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Low-Carbon Ecological Tea: The Key to Transforming the Tea Industry towards Sustainability

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Abstract: The realization of the value of ecological products has led to an economic means for reducing carbon emissions in China. Tea is one of the most important cash crops and one of the most popular beverages in the world. Due to the complex the tea industrial chain, it is considered to be an industry with high carbon emissions. Ecological tea products with low-carbon attributes can be considered a linkage of ecology, economy, and society. Based on this, this paper presents research on low-carbon ecological tea (LCT). Herein, we construct the formational logic of low-carbon ecological products, explore the connotations of LCT, and form a conceptual pathway for realizing LCT to contribute to climate change mitigation and adaptation. This paper starts from the upstream, midstream, and downstream of the industrial chain; it establishes three value realization pathways that keep, as a priority, the promotion of ecological industrialization, focus on restoration to improve the ecology of the industrial chain, and innovate technology to expand the industrial chain. The pathways are a set of low-emission production solutions that use techniques to enhance carbon sequestration in soil, reduce the use of fertilizers and pesticides, and help shift to clean energy from low-emission sources in the stages of plantation, processing, and distribution. In the process of realizing LCT, the government plays an important role, and its support and guidance are needed. Based on stakeholder theory, this paper builds an implementation mechanism that focuses on the micro perspective (users, organizations), integrates the mesoscopic perspective (industry), and relies on the macro perspective (government).

Keywords: low-carbon ecological products; ecosystem services; tea industry; industrial chain; stakeholders

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1. Introduction

Ecosystem services (ESs) contribute to human welfare both directly and indirectly. The value that ESs provide to humans even exceeds the economic system, but they have been ignored due to the lack of scientific accounting indicators (Costanza et al., 1997) [1]. Costanza's research has attracted people's attention to the ESs contributing to human welfare beyond providing economic benefits, and localized efforts have been made in China. In 2010, "National Main Functional Zone Planning" was released, representing the first time in which the concept of ecological products was proposed in China [2]. Ecological products are closely related to ESs [3], including provisioning, regulating, and cultural services [4]. It is acknowledged that ecological products possess low-carbon attributes, and CO_2 emissions can be reduced through the practice of prioritizing ecological products [5]. Through an evaluation of greenhouse gas (GHG) emissions during the life cycle of tea in Sri Lanka, Vidanagama et al. (2018) found that electricity consumption is the main source of GHG emissions, and fuel conversion contributes to reducing GHG emissions [6].

Lin et al. (2019) reduced the input of chemical fertilizers and increased the application of organic fertilizer in rice paddies. Subsequently, carbon emissions decreased, biodiversity was enhanced, and the quantity and quality of the ecological products from the rice paddies were improved; therefore, remarkable ecological, social, and economic benefits have been achieved [7]. The realization of the value of ecological products has provided an economic means for China to reduce carbon emissions [8].

Tea is one of the most important cash crops and one of the most popular beverages in the world. To meet the growth requirements of tea plants, the application of nitrogen fertilizer in tea gardens needs to be even greater than that of other major crops, reaching 2.6, 4.2, and 5.0 times that of rice, corn, and wheat [9]. In the agricultural sectors of some countries, tea gardens have become a significant contributor to GHG emissions. In terms of emission intensity per unit output, tea gardens emit significantly more GHGs than other dryland crops [10]. Compared to other agricultural products, post-processing after tea plucking generates large amounts of GHGs due to energy use [11]. As the world's largest tea producer, China accounts for 85% of the N_2O emissions from tea gardens globally [12]. As a cash crop, the tea industry is taken as a characteristic feature of rural revitalization in China. There is an urgent need to study the tea industry as a typical example of agriculture to explore comprehensive solutions for reducing GHG emissions.

