was conducted. Besides, the application process of carbon effect accounting of land consolidation with the goals of carbon peaking and carbon neutrality. Therefore, we hope this study will play an effective role to advance the carbon effect research in the regulation of agricultural land.

Keywords: Land consolidation; Carbon peaking and carbon neutrality goals; Agricultural land remediation; Carbon effect

Online publication: September 15, 2022

1. Introduction

Climate change caused by greenhouse gas emissions has become a major challenge for human development that needs to be addressed. In September 2020, China has put forward the goals of 2030 carbon peak and 2060 carbon neutralization, and at the same time introduced the carbon peaking and carbon neutrality goals into the overall layout of ecological civilization construction. In order to achieve carbon peaking and carbon neutrality, all sectors of society need to be actively involved, including industry, agriculture, land governance, and so on. Therefore, by exploring the carbon effect from agricultural land remediation, it will be effective in promoting the implementation of the carbon peaking and carbon neutrality goals.

2. Mechanism and accounting method of carbon effect of land remediation

(1) Carbon effect mechanism of land remediation

The carbon effect mechanism of land remediation is to comprehensively improve the area and quality of effective cultivated land and optimize and improve land production conditions by using a series of technologies such as land leveling technology, irrigation technology, drainage technology, field road construction, farmland protection technology and ecological environmental protection [1]. Based on the analysis of the carbon effect mechanism of agricultural land remediation, its carbon effect is mainly reflected in the three dimensions of project implementation, land structure and land use [2]. The implementation of the carbon effect of the project is to change the regional land use structure through effective land remediation, and reduce the disturbance of external factors to the land carbon balance from the perspective of ecosystem [3]. The carbon effect of land structure is based on the regulation of land, which effectively develops a series of low-efficiency land plots in the region, such as wasteland, ridges, barren pits and ponds, effectively adjusts the structural layout and spatial layout of land use, and realizes the transformative carbon effect. The carbon effect of land use is to realize the scale and mechanization of land use through effective regulation according to the land characteristics, promote more mature production conditions, and significantly improve the supporting production functions such as farmland transportation, protection, irrigation and drainage [4].

According to comprehensive analysis, the regulation of agricultural land is based on the regulation of agricultural land. After the project is approved, based on the leveling project, irrigation and drainage project, farmland protection project and road construction, the carbon effect of three dimensions of land structure change, project implementation and land use mode will be finally realized [5].

(2) Carbon effect accounting method.

First of all, for the calculation of the carbon effect of the project implementation, it is necessary to confirm the carbon source nodes in the project implementation stage, that is, the consumption of steel materials and cement materials in the construction stage, and the energy consumed in the construction stage, such as electric energy, water resources, gasoline, diesel, etc. The carbon emission of production materials and energy consumption can be calculated based on the material balance algorithm, that is, the consumption of materials and energy consumption are multiplied by the corresponding carbon emission coefficient, and the calculation expression is as follows:

$$C_p = \sum_{j=1}^{n} E_j * f_j \tag{1}$$

In equation (1), C_p is the carbon emission generated by material consumption and energy consumption during the construction stage of agricultural land remediation project, with the unit of kg. .E_j refers to the usage of different energy and materials, and the unit is kg.Then f_j refers to the carbon emission coefficient during the consumption of various materials and energy

Secondly, in the calculation stage of carbon effect of land structure, the carbon reserves of different land use types can be calculated based on soil carbon reserves and vegetation carbon reserves. The calculation is based on the carbon density of soil and vegetation combined with the area of different land use types. The calculation expression is as follows:

$$C_s = \left(C_{s_{final}} - C_{s_{final}}\right) = \sum_{i=1}^{n} L_i (S_i + P_i) \tag{2}$$

In equation (2), C_s, $C_{s_{final}}$ and $C_{s_{initial}}$ are the changes of total carbon reserves in the project area before and after the regulation respectively. The other reserves in the project area after and before the regulation, both use the unit kg. L_i, S_i and P_i are the area changes of I land use types before and after remediation, soil carbon density and vegetation carbon density of I land use types, respectively. The units are m^2, kg/m^2, kg/m^2

Finally, the carbon effect of land use is calculated mainly based on the economic output of crops, the average economic coefficient and water content of major crops, and then combined with the carbon absorption of crops. The expression is shown in equation (3):

$$C_{i_{absorption}} = (1 - W_i) * \frac{1}{H_i} * f_{i_{absorption}} \quad (3)$$

