EVALUATING THE EFFECTIVENESS OF CARBON CREDITS IN AGRICULTURE: CASE STUDIES FROM SOUTHEAST ASIA AND IMPLICATIONS FOR THE MEKONG DELTA, VIETNAM

Nguyen Bich Ha Vu[*]

Tien Giang University

Email: nguyenbichhavu@tgu.edu.vn

ABSTRACT

The agricultural sector in Southeast Asia is a significant contributor to global greenhouse gas emissions, necessitating the exploration of mitigation strategies such as carbon credits. This research evaluates the effectiveness of carbon credit mechanisms in agricultural practices, with a particular focus on rice farming across Thailand, Vietnam, and Indonesia. These countries were selected due to their prominence in Southeast Asian rice production and the presence of diverse carbon credit initiatives. Through a comparative case study analysis of existing carbon credit programs, this study examines their economic viability, technical feasibility concerning Measurement, Reporting, and Verification (MRV), and social equity impacts. The findings reveal both the potential and the challenges associated with these programs in incentivizing sustainable agricultural practices and reducing emissions. Based on the analysis, the report concludes with tailored recommendations for the application of carbon credits in the Mekong Delta region of Vietnam, considering its unique agricultural context and vulnerabilities to climate change.

Keywords: Agricultural carbon market, Carbon certification, Climate change, Mekong Delta, Rice cultivation.

1. INTRODUCTION

Globally, agriculture contributes significantly to greenhouse gas emissions, necessitating effective mitigation strategies [1]. Carbon credits have emerged as market-based instruments incentivizing emissions reduction and carbon sequestration by assigning monetary value to greenhouse gas avoidance [2, 3]. Southeast Asia, with its substantial agricultural base and climate change vulnerability, presents a critical context for assessing carbon credit potential [4]. Rice farming, dominant across the region, contributes approximately 10% of agricultural greenhouse gas emissions and 12% of global methane emissions, making it a priority for mitigation efforts [5].

Despite growing interest in agricultural carbon markets, comprehensive evaluation of their effectiveness in Southeast Asia remains necessary. This research examines real-world outcomes of these initiatives in Thailand, Vietnam, and Indonesia, selected for their substantial rice production and varying implementation stages [6, 7]. The analysis considers economic viability, technical feasibility of implementation (particularly MRV systems), and impacts on social equity.

Vietnam's Mekong Delta faces exceptional climate change vulnerability, including rising sea levels and increased salinity, threatening agricultural productivity [4, 8]. As Vietnam's "rice basket," producing over 55% of the country's rice and 95% of exports, the region supports approximately 1.5 million small-scale farmers [5]. Lessons from other Southeast Asian countries can inform context-specific initiatives for the Mekong Delta, considering its fragmented landholdings (averaging less than 1.5 hectares per household) and predominance of smallholder farmers [5, 9]. This research aims to offer insights for developing environmentally sound, economically viable, and socially beneficial carbon credit mechanisms for the Mekong Delta's agricultural communities. While drawing lessons from Thailand and Indonesia, this research acknowledges the significant differences in agricultural ecosystems, farm scales, policy contexts, and the availability of granular quantitative data (e.g., standardized MRV costs per hectare) across these countries, thus emphasizing context-specific implications rather than direct generalization for the Mekong Delta.

2. METHODOLOGY

2.1. Comparative case study analysis

This research employs a comparative case study approach examining carbon credit programs in rice farming across Thailand, Vietnam, and Indonesia. This methodology facilitates in-depth understanding of implementation complexities in diverse agricultural contexts [10]. Country selection was purposive, based on regional rice production significance and active carbon initiatives: Thailand's "1.5 Million Hectares Rice Paddy Project" [11], Vietnam's "One Million Hectares High Quality and Low-Emission Rice" project [7], and Indonesia's emerging agricultural initiatives within a broader carbon market framework [12]. This comparison identifies patterns, challenges, and best practices applicable to the Mekong Delta.

2.2. Data sources

The study utilizes a mixed-methods approach, drawing from academic literature, industry reports from organizations like ASEAN Climate Resilience Network, IRRI, and World Bank, government publications, and project-level data from initiatives like Green Carbon's projects [11, 13] and the TRVC project [14]. Statistical data on rice production, agricultural emissions, and farmer incomes provide quantitative context [15].

2.3. Analytical framework

Program effectiveness is evaluated across three dimensions: economic, technical, and social. Economic effectiveness examines financial implications for farmers, including Vietnam's "One Million Hectares" project reporting potential 30% profit increases [7]. Technical effectiveness focuses on MRV system reliability, considering baseline setting, additionality, and emission estimate accuracy [16], with projects like Can Tho's model achieving reductions up to 12 tons CO_2e/hectare [6]. Social effectiveness evaluates program inclusivity, particularly regarding smallholder participation and benefit distribution [17], exemplified by Thai Rice NAMA's 97,000+ participating households [18] and TRVC's 200,000 targeted households [19]. This multidimensional framework ensures holistic evaluation of environmental outcomes alongside economic and social implications.

