Financial feasibility planning for the One Million Hectares program to transition to low-emission and high-quality rice in Vietnam and access to carbon credit markets

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Preface

We extend our gratitude to all those who actively participated in this research, contributing their valuable insights and expertise. Special thanks are due to the commissioner of this investigation, Katherine Nelson, and the International Rice Institute (IRRI) team composed of Alisher, Trang, and Amber, whose guidance and collaboration were indispensable throughout this process.

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Your collective efforts have enriched this study and propelled us toward a deeper understanding of the challenges and opportunities inherent in the pursuit of sustainable agriculture initiatives.

Summary

Traditional rice farming systems contribute considerably to greenhouse gas (GHG) emissions globally and in Vietnam, but they also offer a large potential for emission reductions. As part of the national strategy of Vietnam to reduce GHG emissions, the government has recently launched the 'One Million Hectares of High Quality, Low-Emission Rice' project (1Mha). The goal of our report is to assess the financial feasibility of this project. In order to do so we looked into to the requirements for scaling up the VnSAT that depend on the coordination between different stakeholders, strategies for dissemination of knowledge, the political context of carbon markets and the development of a reliable MRV system. We also investigated the current and future risks for the implementation of the project and its financial feasibility. This analysis resulted in a number of risks and barriers that range from Financial to Technological. In the cost-benefit assessment, the net annual revenue and the emission reductions were calculated for a business-as-usual (BAU) and 1MHa project scenario for the 1MHa. In the long-term, the project is projected to be profitable and is predicted to contribute an emission reduction of 38.1% over its 21-year lifetime, although it remains unclear whether carbon credit revenue is still feasible while meeting NDC requirements by the 2030 target.

The research questions were addressed by literature reviews, interviews with key stakeholders and through risk analysis, and cost-benefit analysis. Literature was examined to gather documented risks and cost data, while stakeholder interviews were based on qualitative questions focusing on perceived risks and costs linked with sustainable rice farming practices. Scenarios for implementing the 1Mha were formulated and refined through the interviews, and subsequent cost and benefit calculations were carried out utilizing the COMPARE-tool (International Rice Research Institute, Vietnam).

1. Financial feasibility of carbon emissions reduction projects in rice farming and access to carbon credit markets.

1.1 Current Situations

The increased concentration of greenhouse gases(GHGs) in the atmosphere increases the greenhouse effect, resulting in global warming (Hussain et al., 2015). Rice cultivation accounts for 1.3-1.8% of total global GHG emissions, which is equivalent to the entire global air transportation emissions (FAOSTAT, 2022). This is because the flooded conditions in traditional paddy field rice farming led to the production of methane (Singh et al., 2018). In traditional rice farming, emissions are mainly categorized into emissions from cultivation, crop residue incorporation, and burning straw (Wang et al., 2023).

Vietnam's updated Nationally Determined Contribution (NDC) increased unconditional targets to 15.8% and conditional to 43.5% for carbon emissions reductions (Vietnam, 2022). In Vietnam, agriculture contributes about 33% of total emissions, with the rice sector alone responsible for 50.5% of total agriculture emissions (World Bank, 2022). Most rice farmers (89%) are smallholder farmers with 0.5-2 hectares of farms (FAO, 2018). Many smallholder farmers participate in agricultural cooperatives, which improves access to inputs and machinery, and increases the overall profitability of farms (Tran et al., 2022). In the Mekong River Delta (MRD) region which produces 54% of the nation's rice, 78% of land is dedicated to rice farming, involving 80% of the population (Maitah et al., 2020).

Rice farming has the largest relative mitigation potential in the agriculture sector (Roe et al., 2021). To achieve NDC, Vietnam has been focusing on three agronomic practices: alternative wetting and drying (AWD), One Must Do Five Reductions (1M5R), and sustainable rice platform (SRP). AWD disrupts methane production, limiting water use in rice paddies (Vu et al., 2022). 1M5R encourages farmers to use certified seeds and reduce the seed rate, use of fertilizers, pesticides, water, and post-harvest losses (Tho & Dung, 2023). SRP is a multi-stakeholder platform to promote resource efficiency and sustainable trade flows, production and consumption operations, and supply chains in the global rice sector. Transitioning traditional farming into sustainable farming practices will contribute to GHG emission reductions. However, several financial, social-economic and technological risks are involved, which could limit this transition.

