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Climate Change Adaptation and Emission Reduction Models in the Mekong Delta, Vietnam

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Abstract

This paper aims to synthesize research, articles, topics, and projects related to farming models that adapt to climate change and reduce greenhouse gas emissions in the Mekong Delta, considering current climate change conditions. It analyzes issues related to the economic, social, and environmental effectiveness of common models in the Mekong Delta. Furthermore, it proposes solutions and policies concerning climate adaptation and greenhouse gas emission reduction models to promote effective and sustainable development in the future.

Keywords: Farming models, adaptation, climate change, greenhouse gas emission reduction, Mekong Delta

1. Introduction

Climate change (CC) could have serious adverse effects on the economy, with an anticipated GDP decline of approximately 4% annually from now until 2050, increasing to 5-11% from 2050 to 2100. This GDP reduction is primarily due to a decrease in consumption, followed by reductions in investment and government spending. Labor productivity also significantly impacts GDP reduction, highlighting the effects of CC on workers' ability and performance (Nguyen Thi Phu Ha, 2024). The Mekong Delta and the agricultural sector are expected to suffer the most, requiring effective adaptation policies to protect the economy and communities. Increasing investment in sustainable technology, improving resource management, and supporting farmers will be essential to mitigate these future negative impacts.

The Mekong Delta (MD) faces severe impacts from CC, with serious issues such as rising sea levels, saltwater intrusion, erosion, and flooding. These challenges not only threaten the sustainable development of agriculture but also greatly impact national food security. Agriculture, the primary livelihood for many households in the region, is impacted by increasing

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saltwater intrusion and climate change, which may lead to reduced food production and a heightened risk of poverty (Nguyen Thi Tuyet Mai, 2018). Additionally, economic and social losses due to natural disasters and CC may worsen the difficulties for local residents. Effective solutions, such as developing climate-adaptive farming models, improving irrigation infrastructure, and enhancing community training, are needed to address these issues. Collaboration between the government, businesses, and citizens is crucial to ensuring food security and sustainable development for the MD in the future (Dinh Quang Hieu, 2019).

The Vietnamese government's Resolution 120/NQ-CP and Resolution 13-NQ/TW aim to promote sustainable development in the MD under climate change, reflecting a strategic vision through 2045. Specifically, Resolution 120/NQ-CP focuses on climate adaptation and sustainable agricultural development, while Resolution 13-NQ/TW outlines socio-economic development and national defense directions for the region. The action plan under Resolution 78/NQ-CP specifies tasks and solutions, including:

(i) Resilient agricultural production: Developing farming methods resilient to and adaptable to CC.

(ii) High-efficiency organic agriculture: Promoting organic agriculture and optimizing production processes to increase agricultural product value

(iii) Seed and processing technology: Investing in technology for seeds, processing, and preservation of agricultural and aquatic products to enhance quality, product value, and reduce environmental impacts

These measures not only strengthen the resilience of agriculture in the MD but also aim toward a more sustainable and efficient agricultural future.

However, the region faces numerous threats from CC and the depletion of natural resources. Under CC conditions, new perspectives on development directions are needed, and transforming the sustainable development model in the MD will help reduce vulnerability to economic shifts and climate-induced natural disasters. Therefore, although there has been significant research on CC adaptation and emission reduction models in the MD, no systematic review of these models has been compiled. This article addresses the urgent need to systematize CC adaptation and emission reduction models.

2. Objectives

- Summarize climate change adaptation and emission reduction models in the Mekong Delta (MD) under the conditions of climate change.
- Propose solutions and policies to enhance the effectiveness and sustainability of these adaptation and emission reduction models in the MD for the future.

3. Methodology

A literature review approach was employed, drawing on relevant articles, projects, studies, and reports from agencies related to this topic. These sources were analyzed and synthesized to provide information on climate-adaptive farming and greenhouse gas reduction models in the

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Mekong Delta. Based on this synthesis, recommendations for solutions and policies to promote the sustainable and efficient development of these models in the MD are proposed.

4. Results and Discussion

Climate-adaptive and emission-reduction farming models are essential for addressing the challenges of climate change in the MD. Key adaptive and low-emission farming models in the MD include:

4.1. The "Floating Rice - Vegetables - Natural Fish" Model:

The "natural" approach to rice cultivation, integrated with vegetable and natural fish intercropping, is a sustainable and beneficial trend. This model not only meets economic and environmental goals but also supports emission reduction, ensuring the safety and future security of the MD in a climate increasingly affected by change. Promoting "natural" agricultural development is a story of economic, historical, social, and cultural significance for the MD, carrying forward the spirit of Resolution 120 for sustainable development and climate adaptation (Andy Large, 2024).

