Frontiers in Economics and Management Volume 6 Issue 3, 2025
ISSN: 2692-7608 DOI: 10.6981/FEM.202503_6(3).0017

Research on the Construction of the Agricultural Carbon Emission Accounting System

Yu Zhang

School of Accounting, Lanzhou University of Finance and Economics, Lanzhou, China

Abstract

As global climate change intensifies, agriculture, a major source of greenhouse gas emissions, has become central to climate change mitigation strategies. China's agricultural carbon emissions, as a leading global producer, significantly affect the global climate system. Thus, developing an effective agricultural carbon emission accounting system is essential for addressing climate change, achieving carbon neutrality, and promoting agricultural green transformation. This paper reviews international and domestic research on agricultural carbon emission accounting, analyzing the challenges and limitations of current systems. Based on IPCC guidelines, it defines the goals, scope, and principles of agricultural carbon emission accounting, highlighting accuracy, transparency, and completeness. The paper also explores the development of an agricultural carbon emission accounting system, including the identification and classification of emission sources, selection of measurement methods, and the establishment of accounting frameworks. The findings offer valuable insights for enhancing China's agricultural carbon emission accounting system.

Keywords

Agricultural Accounting; Agricultural Carbon Emissions; Carbon Emission Accounting.

1. Background of Agricultural Carbon Accounting

Currently, global climate change represents a pressing challenge that requires a collective global response, with greenhouse gas emissions gradually becoming a central issue of international focus. Agriculture, as a significant source of greenhouse gas emissions, plays a crucial role in climate change. According to data from the Food and Agriculture Organization (FAO), annual greenhouse gas emissions from global agricultural activities account for about a quarter of total global emissions. Given that China is one of the largest agricultural producers in the world, its agricultural carbon emissions have a particularly significant impact on the global climate system.

Therefore, the establishment and improvement of an agricultural carbon emission accounting system is not only a critical step in addressing the challenges posed by climate change and advancing carbon neutrality goals but also a core strategy for promoting the transition of agriculture to a green development model and ensuring long-term sustainable agricultural development.

At the international level, there has been a substantial foundation for research on agricultural carbon accounting, particularly in developed countries. The Intergovernmental Panel on Climate Change (IPCC) has published the "Guidelines for the Estimation of Greenhouse Gas Emissions from Agriculture, Forestry, and Other Land Use" (known as the IPCC Guidelines), which have become an important global standard for agricultural carbon accounting, providing countries with a unified framework.

Countries in Europe and North America, among others, have explored various methods for accounting agricultural carbon emissions, covering the identification of greenhouse gas

ISSN: 2692-7608 DOI: 10.6981/FEM.202503_6(3).0017

emission sources, estimation of emissions, and evaluation of mitigation measures. The United States, Australia, and other nations have established carbon accounting models based on Life Cycle Analysis (LCA), and have conducted research on agricultural carbon emission management and reduction strategies.

In China, agricultural carbon accounting is a relatively new field, but research has increased in recent years with the gradual advancement of environmental protection policies. Chinese scholars mainly focus on the methods for accounting agricultural carbon emissions, especially methods based on LCA and regional agricultural data for carbon emission estimation. Some local governments and agricultural enterprises have also begun to explore practical approaches to agricultural carbon accounting. However, existing research tends to focus on specific fields or regions and lacks a systematic and standardized agricultural carbon emission accounting system. Moreover, there are deficiencies in the construction of information systems and the cultivation of professional talent. As a result, developing a carbon emission accounting system that fits China's agricultural characteristics has become a key issue that needs urgent resolution.

2. Current State of Agricultural Carbon Accounting System

As an emerging field in accounting, agricultural carbon accounting primarily relies on environmental laws and regulations to identify and measure agricultural enterprises' performance in fulfilling low-carbon responsibilities and implementing energy-saving and emission-reduction measures. This system reports and evaluates the efficiency of resource utilization in agricultural operations and reveals the effectiveness and social benefits of using natural capital. Specifically, agricultural carbon accounting involves the calculation of carbon emissions and carbon sequestration, as well as matters related to carbon trading rights in business operations. Furthermore, the carbon regulatory environment and trading strategies of enterprises also significantly affect their financial reports.

Currently, China is accelerating the improvement of its carbon emission statistical accounting system. The "Plan for Accelerating the Establishment of a Unified and Standardized Carbon Emission Statistical Accounting System" indicates that by 2025, a unified and standardized carbon emission statistical accounting system will be further optimized, with data quality significantly enhanced to provide scientific and reliable support for achieving carbon peak and carbon neutrality goals. In addition, China is actively participating in the formulation of international standards, such as ISO 14067, which aims to address the specific calculation methods for product carbon footprints.