Emission reductions can be monetized through carbon credits. Worldwide the carbon market is estimated at 280 billion dollars in 2020, of which only one percent is issued for agricultural purposes (World Bank, 2021). Vietnam has traded 30 million tons of carbon in compliance carbon markets and 10 million tons in voluntary markets (USAID, 2022). In Agriculture Forestry and Other Land Use (AFOLU), voluntary carbon credits are only granted to the forestry sector (World Bank, 2022). However, emission reductions in rice farming have not yet been monetized through the carbon market. The World Bank Group has been collaborating with counterparts in Vietnam to connect emission reductions in rice farming through support for targeted projects. For instance, the Transformative Carbon Asset Facility (TCAF) supports the recently launched government program to transition one million hectares to high-quality, low-carbon rice.

The one million hectares project (1Mha) aims to implement sustainable farming practices in the MRD region in Vietnam (Tho & Dung, 2023). To achieve this aim, the rice value chain will be restructured. The timeline of the project is divided into two phases. In the first phase, 180.000 hectares of farming will be converted to the new standards by 2025. These lands are currently under the VnSAT project (Vietnam Sustainable Agriculture Transformation Project). This phase will focus on consolidation in areas such as training and establishing an MRV (Measuring, Reporting, and Verifying)- system. In the second phase (2026-2030) the newly established farming practices will be upscaled to an additional 820.000 hectares.

1.2 Main Research Question and Sub-questions

The main objective of this project is to scrutinize the financial feasibility of scaling up sustainable practices in Vietnamese rice farming for carbon emission mitigation. To accomplish this objective, three research objectives will be identified as follows:

i) Illustrating requirements to scale VnSAT to the magnitude of the 1Mha;
ii) Delineating risks associated with the implementation of carbon credit projects; and
iii) Assessing the costs and benefits inherent in the expansion of rice management practices set by the 1Mha

1.3 Our Commissioner

This project was commissioned by Katherine Nelson, a climate change specialist at the International Rice Research Institute (IRRI) which plays a defining role in the innovation of the rice sector. Given the potential of rice production to contribute to GHG emission reductions, the Vietnam government aims to transition from traditional rice farming to a climate-smart, food-secure system. Understanding the opportunities, challenges, and risks of carbon mitigation in rice production, in the context of Vietnam, sets a foundation for developing strategic targets and plans to enable future sustainable transition efforts.

2. Scaling up VnSAT to the size of the 1Mha project

2.1 Stakeholder analysis

The 1Mha project evolved from a government development plan with multiple domestic and international stakeholders and actors. To scale up to the 1Mha project, this project investigated the requirements and the current situation of those requirements. Based on the five interviews and literature review, the stakeholders' interests were identified (Table 1), including issues from risks. These interests were utilized for the stakeholder map by reflecting the potential benefits they expect in the 1Mha project. The relation and matrix analysis resulted in a network of 16 stakeholders, linked together through the types of exchange and interactions (Fig. 1). Through the stakeholder analysis, stakeholders were identified with their capacity and willingness to promote carbon mitigation and contribute to establishing carbon markets for Vietnamese rice production.

Table 1. Stakeholders' interest and main issues through this project.

Interest categories	Main issues	Stakeholders
Carbon mitigation	Mitigation works Relocation	The Ministry of Agriculture and Rural Development (MARD) TCAF
Carbon credit	Unidentified MRV Different MRV standards depending on the program Lack of trading platform Low market demand Low reliability Uncertain BAU Lack of regulations and policies Amount of verified carbon credits	MARD Carbon Market Platform Voluntary carbon market certifier IRRI TCAF donor countries Department of Foreign Affairs and Trade (DFAT) Private rice companies
Rice production	Farmers' willingness Resource competition between farmers Lack of access to agricultural credit for smallholder farmers Lack of investment Lack of infrastructure (irrigation, machinery) Lack of labor Innovative farmers not yet in a cooperative	Farmers (Cooperatives) IRRI Vietnam Academy of Agricultural Sciences (VAAS) SRP Private rice companies Department of Crop Production (DCP)
Straw management	Lack of infrastructure of collection, transportation, storage	Farmers (Cooperatives) IRRI VAAS Potential private investors

