

Research on Carbon Footprint of Tea Supply Chain Based on Cloud Computing Technology

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ABSTRACT

Global warming has become a common problem and challenge faced by humanity. Tea, as one of the traditional characteristic economic crops in China, is widely planted in many provinces in southern China. The supply chain processes of tea cultivation, processing, retail, and logistics emit large amounts of carbon dioxide and harmful gases, causing serious environmental impacts. However, different stakeholders in the tea supply chain, especially small and medium-sized enterprises, lack technical and financial support to optimize and measure their carbon emissions. This article proposes an integrated system that utilizes cloud computing technology to enable stakeholders in the tea supply chain to minimize and measure their carbon emissions at reasonable costs.

KEYWORDS

Carbon footprint; Tea supply chain; Cloud technology

1. INTRODUCTION

Global warming and energy scarcity have become common problems and challenges faced by humanity. In this context, climate change and global greenhouse gas emissions have attracted the attention of stakeholders from different industries in the supply chain. All enterprises and organizations in the supply chain are looking for ways to reduce carbon emissions and environmental burden. As an organic whole, the carbon emissions of one link in the supply chain will affect other links. Therefore, it is necessary to apply integrated systems to reduce the carbon footprint of the tea supply chain.

In recent years, "carbon footprint" has received widespread attention from scholars and practitioners. The Carbon Trust in the UK defines carbon footprint as "the total amount of greenhouse gas emissions directly or indirectly caused by people, organizations, or products." Tea is one of the most distinctive economic crops in China, widely planted in provinces such as Zhejiang, Fujian, Anhui, Hubei, Jiangxi, Yunnan, and Guizhou. In 2010, the planting area of tea trees in China was $1.95 \times 10^6 \text{hm}^2$, and the total tea production was $1.45 \times 10^6 \text{t}$, accounting for about 50% and 30% of the global planting area and total production respectively. The traditional measurement of carbon footprint in the tea supply chain is done in a decentralized manner, involving plantations, processing plants, retailers, and logistics links. At present, there is no integrated carbon footprint measurement system that considers all aspects of the tea supply chain as a whole. This article focuses on the lifecycle of tea and applies cloud computing technology to integrate the separation factors in the tea supply chain with minimal resources.

2. LIFE CYCLE ASSESSMENT OF TEA PRODUCTS

Using the life cycle assessment method, it is believed that carbon emissions exist throughout the tea production process. This study covers the entire tea production process from plantations to logistics, processing plants, logistics, and retailers.

3. SOURCES OF CARBON FOOTPRINT IN TEA SUPPLY CHAIN

3.1. Plantation

In the carbon footprint of the tea supply chain, greenhouse gases such as carbon dioxide emitted by plantations account for a significant proportion. During the tea planting process, carbon emissions are generated from fertilization, pesticide spraying, irrigation, and other processes. Usually, tea plantation operators are small and medium-sized enterprises or agricultural families, lacking funding and technical support, making it difficult to measure and calculate the carbon emissions during the tea plantation process. In the integrated measurement system based on cloud computing technology proposed in this article, plantation operators transmit the carbon emission data of the planting process to a private cloud and apply SaaS (Soft as a Service) to minimize the carbon footprint.

3.2. Logistics Process

Due to the characteristics of moisture absorption, odor absorption, aging, and heat sensitivity of tea products, it is not only necessary to control temperature and humidity during the tea logistics process, but also to avoid transporting goods with odors in the same vehicle. The characteristics of tea require the use of vehicles with temperature and humidity regulation functions for transportation, and temperature and humidity regulators consume more fossil fuels.

In the tea logistics process, some small and medium-sized logistics companies do not have professional technical and financial resources to measure the carbon footprint of their business processes. Retailers can choose carbon emission calculation methods for cooperative logistics companies and transfer the data to private clouds. Logistics companies can use SaaS to measure the carbon emissions of the logistics process.

3.3. Processing Plant

The basic process of tea processing varies slightly depending on the variety. In the process of tea processing, carbon footprint mainly comes from energy consumption, packaging, and prediction bias. The processing of tea leaves, such as the roasting process, aims to rapidly destroy the activity of enzymes through high temperature, stop their enzymatic oxidation, and fix the quality formed during the greening process. The frying process uses electric rollers and liquefied gas killing machines, which consume fossil fuels and produce carbon footprints. In packaging, the consumption of packaging materials, especially the waste caused by improper use, will increase carbon emissions. Inaccurate sales forecasts can lead to excessive tea production, resulting in a higher carbon footprint.

