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Enhancing the Advancement of Agricultural Carbon Emission Reduction via China's Agricultural Carbon Trading

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Abstract: Nowadays, agricultural carbon emissions become one of the reasons for the global greenhouse effect. Thus, it is imperative to effectively lower carbon emissions from the agricultural domain. China has the largest corporate production and fertilizer consumption in the world. Greenhouse gases such as Carbon dioxide (CO₂), Nitrous dioxide (N₂O), and Methane (CH₄) are produced via heavy agricultural activities. Agricultural Carbon Trading (ACT) could maximize the total amount of gases produced in agricultural activities by trading the carbon emissions in a separate market. This study evaluates the feasibility of ACT to reduce agricultural emissions in China. It delves into the development of the agricultural market in developed countries and compares it with China. Firstly, the successful factors that could be applied to the carbon trading market of China are examined. Secondly, relevant policies for supporting the future ACT market are analyzed. Thirdly, the advantages and disadvantages of the existing Chinese carbon trading system are discussed.

Keywords: agricultural; carbon trading; carbon emission; greenhouse gas emission; carbon neutral

1. Introduction

1.1. Introduction and Crisis of Global Greenhouse Gas Emission

The vital risks brought by surplus atmospheric carbon to terrestrial life have been highlighted in the National Aeronautics and Space Administration Earth Observatory (NASA EO). Greenhouse gases (GHGs) encompass carbon dioxide (CO₂), methane (CH₄), and halocarbons, which play indispensable roles in regulating thermal balance of the Earth and retaining heat within the atmosphere. In the absence of them, the Earth would become extremely cold. However, overabundant gases could lead to high temperatures of about 400°C. Thus, an optimal concentration of GHGs in the atmosphere should be maintained to ensure climatic balance of the Earth.

With the development of pivotal sectors like commerce, agriculture, and industry, significant social progress has been realized. It is noteworthy that this development has exerted a deep impact on the global climate. As shown by research, the global average temperatures are elevating at a rate of 0.2°C every ten years (Samset et al., 2020). The agricultural industry, which occupies about 17% of global greenhouse gas emissions, contributes to this phenomenon. Under this background, there are lots of challenges to seek for energy efficiencies and emission reduction.

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1.2. Chinese Environmental and Carbon Emission Crisis

China is the largest carbon emitter in the world so it undertakes a great responsibility of alleviating the emissions of greenhouse gases. In 2020, the Chinese government released the *Second National Pollution Source Census* and disclosed the presence of 3.5 million pollution sources in the country by 2017. This also marks a crucial moment in public awareness concerning the environmental issues' severity. What's more, this revelation has stimulated the government to heighten focus on environmental challenges, to promote sustainable development.

The contemporary environmental crisis is mainly characterized by excessive carbon emissions. The Potsdam Research Institute for the Effect of Climate Changes (PIK) highlights China's position as the leading emitter globally, with emissions totaling 14.3 billion metric tons of CO₂, significantly surpassing the United States, which emitted 6.2 billion metric tons as the second-largest contributor. (Amy et al., 2023) Despite China's rapid progress, the environmental repercussions of such growth, particularly pollution, cannot be overlooked.

1.3. The Current State of Chinese Agriculture's Carbon Emission

According to data from the Food and Agriculture Organization (FAO), the Ministry of Agriculture and Rural Affairs of the People's Republic of China emits approximately 782.8 million tons of greenhouse gases, positioning it as the world's leading source of agricultural emissions. (FAO et al., 2020) In 2022, the Chinese Department of Agriculture formally recognized this issue, signifying that agricultural carbon emission was incorporated as a crucial area of concern.

The strategic objective set by the Chinese government is to reach a "Carbon Peak" by 2030. This milestone signifies that the total volume of carbon emissions will reach its maximum before commencing a downward trajectory. Subsequently, the ambition extends to achieving "Carbon Neutrality" by 2060, wherein the emissions and absorption of GHGs are anticipated to attain a state of equilibrium, culminating in net zero emissions. In addition, this initiative manifests a deep commitment to tackling climate change by alleviating the environmental influence of agricultural practices, thereby promoting sustainability worldwide.