3. THEORETICAL BACKGROUND

3.1. Economic theory of carbon markets

Carbon markets operate on the fundamental principles of supply and demand, aiming to reduce greenhouse gas emissions by creating a financial incentive for doing so [3]. Emitters that exceed their permitted levels of emissions can purchase carbon credits from entities that have reduced or removed emissions below their established baseline [3]. This mechanism establishes a carbon price, which can also be implemented through carbon taxes or cap-and-trade systems, thereby internalizing the external cost of carbon emissions [20]. In the context of agriculture, most carbon credit activity currently takes place within voluntary carbon markets, where companies or individuals voluntarily purchase credits to offset their emissions or meet sustainability goals, rather than being mandated by government regulations [16]. The economic rationale is that by providing a financial reward for emission reductions or carbon sequestration, these markets can drive more efficient allocation of resources towards climate-friendly practices in the agricultural sector [21].

3.2. Key agricultural economics concepts in carbon markets

Several key concepts from agricultural economics are particularly relevant to the functioning and evaluation of carbon markets in the agricultural sector. Transaction costs, which include the expenses associated with participating in these markets such as verification and aggregation, can significantly impact the profitability of carbon credit schemes for farmers, especially smallholders [17]. High transaction costs can deter smallholder participation, as seen in some early carbon market initiatives [22]. The concept of baseline and additionality is critical to ensure that carbon credits represent genuine emission reductions that would not have occurred in the absence of the program [23]. Ensuring additionality in agricultural projects, where practices may change for various reasons, can be challenging [24]. Inclusivity and social equity highlight the importance of designing carbon credit programs that allow for the participation and benefit of all farmers, including smallholders and marginalized communities, without exacerbating existing inequalities [17]. Programs that fail to adequately engage smallholders may miss significant emission reduction opportunities and perpetuate inequalities [25]. Permanence, referring to the long-term storage of sequestered carbon, and leakage, the potential for emissions to increase elsewhere as a result of reductions in a specific project area, are also crucial considerations for the environmental integrity of agricultural carbon credits [23]. For instance, if reduced deforestation in one area leads to increased deforestation in another, the overall environmental benefit is negated [26]. These theoretical concepts provide a framework for analyzing the effectiveness and fairness of carbon market mechanisms in promoting sustainable agriculture.

4. ANALYSIS AND EVALUATION OF CARBON CREDIT EFFECTIVENESS

4.1. Economic dimensions

The economic effectiveness of carbon credits in Southeast Asian agriculture is multifaceted, extending beyond direct payments for credits. While programs offer financial incentives, potentially increasing farmer income-as exemplified by Green Carbon's Thai rice project targeting an additional $100/hectare/year [11] and Dak Lak farmers in Vietnam earning over 1.5 million VND/hectare from credit sales [27]-a holistic view of economic feasibility demands a comprehensive cost-benefit analysis. This analysis must rigorously

account for oft-overlooked 'hidden' costs. These include upfront investments for technological transitions to low-emission practices, the labor and resources required for ongoing monitoring and data collection, fees for aggregation services, and crucial market-related risks such as carbon price volatility [2] and uncertainties in market access. These elements can significantly influence the net economic return for smallholders.

Transaction costs associated with implementing new farming practices, data management, and verification processes also present substantial hurdles, particularly for individual smallholder farmers [17]. To mitigate these, aggregators and intermediaries are pivotal, facilitating market access and potentially reducing individual burdens by bundling credits from multiple small farms [17]. Beyond credit revenue, participation can yield further economic advantages. For instance, Vietnam's "One Million Hectares" project has demonstrated that sustainably produced, low-emission rice can command higher market prices and reduce production costs, leading to increased overall profitability for farmers [7, 28]. A case from Can Tho showed profit increases of VND 3.5 million per hectare per crop due to these combined effects [29]. Therefore, achieving true economic viability for agricultural carbon credits hinges on delivering stable and sufficient net financial benefits, minimizing participation burdens, and actively fostering robust market opportunities for sustainably produced crops.

4.2. Technical dimensions (MRV)

The technical effectiveness of agricultural carbon credits hinges on the reliability and accuracy of Measurement, Reporting, and Verification (MRV) systems. These systems are essential for quantifying and tracking emission reductions, particularly for methane from rice paddies and carbon sequestration in soils [17]. Accurately quantifying emission reductions at the farm level presents challenges due to the inherent variability of agricultural practices and environmental conditions [6]. Technologies such as remote sensing, IoT devices, and artificial intelligence are increasingly being explored to improve the efficiency and accuracy of MRV processes in agriculture [16]. For example, Regrow Ag's platform is used for MRV in Vietnam's TRVC project, utilizing remote sensing and process modeling [30]. Satellite technology can monitor land cover and vegetation, providing insights into carbon sequestration [16]. Transparent and standardized MRV protocols, aligned with international standards like those developed by the Gold Standard and Verra [31], are crucial for ensuring the credibility and integrity of carbon credits, building trust among buyers and sellers in the market [16, 17]. The technical credibility of agricultural carbon credits, therefore, depends on the continued development and adoption of robust and accurate MRV systems that can effectively address the unique challenges of measuring emissions and removals in agricultural landscapes.