Because of its high added value, the ecological product of tea [13] is already a well-developed commodity circulated in the market. According to the "China's Tea Production and Sales Form Report 2022" (https://www.sohu.com/a/709664535_121748621, accessed on 23 April 2024), released by the China Tea Circulation Association, China's total output of dried tea leaves exceeded 3.18 million tons, with a value of CNY 318 billion. In the framework of the rural revitalization development strategy, the added value of tea culture, ecology, and leisure tourism has been greatly promoted in recent years [14], and the tea industry has been sustainably transformed due to the prominence of ecological value realization. Thus, ecological tea products with low-carbon attributes can be considered representative of a linkage between ecology, economy, and society, as Costanza proposed [15]. Now, ecological tea products such as low-carbon ecological tea (hereafter referred to as LCT) could be synergized with China's national carbon peaking and carbon neutrality goals, focusing on a set of low-carbon solutions for tea production. In the context of China, these solutions can be summarized as efforts aimed at enhancing carbon sequestration in soil, reducing the use of fertilizers and pesticides, and shifting from fossil energy to clean energy in the plantation, processing, and distribution stages; this results in the tea garden landscape being protected, biodiversity being improved, soil erosion being reduced, and the application of green labels being expanded. The feasibility of LCT has been confirmed through case studies in Fujian province and other regions in China; it has been shown that instead of using chemical fertilizer, organic tea plantations can improve soil fertility, carbon accumulation, and product quality without the loss of economical profit [16]. Additionally, GHG reduction can be realized with the adoption of cleaner energies such as solar energy, coal gas, and natural gas for tea processing and consumption [17]. Zheng et al. (2023) compared the carbon sequestration capacity of conventionally and organically managed tea gardens in Simao District, Pu'er City, Yunnan Province, China; they found that the organically managed tea gardens have a higher carbon sequestration capacity [18]. Other studies show that the supply of LCT could not only improve climate change resilience but also enrich the value realization path of ecological products [19]. Meanwhile, fewer investigations have been conducted on clarifying the connotations of LCT and how to realize the added value of LCT with certification and labeling.

In this paper, we first clarify the concepts of ecological resources, ecological assets, and ecological products with a literature review to identify the linkage between these concepts and then define the boundaries and the implications of LCT to understand the distinctiveness of and relationship between LCT and ecological products. Secondly, the value realization pathways of LCT, constructed with systematic and normative analyses

from the perspective of industry value chains, are presented. Finally, the value realization mechanisms of LCT are summarized following an inductive analysis.

2. Scientific Concept of LCT

2.1. Theoretical Logic of Low-Carbon Ecological Products

The provision of ecological products starts with the transformation of ecological resources into ecological assets. When realizing low carbon emission through technologies and innovations, low-carbon ecological products (LCT) are formed. As there is a close relationship between ecological resources and ecological assets, we clarify these concepts in this section.

Ecological resources refer to the matters and energies existing objectively on land, water, and space, which are the biotic and abiotic factors that make up the ecosystem, including natural resources and ecological environments. Human survival is based on all the resources provided by nature, such as water, land, minerals, organisms, air, and oceans [20]. Ecological resources are the source of ecological assets and ecological products.

When ecological resources are utilized by humans, they exhibit social and economic attributes such as ownership, use rights, and scarcity, thus possessing the nature of assets. As a result, they are transformed into ecological assets, which are reflective of the value of products obtained from the interactive evolution of humans, ecological resources, and ecological environments. Ecological assets are used in different ways under different natural and socioeconomic conditions. For example, in China, land is owned by the state, and the household contract system is implemented in rural areas. Farmers obtain management rights under the contract, and only part of the land is contracted for management or development to form ecological assets.

Ecological products are linked to the monetization of ESs, which was first introduced in the "National Main Functional Zone Planning" published by the State Council in 2010 in China [19]. They are defined as natural elements that maintain ecological security, ensure the function of ecological regulation, and provide a favorable living environment for humans that includes fresh air, clean water, and a pleasant climate, among other features [21]. Li et al. (2023) pointed out that the provision of ecological products requires the utilization of ecological assets by humans [22]. Therefore, we assume that ecological products encompass not only the natural elements and ecological functions derived from ecosystems but also the various goods and services produced from human activity. Based on the functional attributes of the ecosystem, ecological products are generally divided into material products, regulation service products, and cultural service products. They usually have the function of carbon sequestration [5] and are produced in an environmentally friendly manner, possessing low-carbon attributes [23].

Against the background of China's strategy for achieving its carbon peaking and carbon neutrality goals to address climate change, the implications of using ecological products have been enriched due to their low-carbon attributes. Thus, in this paper, we aim to outline low-carbon ecological products. The study's methodology is depicted in Figure 1. In this paper, we firstly analyze the low-carbon features of ecological tea, then investigate how to develop LCT synergistically with the effects of intensified ecological civilization construction, and then focus on how to promote the low-carbon tea industry through technological improvements and the innovation of institutional mechanisms.