2. The Development of Agricultural Carbon Trading

2.1. Introduction to Agricultural Carbon Trading

As a part of carbon trading, ACT is conducive to controlling the amount of CO₂ released by the organizations. In this system, every group obtains a certain amount of carbon they're permitted to emit. Beyond that, they need to buy extra carbon credits if they desire to emit more. In terms of the Carbon Trade Exchange, it is a famous online place for people to buy and sell these carbon credits at relatively fair prices.

In spite of the good performance of carbon trading in heavy industries, it is not as developed for the agricultural industry. At the same time, it is more difficult to ascertain the amount of CO₂ released by farms in comparison to energy companies. At present, there is a lack of a convenient way to assess the exact amount of CO₂ from farming. What's more, different nations are still attempting to seek the optimal solution.

2.2. Agricultural Carbon Regulation in Developed Countries

Through collaboration, the US, Germany, and Australia have set up accurate regulations and methodologies to precisely assess CO₂ emissions from farms. This initiative marks a great step towards comprehending and alleviating the environmental influence of agricultural activities, which aligns with the global endeavour to boost sustainable farming practices.

America is not only one of the leaders in boosting a low-carbon economy but also the world's most significant base for energy-saving and emission-reduction technologies. In

2009, the American Clean Energy and Security Act (CESA) was passed. For the first time, America established quantitative goals for medium- and long-term greenhouse gas (GHG) emissions reductions, involving offsets for agriculture and forestry. At the same time, the U.S. was the world's first nation to create a legally binding climate.

Apart from that, laws and regulations on green and low-carbon agricultural production have been formulated. Based on the *National Environmental Policy Act*, America has enacted specific laws like the Soil Conservation and Domestic Quota Act. In 1947, the *Federal Insecticide, Fungicide, and Rodenticide Act* (i.e. the *Pesticide Act*) was implemented in the US, which played a vital role in ensuring the scientific usage of agricultural inputs as well as the prevention and control of agricultural pollution. At the same time, the *Pesticide Registration and Classification Program* and the *Pesticide Residues in Agricultural Products Regulations* have been introduced to reinforce the management of pesticides.

Besides, the governmental farming department in Australia has launched guides regarding how to compute the CO₂-eq generated by farms. According to the guidebook, the farmers need to constantly track a few things (e.g. the amount of nitrogen fertilizer applied to their crops). By virtue of these steps, farmers can understand the amount of CO₂-eq generated by their farm. This is an element of a bigger endeavour to make farming more environmentally friendly by managing the CO₂ released into the air.

Germany has cutting-edge precision machinery in fields such as aviation and agriculture, which greatly heightens farming productivity via advanced agricultural machinery. According to the GNETS report, agricultural emissions account for 8% of the national gross greenhouse gas emissions. In order to deal with this issue and achieve "Carbon Neutrality" by 2050, a Carbon Trading System, which prices carbon credit at EUR 30 (USD 31.58) per ton of CO₂-eq, has been introduced by the German government. From the year of 2026, the price will increase from EUR 55 (USD 57.92) to EUR 65 (USD 68.45) per ton. At the same time, this initiative has produced EUR 13.6 billion (USD 14.32 billion) in revenue, highlighting Germany's commitment to sustainable agriculture.

2.3. Benefit from Agricultural Carbon Trading

ACT plays a vital function in limiting gross CO₂ emissions and nurturing decline to bolster a healthier international context. In general, the heavy sectors tend to be controlled by big institutions. By contrast, the agricultural industry mainly consists of family-owned farms and small-scale operations. The implementation of a robust Carbon Trading System not only serves to regulate emissions but also carries significant educational value in promoting environmental protection and sustainable development. Familiarizing more individuals and smaller entities with this system, it enhances their understanding and commitment to environmental stewardship, thereby extending the benefits of sustainable practices across a broader spectrum of the agriculture industry.

