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A comprehensive review on agricultural greenhouse gas emission reductions in China: opportunities and challenges

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Abstract

China is the world's largest carbon emitter. Reducing greenhouse gas emissions from agriculture, one of the main sources, is a channel for achieving China's carbon peaking and carbon neutrality targets on schedule. To clarify the status and prospects of greenhouse gas (GHG) emissions reduction in Chinese agriculture, this paper focuses on macro-level factors such as policies, economy, society, and technology, meso-level factors such as agricultural digital transformation and carbon trading market construction, and micro-level factors such as individual farmers and household influences on agricultural emissions reduction. Therefore, this article examines the strengths, weaknesses, opportunities, and threats in China's agricultural greenhouse emission reductions by SWOT. It is concluded that optimized industrial structure and technological progress are strengths, while weak low-carbon awareness among farmers and the limitations of traditional small-scale production methods are weaknesses. Aligning with national development direction, absorbing foreign experiences, and integrating with digitization are opportunities. The imbalance between the economy and emission reduction and the significant regional differences are the threats. Overall, China's efforts are on the right track, but urgent action is needed to improve the quality of farmers and transform the agricultural economy, which requires fundamental changes. Based on this, suggestions are proposed for farmers, businesses, and government from four aspects: promoting and expanding pilot demonstration areas for agricultural carbon sequestration trading, building regionally superior agricultural products and specialty industries, synergistic cooperation for technology development and promotion, improving farmer educational level in the form of agricultural cooperatives, so as to help balance economic and environmental benefits in reducing agricultural GHG emissions.

Keywords: Greenhouse gas emissions, SWOT, agriculture

INTRODUCTION

One of the biggest worldwide problems facing humanity is global warming[1], which is mostly caused by the steady increase in the concentration of greenhouse gases (GHGs) in the atmosphere, such as methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), and so forth. The signatories to the Paris Agreement have committed to stepping up efforts to keep warming to 1.5 °C and limit global average temperature increases to no more than 2 °C over pre-industrial levels. To achieve this goal, the nations have to work together to address the significant challenge of reducing GHG emissions.

The greenhouse gas emissions from agricultural production account for 17% of China's total emissions, but only 7% of the United States' and 11% of the global total[2]. Therefore, reducing agricultural carbon emissions (ACE) will have more significant effects for China than for other countries. As a responsible power, China submitted its Fourth National Communication on Climate Change and Third Biennial Update Report to the Secretariat of the Convention in 2023. The policies and measures China implemented to combat climate change during the "Thirteenth Five-Year Plan" period are fully documented in these two publications, as well as the progress and achievements made. They also indicate that the total greenhouse gas emissions from agricultural activities amounted to 7.93 billion tons.

Between 1961 and 2018, there was a general upward trend in China's agricultural carbon emissions, which could be divided into three phases: a period of stable growth from 1961 to 1978, a phase of rapid growth from 1979 to 1996, and a period of stability followed by a peak from 1997 to 2018[3]. Overall, the carbon emissions from Chinese agriculture have been brought under control, suggesting that the efforts to mitigate emissions have achieved certain results. However, considering China's substantial total carbon emissions, it is evident that agricultural carbon emissions cannot be ignored. There is still a great deal of potential for reducing emissions in this area.

China, the largest greenhouse gas emitter in the world, has demonstrated its determination and responsibility for addressing climate change. At the 75th session of the United Nations General Assembly in 2020, China first proposed the ideas of "carbon peak" and "carbon neutrality". In 2021, the State Council issued the "Action Plan for Peak Carbon Emissions by 2030" and the "Opinions on Thoroughly Implementing the New Development Concept and Achieving Peak Carbon Emissions and Carbon Neutrality", emphasizing carbon sequestration and emissions reduction in rural agriculture. The "National Agricultural Green Development Plan for the 14th Five-Year Plan" reiterated the need to develop low-carbon and green agriculture, which effectively provides guarantees for achieving carbon neutrality. In 2022, the Ministry of Agriculture and Rural Affairs and the National Development and Reform Commission jointly issued the "Implementation Plan for Emission Reduction and Carbon Sequestration in Agriculture and Rural Areas", which systematically deploys efforts to promote emission reduction and carbon sequestration in agriculture and rural areas. The "14th Five-Year Plan" is a crucial period for both China's agricultural economic growth and carbon neutrality goals[4].