In equation (3), $C_{i_{absorption}}$ represents the carbon absorption of class I unit crops, in kg/kg, W_i represents the average moisture content of class I unit crops, and the unit is in %. H_i represents the economic coefficient of class I crops, the unit is in %. The carbon emission of crops per unit yield is calculated by equation (4):

$$C_{i_{emission}} = C_{ia} + C_{ib} \quad (4)$$

In equation (4), the carbon emission per unit crop of class I is $C_{i_{emmision}}$, and the unit is kg/kg. C_{ia} and C_{ib} are respectively the carbon emissions of class I unit crop production stage and ecosystem, both in kg/kg. Combined with the above equations 3 and 4, the carbon sequestration and carbon emission per unit output of different crops in agricultural land are calculated. At the same time, based on the annual change value of carbon net sink before and after the land remediation project, the carbon effect after the transformation of the utilization mode of excavated land can be comprehensively reflected. The calculation expression is shown in equation (5):

$$C_g = \sum_{i=1}^{n} Y_i \left(C_{i_{absorption}} + C_{i_{emission}}\right) \quad (5)$$

In equation (5), the change value of annual net carbon sink before and after land remediation is C_g, and the change value of annual economic output of class I crops after land remediation is Y_i, and the unit is kg.

2. Requirements for agricultural land regulation in order to achieve carbon peak and carbon neutrality

(1) The connotation of the carbon peaking and carbon neutrality goals

The "Global Warming Of 1.5°C Special Report" released by Intergovernmental Panel of Climate Change (IPCC) pointed out that if we are unable to control the pace of global warming to 1.5 °C, the climate will continue to deteriorate, at that time, a large amount of natural systems function, structure degradation, will produce a permanent shift after the break through the threshold. However, the current voluntary emission reduction sharing submitted by all countries in the world may not be able to implement the target proposed in the Paris Agreement [6]. Because of this, China has made a commitment to achieve carbon peak and carbon neutrality. In order to effectively and truly contribute to China's efforts in global climate governance, China's relevant functional departments began to rapidly adjust and transform the energy structure and industrial structure, and boost the research and development of low-carbon technologies, in order to achieve carbon peak and carbon neutrality by 2030 and 2060 [7].

(2) Path to achieving "double carbon" goal from the perspective of land regulation

From the perspective of land consolidation, the path to achieve the "double carbon" goal includes four directions: agricultural land consolidation [8], the consolidation of construction land, the protection and restoration of rural ecology, and the protection of rural history and culture [9]. In 2019, the Ministry of natural resources issued the document "Notice on Carrying Out Comprehensive Land Remediation Throughout the Region", which clearly pointed out two "5% requirements," namely: the area of new permanent basic farmland should not be less than 5% of the adjusted area; the area of new cultivated land in the remediation area should not be less than 5% of the original cultivated land area; as well as providing clear guidance on the increase of cultivated land area; and the centralized remediation of fragmented cultivated land [10].

(3) Analysis on the relationship between carbon peaking and carbon neutrality goals and agricultural land regulation.

The special report on global warming of 1.5 °C issued by IPCC points out that agriculture, forestry and other land use activities have played an effective role in achieving global warming below 1.5 °C, slowing land degradation, protecting biodiversity, restoring ecosystem functions and developing sustainable agriculture [11]. In 2018, TNC Nature Conservation Association found in its research that ecosystem restoration and protection for farmland, forests, grasslands and wetlands can effectively achieve the goal of controlling global warming up to 2 °C in the Paris Agreement, and can contribute 37% to the mitigation potential of climate change. Land use and land management greatly affect the emission level of greenhouse gases [12]. Some scholars pointed out that the reduction of cultivated land area and the transformation of a large area of cultivated land into construction land will increase carbon emissions and reduce the carbon sequestration capacity of the ecosystem. Therefore, increasing the area of cultivated land and regulating agricultural land can effectively reduce carbon emissions, improve the soil organic carbon content and carbon sequestration capacity, and increase green carbon sink [13].

3. Research on the application of carbon effect accounting of land remediation under the carbon peak and carbon neutrality goals

(1) Basic data processing of carbon effect calculation of land remediation

During the calculation of the carbon effect of land remediation, it is first necessary to sort out the regional data of the land remediation project, including the collection of engineering materials and energy consumption data in the land remediation project. At the same time, around the project budget, the quantities, energy consumption of machine shifts, and unit price of construction materials are classified item by item, and the carbon emission coefficient of the whole region is calculated based on the calculated materials and energy consumption. After data processing and collection, the carbon effect of project implementation, land structure and land use can be calculated in combination with the carbon effect calculation method of land remediation in **Part 1** of this paper.