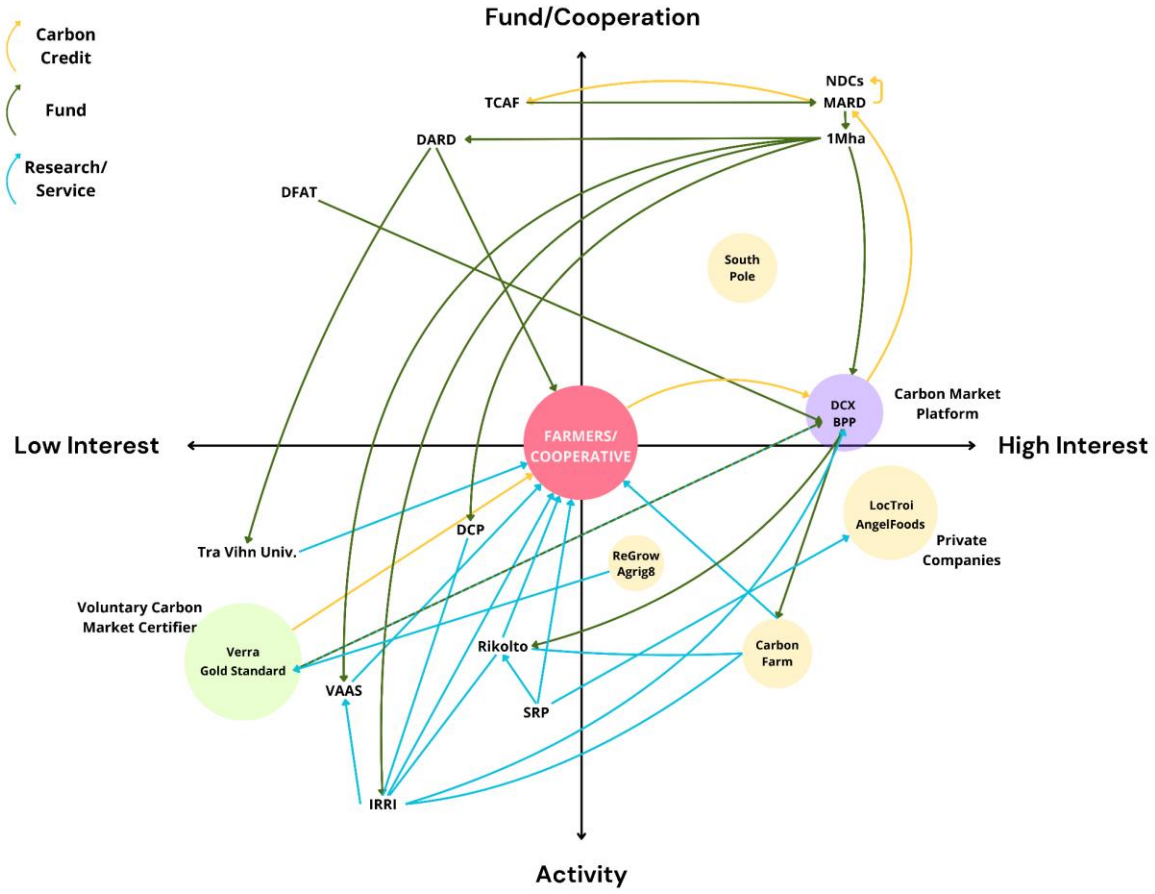

Fig. 1. Stakeholder action and interest matrix with relations. Green, blue, and yellow arrows indicate the trading of funds, research and service, and carbon credit, respectively. The violet circle represents the carbon market platform, the green circle indicates the voluntary carbon market certifier, and the yellow circle represents the private companies.

Based on this analysis, three requirements were identified: (i) organizational and training strategies; (ii) legal and regulatory policies and systems on carbon credit; and (iii) MRV systems.

2.2 Organizational and Training Strategies

Following the development of an agronomic practice training guideline, training is provided among farmers and cooperatives to enhance the efficacy of business operations (The Ahn, 2024). The forthcoming training sessions necessitate prior voluntary registration by farmers and cooperatives, which means that promotion and Farmer's voluntary engagement are essential in the successful implementation of the proposed practices. The Vietnamese government has advocated for the involvement of cooperatives in capacity-building services.