3. The Advantages and Disadvantages of Agricultural Carbon Trading in China

3.1. The Advantages of Agricultural Carbon Trading in China

The implementation of ACT in China has advantages, reflecting a unique strategy for managing the agricultural sector and the determination to support environmental protection. Key facts in the advantages of agriculture include the following:

3.1.1. Emission Reduction

According to the above data, Chinese agriculture is responsible for emitting 782.8 million tons of GHGs annually, positioning it as the world's leading emitter in the agriculture sector. The introduction of a capping and trading system for carbon credits in agriculture is poised to significantly reduce these emissions. Before the Conferences of the Parties (COP) in 2015, the Chinese government committed to a reduction of CO₂ intensity by 60% to 65% by the year 2030, relative to 2005 levels (Karplus & Carnegie Mellon University, 2021). The implementation of an Agricultural Carbon Trading System is expected

to play a crucial role in achieving this ambitious national objective, demonstrating China's proactive approach to addressing climate change while promoting sustainable agricultural practices.

3.1.2. Financial Incentive for Owner of Farm

Small-scale farm owners and agricultural organizations gain significant advantages from participating in the Carbon Trading System by selling surplus carbon credits. Data from the official Chinese carbon trading platform indicates that the price per carbon credit unit varies across different regions. Notably, there was a consistent upward trend in carbon prices annually before COVID-19 (Figure 1), presenting an opportunity for farmers to get financial support by selling unused carbon units at competitive market rates.

Conversely, agricultural entities that exceeded their carbon emission quotas are faced with two primary options: they can purchase additional carbon units through the Carbon Trading System to satisfy regulatory limits, or they can invest in the adoption of low-carbon technologies. The latter strategy not only aids in mitigating carbon emissions but also enhances operational efficiency and productivity within the agricultural sector. This dual approach underscores the Carbon Trading System's role in promoting environmental sustainability while offering economic incentives for greener practices in agriculture.

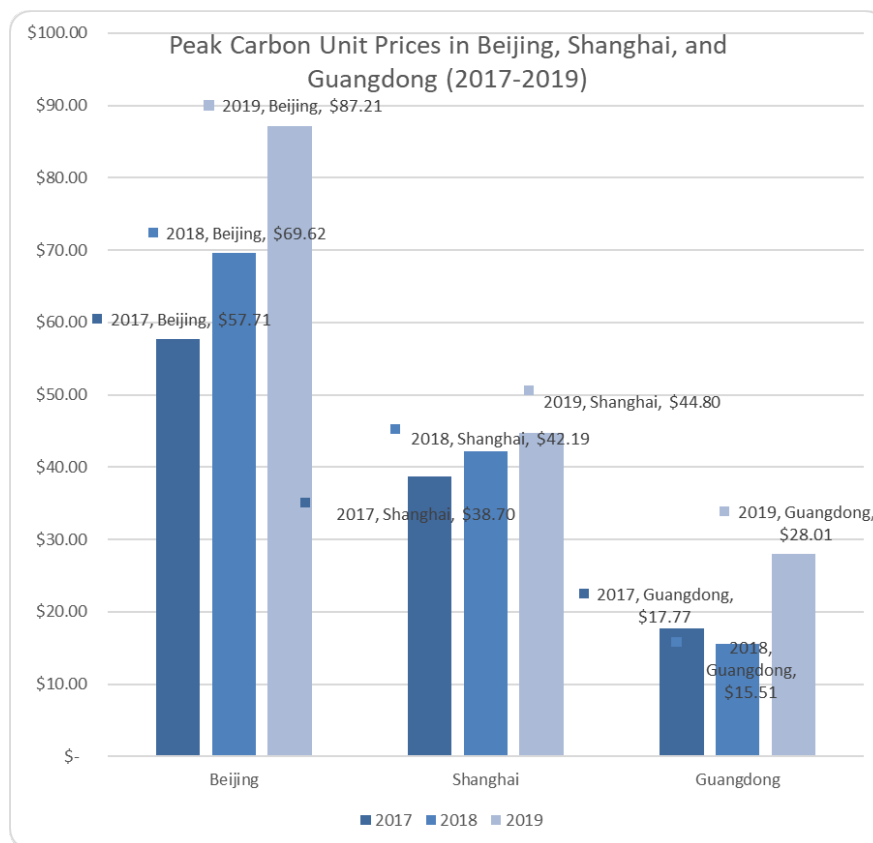


Figure 1. 2017-2019 Peak Carbon Unit Prices in Beijing, Shanghai, and Guangdong.