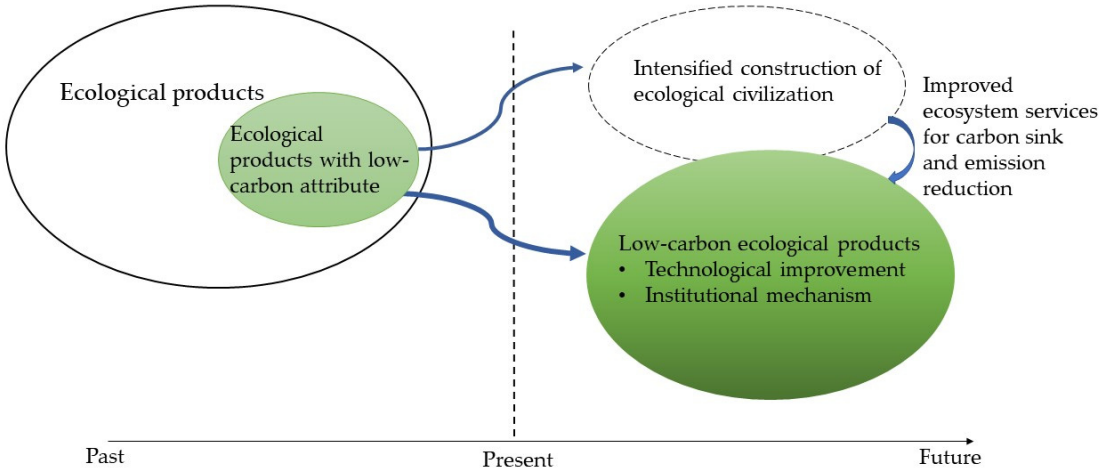

Figure 1. The formation logic of low-carbon ecological products.

2.2. The Boundaries and Implications of LCT

LCT is a relative concept that reflects the low-carbon effect through horizontal and vertical comparisons of carbon emissions. We stratify LCT into two dimensions: horizontal comparisons of low-carbon effects and vertical comparisons of GHG emissions. Horizontally, carbon emissions are compared with similar products. Vertically, emissions are compared with the past industry chain. LCT is based on the tea garden ecosystem, expending the low-carbon potential of the whole chain. Besides reducing GHG emissions, high-quality tea is produced to expand not only the provisioning services but also the regulating service and cultural services. According to different industrial development stages, the realization pathway of the concept of LCT is as follows:

(1) Under the traditional tea manufacturing mode, the GHG emissions of tea are not regarded as a constraint condition, meaning there is a business-as-usual emission trend. GHG emissions are high under the extensive management mode, which does not pay attention to ecological impact and mainly pursues economic benefits.

(2) Technological improvements lead to fewer resource inputs and increases in energy use efficiency, decreasing GHG emissions and enhancing the carbon sequestration capability of tea gardens. The measures include the use of clean energy, cultivating tea varieties with stronger carbon sequestration capacities, and developing energy-efficient equipment and new types of fertilizers (slow/controlled-release fertilizers, water-soluble fertilizers, commercial organic fertilizers, and bio-fertilizers [24]). Practices such as the no-tillage approach, fallowing, or intercropping for weed control in tea gardens, which reduce energy consumption derived from gasoline or diesel, are also included [25]. The adoption of physical and biological pest control measures as alternatives to chemical pesticides achieves the goal of pest management in tea gardens. Through technological improvements, carbon emissions from the tea industry could fall further, and carbon neutrality could ultimately be achieved with offsetting measures.

(3) Institutional mechanisms, including the innovation of the capital mechanism, the formation of policies, and raising the public's awareness of environmental protection, are measures for securing the success of technological improvements. The conceptual pathway for realizing LCT is shown in Figure 2. From the practices implemented already, these alternative measures will reduce carbon emissions, so the carbon emissions per unit of production will be lower. Evidence from scholars supports this finding. He et al. (2022) found that in green tea production, the use of 30% organic fertilizer as a substitute for chemical fertilizers and the replacement of fossil fuels such as coal, oil, and natural gas with clean energy sources leads to a reduction in carbon emissions of 45.85% compared to the original methods [11]. Specifically, the

plantation phase has a significant impact on the quality of tea, as well as the ecological environment, and optimizing agricultural inputs can lead to a reduction in carbon emissions. Kouchaki-Penchah et al. (2017) identified the potential for reducing GHG emissions derived from tea production in India, estimating a reduction of around 19% following the optimization of farming inputs [26]. Cichorowski et al. (2015) found that in Darjeeling tea production, substituting chemical fertilizers with manure could reduce GHG emissions from 9.6 to 3.3 kg CO_2-eq per kg of tea [27].