Early research on agricultural carbon emissions focused on the calculation of carbon emissions, mainly involving the determination of agricultural carbon sources and the estimation of total agricultural carbon emissions, aiming to identify the temporal dynamic evolution characteristics of carbon emissions[5]. West measured agricultural CO_2 emissions based on agricultural inputs and energy consumption of agricultural machinery[6]. Later, scholars measured the total amount of agricultural carbon emissions from multiple dimensions. For example, in the dimension of time, Jin *et al.* found that China's carbon emissions have increased overall since 1961, experiencing stable growth, rapid growth, and stabilization phases, with agricultural greenhouse gas emissions in China reaching 870 million tons in 2018[7]. In terms of gas composition, agricultural greenhouse gases mainly include methane and nitrous oxide, but the proportion of CO_2 is increasing[8]. Regarding carbon sources, the continuous acceleration of agricultural modernization has made energy consumption the primary source of carbon emissions[9].

The calculation of agricultural carbon emissions lays the foundation for further exploring the influencing factors of agricultural carbon emissions reductions. At the macro level, most scholars apply the KAYA model and the LMDI model to conduct factor analyses at various levels, such as national, regional, inter-provincial, and county levels[10-12], and then utilize the XGBoost model or the Grey Model GM(1,1) to forecast carbon emissions for several years in the future. These researchers mostly believe that regional economic development generally plays a significant role in increasing agricultural carbon emissions, while factors such as urbanization, agricultural production efficiency, agricultural industrial structure, regional industrial structure, and labor factors all have inhibitory effects on agricultural carbon emissions.

Taking spatial correlation into account, space, economics, and technology are the key drivers. Specifically, regional spatial adjacency, similarity of agricultural industry structures, degree of regional agricultural product transfer, number of inter-regional agricultural leading enterprises, and technological progress differences all significantly influence the regional correlations in agricultural carbon emissions[13].

At the macro level, in addition to the influencing factors such as society, economy, and energy that are decomposed by the KAYA model and the LMDI model, policies and regulations must also be taken into consideration.

Scholars have summarized and analyzed the policies on promoting low-carbon agriculture in major developed countries[14,15]. They have proposed insights such as establishing industrial standards, financial systems, subsidy mechanisms, and certification mechanisms. Other scholars have discussed various types of environmental regulations, such as financial and tax policies, agricultural insurance policies, agricultural subsidy policies, and market incentive-based environmental regulations[16-18]. Additionally, some scholars have quantitatively analyzed and argued that agricultural GHG emissions can be effectively decreased by increasing national financial investment and administrative orders; excessive administrative orders are likely to harm farmers' interests in the process of policy implementation[19].

At the meso level, in recent years, the potential of agricultural digitization to promote greenhouse gas emission reduction has become a research hotspot. Digital finance, digital economy, digital transformation, digital agriculture, and so on have become the research buzzwords in this field. Upgrading of industrial structure, technological innovation, scale of operation, financial services and human capital can all serve as mediator variables for digitization and agricultural emission reduction. When the level of economic development, environmental regulation and digitization reach a certain degree, the effect of emission reduction is better[20-22].

At the micro level, given the small-scale production and household-based management characteristics of agriculture in China, agricultural production decisions are directly influenced by household features and factors. Therefore, some studies have focused on examining the factors influencing agricultural emissions reduction from the household perspective. Per capita education and agricultural income are both enduring and effective factors influencing energy conservation and emissions reduction in agriculture[23]. Studies indicate that enhancing farmers' awareness of climate change significantly increases their willingness to adopt emission reduction technologies. Furthermore, the widespread adoption of emission reduction technologies can be significantly improved through technology demonstrations. Additionally, the accessibility of agricultural technology extension services, the availability of credit, and irrigation infrastructure significantly influence all farmers' willingness to adopt these technologies[24]. Farmers' perceptions, attitudes, satisfaction, consciousness, and motivation all have a strong positive influence on farmers' willingness for low-carbon production[25].