(2) Calculation and analysis of carbon effect of project implementation

Combined with the carbon effect c method from the perspective of the implementation of the former cultural and industrial agricultural land remediation project, on the basis of understanding the regional carbon emissions and carbon sinks of the agricultural land remediation and construction project, and mastering whether the agricultural land remediation and construction area is in the state of carbon source, first, it is necessary to calculate the carbon emissions consumed by the construction materials such as cement, steel and wood in the implementation stage of the project, and calculate the carbon emissions caused by the energy consumption of electricity, diesel, gasoline and so on. Secondly, based on formula calculation, it is necessary to analyze the carbon emissions of land leveling, irrigation projects and drainage projects from the dimension of project category, and master the carbon emissions of field road construction projects. Lastly, it is necessary to calculate the carbon sink of farmland protection projects, and analyze the amount of carbon emission offset achieved by farmland protection projects. **Table 2** shows the calculation results of carbon effect from the perspective of project implementation in a certain agricultural land remediation project:

Table 2. Carbon emissions of construction materials and energy consumption of an agricultural land remediation project

Type of work	Material Science	Steel products	Cement	Gasoline	Electric energy	Glass	Diesel oil	Lime
Land leveling	Carbon emissions	0	0	0	0	0	1272	0
Irrigation and drainage work	Carbon emissions	1494	3792	124	432	3	197	50
Field road works	Carbon emissions	0	1144	0	16	0	61	0
Farmland protection	Carbon emissions	0	0	0	0	0	0	
Total carbon emissions		1494	4946	124	448	3	1530	0

As shown in **Table 2**, based on the calculation formula in **Part 1** of this paper, the carbon emissions of construction materials and energy consumption of an agricultural land remediation project are obtained. In this project, irrigation works and drainage works have the highest carbon emissions, and field road works have relatively serious carbon emissions in terms of cement consumption [14].

(3) Calculation and analysis of carbon effect of land structure

The carbon effect of land structure is the impact on the regional carbon balance after the change of land use structure. Based on the calculation method in the first chapter of this paper, we can get the increase of agricultural land, the decrease of construction use, the decrease of water areas dominated by rivers and ponds, and the decrease of unused land under the background of agricultural land remediation projects. Finally, combined with the calculation formula, we can master the increase level of carbon reserves under all land use types, including cultivated land area, irrigated land area, dry land area, farmland roads, ditches, ridges and pond water surface changes in carbon storage caused by changes in grassland area. Generally, the increase of cultivated land area will bring the most significant effect of increasing carbon reserves, while the decline of land use structure such as water area, grassland and unused land will also increase carbon reserves to a certain extent.

(4) Calculation and analysis of carbon effect of land use

After the implementation of the remediation project, the following analysis can be carried out under different land use based on the calculation formula in the first chapter of this paper. At present, under the background of agricultural land regulation, the main land use will be according to different regional climate environments, thus plant different crops to achieve the carbon effect goal, and different land structures will usually adopt different uses. In the middle region of China, the rice ↔ wheat crop rotation form is usually used under the paddy field structure, and the dry field structure and irrigated land structure, which usually uses the wheat ↔ wheat crop rotation form.

Generally speaking, the exertion of carbon effect is not only expressed in terms of carbon sink, but also reflected based on the increase of crop yield. For example, after the remediation of agricultural land in rural areas of a province, the annual net carbon sequestration was 23088 t before the remediation, and after remediation, the annual net carbon sequestration was increased to 28547 t. When rice ↔ wheat rotation was used in paddy field and wheat ↔ rape rotation was used in dry field and irrigated land, the yield of rice, wheat and rape was significantly increased after the remediation, and the yield of rice was increased from 8201kg/hm^2 before the remediation to 8944kg/hm^2 after the remediation. The single yield of wheat increased from 3970kg/hm^2 before the regulation to 5740kg/hm^2 after the regulation, and the single yield of rape increased from 1670kg/hm^2 before the regulation to 2280kg/hm^2 after the regulation, which fully indicates that under the background of agricultural land regulation, reasonable choice of utilization methods will also obtain different carbon effect harvest [15].

4. Conclusion

Irrigation and drainage projects account for relatively high carbon emissions in agricultural land remediation projects, and the use of construction materials such as cement and steel is the main source of carbon emissions. Increasing the area of cultivated land can effectively increase the carbon storage of regional agricultural land and the annual net carbon sink of the region. In addition, different ways of land use after land remediation will produce different carbon effects. Therefore, this paper suggests that our local governments should speed up the process of land remediation in rural areas to effectively to achieve the dual carbon goal.

Disclosure statement

The authors declare no conflict of interest.

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