This unique model, rooted in the MD, enables farmers to harmonize with nature in a controlled way that benefits both people and the ecosystem (Vo Thi Thu Cuc, 2016). Although the foundation for promoting organic agriculture, especially organic rice, is established and in line with current consumer trends, the economic value and farmer benefits remain low. Additionally, not every "natural" model is highly effective. Therefore, small-scale demonstration models are needed to show effectiveness, which can then be expanded alongside regional linkages, consumption networks, and market development. This approach maximizes benefits and fosters a culture of natural agriculture among the MD's residents (Nguyen Van Kien et al., 2023).

4.2. The Rice-Fish-Lotus Farming Model Adapted to Climate Change

This "nature-based" model supports both environmental conservation and the sustainable use of aquatic resources, offering a viable livelihood for farmers adapting to climate change. The model minimizes chemical fertilizer and pesticide use, encouraging healthier, pest-resistant rice plants with high yields and reduced environmental pollution (Trinh Phuoc Nguyen et al., 2023). Studies show that rice yield in this model exceeds that of traditional monoculture by 6-10%, while the use of fertilizers and pesticides decreases by 35-45%. The model also provides seasonal employment during the flood season, allowing locals to harvest fish and further contribute to greenhouse gas reduction and climate resilience (Trinh Phuoc Nguyen et al., 2023).

4.3. The Rice-Fish-Fallow Model

In the Mekong Delta, integrating fish farming within rice fields is an intelligent use of the annual flood season to enhance agricultural productivity. Starting in late July or early August, farmers introduce fish into flooded rice fields, where they naturally control pests and enrich soil fertility by breaking down organic matter. This reduces the need for fertilizers and pesticides, thereby cutting costs. Additionally, rice crops can serve as fish feed, lowering food expenses for the fish

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(Cao Quoc Nam et al., 2016). This model not only boosts income but also provides a sustainable livelihood solution in response to rising agricultural input costs. The lower labor and investment requirements make it a promising option for further implementation in subsequent seasons, particularly during early floods, while integrating seasonal rice varieties that enhance ecosystem stability and increase household income through fish harvests (Trinh Phuoc Nguyen et al., 2024).

4.4. The Eco-Friendly Smart Rice Farming Model Adapted to Climate Change

This ecological rice field model involves planting flowering plants along rice field edges to attract beneficial insects and parasitic wasps, naturally controlling pests that harm rice crops. The core principle relies on ecological technology, leveraging natural species interactions within the same environment (Nguyen Cong Thuan et al., 2022). The smart rice farming model has shown substantial benefits, reducing seed usage per hectare by over 40% through clustered seeding methods. It also saves 250 kg of NPK fertilizer per hectare and cuts down labor costs for fertilization to only 120,000 VND per hectare compared to traditional methods (Huynh Quang Tin et al., 2011). This approach yields sturdy, pest-resistant rice with high productivity, resilient to rain-induced lodging. Additionally, it minimizes greenhouse gas emissions, protects the environment, and promotes farmer health, all while lowering production costs and enhancing profitability. This model meets criteria for sustainable rice production initiatives (Nguyen Hong Tin et al., 2021) and aligns with the plan to produce one million hectares of high-quality rice in the Mekong Delta, promoting green growth and minimizing environmental impacts (Bui Thi Thu Trang, 2021).

4.5. The Rice-Shrimp Farming Model Adapted to Climate Change

The rice-shrimp rotational model, alternating between shrimp and rice cultivation, is both economically and environmentally effective. Rice planting on shrimp-farmed land greatly improves the soil, with rice and shrimp benefiting each other in the rotation. Salt- and acid-resistant rice varieties, planted after shrimp farming, enrich the soil and provide natural food for shrimp, producing safe, high-quality rice without pesticide use. Shrimp grown in rice fields have abundant food, leading to rapid growth and low disease risk, supplying high-quality shrimp for export (Ngo Hoang Dai Long and Duong Hoang Loc, 2019). This model points to the need for a sustainable development shift in the Mekong Delta, focusing on increasing sustainable agricultural yields and income, strengthening climate resilience, and reducing greenhouse gas emissions (Nguyen Cong Thanh, 2018).

4.6. The Organic Rice Farming Model Adapted to Climate Change

Organic rice farming adapted to climate change is a sustainable agricultural method that minimizes the negative effects of climate change on rice production. This model integrates advanced techniques, such as alternate wet-dry irrigation to save water, and cultivation practices like “one must, five reductions” and “three reductions, three increases” (Nguyen Cong Thanh, 2018). Farmers are encouraged to use certified seeds, select varieties suited to their region, and limit seeding rates to below 80 kg/ha (Bui Thi Phuong Loan et al., 2019). Fertilizer use is reduced, along with fewer pesticide applications, based on local agriculture advisory

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recommendations and specific soil, water, and weather conditions. This approach protects the health of both farmers and the environment.