4.3. Social dimensions

The social dimensions of carbon credit effectiveness in Southeast Asian agriculture are critical for ensuring equitable and sustainable outcomes. Inclusivity, particularly the participation of smallholder farmers, is paramount, as they constitute a significant portion of the agricultural sector in the region [5, 17]. Factors such as access to information about carbon credit programs, the availability of technical assistance to implement required practices, and access to financial resources to cover upfront costs all influence smallholder participation [17]. Social equity implications must also be carefully considered, ensuring that the distribution of benefits from carbon credit programs is fair and does not exacerbate existing inequalities or exclude marginalized groups. Community engagement and local participation in the design and implementation of carbon credit projects are vital for fostering

social acceptance and long-term sustainability [23]. For instance, the Katingan Mentaya project in Indonesia, while primarily focused on peatland conservation, also supports the livelihoods of over 40,000 Dayak people through income from carbon credit sales [32]. Furthermore, concerns about "greenwashing" arise if carbon credits do not represent genuine emission reductions or if adequate social and environmental safeguards are lacking [16]. Ensuring the social effectiveness of carbon credits requires a strong focus on equity, inclusivity, and genuine community involvement to deliver benefits to the most vulnerable while upholding environmental integrity [33].

5. CASE STUDIES OF CARBON CREDIT PROGRAMS IN SOUTHEAST ASIA

5.1. Thailand

Thailand has been proactive in exploring carbon credit mechanisms to mitigate emissions from its significant rice farming sector. The "1.5 Million Hectares Rice Paddy Project" by Green Carbon aims to generate carbon credits across half of Thailand's AWD-suitable rice paddies by 2027, targeting an additional income of $100 per hectare annually for farmers [11]. This project collaborates with Rajamangala University of Technology Phra Nakhon and Zimmermann Co., Ltd. to expand AWD adoption [11]. The German-backed "climate-smart" rice project, with a substantial budget of €118 million, aims to support over 253,000 Thai rice farmers in adopting climate-smart practices, projecting a reduction of 2.44 million tonnes of CO_2 equivalent by 2028 [34, 35]. This initiative promotes technologies like AWD and involves GIZ (35). The "Thai Rice NAMA" project, a collaboration between IRRI and GIZ, successfully introduced low-emission technologies such as AWD and laser land leveling to approximately 100,000 farmers in central Thailand from 2018 to 2024, providing valuable lessons for future projects [6, 36]. Building on this success, the Green Climate Fund is investing in the "Thai Rice: Strengthening Climate-Smart Rice Farming" project (FP214), aiming for a transformative shift towards climate-smart agriculture by empowering vulnerable farmers with knowledge and tools for increased resilience and emission reduction [37]. However, this project has faced scrutiny regarding farmer engagement and potential export-oriented policy perpetuation [38]. These case studies illustrate Thailand's multi-faceted approach to leveraging carbon credits in rice farming, involving government initiatives, international collaborations, and private sector involvement.

5.2. Vietnam

Vietnam has demonstrated a strong commitment to low-emission rice production in the Mekong Delta through various carbon credit initiatives. The "One Million Hectares High Quality and Low-Emission Rice in the Mekong Delta" project, supported by the World Bank and the TCAF, aims to reduce greenhouse gas emissions and promote green growth across 12 provinces [7]. Pilot phases have shown promising results, with farmers reporting lower input costs, higher rice prices, and increased incomes, fostering enthusiasm for participation [7, 28]. Green Carbon is also actively participating in this project, focusing on expanding AWD adoption across up to 266,000 hectares in the Mekong Delta to reduce methane emissions and generate carbon credits, collaborating with local research institutions for MRV [13]. The "Transforming Rice Value Chains for Climate Resilient and Sustainable Development in the Mekong Delta" (TRVC) project, funded by the Australian Department of Foreign Affairs and Trade (DFAT) and managed by SNV Netherlands Development Organisation, uses a pay-for-results mechanism to incentivize innovative rice production technologies that reduce emissions and increase farmer incomes [14, 19]. This project utilizes Regrow Ag's platform for MRV and aims to generate around 200,000 carbon credits,

contributing to Vietnam's NDC [14, 30]. Additionally, the Ministry of Agriculture and Rural Development (MARD) is collaborating with IRRI on various initiatives to promote low-emission rice farming and explore the potential of carbon credits in the Mekong Delta region [6, 39]. These initiatives highlight Vietnam's proactive stance in utilizing carbon finance to achieve its climate goals in the crucial Mekong Delta rice sector.

5.3. Indonesia

Indonesia has established a comprehensive regulatory framework for carbon markets, including the launch of the Indonesia Carbon Exchange (IDXCarbon) under the supervision of the Financial Services Authority of Indonesia (OJK) [12, 40]. This framework supports the country's ambitious emission reduction targets [41]. While Indonesia's carbon market initiatives predominantly focus on forestry and peatland restoration due to its extensive carbon-rich ecosystems [32, 42] agricultural sector developments are also emerging. The Katingan Mentaya project in Central Kalimantan is a significant peatland conservation and restoration initiative generating carbon credits through avoided deforestation, benefiting local communities [32]. However, concerns regarding the quality and additionality of some avoided deforestation credits have been raised [32]. In sustainable agriculture, LEAF (Lawrencedale Agro Processing India) has partnered with Verdana International to enter Indonesia, aiming to deliver climate-resilient agriculture solutions and generate high-impact carbon credits for millions of smallholder farmers, utilizing digital technology for simplified carbon validation [43]. Other initiatives include projects focused on biogas production from cattle manure [44] and sustainable land management practices enhancing carbon storage in agricultural lands [45]. Indonesia's evolving approach to carbon markets emphasizes establishing a robust regulatory environment and attracting investment in projects contributing to its climate goals.