Upon the establishment of the training guideline, institutional bodies such as the Vietnam Academy of Agriculture Science (VAAS) assume the responsibility of coordinating outreach efforts with community extension groups to investigate prospective participants for the training initiative (The Ahn, 2024). Subsequently, these organizations focus on cooperative leaders. Consequently, equipped with the requisite knowledge and skills, these cooperative leaders act as conduits for disseminating training content to farmers within their cooperatives. This hierarchical training structure necessitates the development of robust community networks related to the organization, with a prerequisite condition that farmers be incorporated into cooperative entities.

Another training strategy is using Farmers Field School (FFS). FFS is a group-based learning process aimed at farmer empowerment, community development, and education on sustainable farming practices (To

Dang, 2015). The Trà Vinh University, for instance, which is located in the MRD region, utilizes the FFS platform to facilitate practical training for farmers (Gupta *et al*, 2023). Through field experimentation, farmers are exposed to various agricultural methodologies with the assessment of their efficacy and feasibility. One such approach introduced to farmers is AWD. The university installed digital monitors and collaborated with farmers to optimize irrigation practices. Instead of using the traditional flooding methods, farmers were trained to use applications for real-time water level monitoring, thereby facilitating the successful pilot implementation of AWD. This transition from research to field application requires substantial investments in scaling up initiatives and the deployment of requisite infrastructure such as remote sensing technologies, applications, and irrigation systems.

2.3 Legal and Regulatory Policies and Systems on Carbon Credit

The Carbon market system operates under a global and national governance framework (Table 2). Vietnam has instituted a legal framework alongside policies to establish a carbon market (USAID, 2022). The integration and boundaries between these policies must be unequivocally defined to mitigate the risk of inducing confusion or fragmentation of efforts (Ramthan & Chen, 2024). Furthermore, enhancing cooperation between central entities such as MARD and local governments such as DARD is essential to ensure cohesive understanding across all relevant agencies regarding the role and efficacy of emissions trade, thereby avoiding potential conflicts from future policies.

Table 2. Governance Framework operating carbon market system in Vietnam.

Governance Framework	Description
International commercial law obligations	Vietnam fully complies with the World Trade Organization (WTO) as a member of WTO, which potentially influences the enactment of legislation to build carbon markets.
Regional commercial and investment law obligations	Vietnam has entered into bilateral Free Trade Agreements (FTAs), which grant certain trade preferences to participating countries but can create platforms for carbon markets.
Sustainable development goals of the national climate change strategy.	Vietnam signed the Kyoto Protocol and the Paris Agreement. In the Paris Agreement, Vietnam aims to target climate change and GHG emissions: Nationally Determined Contributions (NDC).
The national system of policies, laws, and regulations	Decree 06/2022/ND-CP dated January 7, 2022, on mitigation of greenhouse gas emissions and protection of the ozone layer Circular 01/2022/TT-BTNMT dated January 7, 2022, detailing the implementation of the Law on Environmental Protection. In the field of climate change response Circular No. 17/2015/TT–BTNMT stipulates the construction and implementation of the project under the Common Credit Mechanism within the framework of cooperation in the field of environmental protection—Low-carbon growth between Vietnam and Japan. Decision No. 01/2022/QDTTg dated January 18, 2022, promulgates the list of fields and facilities that emit greenhouse gasses that must carry out a greenhouse gas inventory

Between 2021-2030, Vietnam will maintain the engagement in the "Partners for the Implementation of Carbon Markets" initiative by the World Bank to establish and develop a carbon market (USAID, 2022). The Transformative Carbon Asset Facility (TCAF) has supported the government program to transition one million hectares to high-quality, low-carbon rice within this framework. This financial assistance serves multiple objectives: the achievement of NDCs, the implementation of market-based carbon pricing, and private-sector investments in low-carbon technologies. Upon the successful realization of the NDCs, carbon credits issued from emission reductions in this project will be allocated back to donor nations based on the TCAF agreement formula (TCAF, 2020):

$$\frac{NPV}{NPV + \frac{Total\ reduction - NDC}{Total\ reduction} \times TGV} \times (Total\ reduction - NDC)$$

However, the precise quantity of carbon credits slated for distribution to donor nations remains uncertain, primarily attributable to the perceived lack of transparency within the operations of TCAF.