In summary, scholars have quantitatively analyzed the impact of agricultural emissions reduction from macro-level factors such as policies, economy, society, and technology, meso-level factors such as agricultural digital transformation and carbon trading market development, and micro-level factors related to individual farmers and households. While quantitative studies provide scientific and objective results, the research topics are relatively limited, lacking a systematic classification and summary of influencing factors. This article, based on existing literature, utilizes SWOT to integrate and categorize factors from the above three levels along with other information, assessing the strengths, weaknesses, opportunities, and challenges of agricultural greenhouse gas reduction, for the current situation and prospects of greenhouse gas reduction in Chinese agriculture. Furthermore, the article also presents reasonable recommendations for future agricultural emissions reduction, aiming to balance the economic benefits of agricultural production and the environmental benefits of GHG emission reduction and weaken the decoupling effect between these two benefits, bringing agricultural policies and ecological policies in line with socio-economic development planning.

METHOD

Scholars have conducted quantitative and qualitative overviews of GHG emission reductions. A typical quantitative approach is meta-analysis. The advantage of this method lies in combining and analyzing multiple comparable individual research results, yielding highly objective and scientific findings. However, when using this method, the sources of literature may be limited, leading to publication bias and other biases. Additionally, the findings are greatly influenced by the quality of the literature. Moreover, some differences in statistical methods mean that the studies are heterogeneous and have different indicators, which can also lead to bias. Therefore, this paper abandons this method.

This paper prefers qualitative review. Three classic strategic management tools -SWOT, PEST, and Porter's Five Forces model - can all serve as alternative methods. However, PEST and Porter's Five Forces are excluded from this analysis primarily because SWOT can clearly present the analysis results in a matrix format, which facilitates targeted decision-making.

SWOT was proposed by K. Andrens in the 1960s. The four alphabetic characters represent strengths, weaknesses, opportunities, and threats. This method, based on situational analysis within the context of internal and external competitive environments, lists various internal strengths, weaknesses, and external opportunities and threats closely related to the subject of study, and arranges them in a matrix format for a series of corresponding suggestions. As a result, based on the views of scholars, this article analyzes the strengths, weaknesses, opportunities, and threats of China's agricultural emission reduction by SWOT so that we can leverage strengths and mitigate weaknesses, providing valuable recommendations for achieving carbon reduction and sequestration in agriculture and meeting dual carbon goals.

DISCUSSION

By considering the macro, meso, and micro influencing factors, we can utilize SWOT to integrate and classify them to explore the strengths, weaknesses, opportunities, and threats of agricultural emissions reduction in China (as shown in Figure 1).

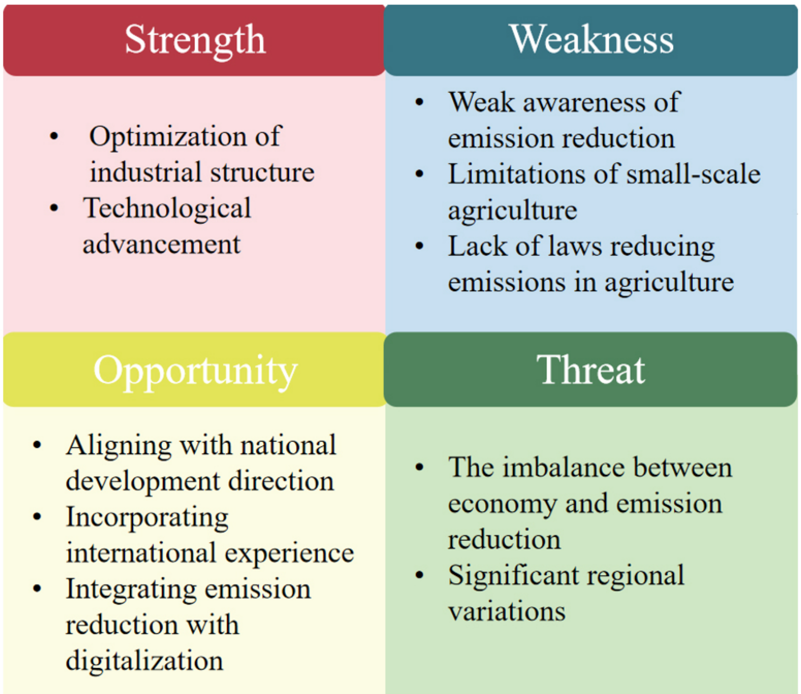

Figure 1. Agricultural GHG emission reduction in China.