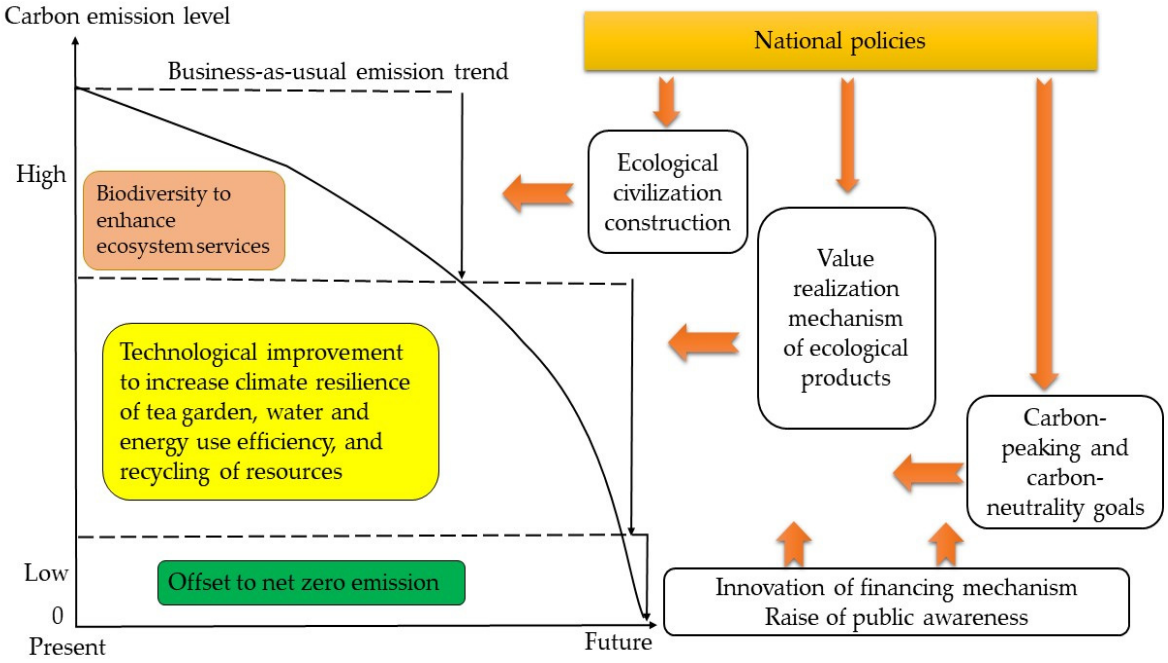

Figure 2. The conceptual pathway for realizing LCT.

One important outcome of using LCT is the environmental benefits that can be gleaned from its implementation. Based on life cycle analysis, Xu et al. (2021) found that by improving fertilizer use efficiency, adopting new varieties and using renewable energy, the environmental impact regarding tea can be significantly reduced by 28–98% [28]. By adopting the best recommended fertilization practices and using biomass as energy for tea processing, potential reductions in GHG emissions of 16.66 Mt CO_2-eq could be achieved, which accounts for 58% of the total amount of emissions [29]. Gong et al. (2008) carried out an experiment in Shaanxi Province in China and found that tea quality was enhanced in compound tea gardens with improved sunlight conditions, lower air temperatures, enhanced soil humidity, increased soil organic matter, reinforced air humidity, and improved soil nutrient conditions [30]. LCT represents a public good requiring support, and the commercial demand for LCT among the public and enterprises is high. From the perspective of the public, climate change and the degraded environment have led to an increase in the public's awareness of environment protection. The public's notion of green consumption has gradually strengthened, and they are paying increasing attention to the impacts of behaviors on the environment and society. The emission reduction potential of LCT aligns with people's desire to contribute to environment protection [11]. Moreover, LCT has become increasingly popular among consumers through developing eco-tourism and leveraging the value of tea culture [31]. Ochieng et al. (2013) compared Rainforest Alliance-certified and non-certified tea gardens in Kenya, and the results showed that Rainforest Alliance Certification (RFC) can bring significant social and environmental benefits to certified tea gardens [32]. For farmers and enterprises, LCT could increase profits. To sum up, the concept of LCT meets the current policy and market needs.

However, to realize the value of LCT, enterprises must first deal with the environmental problems left over from extensive development. China has firmly upheld the belief

that green ecosystems are invaluable assets and adhered to the policy of giving priority to protection and restoration. In order to match the government's strategy, low-carbon transformation should focus on the planting phase and be optimized according to the industry chain prospect. Therefore, this study designs the value realization pathways of LCT based on the following three aspects: protection, restoration, and innovation.

3. The Value Realization Pathway of LCT

LCT possesses multiple attributes, such as its good publicity, positive and negative externalities, and operational properties. In the long term, LCT will be an inevitable requirement for sustainable development. As a kind of high-quality ecological product, it needs to follow the pathway of industrialization and marketization. Its scarcity and versatility are the internal driving forces for enterprises. In the short term, China faces the dilemma of insufficient social participation in environmental protection and insufficient endogenous motivation. The launch of LCT requires financial and policy support, and government actions (incentive policies, setting market access rules, and credit tilt) have become the external pull for the realization. It is difficult for cash crops such as tea to achieve a win–win situation in terms of economic and ecological benefits [33], so support and guidance from the government and policies are needed to develop LCT. For example, the Land Conservation Program (Conservation Reserve Program, CRP) implemented in the United States encourages landowners to return farmland by providing financial subsidies [34]. Thus, the value realization of LCT needs the participation of the government. Meanwhile, more and more attention has been paid to integrated management from the perspective of the industry chain [35]. This paper starts from the upstream, midstream, and downstream of the industry chain; considers the behavior of different entities; and, based on the targets of ecosystem protection, resources conservation, and efficient utilization, describes the three pathways of value realization, which focus on protection, restoration, and innovation and creation.