However, the development of agricultural carbon accounting still faces several challenges. First, the lack of clear regulations or standards leads to uncertainty in the implementation of carbon accounting. Second, the theoretical system of carbon accounting is still underdeveloped, which may lead to difficulties in understanding and applying the methods in practice. Additionally, the shortage of professional talent in the field of carbon accounting creates a human resource gap for many enterprises. Furthermore, public awareness of low-carbon environmental protection remains relatively weak, which may affect the acceptance and effectiveness of carbon accounting in society. Lastly, the absence of a sound supervision mechanism may result in issues during the execution of carbon accounting that are difficult to correct in a timely manner.

In conclusion, while China has made some progress in advancing the agricultural carbon accounting system, further efforts are needed in the areas of theoretical research, talent development, and regulatory framework construction.

ISSN: 2692-7608 DOI: 10.6981/FEM.202503_6(3).0017

3. Theoretical Basis of Agricultural Carbon Emission Accounting

3.1. Objectives of Agricultural Carbon Emission Accounting

The core objective of the agricultural carbon emission accounting system is to accurately and comprehensively quantify the greenhouse gas emissions generated in agricultural production processes and provide scientific and transparent carbon emission data to policymakers, enterprises, and the public. According to the "2006 IPCC Guidelines for National Greenhouse Gas Inventories" (referred to as the IPCC Guidelines), carbon emission accounting should adhere to the principles of scientific accuracy and transparency to ensure that the data provided genuinely and comprehensively reflects the actual situation of carbon emissions in agricultural activities.

In addition, agricultural carbon accounting should provide data support for the formulation of agricultural reduction policies and promote the green transformation of agricultural production processes.

Specifically, the objectives of agricultural carbon emission accounting can be refined into the following aspects:

1) Accurate Quantification of Carbon Emissions: By using precise accounting methods, the carbon emissions from different agricultural production stages, including planting, livestock breeding, and agricultural machinery usage, should be quantified.

2) Comprehensive Identification of Carbon Emission Sources: All carbon emission sources in agricultural production should be fully identified and classified to ensure that the accounting system covers all major emission sources.

3.2. Objects of Agricultural Carbon Emission Accounting

The objects of agricultural carbon emission accounting mainly include activities and processes related to carbon emissions in agricultural production. According to Smith, P., et al. (2014), agricultural carbon emission sources can generally be categorized into the following types:

1) Agricultural Production Activities: Activities such as tilling, irrigation, and fertilization directly or indirectly release greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

2) Livestock Farming Activities: Livestock farming, particularly the raising of ruminants such as cattle and sheep, is a major source of methane emissions in agriculture.

3) Use of Agricultural Machinery: The widespread use of machinery in agricultural production also results in significant greenhouse gas emissions, particularly carbon dioxide from diesel engines.

4) Agricultural Waste Management: The treatment of agricultural waste, such as straw burning and pesticide packaging waste disposal, is another important source of carbon emissions.

When constructing the agricultural carbon emission accounting system, it is essential to define the specific nature and contribution of these different emission sources, thereby providing data support and theoretical foundations for subsequent accounting methods and reduction measures.

3.3. Principles of Agricultural Carbon Emission Accounting

According to the IPCC Guidelines, the main principles for agricultural carbon emission accounting include:

1) Principle of Accuracy: The accounting methods should be as accurate as possible to minimize errors and uncertainties. Agricultural carbon emission accounting should rely on high-quality data, such as agricultural production inputs, energy usage, and soil carbon stocks.

ISSN: 2692-7608 DOI: 10.6981/FEM.202503_6(3).0017

2) Principle of Transparency: The accounting process should be open and transparent. All assumptions, calculation methods, data sources, and uncertainties should be clearly labeled to ensure the traceability and verifiability of the accounting process.

3) Principle of Completeness: The accounting system should cover all carbon emission sources in the agricultural production process, not only including traditional agricultural activities but also considering agricultural waste management and machinery usage.

4) Principle of Consistency: The accounting methods should maintain consistency across different regions, time periods, and production systems to facilitate cross-regional and cross-temporal data comparison and analysis.

5) Principle of Cost-effectiveness: Considering the diversity of agricultural production and regional differences, the accounting methods should balance practical feasibility and economic efficiency, avoiding overly complex and costly data collection and processing methods.

4. Construction of the Agricultural Carbon Emission Accounting System

4.1. Identification and Classification of Agricultural Carbon Emission Sources

The identification and classification of agricultural carbon emission sources is a foundational task in the construction of the agricultural carbon emission accounting system. Accurate identification and classification of emission sources are essential to ensure the accuracy and comprehensiveness of carbon emission accounting.

(1) Direct Emission Sources

The primary focus of agricultural carbon emission accounting includes the activities and processes related to carbon emissions in agricultural production. According to the study by Smith et al. (2014) titled "Agricultural Greenhouse Gas Emissions: Mitigation Options and Strategies," agricultural carbon emission sources can be divided into the following categories:

1) Agricultural Production Activities: These activities include tilling, irrigation, and fertilization, which directly or indirectly release greenhouse gases, primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

2) Livestock Activities: Livestock farming, particularly the breeding of ruminants such as cattle and sheep, is a significant source of agricultural carbon emissions. Methane emissions from the digestive processes of these animals represent a substantial portion of agricultural greenhouse gas emissions.