Strengths

Optimization of industrial structure

Industrial structure is a key element that affects agricultural carbon emissions[26]. In the process of agricultural production, the input of production factors such as fertilizers and pesticides, as well as the substitution of machinery for labor, to a certain extent, brings about the improvement of production efficiency, but inevitably leads to increasing fossil energy consumption and agricultural carbon emissions. The industrial structure directly determines the energy consumption structure, which is closely related to carbon emissions.

Rationalization of industrial structures has a positive impact on carbon reduction[27]. In Shandong Province, China, the added value of planting and animal husbandry in agriculture decreased from 82.8% in 2000 to 76.0% in 2020. On the contrary, forestry and fishery, the lower-carbon industries, have seen an increase, indicating that Shandong Province is continuously adjusting its agricultural industry structure and developing low-carbon agriculture[28].

Technological advancement

Agricultural technologies generally include biological (genetic resources, *etc*.), chemical (fertilizers, pesticides, agricultural films, *etc*.), mechanical (agricultural machinery, equipment, *etc*.), and other technologies. Technological progress has always been considered an important way to lower agricultural carbon emissions. It may have two effects on agricultural greenhouse gas emissions. On the one hand, technological progress can encourage farmers to expand production, input more production factors, and consume more fossil energy, leading to more agricultural greenhouse gas emissions.

On the other hand, technological progress helps to increase agricultural productivity. By inputting the same production factors, the same or more agricultural products can be obtained. Therefore, if demand for food does not increase significantly, the reduction of input elements reduces agricultural greenhouse gas emissions. In recent years, China's agricultural emission reduction technologies have been continuously developed, mainly involving planting carbon sequestration, animal husbandry carbon reduction, agricultural machinery energy saving, and green low-carbon technologies in processing and circulation fields. The Agricultural Ecology and Resources Protection Station of the Ministry of Agriculture and Rural Affairs has announced the top ten technological models for agricultural carbon emission reduction and carbon sequestration. This is the first time that agricultural and rural areas have released related technological models on the theme of emission reduction and carbon sequestration. Most studies have shown that technological progress in China has made a prominent contribution to emissions reduction[29].

Weaknesses

Weak awareness of emission reduction

Residents generally have low-carbon cognitive awareness, uncertain low-carbon attitudes, and heterogeneous low-carbon behaviors[30]. Currently, the majority of farmers primarily rely on experiential operations, with a relatively low level of education and lack of advanced concepts of modern agriculture. It is difficult to accept the national policies on carbon reduction, and to effectively use advanced technologies and management practices in agricultural production. In addition, as economic agents, farmers are more concerned about increasing their own income rather than improving ecological benefits. Taking carbon reduction technologies such as biogas and straw returning as examples, although these technologies are beneficial for emission reduction, they do not create profits for farmers, which has hampered the spread of technologies.

Limitations of small-scale agriculture

Small-scale agriculture is characterized by small-scale, autonomous cultivation and management, exchange with nature, self-sufficiency, and mutual isolation. In some small-scale production systems, problems such as land fragmentation, over-cultivation, and improper crop rotation may lead to land degradation and soil organic carbon loss, thereby increasing carbon emissions. Additionally, some farmers may still use traditional farming patterns, such as traditional irrigation and low mechanization levels, leading to higher carbon emissions from energy consumption. Furthermore, the short-term nature of farmers' interests contradicts the long-term nature of land carbon reduction emissions, making it difficult to implement policies and promote agricultural technologies.

Lack of laws reducing emissions in agriculture

China embraces the concept of governing the country according to law. The number of low-carbon policies from 2011 to 2021 has remained stable at a relatively high level, indicating that during this period, the Party and the government were deepening and intensifying low-carbon policies[31]. The formulation of specialized laws for agricultural emission reduction is an inevitable trend in the future. However, the legal framework related to agricultural emission reduction in China is somewhat lacking now. The relevant content on agricultural emission reduction is mainly mentioned in governmental plans, such as the "14th Five-Year National Plan for Green Agricultural Development" and the "13th Five-Year Plan for Comprehensive Energy Conservation and Emission Reduction Work". Compared to other countries, such as Australia with the "Carbon Farming Initiative Act"[32], China still needs to further develop and refine its laws on carbon reduction in agriculture.