3.1. Protection as a Priority and the Promotion of the Industry's Ecological Aspects

The concept of ecological products places more emphasis on the response of the ecological environment to human activities, which are particularly prominent in LCT. The primary tasks required to protect the existing industrial chain are stopping humans from interfering with the stability of ecosystems; controlling the effects on ecological spaces or resources, energy consumption, and so on within a range of stable ecosystems; safeguarding the social environment and market capacity; and achieving scale sustainability.

The main way to improve carbon sequestration is through ecological protection [36]. In the upstream of the industry chain, through ecological management, the carbon sequestration advantages of the perennial cultivation system in tea gardens are utilized to enhance the biodiversity of the tea garden ecosystem. Maintaining soil health is of great benefit for enhancing soil carbon sequestration capacity. Thus, the value of regulation services can be increased. In the midstream of the chain, the focus is on protecting traditional processing techniques, reducing the consumption of fossil fuels, and enhancing the value of tea. In the downstream of the chain, it is necessary to protect and excavate tea's cultural heritage and enhance the value of cultural services. Specific methods are shown in Table 1.

Table 1. The protection pathway for realizing the value of LCT products based on the industry chain.

Tea industry Chain		Typical Low-Carbon Practices	Implementation Pathway	Implementation Entity
Upstream	Planting, management, and harvesting	Organic fertilizer, returning straw to the field, intercropping functional plants to reduce weeds [37]. Sticky traps and solar insecticidal lamps, ecological windbreak forest, and manual weeding.	Ecological compensation, benefits from ecological industrialization, and regulation	Government

Table 1. *Cont.*

Tea industry Chain		Typical Low-Carbon Practices	Implementation Pathway	Implementation Entity
Midstream	Processing	Replacing machines with labor, clean energy.	Ecological compensation, benefits from ecological industrialization	Government and enterprise
Downstream	Logistics	New energy transportation vehicles, photovoltaic power generation, simplified packaging.	Incentive policies	Government and enterprise
	Sales	Tea-related cultural services, tea art performances and experiences.	Benefits from ecological industrialization	Enterprise

3.2. Restoration as a Priority and the Improvement of the Industry Chain's Ecology

The tea plantation area in China has expanded from 2367 × 10^3 ha in 2003 to 3330 × 10^3 ha in 2022, increasing by 41%, with an average annual growth rate of 6%. The extent of expansion was the largest from 2006 to 2007, reaching 12% (calculated according to data from the National Bureau of Statistics on tea plantation area). China ranks first in the world in terms of tea production and the number of tea farmers [17]. However, increases in yield, soil acidification, and the weakening of photosynthesis have occurred due to the inefficient management of tea plantations, including the over-reliance on the application of chemical fertilizers [38,39]. What is worse, the pursuit of greater yields and occupation of forests and cultivated land has resulted in soil erosion. In order to improve production efficiency, the use of machinery during harvesting and processing has become common, but this increases energy consumption. Meanwhile, excessive packaging causes waste. All of these activities weaken carbon sequestration capacities and increase GHG emissions. Targeting some of the ecological damage caused by extensive and unsustainable management, restoration projects led by the government will be carried out to improve the ecological conditions of the industry chain.

In the upstream of the industry chain, ecological management could be improved through intensive management. China's tea production is generally based on small-scale farming. In Anxi County, Fujian Province, which is a major tea-producing county in China, the majority of tea planting areas range from 0.33 to 0.67 ha [40]. In addition, due to the outflow of rural labor, unused land resources, abandoned tea gardens, and fragmented land, large-scale planting and production are hindered. Studies show that enlarging the scale of organic tea plantations helps to decrease pest infestation [41]. Integrating dispersed tea gardens, as well as carrying out large-scale centralized operations and management, can have a certain effect on alleviating diseases and facilitate pest control. The government can collect fragmented tea gardens through leasing, authorization and trusteeship, etc., in order to introduce external resources and facilitate linkages between resource entities and capital organizations. While conducting large-scale operations, it is necessary to control planting density. In the midstream of the chain, technological innovation should be made, and the use of clean energy should be promoted. New distribution methods should be adopted to improve the efficiency of downstream circulation. The relevant pathways and methods are shown in Table 2.

Table 2. The restoration pathway for realizing the value of LCT based on the industry chain.

