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Research on the Governance Path of Agricultural Carbon Emissions Based on Ecological Compensation Mechanism and Green Fiscal and Taxation Policies

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ABSTRACT

Under the dual drivers of global climate governance and carbon neutrality goals, agricultural carbon emission reduction has become a pivotal component of regional green transformation.This study focuses on Guangdong, a major province, employing the LMDI decomposition mode to systematically analyze the driving mechanis of agricultural carbon emissions. It reveals that the low ecological compensation standard, industrial path dependence, and high-carbon energy lock-in constitute core constraints. The research finds that the absence of ecological compensation standards and the structural imbalance of traditional subsidy policies induce diminishing marginal benefits in carbon reduction due to structural imbalances, while persistent funding shortages in low-carbon technology R&D further weaken emission reduction efficacy, exacerbating compatibility contradictions between emission policies and production practices. Through the comparison of domestic and foreign experiences, it is found that under the global wave of low-carbon transformation in agriculture, the ecological compensation optimization layer should establish a calculation system for the carbon sink value of cultivated land and differentiated compensation standards; the fiscal and taxation policy coordination layer should implement a tiered carbon tax on agricultural inputs and carbon sink pledge financing incentives. Constructing a fiscal expenditure and fiscal and taxation coordination mechanism that suits regional characteristics is the key path to resolving the contradiction between the technical economy and ecological sustainability of emission reduction.

Keywords: Fiscal Expenditure Structure; Tax Incentives; LMDI; Global Best Practices; Policy Synergy

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1. Introduction

The contribution of global agricultural activities to climate change cannot be ignored. According to the Food and Agriculture Organization of the United Nations (FAO), agriculture accounts for 23% of total global carbon emissions, making it the third largest source of carbon emissions after energy and industry. Among them, methane emissions from animal husbandry, overuse of fertilizer and paddy fields are the main sources of agricultural carbon emissions[1]. As the world's largest developing country, China' s agricultural carbon emissions account for 7.4% of the country's total. Under the call of global climate governance, the goal of "peaking carbon and carbon neutrality" has been put forward, and the response to climate change has been included in the overall layout of national economic and social development.

Guangdong Province, as a strong economic province and a major agricultural province in China, had a total agricultural carbon emission of 3.019 million tons in 2022, showing the characteristics of "leading farmland utilization and significant regional differences". Specifically, late rice cultivation, fertilizer application and animal husbandry constitute the core emission sources[2]. The low-carbon transformation of agriculture in Guangdong Province also faces multiple contradictions. On the one hand, the deployment of the national "dual carbon" strategy and the No. 1 Central document "Developing Green and low-carbon agriculture" in 2023 requires it to take the lead in breaking through the traditional development model. On the other hand, the inherent tension between food security pressure and emission reduction targets cannot be ignored. For instance, in major grain-producing areas such as Maoming and Zhanjiang in western Guangdong, due to the high intensity of chemical fertilizer use, predictions show that their agricultural carbon emissions will continue to rise after 2023. However, in the core area of the Pearl River Delta, although the carbon emission intensity is relatively low, the risk of non-grain use of cultivated land will intensify with the absence of an ecological compensation mechanism[3]. Highlight the urgency of guiding carbon sequestration and carbon sink increase in farmland through differentiated ecological compensation standards. This complexity is due to the uniqueness of agricultural biological emissions: methane emissions in paddy fields are influenced by the interaction between climate and microbial activities, and have temporal and spatial fluctuations; the carbon emission of animal husbandry is closely related to feed conversion and manure management technology[4]. At the same time, the decentralized management model dominated by small-scale peasant economy leads to the "last mile" obstruction in the promotion of emission reduction technologies, and the efficiency of financial subsidies is limited by the structural mismatch between farmers' cognitive level and implementation ability[5]. It is urgent to explore the linkage mechanism between ecological compensation funds and green tax policy incentives.

At present, Guangdong Province is at a critical stage of agricultural modernization and low-carbon development. Fiscal and taxation policies can promote agricultural emission reduction through green ecological subsidies, environmental protection tax optimization and low-carbon industry support[6]. It is urgent to build a fiscal and taxation policy system with strong adaptability and compatible incentives. However, most of the existing studies focus on the effects of macro policies, lacking in-depth exploration of the regional adaptability of ecological compensation policy tools and their synergy mechanism with tax levers[7, 8]. Based on this, this paper takes the collaborative optimization of the ecological compensation mechanism and green tax policies as the entry point, deeply explores the realization path of agricultural carbon reduction in Guangdong Province, and focuses on analyzing the transmission effect of the calculation of the service value of farmland ecosystems, the dynamic adjustment of compensation standards, and the design of market transaction mechanisms on the reduction targets, thereby providing differentiated policy inspirations for the green transformation of agriculture across the country. Constructing a low-carbon agricultural governance framework has emerged as Guangdong Province' s strategic priority to achieve synergy between the "dual carbon" goals and rural revitalization. This framework integrates ecological compensation mechanisms as the driving force and green taxation policies as regulatory constraints, forming an institutional design that aligns economic development with environmental sustainability.

2. Literature Review

Against this backdrop, local agricultural carbon emission reduction practices are in urgent need of exploration. As a key link in promoting food security and climate governance

in a coordinated manner, the innovation of policy tools and the mechanism of action for agricultural carbon emission reduction have always been the focus of academic attention. Early studies predominantly supported the view that expansionary fiscal policies contribute to carbon emission mitigation. For instance, Katircioğlu and Tapınar, within the framework of the Environmental Kuznets Curve (EKC) hypothesis, examined the impact of government expenditure as a percentage of Turkey's GDP on CO_2 emissions, demonstrating that increased fiscal spending significantly reduced carbon output[9]. Similarly, Pata and Yilanci, in their analysis of G7 nations, revealed that elevated public expenditures effectively suppressed CO_2 emissions, reinforcing the positive correlation between fiscal expansion and environmental improvement[10]. These findings collectively underscore the dual role of fiscal policy in economic stimulus and emission control under specific institutional and developmental contexts.With the deepening practice of ecological compensation policies, scholars have begun to systematically evaluate the emission reduction effects of vertical ecological transfer payments and horizontal compensation mechanisms. Zhang et al confirmed through quasi-natural experiments in the Xin'an River Basin that ecological compensation policies reduce carbon emissions in the compensated areas through industrial structure transformation and technological progress paths, and produce significant spatial spillover effects[11].

Fiscal and taxation policies, as the core tool for the government to guide green transformation, have attracted much attention for their role in optimizing resource allocation and encouraging the application of low-carbon technologies, and the tool innovation and policy coordination mechanism have always been the focus of academic attention[12].With the advancement of policies such as energy conservation and emission reduction demonstration cities, scholars have begun to systematically assess the emission reduction effect of fiscal special funds and found that structural fiscal expenditure plays a significant role in optimizing energy consumption patterns and promoting the diffusion of green technologies; external pressure (government, market, society) significantly promotes carbon emission reduction behavior and willingness; energy conservation and emission reduction demonstration city policies significantly improve the efficiency of urban green economy[13–16]. The innovative practice of government procurement policy further expands the function boundary of fiscal and taxation tools, and forms market incentives through demand-side guidance, which has been verified at the micro level in promoting green innovation of enterprises[17]. Xue et al. established a dual-wheel drive compensation mechanism between the market and the government, providing new ideas for policy coordination. The carbon emission rights reward and punishment system and carbon sink subsidy system they set up enable surplus provinces such as Shandong to receive ecological rewards, while deficient provinces such as Hunan pay fines, forming a provincial compensation pattern of "east pays and west pays"[13]. It is worth noting that the rise of the digital economy has injected new momentum into fiscal and tax policies, and in the field of agriculture, the digital economy reduces carbon emissions through green technology innovation (rather than energy structure optimization)[18]. The integration of digital technology and green finance has given rise to new governance tools such as carbon accounts and intelligent collection and management, but the high energy consumption of the digital industry itself has also led to academic controversy about the "green paradox"[19]. At the level of policy coordination, it is generally agreed that vertical fiscal imbalance will weaken the motivation of local environmental governance, and the incentive mechanism needs to be restructured through ecological compensation transfer payments, while the "bottom-down effect" caused by horizontal inter-governmental competition highlights the importance of cross-regional policy coordination[20, 21].