The model also reduces fertilizer input significantly (average nitrogen use is reduced by 19.2 kg/ha, phosphorus by 24.1 kg/ha, and potassium by 5.9 kg/ha), achieving rice yields approximately 6.6% higher than traditional methods (Mai Van Tinh, 2016). In provinces like Vinh Long and Kien Giang, profits were higher by 1.4 to 6.6 million VND per hectare, while promoting farmer awareness of new technical advancements, water conservation, balanced fertilization, and pest management via Integrated Pest Management (IPM) (Crop Production Department, 2024).

Notable differences between this organic model and traditional methods include the use of certified seeds, water management practices, and optimized fertilizer use. Emissions analysis shows that the smart farming model emitted 23.8% less greenhouse gas in the 2018 winter-spring season and 14.5% less in 2019 compared to control plots. The main factor contributing to this reduction is the alternate wet-dry irrigation method (Nguyen Tuyet Mai, 2018).

According to Nguyen Van Kien (2023), the Sustainable Development Plan for one million hectares of high-quality, low-emission rice production in the Mekong Delta aims toward organic rice cultivation by 2030, reducing annual CO_2 emissions by nearly 11 million tons if fully implemented across the Delta's 1.9 million hectares of rice. Recycling 70% of rice straw could further lower emissions by 50% compared to field burning. Additional CO_2 reductions of 12 to 23 tons are possible through climate-resilient practices, such as improved post-harvest management and straw reuse (Dinh Quang Hieu, 2019).

4.7 Solutions for Developing Climate-Adapted and Low-Emission Farming Models in the Mekong Delta (ĐBSCL)

The Mekong Delta is implementing various low-emission solutions to reduce methane (CH_4) emissions in rice production. Studies (Crop Production Department, 2024; Nguyen Hong Tin et al., 2021; Huynh Quang Tin et al., 2011; Nguyen Cong Thuan et al., 2022; Nguyen Cong Thanh, 2018) indicate the need for effective adaptive and mitigative farming models for the Delta. These solutions are categorized and analyzed as follows:

Water Management

- **Alternate Wetting and Drying (AWD):** This method reduces flooded time in fields, lowering methane emissions and allowing farmers better control over irrigation.
- **Mid-Season Drainage (MSD):** Temporarily drying fields decreases methane emissions and can improve crop yield.

Integrated Crop Management

- **"Three Reductions - Three Increases" (3R3I):** Reduces seed, fertilizer, and pesticide usage while enhancing yield, quality, and profit, thus lowering emissions and saving costs.

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- **"One Must - Five Reductions" (1M5R):** Encourages using a single certified seed type while reducing seed, fertilizer, pesticide, water use, and post-harvest losses for greater production efficiency.

Straw and Agricultural By-Product Management

Effective straw management, such as composting, livestock feed, or biochar production, mitigates methane emissions from straw decomposition.

Land Use Transformation

- **Rice-Shrimp Systems:** This mixed-farming model maximizes water resources, increases farmer income, and reduces methane emissions in rice production.
- **Shifting to Fruit and Vegetable Crops:** The Delta's climate and soil conditions are favorable for fruit and vegetable cultivation, boosting income, biodiversity, and climate resilience.

Benefits of These Solutions

- **Increased Farmer Income:** Transforming low-efficiency rice fields into diverse crops raises income and improves livelihoods.
- **Biodiversity Enhancement:** Mixed farming and crop shifts create diverse habitats.
- **Climate Resilience:** These solutions enhance farmers' adaptability to climate fluctuations and mitigate adverse impacts.

5. Conclusions and Recommendations

5.1Conclusion

Climate-adapted, low-emission farming models in the Mekong Delta yield economic, social, and environmental benefits. They not only bolster farmers' resilience but also contribute to natural resource conservation, life quality improvement, and sustainable development. Transforming inefficient rice land into alternative crops, such as vegetables, perennials, and fruits, is a strategic adaptation and mitigation approach in the Delta. Low-emission rice practices in the region also curb methane emissions, promoting sustainable agriculture. These methods require supportive policies and technological investment for optimization.

5.2Recommendations

From the analysis, the following policy recommendations are proposed for climate-adapted, low-emission farming models:

- **Educational and Awareness Initiatives:** Training programs on sustainable farming and climate adaptation for farmers.
- **Research and Development Investment:** Increase research on crop varieties and methods suitable for changing climates.
- **Encourage Collaboration:** Facilitate farmer cooperatives for knowledge sharing, resource pooling, and market access.

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- **Infrastructure Development:** Invest in agricultural irrigation, drainage, and infrastructure to mitigate disaster losses.
- **Land-Use Planning:** Create policies for rational land-use planning, avoiding farming in vulnerable areas.
- **Crop Diversification:** Promote diversification to enhance resilience and reduce risk.
- **Technology Advancement:** Encourage the application of IT, sensors, and big data in farming.
- **Water Resource Management:** Develop policies for efficient water resource protection and management, especially in drought-prone areas.
- **International Cooperation:** Participate in global programs to exchange expertise, technology, and resources for climate response.

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