6. LESSONS FOR THE MEKONG DELTA, VIETNAM

6.1. Key lessons from case studies

The case studies from Thailand, Vietnam, and Indonesia offer crucial insights for the potential implementation of carbon credits in the Mekong Delta. It is important to note that direct quantitative comparisons, such as MRV costs per unit area, are challenging due to variations in program scale, adopted technologies, and reporting standards across the studied initiatives and limited availability of such specific data in public reports. Therefore, the lessons drawn are primarily qualitative and contextual, highlighting common themes and challenges. A significant success factor observed across these countries is strong governmental support and the active involvement of international organizations in facilitating the development and implementation of carbon credit programs [6]. The adoption of technologies like AWD has consistently proven effective in reducing methane emissions in rice farming [6, 11]. For instance, a comprehensive synthesis of studies across four Southeast Asian sites (Vietnam, Indonesia, Thailand, Philippines) reported that AWD significantly reduced methane (CH4) emissions compared to continuous flooding, with a weighted average reduction of 31% (calculated from Scaling Factor 0.69; 95% Confidence Interval for SF: 0.61–0.77, implying a reduction range of 23-39%) across the sites [46]. Other reviews and meta-analyses report average reductions potentially reaching 48% or higher under certain conditions [47]. Importantly, these reductions in emissions and water savings (often reported in the range of 15-30%) were generally achieved without statistically significant negative impacts on rice grain yield when AWD was implemented correctly [46, 48]. However, several challenges persist. High transaction costs associated with

participation, particularly for smallholder farmers who constitute around 85% of rice producers in the Mekong Delta [5], remain a substantial barrier [17]. Ensuring the reliability and accuracy of MRV systems in the complex agricultural landscapes of Southeast Asia is another ongoing challenge [16]. Moreover, guaranteeing the genuine participation and equitable distribution of benefits to smallholder farmers, while maintaining the environmental integrity of carbon credits, requires careful program design and implementation [17]. The experiences of these countries highlight the necessity of adopting context-specific approaches that consider the unique agricultural and socioeconomic conditions of each region to maximize the effectiveness and fairness of carbon credit mechanisms [17].

To further contextualize the challenges and opportunities for agricultural carbon credits, it is instructive to consider experiences from other carbon market mechanisms. The Clean Development Mechanism (CDM), a project-based mechanism under the Kyoto Protocol, provided valuable, albeit mixed, experiences. Key lessons relevant for current voluntary agricultural carbon markets include the critical importance of robustly demonstrating additionality (ensuring projects would not have occurred otherwise) [24], managing often high transaction costs that disproportionately affected smaller projects [17, 23], and the complexities involved in developing and implementing rigorous Measurement, Reporting, and Verification (MRV) methodologies [16]. Similarly, regional experiences with REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiatives offer pertinent insights. REDD+ projects have grappled with ensuring permanence of emission reductions, effectively addressing leakage (where emissions are displaced outside project boundaries) [26], and guaranteeing meaningful community participation and equitable benefit-sharing [25, 33], often alongside navigating complex land tenure issues. These challenges mirror potential difficulties in agricultural carbon credit schemes, particularly concerning the long-term adoption of sustainable practices and ensuring benefits reach smallholder farmers. By examining these precedents, current agricultural carbon credit initiatives can proactively design strategies to mitigate similar risks and enhance their effectiveness and environmental integrity.

6.2. Recommendations for the Mekong Delta

Applying the lessons learned from the case studies to the Mekong Delta necessitates a tailored strategy that addresses the region's specific characteristics and vulnerabilities.

Addressing Fragmented Landholdings: Given the prevalence of small and fragmented landholdings in the Mekong Delta, where the average farm size is less than 1.5 hectares [9], promoting the aggregation of farmers through cooperatives or farmer groups is crucial to reduce transaction costs associated with carbon credit programs [17]. Learning from successful cooperative models in sustainable shrimp aquaculture [49] or fruit farming [50] in the region can provide valuable insights. Aggregation can enhance farmers' collective bargaining power, improve access to technical assistance, and streamline MRV processes.

Managing Climate Change Vulnerabilities: Carbon credit programs in the Mekong Delta should prioritize the promotion of climate-smart agricultural practices that enhance the resilience of rice farming to the specific climate change impacts facing the region, such as salinity intrusion, increased flooding, and rising temperatures [4, 8, 28]. While AWD is a promising technology for reducing methane emissions, exploring other adaptive strategies, including the diversification of cropping systems in suitable areas [4, 51], and promoting the use of climate-resilient rice varieties, should also be considered within the framework of carbon credit initiatives.