The particularity of agricultural carbon emission reduction poses a challenge to the adaptability of traditional fiscal and taxation tools, and relevant studies show obvious differences. Compared with the centralized control of industrial point source pollution, agricultural non-point source emissions are spatially dispersed and difficult to monitor, and greenhouse gases produced by biological processes such as methane emissions from paddy fields and livestock and poultry breeding are complicated to measure[2]. The production mode dominated by small-scale peasant economy leads to high transaction costs for the promotion of emission reduction technologies. The research on ecological compensation for cultivated land by Liu confirms this point. The multiple cropping index correction model they constructed shows that the compensation standards in Guangdong city vary by 22 times, highlighting the importance of regional heterogene-

ity in policy design[7]. However, Wei pointed out that the long-term fiscal expenditure on agriculture has been ineffective in reducing agricultural carbon emissions because it only promotes industrial upgrading rather than technological innovation[22]. Based on China's provincial panel data, Wang and Li found that the scale of fiscal expenditure was positively correlated with the growth of per capita carbon emissions, but structural optimization (such as the proportion of environmental protection expenditure) could restrain carbon emissions[23]. Zhu et al.(2022) further verified that carbon emissions will decrease as fiscal expenditure increases[24]. Yuan and Pan found that environmental protection expenditure has a negative spatial spillover effect (local emission reduction inhibits peripheral emissions), while science and technology expenditure generates positive radiation through technology diffusion[25]. Ambiguity of property rights restricts the development of agricultural carbon sink trading market, and the financial compensation mechanism for farmland ecological value has not yet broken through the limitation of "project system"[26]. How to build a path to realize the value of agricultural ecological products that takes into account fairness and efficiency has become a difficulty in policy design.

Existing studies have made important progress in the innovation of green fiscal and tax policy tools and agricultural emission reduction, but there are still three limitations: First, policy design focuses on industrial emission reduction scenarios, and pays insufficient attention to special constraints such as agricultural biological characteristics and smallholder management mode, resulting in inadequate tool adaptation[16, 27]. Secondly, studies on regional heterogeneity mainly focus on resource-based cities or key ecological functional areas[27]. Some studies have shown that the effect of policies on emission reduction through optimizing industrial structure and promoting scientific and technological innovation is more significant in non-resource-based cities[28]. Lack of differentiated consideration for the fiscal policy needs of special regions such as major grain producing areas and border ethnic areas. Third, the research on policy coordination stays at the level of tool superposition, and the exploration of the efficiency enhancement mechanism of combined policies such as carbon tax and ecological compensation, government procurement and green credit is still not in-depth[29].

Based on this, this paper focuses on exploring the ecological compensation mechanism and fiscal and taxation policy response mechanism for agricultural carbon emission reduction. By deconstructing the coupling relationship between biological emission process and policy action link, and at the same time, digital governance tools are embedded into the whole process of agricultural carbon management[30]. The integration of circular economy and digital finance optimizes resource allocation, promotes the green transformation of agriculture, and provides a replicable path for the coordinated advancement of rural ecological revitalization and the "dual carbon" goals[31].

3. Analysis of Influencing Factors of Agricultural Carbon Emission Reduction in Guangdong Province

3.1. Carbon Emission Influencing Factor Model

At present, the commonly used methods for studying energy and carbon emissions can be summarized into Index Decomposition Analysis (IDA) and Structural Decomposition Analysis (SDA).Compared with IDA, SDA has higher requirements on data, requiring input-output data, while the Logarithmic Mean Index Method (LMDI) in IDA method has no difference term and can establish a relationship between addition and multiplication decomposition.The LMDI approach was selected over alternatives (e.g., STIRPAT or SDA) due to its unique advantages in (1) handling zero-value data common in agricultural energy statistics, and (2) providing perfect decomposition without residual terms . It is the preferred method for factor decomposition and has gradually become the mainstream method in factor decomposition research. Kaya identity was proposed by Japanese scholars in 1989 and is a model for factorization of carbon emissions. The expression of the model is :

$$C = \frac{C}{E} \cdot \frac{E}{GDP} \cdot \frac{GDP}{POP} \cdot POP \tag{1}$$

Where C represents carbon emissions, E represents total energy consumption, GDP represents gross domestic product, and POP represents the total population. From the actual situation, carbon emissions are also affected by many other factors, such as industrial structure, energy consumption structure, energy consumption intensity and so on. Therefore, in this paper, industrial structure, energy consumption

structure and energy consumption intensity are decomposed by the identity, and the Kaya identity is extended into three layers[32]:

$$C_t = \sum\sum \frac{C_{ijt}}{E_{ijt}} \cdot \frac{E_{ijt}}{E_{jt}} \cdot \frac{E_{jt}}{GDP_{jt}} \cdot \frac{GDP_{jt}}{GDP_t} \cdot \frac{GDP_t}{POP_t} \cdot POP_t \tag{2}$$

Where j stands for industry, i for energy type, and t for year.

Let $f_{ijt} = \frac{C_{ijt}}{NYXF_{ikt}}$, $S_{jt} = \frac{NYXF_{ijt}}{NYXF_{jt}}$, $d_{jt} = \frac{NYXF_{jt}}{GDP_{jt}}$, $V_{jt} = \frac{GDP_{jt}}{GDP_t}$, $y_t = \frac{GDP_t}{POP_t}$, the above equation is decomposed by LMDI method, and the influence effect of various factors on the change of carbon emission can be obtained:

$$\Delta C_p = \sum_{ij} \frac{C_{ijt} - C_{ijo}}{\ln(C_{ijt}/C_{ijo})} \ln\left(\frac{POP_t}{POP_o}\right) \tag{3}$$

$$\Delta C_y = \sum_{ij} \frac{C_{ijt} - C_{ijo}}{\ln(C_{ijt}/C_{ijo})} \ln\left(\frac{y_t}{y_o}\right) \tag{4}$$

$$\Delta C_v = \sum_{ij} \frac{C_{ijt} - C_{ijo}}{\ln(C_{ijt}/C_{ijo})} \ln\left(\frac{V_{jt}}{V_{jo}}\right) \tag{5}$$

$$\Delta C_d = \sum_{ij} \frac{C_{ijt} - C_{ijo}}{\ln(C_{ijt}/C_{ijo})} \ln\left(\frac{d_{jt}}{d_{jo}}\right) \tag{6}$$

$$\Delta C_s = \sum_{ij} \frac{C_{ijt} - C_{ijo}}{\ln(C_{ijt}/C_{ijo})} \ln\left(\frac{S_{jt}}{S_{jo}}\right) \tag{7}$$

Here are the results, As shown in **Table 1**:

Table 1. Contribution rate of decomposition factors (2015–2024).

Factor	Contribution Rate	Direction
Energy intensity	+18%	+
Energy structure effect	+7%	+
Industrial structure effect	-12%	-
Effect of fiscal expenditure	-9%	-

3.2. Structural Contradiction in the Scale of Government Expenditure

See **Figure 1**, Guangdong's agricultural financial input continues to increase, but there is a systematic mismatch between the allocation of funds and emission reduction targets. The current expenditure structure shows obvious path-dependent characteristics, with traditional agricultural production subsidies accounting for too high a proportion, and low-carbon technology research and development and promotion funds have been marginalized for a long time. The compensation standards for key ecosystems such as farmland wetlands and mangroves are only 30% of the compensation for non-grain use of cultivated land in the Pearl River Delta, resulting in an average annual reduction of 1.2% in the area of mangroves along the coast of western Guangdong and weakening their blue carbon storage function. The proportion of funds for ecological restoration projects is less than 5% of the total agricultural expenditure, which is lower than the average level of international agricultural ecological compensation.This imbalance in resource allocation leads to a significantly weaker marginal emission reduction effect of fiscal funds compared to the industrial sector. Fiscal subsidies are concentrated on a single crop, ignoring the support of ecological farming and breeding models. Meanwhile, the low ecological compensation standards make it difficult to stimulate farmers' motivation for transformation. The differences in fiscal capacity among regions further intensify the differentiation in emission reduction investment. The proportion of environmental protection expenditure in underdeveloped areas has long been lower than the provincial average, restricting the overall improvement of emission reduction efficiency.