Tea Industry Chain		Typical Low-Carbon Practices	Implementation Pathway	Implementation Entity
Upstream	Planting, management, and harvesting	Returning tea to forests, retaining the height of tea trees, organic fertilizers, large-scale low-density management, biochar application, constructing terraces on steep slopes	Ecological compensation, benefits from ecological industrialization	Enterprises and financial and insurance companies

Table 2. *Cont.*

Tea Industry Chain		Typical Low-Carbon Practices	Implementation Pathway	Implementation Entity
Midstream	Processing	Labor, use of clean energy	Incentive policies, market access rules, and benefits from ecological industrialization	Government, enterprises, research institutes, and universities
Downstream	Logistics	Packaging reduction	Policy orientation, standard constraints, public guidance	Government
	Sales	Live streaming at the original place, offline experiences, and brand building	Industrial ecological benefits	Enterprises

3.3. Innovating Technology and Expanding and Extending the Industry Chain

Climate change is a global issue that has attracted public attention and participation and has policy foundations and market potential. LCT highlights reducing GHG emissions and minimizing the impact of climate change in the entire chain. LCT enriches the concepts of high-quality ecological agricultural products. It is necessary to adopt creative development pathways to expand and extend the tea industry chain. First, it is suggested to cultivate innovative tea varieties in the upstream of the plantation. Secondly, transformation and innovation are carried out in the midstream, including the recycling of waste tea residue in the planting process, the application of intelligent devices such as IOT (Internet of Things) devices and unmanned aerial vehicles, and collaboration with universities and research institutions to develop new breeds and environmentally sensitive products such as tea-based health products. Finally, in order to facilitate transactions and regulate the circulation of LCT in the downstream, different levels and types of trading platforms are established. Only tea products meeting the low-carbon requirements are allowed to enter the platform, protecting the interests of merchants, investors, and consumers and laying the foundation for promoting the trading of LCT. In the logistics phase, it is beneficial to take advantage of the scale of e-commerce platforms. On the one hand, this helps save storage costs and reduce energy consumption through local warehouse delivery. On the other hand, this helps to develop and create new experiential LCT. The specific implementation pathways and methods are shown in Table 3.

In some areas, the effect of emission reduction has been achieved by adopting different management and technical means. The Climate Change team from the Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, supported by FAO, used a life cycle assessment (LCA) to measure the greenhouse gas emissions of tea production from "cradle" to "grave" in selected tea plantations in Zhejiang province and Guangdong province to assess the potential of low-carbon production methods. A future experiment derived from this pilot study will demonstrate the value of low-carbon approaches to businesses, including cost savings due to efficiency gains and increased product premiums. Zhang et al. (2023) conducted an environmental impact assessment through an LCA of Yunnan black tea in China and proposed a fertilization scheme using 70% organic fertilizer and 30% chemical fertilizer, which can make the planting stage more environmentally friendly and aid the transition to frozen withering and aerobic fermentation processes, presenting a more environmentally friendly approach, resulting in a black tea production method that is lower in carbon emissions and energy-efficient, with minimal adverse environmental impacts [43]. The successful implementation of LCT requires the following conditions: 1) improving capacity building through educating the public to enhance their environmental awareness, as with the enhancement of their green consumption power, the public will increase their demand for LCT; 2) enterprises should be informed that LCT is beneficial to the environment so that their sense of social responsibility is strengthened, and low-carbon technology that can be used at a low cost should

be developed so that the enterprises' goal of increasing income can be met, as this would promote enterprises' willingness and ability to provide LCT; and, finally, 3) government incentives and guidance for the production and consumption of LCT are also needed.

Table 3. The innovation pathway for realize the value of LCT based on the industry chain.

Tea Industry Chain		Typical Low-Carbon Practices	Implementation Pathway	Implementation Entity
Upstream	Planting, management, and harvesting	Breeding tea varieties, organic fertilizers composed of waste tea residue, agricultural operations using machines, and intercropping in tea gardens	Ecological compensation, benefits from ecological industrialization	Enterprises and financial and insurance companies
Midstream	Processing	Visiting factories, research and production of tea derivatives such as green tea powder, tea polyphenols [42], energy-saving equipment	Incentive policies, market access rules, and benefits from ecological industrialization	Government, enterprises, research institutes, and universities
Downstream	Logistics	Origin warehouse	Collaborate with e-commerce platforms and logistics enterprises	Enterprises
	Sales	LCT trading platform, offline experience, and low-carbon ecological certification	Industrial ecological benefits	Government and enterprises

4. Value Realization Mechanism of LCT Based on Stakeholders

The realization of the value of LCT is a systematic project that requires the participation of stakeholders, including the government, market players, social organizations, financial institutions, and consumers [44], which rely on the industry for project implementation. Enterprises make up the industry and are the main suppliers of LCT, which means they play an important leading role in the consumption of LCT. Enterprises are also the focus of government policy implementation. They are the linkage between the government, financial institutions, and scientific research institutions, so they are the main entities of the value realization mechanism. The value of LCT cannot be realized without the government's policy support and guidance. The government is the top designer of industrial development and plays a leading role. This paper uses stakeholder theory to build an implementation mechanism based on micro- (users, organizations), meso- (industry), and macroscopic perspectives (government) (Figure 3).