Opportunities

Aligning with national development direction

As a responsible power, to achieve the "dual carbon" goals, China is dedicated to establishing a reasonable and effective low-carbon policy system, and adjusting relevant institutional arrangements for national low-carbon development. The detailed policy system is shown in the Supplementary Table 1. This policy system has gone through three phases since 1984. In the first phase (1984-2006), China's policies focused on basic agricultural and rural development, which were more concerned with agricultural resource conservation and agricultural infrastructure building rather than directly targeting GHG emission reductions. In the second phase (2007-2016), starting with "China's National Program to Address Climate Change", China's policies began to emphasize climate change mitigation and focus on recycling and sustainable development in various sectors of agriculture, such as planting and animal husbandry. In the third phase (2016-the present), China's ecological civilization construction has entered a crucial period with carbon reduction as the key strategic direction. The objectives of the policies more directly target GHG emission reductions. For example, the "Implementation Plan for Agricultural and Rural Carbon Reduction and Sequestration" in 2022 is the first policy that integrates high-quality development in agriculture with carbon reduction and sequestration, providing a systematic implementation pathway for agricultural and rural carbon reduction and sequestration. Additionally, with the rapid development of technology, policies, such as the "13th Five-Year Plan for Science and Technology Innovation in Agriculture and Rural Areas" and the "Action Plan for the Promotion of the Use of Organic Fertilizers in Flower, Fruit and Tea Cultivation", advocate technological innovation to promote energy conservation and emission reduction in the agricultural sector and enhance the adaptability and resilience of agriculture to climate change.

Incorporating international experience

In the context of the global response to climate change, learning from other experienced countries and regions is beneficial for China in achieving its carbon reduction targets. The reduction methods, patterns, and management mechanisms of these powers such as the United States, the European Union, and Japan can serve as references for the Chinese government.

For example, the United States, Australia and others have carried out farmland soil carbon sink trading. This practice can generate emission reduction carbon credits through farmland management measures such as conservation farming, and utilize carbon offset mechanisms to participate in carbon market trading. In other words, if some farmers and herdsmen can significantly increase their carbon sequestration, reduce their greenhouse gas emissions, or prevent the conversion of their land to other uses that would result in higher greenhouse gas concentrations, they will have the opportunity to obtain emission allowances, which can subsequently be sold on the primary or secondary carbon credits market[33].

China established the national unified carbon emissions trading market at the end of 2017. However, the agricultural sector has not been fully integrated into the carbon market. Currently, only a small number of agricultural emission reduction projects are participating in voluntary greenhouse gas reduction carbon trading activities. By drawing on the legal and regulatory guidance, social capital involvement, and project arrangement of the United States and Australia, China can address the cost-benefit and land rights concerns related to the development of the agricultural trading market.

Integrating emission reduction with digitalization

A number of documents, such as the "14th Five-Year Plan for the Development of the Digital Economy", "Action Plan for the Development of Digital Rural Areas (2022-2025)", and "Guidelines for Digitization of Demonstration Zones for Agricultural Modernization", explicitly call for integrating the development of digital technology and agriculture. Digital agriculture can apply information technology, network technology, and automatic control technology to agricultural production[34,35], improving production efficiency and the level of intelligent, precise management[36,37]. This helps reduce resource waste and inputs of "high-carbon" production factors such as fertilizers, pesticides, and plastic films[38,39]. The level of China's agricultural digital transformation from 2012 to 2021 shows a steady upward trend, although the overall level is not yet high[40]. It has been proved that digital agriculture has a significant inhibitory effect on the intensity of agricultural carbon emissions, which is significant in the eastern and western regions, but not significant in the central region. In terms of the mechanism, agricultural human capital hampers the impact of digital agriculture construction on agricultural carbon emissions. This means that the educational level of the labor force significantly affects the research, application, and dissemination of technologies[41].