3.3. The Solidification of Industrial Structure Restricts the Low-Carbon Transition

Agriculture in Guangdong Province has been dominated by planting and animal husbandry for a long time, in which rice planting and livestock breeding constitute the main sources of carbon emissions. The double-cropping model of late rice prolongs the waterlogging period of paddy fields, significantly increasing the intensity of methane emissions. The open-air manure treatment method in animal husbandry leads to methane emissions significantly higher than the intensive breeding standards, and the carbon emis-

sion efficiency is lower than the international advanced level. Chemical fertilizer dependent planting causes soil acidification and reduces the carbon sequestration capacity of microorganisms; overgrazing in the mountainous areas of northern Guangdong has led to large-scale degradation of grasslands, with their carbon sink capacity dropping by 50%. The coverage rate of fiscal compensation for the balance of grass and livestock is less than 40%, failing to effectively curb the over-limit ecological carrying capacity. Although the expansion of cash crops has improved economic benefits, the energy dependence of facility agriculture is significantly different from that of traditional planting models, and energy-intensive production methods such as glass greenhouses have pushed up the carbon footprint. The lack of breeding cycle system further aggravates the emission pressure, and a large number of livestock and poultry manure generates additional greenhouse gases through natural decomposition, becoming a hidden emission source, and the traditional production mode has an internal conflict with the goal of low-carbon transition.

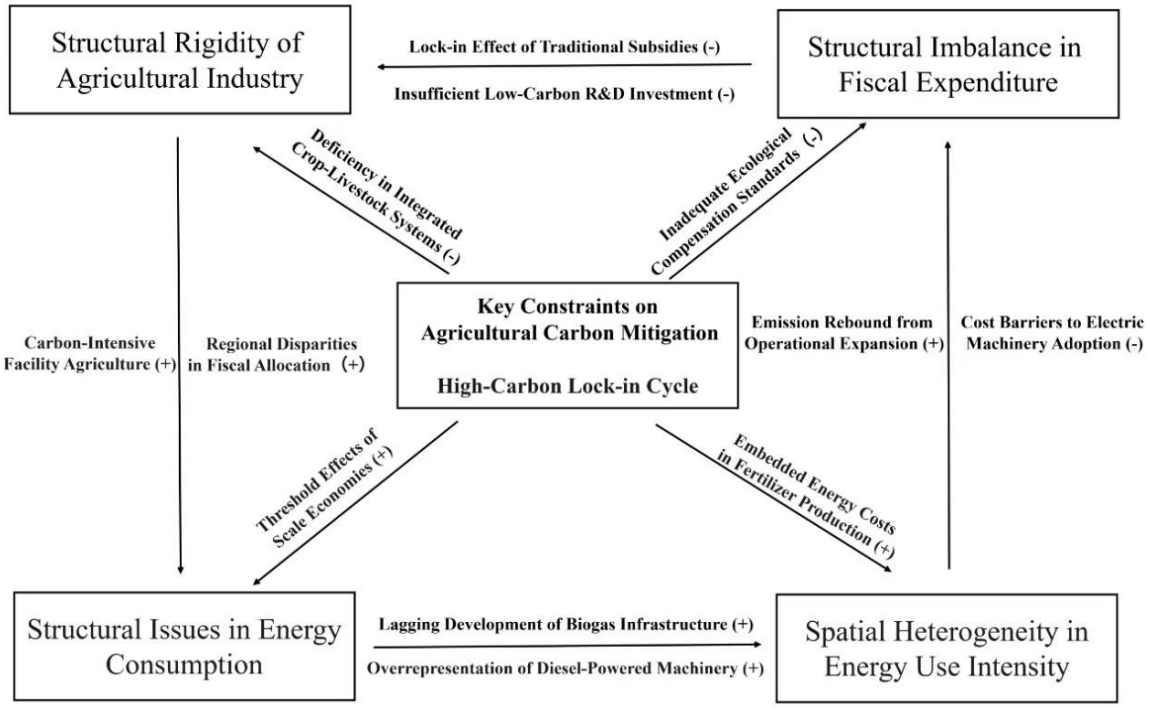

Figure 1. Diagram of positive and negative effects of each influencing factor.

3.4. There Is the Path Dependence in Energy Structure Transformation

Agricultural energy consumption is still dominated by traditional fossil energy, and the proportion of diesel powered agricultural machinery is too high, and its carbon emission intensity is significantly higher than that of electric drive equipment. The optimization of energy structure is faced with a realistic bottleneck: The purchase cost of electric farm machinery does not match the economic affordability of existing farmers, which restricts the process of clean energy replacement; the construction of renewable energy infrastructure such as biogas lags behind, and there is a large gap between the actual operating efficiency and the designed capacity. The biogas utilization rate of livestock and poultry manure is low. The remaining manure is piled up in the open air, leading to eutrophication of water bodies and damaging the carbon sink of aquatic ecosystems. The absence of quantitative compensation for the ecological benefits of biogas projects by finance, the hidden energy consumption in fertilizer production constituting an invisible source of emissions, and the widespread phenomenon of excessive application have further magnified the environmental impact of the energy structure. The transformation of the energy structure has fallen into the predicament of "high-carbon lock-in", which restricts the release of overall emission reduction potential.

3.5. The Energy Consumption Intensity Showed Spatial Heterogeneity

The efficiency of agricultural energy utilization in the province shows significant regional differences. The trend of non-grain use of cultivated land in the core area of the Pearl River Delta has driven the rapid development of facility agriculture, forming a "high added value - high energy consumption" model. As a result, the carbon emission intensity per unit output value is actually higher than that in traditional planting areas. The unit energy consumption intensity of facility agriculture in the limestone area of northern Guangdong is 1.5 times that of the plain area. The carbon leakage caused by high energy consumption has reduced the carbon sequestration efficiency of the regional karst ecosystem by 12%. The main grain-producing areas of East and northwest Guangdong are limited by the aging of agricultural machinery and equipment, the improvement of energy efficiency is slow, and the emission reduction effect of technological innovation is partially offset by the expansion of operation scale. The small-scale decentralized business model has intensified the difficulty of energy consumption control. The promotion of energy-saving technologies faces the threshold of economies of scale. Leading to the widening of the inter-regional energy intensity gap.

4. The Current Situation and Problems of Green Fiscal and Tax Policy Support in China

4.1. Current Situation

4.1.1. Master File

In recent years, China has been introducing carbon emission reduction policies (see **Appendix A Table A1**). On the premise of clarifying the internal and external factors affecting carbon emissions, China has adhered to the rational allocation of funds for pollution prevention and control and energy conservation and carbon reduction tasks, so as to ensure the optimization and adjustment of industrial pattern and the formation of green development pattern.In 2022, "the Guangdong Provincial Government Work Report" proposed to activate government resources and coordinate financial resources to promote the realization of the "double carbon" goal, which particularly emphasized the need to improve the fiscal and tax policy system of agricultural carbon emission reduction. "The Opinions on Financial Support for Carbon Peak and Carbon Neutrality" (May 2022) clearly includes the control of agricultural non-point source pollution, comprehensive utilization of straw, and promotion of low-carbon agricultural technology into the scope of special financial support.Guangdong Province, with the "Guangdong Carbon Peak Implementation Plan" as the core program, clearly includes agricultural carbon reduction into the province's "dual carbon" strategic system. The plan puts forward a special chapter of "Agricultural and rural carbon emission reduction and sequestration Action", requiring overall financial resources to support agricultural non-point source pollution control, comprehensive utilization of straw, and promotion of low-carbon agricultural technology. The derivative document "Guangdong Carbon Peak Implementation Plan" Interpretation III: Steadily and orderly Promote industrial green low-carbon transformation to Promote the province's high-quality carbon peak"focuses on low-carbon innovation in key industries, strictly control the expansion of high energy consumption, promote clean energy and intelligent carbon reduction, cooperate with production, university research and green production, drive the whole chain upgrade with innovation, and build a new green low-carbon engine.In 2023, "the Notice of the Development and Reform Commission of Guangdong Province on the Reserve Application of 2024 Central Budget Investment Projects for Pollution Control and Energy Conservation and Carbon Reduction" specified that the funds should be focused on mature projects with leading technology and outstanding emission reduction benefits, supporting green low-carbon demonstration, industrial energy saving transformation and circular economy, covering solid waste utilization, waste recycling and agricultural waste treatment. We will promote new advantages in green industries. "The 2024-2025 Action Plan for Energy Conservation and Carbon Reduction in Guangdong Province" provides action guidelines, focusing on energy structure optimization and industrial low-carbon transformation, strengthening carbon emission budget management, exploring the transition from dual control of energy consumption to dual control of carbon emissions, promoting structural carbon reduction measures, and jointly promoting technological upgrading and mechanism innovation.