4.1. Macro Level—Build an Organizational Mechanism Led by Local Governments and Coordinated by Multiple Parties

Similarly to many agricultural products, the tea industry is faced with the problem of "small production, big market", and the farmers are mostly small farmers. Anxi County in Fujian Province is a major tea-producing county in China where family-style dispersed production is the main operation mode. The lack of leading enterprises in the industry is a common problem in the national tea industry. The tea industry is the entry point of rural revitalization and the economic pillar of tea-producing areas. Starting from the multiple goals of industrial revitalization, ecological governance, and human well-being improvement, the government plays a leading role in formulating guidelines, standards, and technical systems based on LCT to regulate the development of the industry. The government's policy support and incentive policies are also particularly important for the attributes of public goods such as LCT. At present, LCT has not gained wide recognition in the market, so it is necessary to take enterprises as the main entity that need to make technological innovations while conducting effective marketing and communication to enhance brand image and improve the value added in the value chain. In addition, the government should cooperate with finance organizations to innovate the mechanism through green insurance,

green guarantees, and so on [45]. Furthermore, the government should introduce universities and research institutes to promote industrial innovation through entrustment and project application. Enterprises, universities, and research institutes should work jointly to promote industry–university–research cooperation.

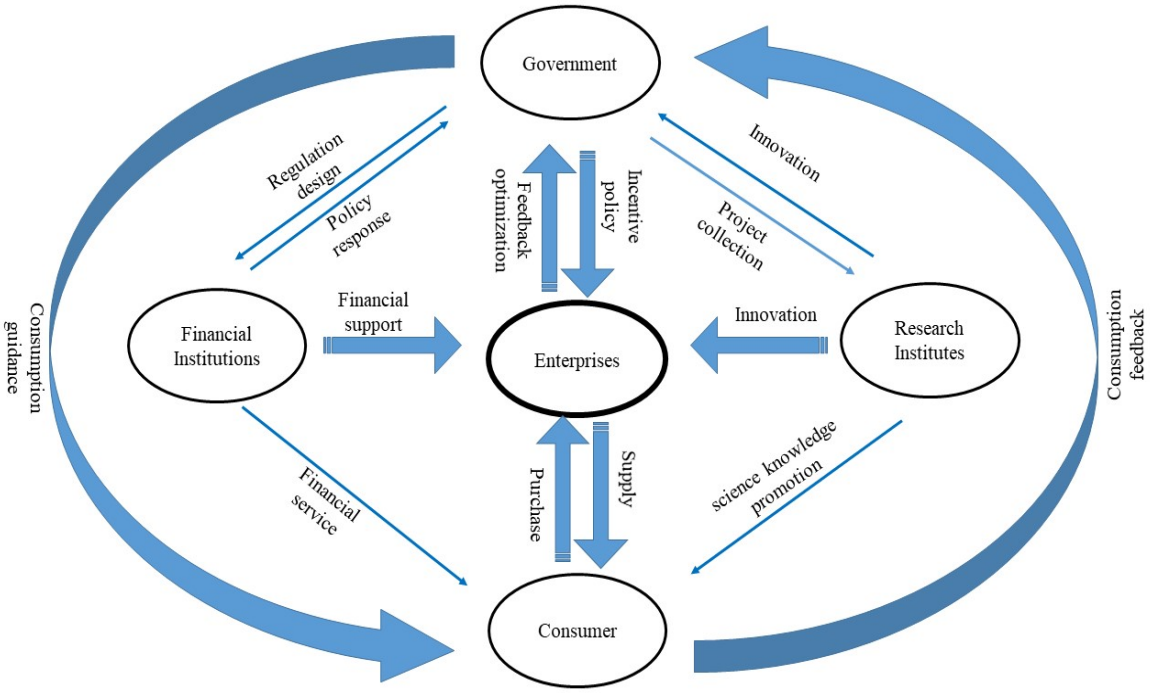

Figure 3. LCT value realization mechanism based on stakeholder theory.