Given opportunities for reforestation and afforestation, abundant renewable energy resources, and commitment to addressing climate change, Vietnam is examined as a country with various advantages to developing a voluntary carbon market (USAID, 2022). Within the framework of voluntary carbon markets, corporations have the discretion to procure carbon offsets to augment their environmental certification (Lou et al., 20). Private sector entities primarily purchase voluntary carbon credits. Integral to the functioning of the voluntary carbon market are the certification processes and the establishment of a carbon trading platform.

Accredited organizations certify voluntary carbon credit with distinct standards from those governing the compliance market (USAID, 2022). These standards are aided by independent verification bodies to ensure that carbon reduction projects follow their strict regulations in offsetting. One example is the Gold Standard integrates the UN Sustainable Development Goals into its certification process for offset projects. The carbon credit certification relies on organizations and their protocols, which influences the quality of carbon credits and subsequently market prices.

To facilitate the trading of carbon credits, a dedicated digital platform must be established. Addressing the specific context of Vietnamese farmers, the Business Partnership Platform (BPP) has been building a partnership to simplify and mitigate the risks related to accessing carbon markets for rice producers in Vietnam (Business Partnership Platform, 2024). Constructing a framework leverages the potential of the rice sector to mitigate methane emissions, thereby providing Vietnamese farmers with a pragmatic and economically feasible avenue to generate supplementary income streams.

2.4 MRV systems

The implementation of novel carbon credit trading systems and the establishment of a reliable functioning market require establishing new rules and procedures governing the measurement, reporting, and verification (MRV) of emissions (USAID, 2022). MRV protocols are vital in providing precise data essential for tracking NDCs and enabling farmers to convert their sustainable practices into tradable credits within carbon credit markets. Historically, tracking carbon emissions in rice farming has been arduous (Saha et al., 2022); however, emerging technologies such as remote sensing and machine learning have revolutionized MRV processes, offering effective means to monitor emissions in rice farming.

Integral to the efficacy of MRV is the requisite reporting to relevant authorities, which ensures a quality control system ensuring compliance with established standards (Long et al., 2019). Furthermore, verifying reported data is essential, a responsibility typically entrusted to either government bodies or an independent third party such as the Gold Standard. This verification process affirms the integrity and accuracy of reported emissions data, thereby enhancing the reliability of the carbon credit trading system.

The collaborative efforts to develop MRV in rice farming involve stakeholders from two distinct sectors: NGO and the private sector. For instance, Carbon Farm has leveraged satellite imagery technology to detect emissions in rice fields (Raturi, 2024). As the development of MRV techniques progresses, the imperative to transition from research-based to practical, farm-applicable systems is vital for scaling up MRV capabilities and achieving widespread adoption across rice farming communities. Ultimately, to achieve the project of

transitioning to one million hectares, the techniques for MRV must be not only effective but also cost-effective. Cost-effectiveness is critical in ensuring the feasibility and sustainability of large-scale measuring systems, thereby promoting broad engagement of stakeholders in rice farming.

3. Risks in implementing the 1Mha project

A risk analysis will be performed to map the risks involved in the project's implementation. This analysis will identify important risks for the implementation of the project and investigate possible solutions.

The risk field has two main tasks, (i) to use risk assessments and risk management to study and treat the risks of specific activities, and (ii) to perform generic risk research and development, related to concepts, theories, frameworks, approaches, principles, methods and models to understand, assess, characterize, communicate and (in a wide sense) manage/govern risk (Aven and Zio, 2014?.

Upon literature review and stakeholder interviews, several risks to the implementation and success of the 1Mha project surfaced, encompassing financial, market, technological and socio-economic domains.