(2) Indirect Emission Sources

Indirect emission sources refer to greenhouse gas emissions caused by agricultural activities indirectly, often stemming from external supply chains or other activities associated with agricultural production. These include:

• Production and Transportation of Agricultural Inputs: The production and transportation of agricultural inputs, such as fertilizers and pesticides, generate carbon emissions. These processes consume large amounts of energy, contributing to significant greenhouse gas emissions.

• Agricultural Waste Management: The treatment of agricultural waste (e.g., straw burning, pesticide container disposal) can also release greenhouse gases.

Based on the characteristics of different emission sources, agricultural carbon emission sources should be classified and quantified to facilitate subsequent accounting and management.

4.2. Methods for Measuring Agricultural Carbon Emissions

Measuring agricultural carbon emissions is a core component of the accounting system. Accurate measurement methods ensure the scientific and practical applicability of carbon

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emission data. The main methods for measuring agricultural carbon emissions include the following:

1) Emission Factor Method

The emission factor method is the most commonly used approach for measuring agricultural carbon emissions. According to the IPCC Guidelines, the emission factor method estimates carbon emissions based on the amount of greenhouse gases emitted per unit of agricultural activity (e.g., fertilizer use, fuel consumption). This method is straightforward and suitable for large-scale, routine agricultural carbon emission assessments.

For example, during fertilizer application, the emission factor corresponding to different types of fertilizers can be used to calculate the associated CO_2 and N_2O emissions.

2) Life Cycle Analysis (LCA)

Life Cycle Analysis (LCA) is a systematic tool used to assess the total carbon emissions throughout the agricultural production process. LCA helps quantify emissions at each stage of the production process, identifying carbon footprint hotspots and facilitating the development of emission reduction strategies.

3) Direct Measurement Method

The direct measurement method involves on-site sampling and analysis to directly measure greenhouse gas emissions. This method is suitable for accurately measuring emissions from specific agricultural activities or sources, such as fuel consumption by agricultural machinery or methane emissions from livestock. Although precise, this method is cost-intensive and is typically used only under specific conditions.

4.3. Setting Up Agricultural Carbon Emission Accounting Accounts

Setting up agricultural carbon emission accounting accounts is a critical step in implementing agricultural carbon management. According to the framework outlined in the IPCC Guidelines, agricultural carbon emission accounting accounts should include the following categories:

1) Agricultural Production Carbon Emission Account

This account is used to record and account for carbon emissions generated during agricultural production, including emissions from soil management, fertilizer use, agricultural machinery, and livestock farming. Each emission source should be accounted for using appropriate measurement methods, with records kept on an annual basis.

2) Agricultural Input Carbon Emission Account

Agricultural inputs, such as fertilizers, pesticides, and seeds, generate carbon emissions during their production, transportation, and use. These emissions should be recorded separately. This account primarily reflects the carbon emissions associated with the external resources and supply chains on which agriculture depends.

3) Carbon Reduction Account

In addition to recording carbon emissions, a carbon reduction account should be established to reflect the carbon reductions achieved through mitigation measures, such as reducing fertilizer use, optimizing cultivation practices, and promoting energy-efficient agricultural machinery. This account will help assess the effectiveness of carbon reduction strategies and the implementation of mitigation policies.

By setting up these accounting accounts, agricultural carbon emissions can be managed in a categorized manner, providing data support for policy-making and management.

4.4. Agricultural Carbon Emission Information Disclosure

Information disclosure is an essential aspect of agricultural carbon emission management. It not only enhances the transparency of carbon emission management but also promotes public participation and societal supervision.

ISSN: 2692-7608 DOI: 10.6981/FEM.202503_6(3).0017

In conclusion, carbon accounting is a crucial element for achieving the development of a low-carbon economy. By strengthening policy guidance and regulation, promoting technological innovation and standardization, establishing comprehensive data collection and accounting systems, advancing carbon trading markets, and enhancing international cooperation, we can better promote the development of a low-carbon economy, achieve carbon reduction targets, and contribute to global environmental protection. In the future, we look forward to more enterprises and institutions actively participating in carbon accounting, working together to combat climate change and contribute to sustainable development.

5. Conclusion

In conclusion, currently, in our country's agricultural accounting information service system, there still exist issues such as an imperfect information service system, distorted accounting information, the quality and professional level of accounting personnel remaining to be enhanced, as well as the lagging of technology application and informatization. It is necessary to establish and perfect the agricultural accounting information service system, strengthen accounting information disclosure and supervision, improve the quality and professional level of accounting personnel, and promote agricultural accounting informatization and technology application, so as to further exert the role of agricultural accounting information services and thereby facilitate the sustained and healthy development of the rural economy and society.

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