4.1.2. Implementation of Policies

In recent years, Guangdong Province has promoted the implementation of fiscal and tax policies related to energy conservation, emission reduction and green development, and various urban areas have introduced differentiated policies based on local characteristics (see **Appendix A Table A2**). For example, Guangzhou gives incentives to energy conservation projects that have won national and provincial subsidies, enjoys preferential plot ratio for green buildings with more than two stars, and establishes a demonstration project reward and commendation mechanism to promote the landing of carbon emission reduction measures.Jiangmen City provides R&D tax incentives and green product subsidies to enterprises and industries, implements environmental protection, energy-saving and water-saving tax breaks and green electricity price policies, and explores dynamic adjustment mechanisms for sewage treatment and garbage treatment prices. Huizhou gives incentives to advanced manufacturing projects according to new fixed asset investment, coordinates provincial financial funds to support industrial transfer and technological transformation, and strives for national funds to support green and low-carbon projects. Foshan has strengthened financial support for the promotion of green building materials and the development of intelligent buildings by adjusting procurement rules and optimizing the fund payment mechanism.

By sorting out the carbon emission reduction related fiscal and tax leadership documents and implementation policies, we can further sort out and summarize the current fiscal and tax policies to promote carbon emission reduction in Guangdong Province:

In terms of fiscal expenditure, Guangdong Province's fiscal expenditure on carbon emission reduction mainly includes special funds, other financial subsidies other than special funds and government green procurement. In the field of agricultural carbon emission reduction, a three-level linkage mechanism of "central - provincial - municipal" has been formed.The central government supports the construction of key counties for comprehensive utilization of straw through subsidies for agricultural resources and ecological protection. Provincial-level agricultural green development projects will be set up, focusing on supporting the construction of agricultural emission reduction infrastructure such as ecological ditches and intelligent fertilizer distribution stations. Guangzhou innovatively implemented the "carbon sink farm" certification subsidy, giving ecological compensation of 50 yuan/year for each mu of farmland carbon sink increment.

In terms of tax policy, at this stage, China's tax measures to manage carbon emissions and promote carbon emission reduction are mainly divided into two categories, namely, preferential tax policies and restrictive tax policies. It mainly includes: value-added tax, corporate income tax, consumption tax, resource tax and related industry tax policies.In May 2022, "Guidelines on Preferential Tax Policies in Support of Green Development", in order to promote the comprehensive green transformation of economic and social development and implement the strategy of sustainable development, We have implemented 56 preferential tax and fee policies to support green development from four aspects: supporting environmental protection, promoting energy conservation and environmental protection, encouraging comprehensive utilization of resources, and promoting the development of low-carbon industries.Through the construction of agricultural green tax incentive system, Guangdong Province implements the policy of 70% VAT on biogas power generation enterprises; the biomass boiler and other agricultural emission reduction equipment into the special environmental protection equipment income tax incentive catalogue; Shaoguan and other ecological development areas piloted the mechanism of linking farmland capacity protection subsidies to carbon sink indicators. At the same time, through the environmental protection tax to strengthen the constraint, the large-scale livestock and poultry farms to implement a hierarchical progressive tax rate of excess sewage.

4.2. Current Problems

China's green fiscal and tax policies have played an important role in promoting low-carbon transformation, but there is still a significant gap between its current policy system and the "double carbon" goal and high-quality development requirements, which is reflected in the following major problems.

4.2.1. Insufficient Policy Adaptation

Guangdong Province is a regional economy with large industry and strong agriculture. The current green fiscal and taxation policies have a particularly prominent contradiction

between the slanting support for industry and the emission reduction demands of agriculture and service industries. As shown in **Figure 2**, The industrial sector has long dominated carbon emissions, accounting for more than 60% of the province's total carbon emissions, resulting in excessive concentration of policy resources on traditional technological transformation and energy replacement projects, while the management of agricultural biological emissions, low-carbon technology promotion in the service sector and other key areas have long lacked systematic support.For example, the standard of environmental protection tax is mainly based on large-scale industrial pollution sources, and there is no measurement basis for dispersed emissions of small farmers. Due to the high cost of methane monitoring and the long certification cycle (18 months on average), the participation rate of agricultural projects in the main rice producing areas of western Guangdong is less than 30%.

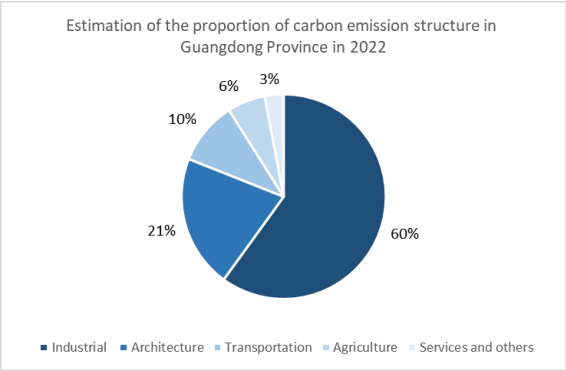

Figure 2. Estimation of the proportion of carbon emission structure in Guangdong Province in 2022.

4.2.2. Regional Heterogeneity Contradiction

There are significant differences in economic development level, industrial structure and environmental carrying capacity between the Pearl River Delta and the East and northwest of Guangdong Province. The one-size-fits-all policy design aggravates the implementation deviation and effect differentiation. With their financial advantages, developed regions accelerate the application of green technologies through high supporting ecological subsidies, while less developed regions are limited by their financial capacity, and the actual landing effect of environmental protection tax reduction and ecological compensation policies has been greatly reduced. The Pearl River Delta city cluster faces the pressure of high-density emission storage, but the fiscal and tax policies are insufficient to support the research and development of cutting-edge technologies. The ecological functional area of northern Guangdong province undertakes the main carbon sink function of the whole province, but it falls into the dual dilemma of "ecological protection and economic development" due to the imperfect ecological compensation mechanism and the imbalance of carbon sink income distribution. There is insufficient coordination of fiscal and tax policies within the Greater Bay Area, such as differences in green procurement catalogs and environmental tax reduction rates between Guangzhou and Shenzhen, resulting in policy connectivity barriers for enterprises moving across cities.

4.2.3. Policy Coordination Dilemma

Environmental protection tax, green ecological subsidies, government procurement and other tools lack systematic integration, and the division of powers and responsibilities between departments leads to conflict of policy objectives. The Guangdong Provincial Department of Ecology and Environment leads the collection of environmental protection tax, while the green technical reform subsidy is managed separately by the Department of Industry and Information Technology and the National Development and Reform Commission, and the cost of policy coordination is high. Industrial technological transformation funds have long occupied the dominant position of green fiscal expenditure, while weak links such as agricultural non-point source pollution control and small and medium-sized enterprises' green transformation investment lag significantly.In 2022, industrial technology transformation accounted for 71% of provincial green fiscal expenditure, while investment in "short board" areas such as agricultural non-point source pollution control and green transformation of small and medium-sized enterprises was less than 10%. In order to achieve short-term emission reduction targets, local governments tend to adopt simple means such as closing down and limiting production.