3.1 Financial Risk

The financial risks defined in this context encompass not only potential monetary losses but also difficulties in securing requisite funding. The lack of investment in progress extends beyond MRV infrastructure to essential components for agronomic practices to mitigate carbon emissions such as irrigation systems, roads, bridges, and machinery (The Ahn, 2024; Nguyen,2023). This deficiency in infrastructure investment is likely exacerbated by historical mismanagement and opacity surrounding the allocation of funds, notably within the VnSAT project. Transparent dissemination of data is essential to empower potential investors with the necessary insights to assess the value proposition of initiatives of the 1Mha project. According to Lou et al. (2023), companies that were willing to invest in high-cost projects that provide significant local co-benefits were driven by values and market competitiveness. Thus, transparency of funding for this project in cooperation with the government will be an important strategy to attract investors.

Specifically, the development and deployment of new MRV protocols, alongside the procurement of requisite technologies, require substantial financial resources from both the public and private sectors. However, entities such as CarbonFarm, engaged in MRV development utilizing earth observation satellite data, encounter challenges in securing investment for acquiring higher quality satellite data (Raturi, 2024). This shortfall in investment poses an impediment to the advancement of MRV systems, ultimately impeding the establishment of carbon markets in Vietnam. Enhanced transparency in information dissemination by the government plays a critical role in attracting investors, allowing them to analyze the feasibility and thus decide on investments.

Additionally, governmental agreements about carbon credit availability post-NDC and TCAF stipulations must be made publicly accessible to mitigate uncertainty. Prospective investors face increased financial risks in the absence of clarity regarding the quantum of carbon credits slated for release into the markets. Furthermore, access to agricultural credit remains restricted for farmers, particularly smallholders, who encounter obstacles in securing agricultural credit from banks (The Ahn, 2024). This restricted access threatens farmers' capacity to adopt and operate sustainable methods, thereby endangering the success of the 1Mha project. In response, governmental efforts to incentivize the formation of cooperatives provide a practical solution, facilitating shared access to infrastructure and machinery while also enhancing farmers' access to carbon markets.

3.2 Market Risk

Market risks refer to the risks associated with the carbon and rice markets. For the carbon markets, the first risk lies with the fact that even though the government is defining the policies and frameworks for its implementation, there is still no domestic carbon market in Vietnam, leading to some insecurity regarding what is to come (Ramthan & Chen, 2024; Raturi, 2024). Through research and conducted interviews, the absence of robust regulations and policies governing the Carbon credit market has surfaced as a risk, as observed by stakeholders such as Agrig8 and Rikolto. This lack causes a feeling of uncertainty and insecurity in the market. As previously mentioned, there is still not an established carbon market, and the government is working on a framework for the policies and regulations that will regulate it.

The Vietnamese Government has established ambitious NDC(s) (Table3), which, due to the requirement of additionality for issuing carbon credits may pose a risk to the eligibility of the emissions reduction from the project (TCAF, 2020).

Table 3. Comparison of emission reduction targets in NDC 2020 and NDC 2022 (Vietnam, 2022).

Sector	Unconditional Contribution				Conditional contribution			
	NDC 2020		NDC 2022		NDC 2020		NDC 2022	
	(%)	(MtCO2e)	(%)	(MtCO2e)	(%)	(MtCO2e)	(%)	(MtCO2e)
Energy	5.5	51.5	7.0	64.8	16.7	155.8	24.4	227.0
Agriculture	0.7	6.8	1.3	12.4	3.5	32.6	5.5	50.9
LULUCF[1]	1.0	9.3	3.5	32.5	2.3	21.2	5.0	46.6
Waste	1.0	9.1	1.0	8.7	3.6	33.1	3.2	29.4
IP	0.8	7.2	3.0	27.9	0.9	8.0	5.4	49.8
Total	**9.0**	**83.9**	**15.8**	**146.3**	**27.0**	**250.8**	**43.5**	**403.7**

[1] Increasing GHG removal

There are also doubts regarding the reliability of the credits related to the utilization of different MRV standards, some standards like the private international carbon trading (ICROA) are more reliable and produces better quality credits when compared to the World Bank or TCAF current standards (Cullinane, 2024). The variability mentioned before will contribute to the differences in Carbon credit pricing wish contemplate a wide range of values (World Bank, 2023). Sharing information and experiences on the development of MRV mechanisms in different countries can facilitate harmonization and help build the foundation for linking emerging systems in the future.