Strengthening MRV Systems: Investing in the development and deployment of robust and cost-effective MRV technologies tailored to the Mekong Delta's agricultural context is essential for ensuring the credibility of carbon credits generated in the region [16]. This includes building local capacity for data collection, analysis, and verification. Exploring the potential of digital MRV solutions, such as satellite-based monitoring and mobile applications for farm-level data recording [16, 28], can help to improve efficiency and reduce costs. Collaboration with international research institutions like IRRI, which has experience in developing MRV systems for rice production [6], can be beneficial.

Ensuring Social Equity and Inclusivity: To ensure that carbon credit programs in the Mekong Delta benefit smallholder farmers, proactive strategies are needed to facilitate their participation. This includes providing accessible information about program requirements and benefits, offering tailored technical assistance in local languages, and establishing fair and transparent payment mechanisms [17]. Learning from projects in Indonesia that focus on engaging marginalized farmers [43] can inform the design of inclusive programs in the Mekong Delta. Ensuring that local communities are involved in the design and implementation of carbon credit projects will also enhance social acceptance and long-term sustainability. A phased rollout strategy for carbon credit programs, potentially prioritizing districts most vulnerable to climate change and with high mitigation potential, could optimize resource allocation and learning. Crucially, substantial investment in capacity-building for provincial and local extension services is needed to equip them with the knowledge and tools to support farmers in adopting new practices and navigating MRV requirements.
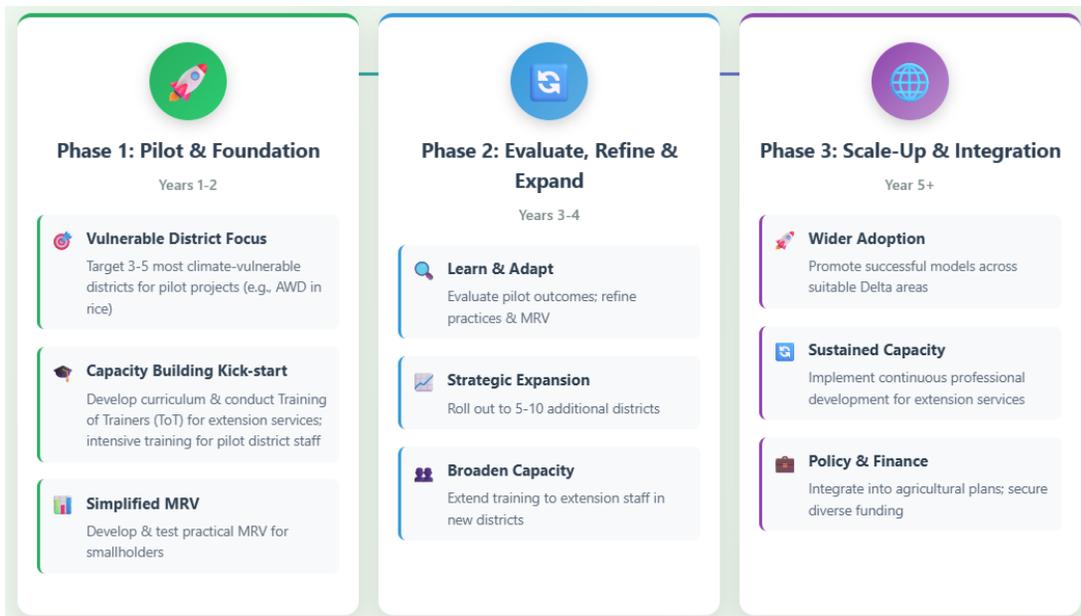

Figure 1. Phased rollout & capacity building for Mekong Delta carbon credits.
(Source: authour's suggestion)

Policy and Institutional Framework: The development of a clear and supportive policy and institutional framework at both national and regional levels is crucial for the successful implementation and scaling of carbon credit programs in the Mekong Delta [17]. Nationally, this framework should align with directives such as Vietnam's Decree 06/2022/ND-CP, which outlines GHG emission reduction targets and provides a foundational legal structure for domestic carbon market development, including agricultural carbon projects. Furthermore, considering regional developments like the emerging ASEAN Carbon Bank

(ACB) initiative could inform strategies for market integration and access to broader carbon finance opportunities. Such a framework must provide specific guidelines for MRV protocols, carbon credit certification standards, and mechanisms for equitable benefit sharing among participating farmers and communities. Streamlining regulatory processes and reducing bureaucratic hurdles will also encourage greater participation.

Financial Sustainability: Ensuring the long-term financial sustainability of carbon credit programs in the Mekong Delta will require attracting diverse sources of funding, including private sector investment and potential linkages to both voluntary and compliance carbon markets [3]. Exploring innovative financing mechanisms, such as blended finance approaches that combine public and private capital, can help to mobilize the necessary resources to support the adoption of low-emission rice farming practices and the generation of high-quality carbon credits in the region. The World Bank's commitment to mobilizing additional non-refundable aid for Vietnam's "One Million Hectares" project [29] exemplifies this need for diverse financial support.