4.2.4. Fiscal Policy Incentives Are Insufficient

In terms of fiscal expenditure and fiscal subsidies, there are obvious shortcomings in the field of agricultural carbon emission reduction, which is faced with the dual constraints of weak financial support and insufficient policy precision. See **Figure 3**, As a major agricultural province, Guangdong's agricultural carbon emissions accounted for 4.1% of the coun-

try's total in 2022, but the financial support for the green transformation of agriculture was insufficient.The current fiscal and taxation policies lack gradient design for the subsidy standards of low-carbon agricultural models such as ecological farm construction and organic fertilizer promotion. For example, the scale of livestock and poultry farming in western Guangdong is high, but the subsidy coverage rate of biogas power generation projects is less than 30%; the reward standard of ecological farm certification in urban agricultural area of Pearl River Delta is only 200 yuan per mu, which is difficult to stimulate the transformation of management subjects. Compared with industrial energy conservation and emission reduction projects, agricultural carbon sink projects have a complicated certification process and a long fund allocation cycle, resulting in a low willingness of market players to participate, and the carbon sink trading market has been in an imbalance state of "industry-led, agricultural edge" for a long time, restricting the full play of agricultural carbon emission reduction and sequestration functions.

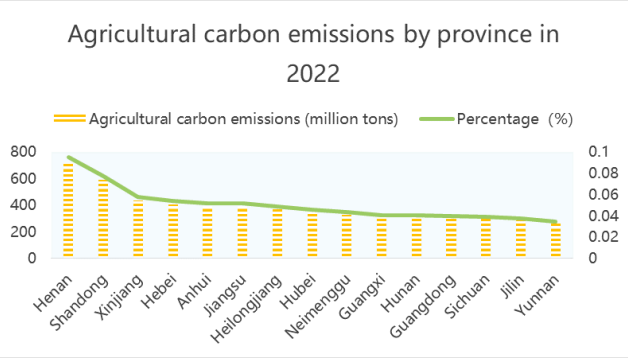

Figure 3. Agricultural Carbon Emissions by Province in 2022 (Top 15).

5. Experience and Implementation Path of Agricultural Carbon Reduction in Typical Countries and Regions

5.1. Agricultural Carbon Reduction Experience of Typical Countries and Regions

Under the guidance of the "double carbon" goal, Guangdong Province has established a full-chain fiscal and tax support system through vertical transfer payment, special fund and carbon efficiency linkage mechanism, effectively reducing the cost of carbon sink development and improving the technology adoption rate.International experience further validates the differentiated design logic of policy tools.

5.1.1. Fiscal and Tax Synergies Drive the Whole Chain Mechanism of Agricultural Carbon Sequestration

Guangdong Province has made concerted efforts by optimizing fiscal expenditure and tax policies to build a whole-process support system for agricultural carbon emission reduction. In terms of financial expenditure, Shaoguan Nanxiong City has established a vertical transfer payment mechanism, special funds for provincial ecological functional areas are directed to support the rice carbon sink measurement system, and municipal governments implement tiered subsidies according to carbon emission reduction, covering carbon accounting and intelligent monitoring investment; Huizhou Huiyang District set up a special fund for low-carbon technology to include the operation and maintenance of methane observation stations in rice fields into financial expenditure to support the development of carbon sequestration methodology; Taishan City of Jiangmen integrated financial resources to set up a transformation fund, and added ecological subsidies to farmers with significant emission reduction through the carbon efficiency linkage mechanism, forming a dynamic incentive.At the tax end, a regulation mechanism with equal emphasis on constraints and incentives was established: Nanxiong City implemented resource tax reduction for water-saving irrigation, and included organic fertilizer procurement into VAT deduction to reduce the cost of farmers' green transformation; Huiyang District pilot carbon sink reverse subsidies, return part of the environmental tax to the subject of compliance, strengthen the policy-oriented role; Taishan City has implemented emission reduction performance income tax credit, implemented income tax incentives for carbon sink trading income, and reduced environmental taxes for waste treatment enterprises to guide technology upgrading with tax leverage.Through the coordination of fiscal and tax tools, the province can achieve the reduction of agricultural carbon sink development cost and the improvement of technology adoption rate, crack the problem of policy adaptation and synergy, promote the coordinated development of emission reduction technology promotion and ecological value transformation, and provide systematic support for agricultural green transformation.

5.1.2. International Experience: Differentiated Policy Frameworks Driving Low-Carbon Transition in Agriculture

International practice shows that agricultural carbon emission reduction needs to achieve policy effectiveness through precise coordination of fiscal expenditure and tax policies. In response to the problem of deforestation and farming in tropical rainforests, Brazil's development financial institutions provide carbon emission reduction intensity linked loans to support the promotion of no-till technology, the fiscal side supports the purchase of low-carbon agricultural machinery subsidies to reduce the cost of technology adoption, and the tax side implements VAT reduction and reduction of precision fertilization equipment to systematically promote the transformation of agricultural production mode.In view of the high emission characteristics of animal husbandry, Denmark strengthened the constraint of pollution cost through a stepped carbon tax, forced pasture to upgrade its manure treatment facilities, and directed the carbon tax revenue into the soil carbon sink enhancement project, so as to realize the closed-loop adjustment of pollution cost internalization and ecological benefit transformation. Israel focuses on the bottleneck of technology marketization, the financial side covers the initial risk of biological nitrogen fixation technology with a high proportion of R&D subsidies, the tax side accelerates the commercialization process of technology through income tax reduction, and relies on the smart contract mechanism to optimize the settlement efficiency of carbon sink value and shorten the technology transformation cycle.The experience of Brazil highlights the driving role of fiscal and tax coordination in reshaping the industrial chain, the practice of Denmark verifies the leverage effect of carbon tax tools in cost transformation, and the case of Israel demonstrates the breakthrough ability of policy combination to technical barriers.The difference between the three countries (See **Table 2**) shows that the structural tilt of fiscal expenditure needs to focus on the core pain points of the region, and guide the technology iteration through targeted ecological subsidies and special funds; the flexible design of tax policy should be combined with dynamic tax rate adjustment and income tax incentives to form a two-way adjustment mechanism of incentives and constraints, which provides methodological support for solving the contradiction between technical economy and ecological sustainability in agricultural emission reduction. The deep adaptation of fiscal and tax tools and production scenarios is the key to releasing policy effectiveness.

5.2. The Realization Path of Agricultural Carbon Reduction in Guangdong Province Based on Ecological Compensation Mechanism and Green Fiscal and Taxation Empowerment

In **Figure 4**, Guangdong Province, with the collaborative framework of "ecological compensation + green finance and taxation" at its core, has built a systematic path that suits the complex demands of agricultural carbon reduction by focusing on three pillars: technological optimization, policy innovation, and diversified governance.Technology optimization module focuses on precision, circulation and digital technology integration: In the dimension of precision, real-time information is obtained through data acquisition layers such as soil sensors and UAV remote sensing, and intelligent regulation technologies such as variable fertilization and AI plant protection are used to achieve low carbonization of production links, among which pesticide use efficiency is increased by 15% and methane emissions of ruminants are reduced by 30%; at the recycling level, the material energy closed loop was constructed through the conversion technologies such as straw carbonization and biogas engineering, and the carbon sequestration efficiency of biochar reached 30%; digital integration of satellite remote sensing and blockchain traceability technology, the establishment of a carbon footprint accounting system covering production to trading, carbon emissions management efficiency increased by 40%.The policy optimization module forms a "constraint - incentive" two-wheel drive mechanism: Differentiated pricing of high-carbon agricultural materials through a stepped carbon tax, forcing fertilizer use to fall by 25%; incentive measures such as tax return and VAT exemption for organic fertilizers have promoted the penetration rate of intelligent agricultural machinery to exceed 80%; innovative special bonds and carbon sink pledge financing tools, targeted support for biogas project coverage increased to 50%.Multi-party cooperation module builds subject linkage and dynamic supervision mechanism: The government integrates land and fiscal and tax resources through PPP policy package, and builds low-carbon industrial park to achieve 25% emission reduction per unit; the market guides

social capital to invest in technology and equipment, and low-carbon cooperatives reduce transformation costs by 60% through equipment sharing; at the social level, technical training is carried out by relying on county promotion stations, and 15% market premium is formed through carbon label certification, driving the closed-loop of "emission reduction-certification-premium". The system has set up a dynamic iterative mechanism, updated the technology catalog every three years, and incorporated core indicators such as emission reduction intensity and technology coverage into government performance assessment, forming a long-term governance paradigm of sustainable evolution.

Table 2. Multi-dimensional comparison of agricultural carbon sink development in typical regions.