3.2. The Disadvantage of Agricultural Carbon Trading in China

China has nearly 1.4 billion population, ranking as the world's second most populous country. As of 2023, the rural population accounts for 477 million individuals. Furthermore, with a grain production volume of 695 million tons, China addresses its leading position in the global agricultural sector. This data indicated a significant influence of the population engaged in agricultural activities. However, the massive rural population presents some challenges to the performance of the ACT system. Key considerations include:

3.2.1. Regulation Difficulties

The implementation of the Carbon Trading System has primarily targeted electric power-generating companies in China. Relevant policies have not been formatted in the agricultural field, due to the difference in the agricultural system compared with countries such as the United States or Australia. China has an average farm size of only 0.2 acres per household (The Third National Survey 2021), while the United States has an average farm size of 445 acres per household (USDA National Agricultural Statistics Service 2022). The regulation of a bigger number of farmers raises serious challenges.

The biggest challenge is the estimation of carbon emissions. Two assumptions are predicted from calculating the carbon estimation. The first assumption, individual households calculate carbon emitted from their farmland independently. However, it requires specialized education to fulfill this purpose. The second assumption, each region establishes a carbon measurement team equipped with sufficient funding. Both assumptions appear to have substantial difficulties.

3.3. Current State Agricultural Carbon Trading

In May 2022, the Xiamen Carbon Trading Center established its first two units of agricultural carbon trading tickets, with ID numbers 0001 and 0002, from two villages, and sold them to a food production company. Villagers were amazed and excited about the fact the idea that "air" could be sold for money. Those two villages were permitted to sell their carbon unit, due to their low agricultural carbon emission from the tea production. The profit from selling unused carbon units would be applied to improve tea-producing equipment. This initial success represents a milestone that sets the stage for the future ACT development.

4. Outlook

4.1. The Government

Taking into account the national conditions of China's agricultural development and local thinking, and with the basic concepts of "food security" and "people-centeredness" as the guiding direction, we build a framework for agricultural low-carbon development experiences and propose policy insights for China, including The framework includes five aspects: laws and regulations, financial and tax support, management and technological innovation, energy transformation and upgrading, and carbon market mechanism. First, keep the bottom line of food security, and scientifically grasp the opportunities of the "dual-carbon" strategy and the risks of food production and operation. Second, adhere to the principle of people-centeredness, and correctly handle the basic relationship in the green and low-carbon transformation of agriculture.

4.2. Farmers

The impact of the country's push to reduce carbon emissions in agriculture farmers' visions is reflected in the following areas.

- 1) improvement of the rural ecological environment: The implementation of carbon emission reduction in agriculture will help to reduce greenhouse gas emissions from agricultural activities, improve the rural ecological environment and enhance the quality of life of farmers. Fresh air, clean water and fertile land will provide farmers with a more livable living environment.
- 2) Promoting sustainable agricultural development: Agricultural carbon emission reduction will promote the development of agriculture in the direction of green, low carbon and recycling, and promote sustainable agricultural development. Through the use of advanced agricultural technology and management measures to improve agricultural production efficiency, reduce the use of ferti-

lizers, pesticides and other agricultural inputs, reduce the pollution of agriculture on the environment, and achieve a harmonious symbiosis between agriculture and the environment.