3.4. Retailers

The carbon footprint associated with retailers mainly arises from energy consumption and inefficient management, resulting in waste caused by stagnant tea sales. Firstly, in terms of energy consumption, as tea retail stores consume a large amount of electricity, it is crucial to use clean energy as much as possible. Secondly, inefficient management leads to stagnant tea sales, and there is a lack of effective communication among various links in the supply chain, which can result in a gap between predicted and actual sales volume, leading to waste and unnecessary carbon footprint increase.

4. INTEGRATED CARBON FOOTPRINT MEASUREMENT SYSTEM BASED ON CLOUD COMPUTING TECHNOLOGY

4.1. Cloud Computing Technology

Cloud computing is a simple and easy-to-use technology with a novel architecture, providing new ideas for carbon footprint management in the tea supply chain. Cloud computing services are divided into three levels, namely IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service). Among them, SaaS provides application services to customers through the Internet, which is very suitable for carbon footprint management of tea supply chain.

4.2. Cloud Structure of Carbon Footprint Measurement System

This article designs a cloud computing architecture that minimizes the carbon footprint of the tea supply chain, including all stakeholders of the tea supply chain, namely plantations, processing plants, retailers, and logistics links. Numerous stakeholders can upload their carbon emission data to private or public clouds to achieve information sharing and resource integration. SaaS applications can provide users with functions such as data transmission, sharing, and data analysis, helping operators in various links understand their own carbon emissions situation and provide specific measures and suggestions to reduce carbon emissions.

4.3. Carbon Footprint Integrated Measurement SaaS System

Taking plantation operators as an example, they can access private clouds through computer network devices and use SaaS for data transmission and sharing. When the plantation operator accesses SaaS, a pop-up window will appear asking the operator to input the necessary information for tea tree planting. Subsequently, a new pop-up window will be received, providing results and feedback on the current carbon footprint of tea tree planting. Feedback in the form of a list of measures, prompting operators to apply specific measures to reduce carbon emissions during tea cultivation. Operators can adopt the best decision combination based on the recommendations in the action list, which will effectively reduce the carbon emissions during their tea planting process. Due to the application of cloud computing technology, the above information of the plantation can be shared and visualized among all participants in the supply chain.

4.4. Specific Implementation Steps

Data collection: Collect carbon emission data from various links in the tea supply chain through sensors, GPS positioning and other technological means.

Data upload: Upload the collected data to the cloud platform to achieve centralized storage and management of the data.

Data analysis: Utilizing the powerful computing power of cloud computing, analyze uploaded data to identify the main sources and key links of carbon emissions.

Suggested measures: Based on the analysis results, provide specific measures to reduce carbon emissions for operators in various links, such as optimizing planting methods, improving processing techniques, and using clean energy.

Information feedback: Provide feedback on proposed measures to all stakeholders, track implementation effects, and continuously optimize carbon footprint management strategies.

5. CONCLUSION

Tea generates carbon footprints during the cultivation, processing, sales, and logistics processes. In the past, participants in the supply chain often focused on their own interests and ignored the harm caused by carbon emissions to the environment. The research on the carbon footprint of tea supply chain based on cloud computing technology can not only help enterprises reduce carbon emissions and improve environmental awareness, but also promote the green transformation and sustainable development of the tea industry. The integrated measurement system proposed in this article applies cloud computing technology to provide a platform for various enterprises in the tea supply chain to measure and optimize the carbon emissions of the supply chain, strengthen cooperation, and enable enterprises to have a more comprehensive understanding of their own carbon emissions situation and take effective measures to reduce emissions, thereby making the business operations of various enterprises in the supply chain more efficient and environmentally friendly. In addition, this study can provide scientific basis for government departments to formulate relevant policies and promote the overall development of the tea industry.

The research on the carbon footprint of tea supply chain based on cloud computing technology has important practical significance and long-term development prospects. By applying cloud computing technology, enterprises can better manage the carbon emissions of the tea supply chain, promote the green transformation and sustainable development of the tea industry. In the future, with the continuous advancement of technology and the deepening of applications, there is reason to believe that carbon footprint management in the tea supply chain will become more scientific, efficient, and environmentally friendly.

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