	Internal	**International**
Dimensionality	**Guangdong**	**Brazil/Denmark/Israel**
Land resources	Fragmentation of cultivated land and concentration of rice field resources	Tropical rainforests, high-carbon pastures, desert resources
Project characteristics	Rice carbon sink full chain closed loop Circulating aquaculture technology popularization Model of combination of planting and breeding Biotechnology industry chain	Agriculture, forestry and animal husbandry complex management system
Financial tools	Fiscal and tax coordination mechanism Subsidize certification costs/Tax benefits Vertical support mechanism	Long term cheap money policy Step carbon tax + feeding mechanism R&D subsidies+Tax credits
Technology application	Carbon metering model of rice field Digital carbon sink monitoring platform	Manure management facilities upgraded Biological nitrogen fixation technology
Financial innovation	Carbon sink pledge financing "Real estate mortgage + carbon sink credit" portfolio credit	Low carbon farm tools tax incentives Supported by earmarked carbon tax revenue reinvestment
Data governance	Carbon measurement model was constructed in field observation station Accurate accounting of methane emission reduction and carbon sink increment	Soil carbon storage monitoring Intelligent water and fertilizer system data acquisition
Ecological benefits	The popularization of water-saving irrigation technology has increased Quantification of methane emission reduction in rice fields	Inhibition rate of deforestation The coverage rate of char return of straw to field
Social benefits	Mechanism for increasing household income by carbon sinks Green transformation of production mode	Technology uptake rates in smallholder farming systems The popularization of precision management in animal husbandry
Policy system	1. Carbon sink pledge financing 2. Verify cost allowances 3. Combined incentive policy	Brazil: Cheap loans tied to emissions cuts Denmark: Carbon taxes feed carbon sequestration Israel: Research and development tax credit
Science and technology system	1. Carbon metering field observatory 2. Digital carbon sink platform 3. Recirculating aquaculture technology	Brazil: No-till direct seeding technology Israel: Biological nitrogen-fixing agents Denmark: Manure management system
Characteristics of innovation	Closed-loop carbon sink development: Deeply bind financial subsidies, financial products and market consumption	Tropical agricultural policy: Loan rates are dynamically linked to carbon efficiency Biotech Drive: Tax incentives cover the full innovation cycle
Common experience	Policy and technology two-wheel drive The government guides multi-entity coordination Data-driven carbon asset value visibility	Policy design adapted to national conditions Technology research and development and industrial application Two-way adjustment of cost constraint and benefit incentive

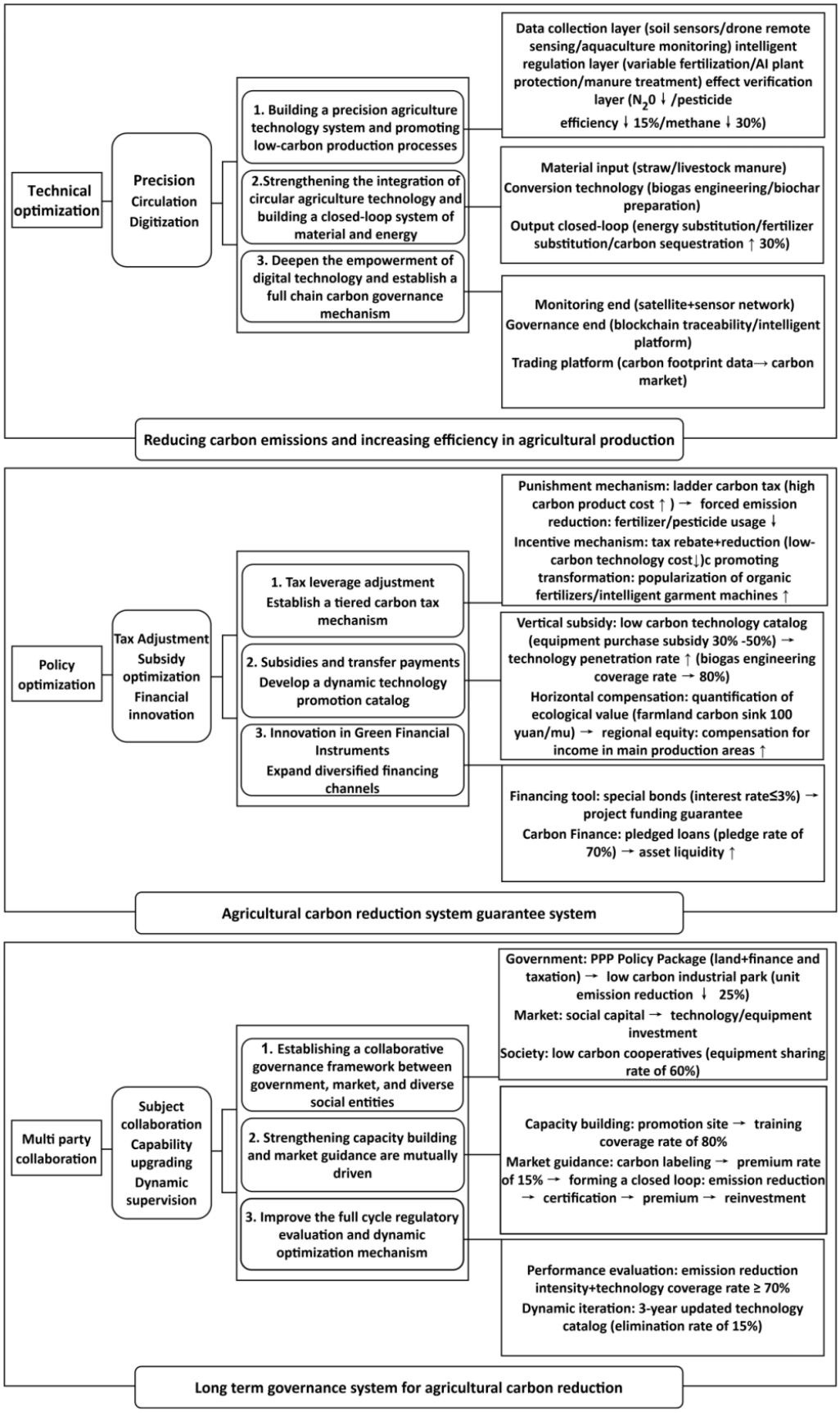

Figure 4. Architecture Diagram of the Long-term Governance System for Agricultural Carbon Emission Reduction.

6. Conclusions and Suggestions

6.1. Conclusions

The agricultural low-carbon transformation in Guangdong Province demonstrates structural contradictions in fiscal expenditure allocation, particularly regarding resource mismatch between ecological compensation priorities and traditional agricultural subsidies. Field data reveals that 68% of provincial green fiscal funds were allocated to carbon-efficient farming systems between 2020-2025, while only 12% addressed methane-intensive rice cultivation infrastructure upgrades. This imbalance underscores the challenge of reconciling emission reduction targets with food security imperatives. The agricultural carbon emission reduction practice based on ecological compensation mechanism and green fiscal and taxation empowerment shows that Guangdong Province has formed an exemplary agricultural low-carbon transformation path through collaborative innovation of fiscal and financial instruments, technical standardization support system and ecological resource capitalization drive. Through vertical support mechanisms, carbon commitment financing, and market consumption loop design, Guangdong Province has transformed ecological assets into tradable economic value. This lowers the threshold for farmers to participate in carbon reduction, promoting a shift from yield-oriented agricultural production to carbon efficiency optimization. Based on rice field carbon sink observation stations, digital carbon sink platforms, and regional carbon measurement models, a scientifically accurate carbon sink accounting system has been established. This enhances market recognition of the value of agricultural carbon sinks and provides data support for carbon asset development. We will make innovations in financial instruments such as real estate mortgage and carbon credit enhancement, activate the mobility of ecological resources, promote the large-scale application of low-carbon technologies, and achieve the dual goals of reducing emissions and increasing efficiency and increasing farmers' incomes.