7. CONCLUSION AND FUTURE RESEARCH

7.1. Summary of findings

This analysis of carbon credit programs in Southeast Asia reveals both the significant potential and the persistent challenges associated with their effectiveness in promoting sustainable agricultural practices, particularly in rice farming. The economic dimensions highlight the importance of stable financial incentives and the need to minimize transaction costs for farmers. However, the overall economic feasibility for smallholders in the Mekong Delta remains contingent on addressing these transaction costs, mitigating risks from carbon price volatility, and ensuring that revenue from credits adequately compensates for investment in new practices and potential hidden costs. The technical aspects underscore the critical role of robust and accurate MRV systems in ensuring the credibility of carbon credits. Socially, the success of these programs hinges on their inclusivity and ability to equitably benefit smallholder farmers and local communities. The case studies from Thailand, Vietnam, and Indonesia illustrate diverse approaches to implementing carbon credit initiatives, offering valuable lessons for future endeavors. For the Mekong Delta, these lessons point towards the need for tailored strategies that address the region's fragmented landholdings, climate change vulnerabilities, and the imperative of social equity.

7.2. Limitations and future research directions

This research, while offering a comprehensive overview, faces certain limitations primarily stemming from varied availability of detailed, project-level data across the selected countries. The lack of standardized, publicly accessible quantitative data-such as consistent MRV costs per unit area or uniform socio-economic impact assessments-constrained direct comparative analysis and highlighted challenges in generalizing findings from Thailand and Indonesia to the Mekong Delta, given its distinct agricultural, land tenure, and policy contexts.

Future research should prioritize more extensive data access, including long-term impact assessments and detailed MRV reports. Key avenues warrant exploration: investigating the long-term sustainability and impacts of existing programs; evaluating the role of carbon standards and certification schemes in market acceptance; and assessing various aggregation models for smallholder inclusion and transaction cost reduction. Crucially, comprehensive, localized cost-benefit analyses in the Mekong Delta are needed,

explicitly accounting for technological transition costs, monitoring expenses, and carbon price volatility risks. Further studies should also include life-cycle assessments of administrative costs, network analyses of credit buyer preferences, and investigations into social and environmental co-benefits or trade-offs of rice-based carbon projects. Examining the impact of specific policy interventions and innovative financing mechanisms to support low-emission rice farming in the Mekong Delta will be vital for sustainable regional development.

REFERENCES

1. Li, Lidong, Tala Awada, Yeyin Shi, Virginia L. Jin, and Michael Kaiser - Global Greenhouse Gas Emissions From Agriculture: Pathways to Sustainable Reductions, Global Change Biology **31** (1) (2025) e70015.

2. Carbon Credits. What are carbon credits? (n.d.). https://www.green.earth/carbon-credits

3. Neyen, J. Carbon Pricing: Theory & Concepts (n.d.) https://neyen.io/carbon-pricing-theory-concepts/

4. Kontgis, Caitlin, Annemarie Schneider, Mutlu Ozdogan, Christopher Kucharik, Van Pham Dang Tri, Nguyen Hong Duc, and Jason Schatz - Climate change impacts on rice productivity in the Mekong River Delta, Applied Geography **102** (2019) 71-83. https://doi.org/10.1016/j.apgeog.2018.12.004

5. WBCSD - Deep dive: Rice (2024). https://www.wbcsd.org/wp-content/uploads/2024/06/Deep-dive-Rice.pdf

6. IRRI - Transforming Thailand's Rice Sector Toward Low Emissions (2024) https://www.irri.org/news-and-events/news/transforming-thailand%E2%80%99s-rice-sector-toward-low-emissions

7. Vietnam Plus - Mekong Delta develops 1 million ha of low-emission high-quality rice, (2023) https://en.vietnamplus.vn/mekong-delta-develops-1-million-ha-of-low-emission-high-quality-rice-post274749.vnp

8. MRC Mekong - Climate Change in the Mekong River Basin, (n.d.) https://www.mrcmekong.org/climate-change/

9. Mekong Eye - Fertility Mekong Delta (2024) https://www.mekongeye.com/2024/10/14/fertility-mekong-delta

10. Yin, Robert K - *Case study research and applications: Design and methods*, Sage publications (2017).

11. Green Carbon - Green Carbon, Inc. has launched the "1.5 Million Hectares Rice Paddy Project" to develop carbon credits in half of the rice paddies in Thailand, (2025) https://green-carbon.co.jp/en/thaiawd-eng/

12. ABNR Law - Indonesia Carbon Trading Series: Registration of Carbon Units on IDX Carbon (2023) https://insightplus.bakermckenzie.com/bm/capital-markets/indonesia-carbon-trading-series-registration-of-carbon-units-on-idx-carbon

13. Green Carbon - 【Japan's First Initiative】 Green Carbon Inc. has officially joined the Vietnam government's One Million Hectares of High-Quality and Low Emission Rice Project and signed new MOUs with three provinces in Vietnam for AWD projects in paddy fields, (2024) https://green-carbon.co.jp/en/100haproject/

14. TRVC - Transforming the Rice Value Chain for Climate Resilient and Sustainable Development in the Mekong Delta (TRVC), (n.d.) https://trvc.vn/eng.html

15. FAOSTAT - Food and Agriculture Organization of the United Nations, (2024) http://www.fao.org/faostat/en/#data

16. Green Up Asia - Understanding MRV Technology for Carbon Credits, (n.d.) https://greenup.asia/understanding-mrv-technology-for-carbon-credits/

17. FAO - The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction (2019) https://www.fao.org/3/ca6030en/ca6030en.pdf

18. Mitigation Action Facility - Thailand – Low-Emission Rice (Thai Rice), (n.d.) https://mitigation-action.org/projects/thailand-low-emission-rice-thai-rice/

19. SNV - Transforming Rice Value Chain for Climate Resilient and Sustainable Development in the Mekong Delta, (n.d.) https://www.snv.org/project/transforming-rice-value-chain-climate-resilient-and-sustainable-development-mekong-delta

20. Stavins, Robert N. - A meaningful US cap-and-trade system to address climate change, Harv. Envtl. L. Rev. 32 (2008) 293.