4.2. Mesoscopic Level—Explore Industrial Development Mechanisms Based on Local Conditions and Regional Policies

China's tea regions can be divided into western, eastern, and southern regions. These three regions have different climatic conditions and geographical environments. Organic tea, i.e., tea made without using synthetic chemicals, meets the standards of the International Federation of Organic Agriculture Movements (IFOAM) and is certified by the organic (natural) food certification organization [41], which has been actively promoted in local areas. The number of organic tea certificates is relatively high in China [46]. As for the western region, ecosystems' carbon sequestration ability is prominent. This should continue to maintain the advantages provided by protective policies and projects. At the same time, a new ecological operation model could be explored. Eco-tourism should be developed to enhance the value of tea-related cultural services while protecting tea heritage. Most importantly, attention should be paid to the protection of scenic spots, limiting the flow of tourists and business, and preventing increases in carbon emissions caused by tourism.

There are more certified organic tea processing products in the eastern (Zhejiang, Hubei, Jiangsu, etc.) and southern (Fujian, Guangdong, Guangxi, etc.) regions in China. On the basis of the original industry, those withing the industry should focus on integrating advanced processing technology and mature skilled workers, excavating the types of deep-processed tea products, and continuing to expand and extend the tea industry chain by developing more tea derivatives. A mature circulation system could be relied upon to facilitate international and domestic tea trading. The premise is to earn the support of the government, financial institutions, and scientific research institutes and cooperate with them.

4.3. Micro Level—Improve the Social Mechanism of Demonstration, Promotion, and Publicity Guidance

The tea market in China is generally in a state of oversupply [47]. Efforts should be made not only on the supply side but also on the consumption side. Due to the frequent occurrence of extreme weather and climate events caused by global warming, public awareness of low-carbon consumption on the consumption side is gradually rising. However, the breadth and depth of this awareness are insufficient [48].

In 2022, the National Development and Reform Commission, together with the Ministry of Commerce, the Ministry of Industry and Information Technology, and other ministries, formulated the "Implementation Plan for Promoting Green Consumption" (https://zfxxgk.ndrc.gov.cn/web/iteminfo.jsp?id=18629, accessed on 23 April 2024), clarifying the division of responsibilities among departments, coordinating the transformation of green consumption of the industrial chain. The government also provided multidimensional support related to technology, law, and policies and services and formulated incentive and restraint measures for the spread of green consumption and the implementation of green consumption behaviors. Therefore, a top-down social promotion mechanism to guide green and low-carbon consumption has been formed. The implementation of this specific mechanism should include the following:

(1) Demonstration zones could be established in areas where the ecological governance of tea gardens and industrial green transformation are prominent. Certain material or reputational awards could be given to some tea enterprises with obvious green consumption effects. These enterprises should be promoted as typical low-carbon cases to achieve brand-benefitting effects, guide other enterprises down the road of low-carbon development, and further stimulate the vitality of green consumption.
(2) It could be possible to use communicative media with wider audience acceptance, distinguish audience groups, and adopt a broadcasting mode with diverse forms and differentiated content and integrate traditional and modern techniques to improve publicity and education.
(3) The good practice of low-carbon green consumption should be summarized in time to help form a document at the national level to provide a practical basis for the design of policies by government departments.

5. Conclusions

The increase in GHG emissions from human activities exacerbates climate warming, the frequency of extreme weather events, and other climate events. Correspondingly, additional climate stress has a negative impact on the agricultural system [49], which makes providing more low-carbon ecological products to the market one of the important directions to explore for sustainable agricultural in the future. China is the largest producer and consumer of tea, and the tea industry is becoming increasingly important. The carbon emissions of the tea industry should not be underestimated. The tea industry has prominent ecological value. As stated in this exploratory study on the low-carbon transformation of the tea industry, LCT could contribute to sustainable development. This study, the key points of which are summarized below, carried out an exploration of LCT so as to form a broad consensus on it [50]:

(1) LCT is the entry point for the sustainability transformation of the tea industry. The practices based on LCT represent a set of technical solutions for enhancing soil carbon sequestration and reducing carbon emissions, providing a new framework for the sustainability of agriculture.
(2) The basic principle for the realization of LCT is to adhere to the principle of innovation, which is driven based on the aspects of the industry chain.
(3) The mechanism for realizing LCT is based on stakeholders. The government plays an important role, while enterprises are the entities set to implement and promote the marketization of LCT.

From the perspective of China's overall carbon emission scale, the impact of the tea industry mainly presents local negative externalities. However, considering the overall requirements of China's construction of ecological civilization, the tea industry is an important research field regarding China's agricultural sustainable development in the future and an important direction to explore in terms of coping with climate change. As an exploratory scientific research study, this paper established concepts and behavioral paradigms in specific fields, clarified the value realization pathways of ecological products in specific industries, and explored the practical logic of the value realization of ecological products [51].

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