Threats

The imbalance between the economy and emission reduction

Past economic growth has come at the expense of the environment and natural resources. Studies have indicated that agricultural economic growth strongly drives agricultural carbon emissions, with a cumulative increase of 154.94% in carbon quantity from 1994-2008[42]. Among major grain-producing areas, Jiangsu province experienced the largest increase in carbon emissions, with an economic factor contributing to a cumulative carbon increase of 138.39% (totaling 13.315 million tons) from 2001-2017 compared to 2000. Hubei province, despite having the smallest increase in agricultural carbon emissions from agricultural economic development, also witnessed a 76.29% increase[43]. In the future, given agriculture's foundational role in the economy, forsaking agricultural growth to advance agricultural carbon emission reduction will inevitably not be implemented. Thus, economic factors remain the primary cause of increased agricultural carbon emissions for a considerable period. Consequently, rural areas are facing a conflict between agricultural economic objectives and emission reduction goals.

Significant regional variations

Due to economic, geographical, and other conditions, different regions in China have different agricultural low-carbon models, such as pig-biogas-fruit-residue-feed model, fruit-residue-fertilize model, and livestock-biogas-fruit-fish model[44,45]. Compared to the eastern regions, western provinces exhibit varying agricultural carbon emission intensities with an overall trend of higher emissions. In terms of carbon emission efficiency, there are also notable provincial disparities in carbon emission efficiency, with significant spatial agglomeration effects observed among provinces[46].

Moreover, there are variations in influencing factors and potential for agricultural carbon reduction across regions[47,48]. For instance, in 2017, the eastern regions such as Zhejiang, Shandong, and Tianjin demonstrated higher carbon emission reduction potentials, while central regions like Hunan and Anhui, northeastern regions such as Liaoning and Jilin, and western regions like Guizhou and Ningxia showed varying levels of reduction potential[49].

IMPLICATIONS

Promoting and expanding pilot demonstration areas for agricultural carbon sequestration trading

Although the Party and the government have introduced high-quality and high-density environmental policies, the agricultural carbon trading market, carbon insurance, loans, supervision policies, and other environmental regulations need to be further improved. In particular, incorporating agriculture into the carbon reduction trading framework is still in its initial stages. In September 2022, the Ministry of Agriculture and Rural Affairs, along with four other departments, jointly issued the "Implementation Plan for Building a National Agricultural Green Development Pilot Zone and Promoting Comprehensive Green Transformation of Agricultural Modernization Demonstration Zones". This document encourages the agricultural carbon sink trading mechanism, which needs to mature through practice.

Pilot programs, as one of the practices, are rooted in China's public policy mechanism, lowering the adjustment costs and potential risks of directly implementing a policy. Many pilot policies have already achieved good results in carbon reduction in Chinese agriculture. In 2024, the "Pilot Work Plan for Agricultural Carbon Sink Trading in the Yangtze River Delta Ecological Green Integrated Development Demonstration Zone" is jointly released by four departments, including the Shanghai Municipal Agricultural and Rural Committee, the Development and Reform Commission, the Ecological Environment Bureau, and the Financial Work Bureau. This plan aims to participate in voluntary emission reduction trading.

To support the demonstration zone, firstly, it is necessary to develop agricultural carbon sink projects such as farmland, orchards, and biogas. Secondly, it is essential to utilize government investment and market-oriented tools, as well as to develop third-party evaluation and certification agencies to enhance the certification level of agricultural carbon sink projects, thereby promoting the agricultural carbon sink value accounting system. Thirdly, it is important to improve green finance policies, which significantly have a positive impact on reducing agricultural pollution and carbon emissions.