21. Nordhaus, William D. - To tax or not to tax: Alternative approaches to slowing global warming, Review of Environmental Economics and policy (2007).

22. Shames, Seth. - How can small-scale farmers benefit from carbon markets?, (2013). https://cgspace.cgiar.org/server/api/core/bitstreams/d6fb8ff7-e496-4cbd-92c9-f14b99dcdd90/content

23. Extension- Agricultural Carbon Markets (2024) https://extension.iastate.edu/agdm/crops/pdf/a1-76.pdf

24. McFarland, Brian Joseph. - Carbon reduction projects and the concept of additionality, Sustainable Dev. L. & Pol'y 11 (2010) 15.

25. Agarwal, Bina - Gender and forest conservation: The impact of women's participation in community forest governance, Ecological Economics **68** (11) (2009) 2785-2799.

26. Atmadja, Stibniati, and Louis Verchot - A review of the state of research, policies and strategies in addressing leakage from reducing emissions from deforestation and forest degradation (REDD+), Mitigation and Adaptation Strategies for Global Change **17** (2012) 311-336.

27. Vietnamagriculture - Dak Lak sells nearly 17 tons of carbon from planting rice (2024) https://vietnamagriculture.nongnghiep.vn/dak-lak-sells-nearly-17-tons-of-carbon-from-planting-rice-d399444.html

28. World Bank - Greening Viet Nam's Rice Bowl: A Mekong Delta Success Story (2024) https://www.worldbank.org/en/news/feature/2024/05/14/greening-viet-nam-s-rice-bowl-a-mekong-delta-success-story

29. Vietnam Law Magazine - World Bank pledges continued support for Vietnam's high-quality, low-emission rice project, (2025) https://vietnamlawmagazine.vn/world-bank-pledges-continued-support-for-vietnams-high-quality-low-emission-rice-project-73795.html

30. Regrow Ag - Regrow Selected as Independent Verifier for Mekong River Delta Emissions Reduction Initiative in Rice Production (2024) https://www.wbcsd.org/news/regrow-selected-as-independent-verifier-for-mekong-river-delta-emissions-reduction-initiative-in-rice-production/

31. Vietnam Agriculture - Low-carbon rice production, insights from experts: The role of MRV (2024) https://vietnamagriculture.nongnghiep.vn/low-carbon-rice-production-insights-from-experts-the-role-of-mrv-d394458.html

32. E360 Yale - Will UN Carbon Market Work? Indonesia Will Provide First Test (2024) https://e360.yale.edu/features/indonesia-carbon-credits-bioeconomy

33. Corbera, Esteve, Katrina Brown, and W. Neil Adger. - The equity and legitimacy of markets for ecosystem services, Development and Change **38** (4) (2007) 587-613.

34. Khaosod English - Green Climate Fund invests 4 Billion Baht to Transform Thai Rice Farming, (2025) https://www.khaosodenglish.com/sustain/2025/03/01/green-climate-fund-invests-4-billion-baht-to-transform-thai-rice-farming/

35. Thai-German Cooperation - Thailand to transform rice sector with 118 million euros climate-smart rice farming initiative (2025) https://www.thai-german-cooperation.info/en_US/thailand-to-transform-rice-sector-with-118-million-euros-climate-smart-rice-farming-initiative/

36. Thai-German Cooperation - Strengthening Thailand's Low-Emission Rice Market: Learnings from the Thai Rice NAMA Project (2024) https://www.thai-german-cooperation.info/en_US/strengthening-thailands-low-emission-rice-market-learnings-from-the-thai-rice-nama-project/

37. Green Climate Fund - FP214: Thai Rice: Strengthening Climate-Smart Rice Farming, (n.d.) https://www.greenclimate.fund/project/fp214

38. GCF Watch - FP214: Thai Rice: Strengthening Climate-Smart Rice Farming by GIZ, (2023).https://www.gcfwatch.org/wp-content/uploads/2023/10/GCFWatch_B37_FP214.pdf

39. Vietnam Plus - Mekong targets low-emission rice production with carbon credit initiative (2024) https://en.vietnamplus.vn/mekong-targets-low-emission-rice-production-with-carbon-credit-initiative-post297974.vnp

40. IDXCarbon - Indonesia Carbon Exchange, (n.d.) https://idxcarbon.co.id/

41. Kearney - Indonesia's Pathway to Net Zero 2060, (2023) https://www.kearney.com/service/sustainability/article/indonesia-s-pathway-to-net-zero-2060