- 3) Increase farmers' income: the implementation of agricultural carbon emission reduction will bring new economic growth points for farmers. On the one hand, by participating in the carbon emission reduction program, farmers can obtain certain economic benefits; on the other hand, with the development of green agriculture, eco-agriculture and other new types of agricultural business, farmers can expand new areas of agricultural production and increase the source of income.
- 4) Raising farmers' awareness of environmental protection: the implementation of carbon emission reduction in agriculture will enhance farmers' awareness of environmental protection and promote their active participation in environmental protection actions. Farmers will pay more attention to the economical use of agricultural resources, reduce the emission of agricultural waste, promote the resource utilization of agricultural waste, and form a green and low-carbon production and lifestyle. In conclusion, the impact of China's promotion of agricultural carbon emission reduction on farmers' vision is positive and will bring farmers a better living environment and a higher quality of life. Apart from that, it is important to enhance policy guidance and technological support so as to trigger farmers' enthusiasm for engagement and boost the development of agricultural carbon emission reduction.

4.3. Enhanced Low-Carbon Technologies Biochar/Water Fertilization

The vision of water-fertilizer integration: water-fertilizer integration technology is an important measure to achieve agricultural water conservation and emission reduction and to improve the efficiency of Agricultural production. China's vision of strengthening water-fertilizer integration technology is to promote the wide application of water-fertilizer integration technology in agricultural production through policy guidance and technical support. What's more, the innovation of the water-fertilizer integration technique should be reinforced to elevate the effectiveness of water and fertilizer usage, lower agricultural production expenses, and boost the development of sustainable agriculture.

In summary, China's development of low-carbon technologies, biochar and water-fertilizer integration will provide strong support for realizing the vision of green, low-carbon and sustainable agricultural development. Beyond that, the government, research organizations, companies, and farmers should cooperate to form a synergy, so as to boost technical innovation and application in these fields. The intensification of low-carbon technologies in China and the development of areas such as biochar and water-fertilizer integration are important for realizing the vision of green, low-carbon and sustainable agricultural development. The following are some explorations of the vision in these areas.

Low-carbon technology vision: With the increasingly serious problem of global climate change, the research, development, and application of low-carbon technologies have become the key to promoting sustainable agricultural development. China's vision of strengthening low-carbon technologies is to reduce greenhouse gas emissions in the agricultural production process, improve agricultural energy efficiency and promote the green transformation of agriculture through technological innovation and popularization and application. Besides, it is crucial to enhance cooperation and exchanges with the international world so as to boost the low-carbon development of international agriculture.

Bio-carbon vision: Bio-carbon, as a new type of carbon emission reduction technology, has a broad application prospect. China's vision of strengthening bio-carbon technology is to improve the productivity and stability of bio-carbon through scientific research and technological innovation and to promote the application of bio-carbon in agriculture. At the same time, we will strengthen the publicity and promotion of biocarbon technology

increase farmers' awareness and acceptance of biocarbon technology and promote the popularization and application of biocarbon technology.

5. Conclusion

One of the biggest challenges faced by the earth is the Climate Change caused by the GHGs emitted by human activities. Limiting the total CO₂ emission through Carbon Trading is the global strategy to combat Climate Change. ACT as a branch of Carbon Trading is an important step in enhancing the effect of controlling CO₂ emissions to better care of the planet. Farming could be more sustainable by trading Carbon Units and applying low-carbon technology.

In the leading in agriculture, China carries a significant burden in fighting Climate Change, with strong social responsibility. President Xi, the current president of The People's Republic of China, has announced the strategy that China will reach a "Carbon Peak" before 2030, and have "Carbon Neutrality" before 2060. Even though enforcing the ACT presents certain difficulties, the benefit of reducing carbon emissions is sustainable for all of society.

Xiamen Carbon Trading Centre has taken one step forward in the examination ACT in the Chinese farmland, and as a result, farmers were able to upgrade their agricultural equipment, and the food production company could emit more CO₂ to improve productivity. This milestone identified the successful development in the Chinese ACT market. The journey of ACT offers a blueprint for creating a healthier planet and a brighter future for all.

The research paper presents an analysis of the current state of ACT both domestically and internationally and explains the implementation process through the use of typical case studies. It demonstrates that ACT is a viable mechanism for achieving sustainable agricultural development, increasing farmers' income, and fostering their prosperity. However, there are existing policy deficiencies as well as inadequate levels of farmer education. The paper also proposes recommendations and measures to address these issues.

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