Building regionally superior agricultural products and specialty industries

Regions need to delve into local resources, climate, historical culture and economy to adjust the structure of industries such as crop cultivation, animal husbandry, fisheries, and forestry. The government and enterprises should jointly promote the cultivation of advantageous agricultural products and special industries that meet local characteristics. For example, well-known products such as Heilongjiang rice, Yunnan tea, Guizhou kiwi fruit, Shaanxi apples, *etc*. In particular, enterprises, as the main players in the market, are directly facing the market and often possess a deeper understanding of the market dynamics than the government. Therefore, enterprises can improve the market competitiveness of these special products under their own brand effect and marketing means. One typical case is that in recent years, the market for small sweet potatoes has not been good, with low purchase prices from middlemen and narrow offline sales channels. The income from small sweet potatoes for families in Yuping Village, Xuancheng, Anhui, varies greatly. After actively understanding the specific situation, PetroChina Anhui Marketing Company has helped the farmers sell agricultural products and brand them through a new form of live-streaming sales. Greening and branding the special industries or products amplify the regional production advantages on the one hand, improve land production from the aspect of opening up the demand side, thus raising the level of farmers' income, and on the other hand, control the additional greenhouse gas emissions from unorganized production. The approach decouples greenhouse gas emission reduction from economic growth, ultimately achieving the dual benefits of ecology and economy, and striving to build livable, business-friendly, and beautiful rural areas.

Diversified synergistic cooperation for technology development and promotion

Agriculture is expected to transform from crude traditional agriculture to modern agriculture, a process that must be guaranteed by advanced technology. In order to realize the sustainability of technological progress, cooperation among the government, enterprises, and farmers is essential to achieving a closed-loop chain of researching and developing technology. Firstly, the government should provide guidance by formulating a development plan for agricultural science and technology, and provide support such as funding and tax incentives by implementing supportive policies. Enterprises should increase their investment in agricultural technological R&D, improve the efficiency and quality of R&D, and take the initiative to promote the results to farmers, helping them better grasp the technology. In this interactive process, new media such as WeChat public accounts and apps can be leveraged. Under these promotion models in Shandong Province and Henan Province, the level of technology adoption has significantly improved. In addition, farmers, as direct users and beneficiaries of technology, should actively participate in technology R&D, because farmers can provide feedback and requirements based on actual situations and their experiences, thus completing the closed-loop chain of technology research and promotion.

Improving technology can also have a positive impact on farmers' incomes. By reducing the use of production factors, such as water, energy, and fertilizers, farmers can reduce production costs. However, initial technological adaptation and training may require a certain amount of investment, which may put economic pressure on small-scale farmers.

Improving farmer educational level in the form of agricultural cooperatives

Agricultural cooperatives are often regarded as an effective tool to bridge the gap between smallholder farmers and modern agriculture, as they can enable both large-scale and low-carbon production. The form is conducive to strengthening the intensive use of material resources, human resources, information resources, and land resources. First of all, this can improve the efficiency of land use, enabling the mechanization of agricultural production, thus increasing the productivity of the land; enable farmers to collectively invest and learn new technologies and policies; promote the use of shared agricultural machinery, allowing equipment to be passed between farmers to reduce the cost; and finally optimize the quality structure and variety structure of the agricultural product, strengthen deep processing of agricultural products, and enhance the value of agricultural products, thereby increasing farmers' income.

CONCLUSION

In order to understand the current status and prospects of agricultural GHG emission reduction in China, this paper applies SWOT to comprehensively assess the strengths, weaknesses, opportunities, and threats of agricultural GHG emission reduction in China. The study finds that China's technology, industry, and development strategies have had a positive impact on emissions reduction, but that awareness of emissions reduction, smallholder economies, and regional disparities are still key obstacles. Overall, China's efforts are on the right track, but upgrading the quality of farmers and transforming the form of the agricultural economy, which are fundamental changes, are urgent. The findings are conducive to deepening the understanding of the factors influencing emissions reduction in agriculture, providing a basis for theoretical research in related fields. They can also serve as a reference for China's agriculture emission reduction policies and practices, offering decision support for promoting emissions reduction in agriculture and advancing sustainable development. However, this study still has some limitations, such as subjective factors influencing the results of SWOT, and the omission of certain important factors due to insufficient literature collection, making it less comprehensive and accurate. Therefore, in future research, researchers can further collect the influencing factors of China's agricultural emission reduction based on more information, and combine SWOT with other qualitative and quantitative research methods, with a view to obtaining a more scientific and comprehensive understanding.

DECLARATIONS

Authors' contribution

Writing - original draft, methodology, formal analysis, conceptualization: Wu J
Writing - original draft, supervision: Xu Y
Writing - review & editing, data curation: Liu Z

Availability of data and materials

Not applicable.

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Conflicts of interest
All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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