42. Abatable - The opportunity for carbon markets in ASEAN, (2024) https://abatable.com/reports/opportunities-for-asean-carbon-markets/

43. Verdana - LEAF partners with Verdana to enter Indonesia, launching Sustainable Agriculture Programs and High-Impact Carbon Credits, (2024) https://verdana.io/leaf-partners-with-verdana-to-enter-indonesia-launching-sustainable-agriculture-programs-and-high-impact-carbon-credits/

44. CGIAR - The Indonesia Domestic Biogas Programme: can carbon financing promote sustainable agriculture? (2020) https://cgspace.cgiar.org/items/f1419620-1287-4ccc-8bbb-73180a0bda44

45. Tracextech - Carbon Offset Projects in Indonesia, (n.d.) https://tracextech.com/carbon-offset-projects-in-indonesia/

46. Tirol-Padre, Agnes, Kazunori Minamikawa, Takeshi Tokida, Reiner Wassmann, and Kazuyuki Yagi. - Site-specific feasibility of alternate wetting and drying as a greenhouse gas mitigation option in irrigated rice fields in Southeast Asia: a synthesis, Soil Science and Plant Nutrition **64** (1) (2018) 2-13. https://doi.org/10.1080/00380768.2017.1409602

47. Suwanmaneepong, Suneeporn, Kulachai Kultawanich, Lampan Khurnpoon, Phatchara Eamkijkarn Sabaijai, Harry Jay Cavite, Christopher Llones, Norden Lepcha, and Chanhathai Kerdsriserm. - Alternate wetting and drying as water-saving technology: An adoption intention in the perspective of good agricultural practices (GAP) suburban rice farmers in Thailand, Water **15** (3) (2023) 402. https://doi.org/10.3390/w15030402

48. Bo, Yan, Xuhui Wang, Kees Jan van Groenigen, Bruce A. Linquist, Christoph Müller, Tao Li, Jianchang Yang, Jonas Jägermeyr, Yue Qin, and Feng Zhou. - Improved alternate wetting and drying irrigation increases global water productivity, Nature Food (2024) 1-9. https://doi.org/10.1038/s43016-024-01081-z

49. WWF - Promoting sustainable shrimp aquaculture for small-scale farmers in Mekong delta (2009) https://wwf.panda.org/es/?163581/Promoting-sustainable-shrimp-aquaculture-for-small-scale-farmers-in-Mekong-delta

50. Rabobank - Better farming in the Mekong Delta (n.d.) https://www.rabobank.nl/en/about-us/rabofoundation/project/011141602/better-farming-in-the-mekong-delta

51. ReliefWeb - Climate Resilient Agriculture in the Mekong Delta, (2024) https://reliefweb.int/report/viet-nam/climate-resilient-agriculture-mekong-delta

TÓM TẮT

ĐÁNH GIÁ TOÀN DIỆN HIỆU QUẢ CỦA CHỨNG CHỈ CARBON
TRONG NÔNG NGHIỆP: NGHIÊN CỨU TRƯỜNG HỢP TỪ CANH TÁC LÚA
Ở ĐÔNG NAM Á VÀ BÀI HỌC CHO ĐỒNG BẰNG SÔNG CỬU LONG

Nguyễn Bích Hà Vũ*

Trường Đại học Tiền Giang

*Email: nguyenbichhavu@tgu.edu.vn

Nghiên cứu này tiến hành đánh giá toàn diện về hiệu quả của chứng chỉ carbon trong canh tác lúa dựa trên case study từ Đông Nam Á và rút ra bài học cho Đồng bằng sông Cửu Long (ĐBSCL). Sử dụng phương pháp phân tích đa chiều, bài viết xem xét các khía cạnh kinh tế, kỹ thuật và xã hội của mô hình chứng chỉ carbon nông nghiệp. Kết quả nghiên cứu chỉ ra rằng mặc dù chứng chỉ carbon mang lại tiềm năng thu nhập bổ sung cho nông dân, việc triển khai vẫn đối mặt với nhiều thách thức như chi phí giao dịch cao, rào cản kỹ thuật trong đo lường, và vấn đề tiếp cận không đồng đều. Phân tích từ mô hình ở Thái Lan cho thấy sự thành công phụ thuộc vào khung pháp lý hỗ trợ, cơ chế tập hợp hiệu quả cho nông hộ nhỏ, và hệ thống MRV (Đo đạc, Báo cáo, Thẩm định) đáng tin cậy. Nghiên cứu đề xuất rằng để áp dụng thành công tại ĐBSCL, cần xây dựng mô hình phù hợp với đặc thù vùng, tăng cường năng lực kỹ thuật cho nông dân, và thiết kế cơ chế phân phối lợi ích công bằng. Những phát hiện này đóng góp quan trọng vào việc phát triển thị trường carbon nông nghiệp bền vững, đồng thời hỗ trợ mục tiêu giảm phát thải và thích ứng với biến đổi khí hậu tại ĐBSCL.

Từ khóa: Biến đổi khí hậu**,** Canh tác lúa**,** Chứng chỉ carbon**,** Đồng bằng sông Cửu Long**,** Thị trường carbon nông nghiệp.