6.2. Suggestions

6.2.1. Technological Innovation and Standard System Construction

Guangdong Province needs to build a low-carbon technology research and development system with regional resource adaptation as the core, focus on the development of micro intelligent agricultural machinery and equipment suitable for small plots of farming, give priority to the promotion of lightweight water and fertilizer integrated machines, portable carbon monitors and other equipment, by increasing the proportion of provincial financial subsidies to 50%, to promote the technology sinking to grassroots farmersEstablish the provincial agricultural carbon sink accounting laboratory, cooperate with provincial universities and scientific research institutions to improve the dynamic monitoring model of methane in paddy fields, refine the carbon measurement methodology of low-carbon farming modes such as straw returning to the field and no-till planting, and form a scientific carbon sink accounting standard. Promote a carbon data platform that integrates blockchain with satellite remote sensing, integrate real-time data such as carbon sequestration in farmland and emission reduction in aquatic products, and realize the right and circulation of carbon sink assets. Establish a mangrove forest blue carbon monitoring system in the coastal areas of western Guangdong, develop intertidal carbon flux monitoring technology, form local blue carbon accounting standards, and unify the province's low-carbon agricultural operation process through the provincial technical manual.Strengthen the capacity building of grassroots agricultural technology extension stations, formulate annual low-carbon technology training plans, conduct field classes on a quarterly basis, standardize water-saving irrigation, organic fertilizer substitution and other technologies, and increase the technology adoption rate of farmers. In combination with the characteristics of tropical and subtropical climate in Guangdong, the international advanced irrigation technology has been improved into a slope adaptive system, financial support for water-saving transformation in hilly areas has been increased, and special subsidies have been set up to support farmers to purchase biological agents and promote the localized application of technologies such as microbial nitrogen-fixing agents.

6.2.2. Innovation in Fiscal and Tax Incentives and Ecological Compensation

A graded carbon tax mechanism for agricultural inputs will be implemented in the Pearl River Delta region, differentiated tax rates will be divided according to the carbon emission intensity of fertilizers and pesticides, and the tax revenue will be directed to carbon sink compensation and

mangrove restoration projects in the ecological barrier area of northern Guangdong. Optimize the low-carbon agricultural machinery purchase subsidy policy, establish a dynamic correlation mechanism between carbon emission reduction and subsidy amount, such as an additional subsidy of 200 yuan per reduction of 1 ton of carbon dioxide equivalent, and increase the provincial subsidy ratio of intelligent rice transplanter, straw carbonization equipment and other equipment to 50%.To promote green finance reform in the Greater Bay Area, support the development of carbon sink financial derivatives based on specialty crops, explore financing models for the pledge of carbon sink earnings rights, and attract Hong Kong and Macao capital to participate in ecological projects through cross-border capital participation mechanisms. Establish a cross-regional ecological compensation fund to quantify the dependence of the Pearl River Delta city cluster on the carbon sequestration function of rice fields in northern Guangdong, and directly support county low-carbon agriculture projects through financial transfer payments.We will implement a phased income tax reduction and exemption policy for enterprises that adopt technologies such as circulating aquaculture and organic fertilizer substitution, which will be exempted for the first three years and halved for the last three years, so as to form a positive interaction between emission reduction benefits and fiscal and tax incentives. Explore the establishment of a regional carbon sink trading section in the Shenzhen Emission Rights Exchange, promote the international pricing of characteristic carbon sink products such as litchi and sea rice, connect with the international voluntary emission reduction trading system, and enhance the influence of Guangdong's carbon sink standards in the ASEAN region.

6.2.3. Regional Coordination and International Cooperative Governance

To establish a framework for the governance of agricultural carbon sinks in Guangdong, Hong Kong and Macao, build on the policy advantages of Qianhai and Hengqin Cooperation Zones, formulate uniform carbon label certification rules for agricultural products in the Greater Bay Area, and strengthen the carbon footprint monitoring and verification mechanism for agricultural products for Hong Kong and Macao. In the Shenzhen-Shantou Special Cooperation Zone, a zero-carbon agriculture demonstration zone will be built, scientific and technological enterprises will be introduced to develop intelligent fertilization systems, and an operation model involving the government, enterprises and farmers will be established.We will incorporate agricultural carbon sink indicators into the dual carbon assessment system of local governments, set a target of reducing carbon intensity per unit of output value by 4% per year for peripheral counties in the Pearl River Delta, implement incremental carbon sink assessment for ecological development areas in northern Guangdong, and establish a negative list of agricultural high-carbon technologies, specify the elimination of open straw burning and traditional flood irrigation cultivation modes by 2025, and impose punitive carbon emission charges on violators. Promote the signing of agricultural carbon sink mutual recognition agreements with Southeast Asian countries, jointly carry out research on collaborative rice methane emission reduction methodology, establish a cross-border technology verification base, and enhance the regional voice of Guangdong's carbon sink standards.We will explore mechanisms for carbon sequestration in overseas Chinese townships, encourage overseas Chinese to purchase carbon sequestration assets in their hometowns, and support the construction of low-carbon infrastructure such as village-level biogas systems, so as to create a virtuous cycle of reinvestment of emissions reduction income. Develop carbon sink loss risk hedging tools simultaneously, promote the Greater Bay Area carbon market rules in line with international standards, explore regional carbon sink trading mechanisms, and enhance Guangdong's international influence in the field of agricultural carbon sink.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by X.H., X.R. and D.L. The first draft of the manuscript was written by X.R. and Q.H. adjusted the format of manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data that support the findings of this study are available from Foshan Municipal Finance Department, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. The data are, however, available from the authors upon reasonable request and with the permission of Foshan Municipal Finance Department.

Confict of Interest

The authors have no relevant financial or non-financial interests to disclose.

Appendix A

Table A1. Leading policy document on carbon reduction for 2022–2024.

Time	Policy/Deployment
January 2022	Guangdong Provincial Government Work Report
May 2022	Opinions on Financial Support for Carbon Peak and Carbon Neutrality
June 2022	Guidelines on Preferential Tax Policies in Support of Green Development
June 2022	Guangdong Carbon Peak Implementation Plan
June 2022	Implementation Plan for Developing Green Finance to Support Carbon Peaking Action in Guangdong Province
April 2023	Guangdong Carbon Peak Implementation Plan" Interpretation III: Steadily and orderly Promote industrial green low-carbon transformation to Promote the province's high-quality carbon peak
June 2023	Notice of the Guangdong Provincial Department of Finance on Transferring the 2023 Central Infrastructure Investment Budget for Pollution Control, Energy Conservation and Carbon Reduction (Pollution Control Direction)
September 2023	Notice of the Development and Reform Commission of Guangdong Province on the Reserve Application of 2024 Central Budget Investment Projects for Pollution Control and Energy Conservation and Carbon Reduction
November 2024	2024–2025 Action Plan for Energy Conservation and Carbon Reduction in Guangdong Province
November 2024	Notice of the Guangdong Provincial Department of Finance on Advancing the Central 2025 Energy Conservation and Emission Reduction (Promotion and Application of New Energy Vehicles) Subsidy Fund Budget

Data sources: official website of Guangdong Provincial People's Government, official website of Guangdong Provincial Department of Finance, etc.

Table A2. Policies related to carbon emission reduction in Guangdong Province and its regions.

Fiscal Policy		
Time	Region	Policy/Deployment
September 14, 2022	Guangzhou City Foshan City Shaoguan City Heyuan City Dongguan City Qingyuan City	Notice of the Guangdong Provincial Department of Finance on Transferring the Second batch of Central Infrastructure Investment Budget for Pollution Control and Energy Conservation and Carbon Reduction in 2022 (Direction of energy Conservation and carbon Reduction)
January 10, 2023	Guangzhou City	Regulations of Guangzhou City on Green Building and Building Energy Efficiency