There is significant uncertainty about which carbon credit markets Vietnamese smallholder farmers will have access to and what the implementation of MRV standards will require from them and how they can benefit from this, but as mentioned before the BPP and other organizations is working on digital platforms that facilitate smallholder farmers' access to carbon markets (Business Partnership Platform, 2024).

Furthermore, distrust in carbon credits derived from rice systems may result from previous instances of project failures, such as the case of the Shell Oil rice carbon credits project (Civillini, 2023). Such failures can undermine confidence in the integrity and viability of carbon credits sourced from rice-based projects. These market risks underscore the importance of establishing transparent and reliable mechanisms for carbon credit certification and trading, as well as developing trust and credibility within the market ecosystem.

For the rice market, the risks lie in the significant volatility of rice prices and the uncertainty regarding the ability to get a premium in price for low-emission rice (Ramthan & Chen, 2024), which may compromise the goal of increasing farmers' income. There are some certifications that people are willing to pay a premium price for, in a study with Vietnamese consumers it was shown that consumers are willing to pay an average of 29% premium for SRP rice and that consumers' willingness is influenced by household income and knowledge related to carbon emissions and climate change (Connor, 2022). The Vietnamese government is also looking to create a National low-emission rice label to valorize this low-emission and high-quality rice from the 1Mha project. Another way to alleviate this risk could be through public-private partnership (PPP) that establish Purchase commitments like the one Unilever has with tea cooperatives in Vietnam (Veco, 2013).

3.3 Technological Risk

Technological risk in this project was defined with two risks: infrastructure and operational. The risks associated with the lack of physical and technological infrastructure were defined as technological - infrastructure risk. There is a lack of infrastructure needed for the implementation of AWD and straw management (collection, transportation, storage) (The Ahn, 2024). Another Technological (infrastructure) risk is the poor resolution, less frequent satellite data, and limited Internet connection for the collection of data from farmers used for the MRV process (Ramthan & Chen, 2024; Raturi,2024). Satellite data with better resolution and frequency can help to improve the accuracy of the MRV process.

Other Technological risks associated with the operationalization of the project were defined as technological-operational risks. One of these risks is the lack of labor availability and knowledge to implement the practices. There is still a significant number of farmers who are not yet in a cooperative which makes it harder to disseminate information, to train them, and makes it harder to get investment, and consequently to adopt sustainable practices (The Ahn, 2024). To reduce this risk, as mentioned before, the government is promoting the creation of cooperatives, when this is not possible farmers can be reached through extension services, water systems, and innovative farmers who are not yet in a cooperative.

Another risk is the fact that the Monitoring system that is going to be used has not been identified (The Ahn, 2024). Clear guidance on MRV helps to improve stakeholder understanding of system requirements. For example, guidance on monitoring will include requirements for monitoring equipment, monitoring, data collection, and emission calculation methods. Reporting guidelines will include data and report format, submission deadlines, responsible agencies, and penalties for false submissions. The verification guidelines will include accreditation standards and procedures, verification requirements, and rules.

There is also a challenge in identifying the baseline; there is not accurate data on the areas that have not implemented AWD yet (Cullinane,2024; Raturi,2024) (Fig. 2). Finally, another big challenge will be the coordination between all the many stakeholders involved in the 1Mha project, as the project does not only include over one million farmers but many stakeholders from the government, research institutes, private companies, and many others.

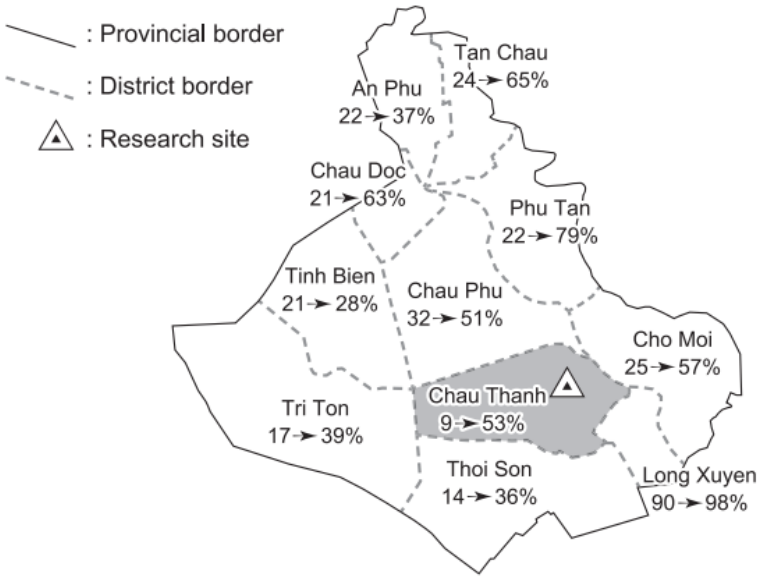

Fig. 2. Rates of AWD technology applied to districts in An Giang province in 2009 and 2013. Source: Yamaguchi et al., 2016.