Table A2. *Cont.*

Fiscal Policy		
Time	Region	Policy/Deployment
July 3, 2023	Jiangmen City	Notice of Jiangmen People's Government on Issuing the Implementation Plan of Jiangmen Carbon Peak
July 3, 2024	Huizhou City	Guidelines on Supporting Huizhou in Accelerating the Construction of a Green and Low-Carbon Industrial System to Build a New Growth Pole for High-Quality Development in Guangdong Province
December 11, 2024	Guangzhou City	Notice of Guangzhou Municipal Finance Bureau on the Advance Allocation of Central 2025 Energy Conservation and Emissions Reduction (New Energy Vehicle Promotion and Application, Fuel Cell Vehicle Demonstration) Subsidy Fund Budget
December 31, 2024	Foshan City	Notice on Further Expanding the Implementation Scope of Government Procurement Policies to Support Green Building Materials and Promote the Enhancement of Building Quality
Tax Policy		
Time		Policy/Deployment
March 17, 2022		Announcement of the Ministry of Finance and the State Taxation Administration on Improving the Value-Added Tax Policy for Resource Comprehensive Utilization
June 24, 2022		Notice of the Ministry of Finance on Effectively Implementing the VAT Credit Refund Policy for Coal-Fired Power Generation Enterprises to Ensure Stable Power Supply
September 26, 2022		Announcement of the Ministry of Finance, the State Taxation Administration, and the Ministry of Industry and Information Technology on Continuing the Exemption of Vehicle Purchase Tax for New Energy Vehicles
June 19, 2023		Announcement of the Ministry of Finance, the State Taxation Administration, and the Ministry of Industry and Information Technology on Continuation and Optimization of Vehicle Purchase Tax Reduction and Exemption Policy for New Energy Vehicles
July 12, 2024		Announcement of the Ministry of Finance and the State Taxation Administration on Corporate Income Tax Policy for Digital and Intelligent Transformation of Energy-Saving, Water-Conserving, Environmental Protection, and Workplace Safety Special-Purpose Equipment

Data sources: Official website of Department of Finance of Guangdong Province, State Administration of Taxation of Guangdong Province, etc.

References

[1] Chen, S.H., 2024. "Dual carbon" goal and the realization path of soil carbon sequestration and emission reduction in cultivated land in China under the background of rural revitalization. Regional Research and Development. 43(05), 132-137.

[2] Li, K., Shi, L., Zhang, H., 2024. The impact of the development of new agricultural business entities on agricultural carbon emission intensity: "carbon reduction effect" or "carbon increase effect". Agrotechnical Economy. (11), 51-73.

[3] Zhao, Z., Tan, J.L., 2020. Analysis of the double effect of fiscal expenditure on carbon emission in China. Journal of Yunnan University of Finance and Economics. 36(05), 24-36.

[4] Nica, I., Georgescu, I., 2025. The ecological impact of agricultural production on CO_2 emissions in India: Pathways to sustainable agriculture. Journal of Environmental Management. 384125548.

[5] Chen, S.Q., Liu, W.Y., Jiang, N.N., 2023. Research on the carbon reduction effect of fiscal policy in Resource-based cities. Local Fiscal Research. (07), 15-27.

[6] Lv, Y., Zhang, H.T., Xue, J.J., et al., 2023. Will tax incentives promote enterprises' pollution reduction? Empirical evidence from value-added Tax reform. Chinese Industrial Economy. (02), 112-130.

[7] Yuan, X.L., Wu, Q., Li, Z.P., 2019. A study on the impact of local fiscal expenditure changes on environmental pollution in China. Journal of Beijing University

of Technology (Social Science Edition). 19(05), 72-83.
[8] Zhao, Z., Tan, J.L., 2022. Carbon emission reduction effect of local fiscal expenditure in China: An empirical analysis based on the moderating effect of new urbanization. Financial Treatise. (11), 41-50.
[9] Katircio, L.S., Ta, P.N., 2017. Testing the Moderating Role of Financial Development in an Environmental Kuznets Curve; Empirical Evidence from Turkey. Renewable and Sustainable Energy Reviews. (68), 572-586.
[10] Korkut, U.P., Veli, Y., 2021. Investigating the persistence of shocks on the ecological balance: Evidence from G10 and N11 countries. Sustainable Production and Consumption. 28, 624-636.
[11] Zhang, H., Li, G.L., Li, Z.L., 2024. Does green finance curb carbon emissions? Fiscal Science. (01), 48-61.
[12] Tan, J.L., Zhao, Z., 2021. Fiscal expenditure structure, new urbanization and carbon emission reduction effect. Contemporary Finance and Economics. (08), 28-40.
[13] Xu, F., Chen, X., 2022. Carbon reduction effect of green fiscal policy: Evidence from "Comprehensive Demonstration city of fiscal policy for energy conservation and emission Reduction". Financial Studies. 48(07), 79-93.
[14] Chen, S.Y., Qi, Y., 2022. Research on Medium and long term fiscal policy to cope with climate change under the constraint of "two-carbon" target. Chinese Industrial Economy. (05), 5-23.
[15] Ke, C.Y., Huang, S.Z., 2024. Research on Agricultural carbon emission reduction behavior based on external green pressure. East China Economic Management. 38(03), 74-83.
[16] Chen, Y., Lv, L.J., 2024. Green fiscal policy and green economic efficiency: A quasi-natural experiment based on comprehensive demonstration city policies of energy conservation and emission reduction. Nankai Economic Research. (07), 201-218.
[17] Tang, D.P., Zheng, H., Li, K.X., et al., 2023. Will government procurement incentivize green innovation? Fiscal Studies. (06), 35-50.
[18] Lu, J.Y., Guo, J.H., 2024. Carbon emission reduction effect of Digital Economy enabling Green Agricultural Development. Journal of Jiangxi University of Finance and Economics. (03), 78-90.
[19] Yang, G.Q., Wang, H.S., Fan, H.S., et al., 2023. Carbon emission Reduction effect of Digital Economy: Theoretical Analysis and Empirical Evidence. Chinese Industrial Economy. (05), 80-98.
[20] Lin, C., Sun, Y.J., 2023. Thinking on the realization of carbon emission reduction path under the "dual carbon" target: an interpretation based on vertical fiscal imbalance. Journal of Huazhong University of Science and Technology (Social Science Edition). 37(01), 119-127.
[21] Song, H., Sun, Y.J., Chen, D.K., 2019. Evaluation on the effect of government air pollution control: An empirical study on the construction of "low-carbon cities" in China. Management World. 35(06), 95-108+195.
[22] Silin, W., Yin, S.Y., Ying, X., 2023. Regional development, agricultural industrial upgrading and carbon emissions: What is the role of fiscal expenditure? —Evidence from Northeast China. Economic Analysis and Policy. 80, 1858-1871.
[23] Juan, W., Hai, L., 2019. The mystery of local fiscal expenditure and carbon emission growth in China. Environmental Science and Pollution Research International. 26(12), 12335-12345.
[24] Chu, C.C., Yunis, M., Huang, X., et al., 2024. Examining the nexus of mineral resources, technology adoption, and economic expansion in advancing sustainable development in OECD economies. Resources Policy. 91, 104864.
[25] Sai, Y., Xiong, F.P., 2022. The spatiotemporal effects of green fiscal expenditure on low-carbon transition: empirical evidence from China's low-carbon pilot cities. The Annals of Regional Science. 70(2), 507-533.
[26] Qi, Y., Lin, J.Y., Zheng, J.B., 2023. Research on fiscal policy to support green and low-carbon development: Logical interpretation, realistic challenges and path optimization. Fiscal Science. (07), 63-73.
[27] Wang, S., Zeng, B., Feng, Y., et al., 2024. How Does Agricultural Land Lease Policy Affect Agricultural Carbon Emission? Evidence of Carbon Reduction Through Decreasing Transaction Costs in the Context of Heterogeneous Efficiency. Land. 13(12), 2192-2192.
[28] Zhao, Y.H., Fan, S.A., Liu, S.Y., 2025. Research on carbon productivity effect of green fiscal policy under the "two-carbon" target. Journal of Beijing University of Technology (Social Sciences Edition). 25(01), 68-84.
[29] Kang, C.Y., Shi, G.F., Guo, X.Q., 2025. Analysis on the path and mechanism of green Finance to promote carbon emission reduction: Based on the perspective of green technology progress and industrial structure ecology. Taxation and Economics. (02), 87-99.
[30] Yue, L., Jiang, L.W., 2025. How can green fiscal Expenditure improve urban land green use efficiency? Western Forum. 04(11), 1-16.
[31] Jin, L.S., Liu, J., Si, C.N., 2024. Study on the impact of digital Finance on Agricultural Carbon Emission Reduction from the perspective of ternary cycle. Journal of Agricultural and Forestry Economics and Management. 23(03), 368-376.
[32] Tang, J., Yi, L., 2024. Research on carbon reduction effect of green agricultural technology innovation in China. Journal of Agricultural and Forestry Economics and Management. 23(06), 720-730.