3.4 Socio-economic Risk

Socio-economic risk refers to the potential negative impact on the 1Mha project arising from economic and social factors. Almost 20% of the risks individuated are part of this category. The socio-economic aspect of the risk analysis pertains to the behavioral patterns exhibited by farmers which may impede the successful execution of the 1 Million Hectares project. This necessitates a comprehensive examination focusing on the farmers' propensity towards adopting and integrating sustainable practices, as well as issues such as insufficient transparency and inherent distrust in data collection processes.

Through further research, it became apparent that the inclination of farmers to embrace sustainable practices correlates significantly with the potential financial gains achievable following transformations in their agricultural practices (Tuan, 2024; Nguyen, 2023). This connection poses a risk that is connected to other factors, particularly financial risk because the funding from investors directly impacts whether farmers can afford to use the sustainable methods required by the 1Mha project. Attention must be directed towards the risks associated with resource availability, which manifest as competition for land and labor resources from urban areas. Mitigating these risks necessitates political intervention for effective management (Nguyen, L. ,2023). One instance could involve the implementation of a taxation system targeting the water consumption within irrigation procedures. This measure would potentially incentivize farmers to exercise greater caution in water usage and to adopt more sustainable practices, such as Alternative Wetting and Drying (AWD).

Additional factors contributing to this risk include the absence of transparency and a deficit in human trust during the data collection process (Ramthan & Chen, 2024; Raturi,2024). Consequently, relying solely on direct inquiries posed to farmers for data acquisition is deemed inadequate, given the absence of mechanisms to authenticate the veracity of provided information. On the other hand, the 1Mha project aims to introduce technological solutions that enhance the reliability and integrity of data and information retrieval processes.

4. Cost-benefit analysis of 1Mha project

The Cost-Benefit Analysis (CBA) serves the purpose of assessing the costs and benefits associated with the 1MHa project. This analysis will be performed with the help of the "COMPARE – Cost Impact Analysis for Rice Emissions (International Rice Research Institute & UNIQUE Forestry and Land Use, Ha Noi, Vietnam)" which has as outputs economic and carbon impacts of different management practices in rice production, making use of the data already used in the tool after accounting for inflation and a BAU scenario.

4.1 Necessity of accounting for Inflation for input prices

The COMPARE tool contains default values from 2019. The world has faced many serious challenges after that, for example, the COVID-19 pandemic and wars, which have especially impacted the prices of certain input materials in a high volatile market, making it necessary to update the recent costs of such products. Figures 3 and 4 show how the prices of common farming commodities like fertilizers, fuel, pesticides and seeds have changed over the last five years respectively. Figure 5 shows the overall inflation over these years.

The accuracy of the cost-benefit analysis can be compromised if inflation is not accounted for. This can affect a project's economic viability and thus, can result in an unfavorable decision-making process.

Fig. 3. Producer Price Index (PPI) of fertiliser, fuel and pesticide from 2014 to 2024. The reference PPI value of 100 was in June 2003 for pesticide and 1982 for fertiliser and fuel respectively. The data used in this dataset is from the US Bureau of Labour Statistics. The assumption here is that we expect the Vietnam economy to fluctuate in a similar fashion as the US (Source: U.S. Bureau of Labor Statistics, 2024).

Fig. 4. The Agricultural Means of Production Purchase Price Index (IPAMPA) from 2014-2023. IPAMPA measures changes in the purchase prices borne by agricultural holdings. This data is collected from The National Institute of Statistics and Economic Studies, France. The assumption here is that we expect the Vietnam economy to fluctuate in a similar fashion as France. (Source- INSEE, 2024)

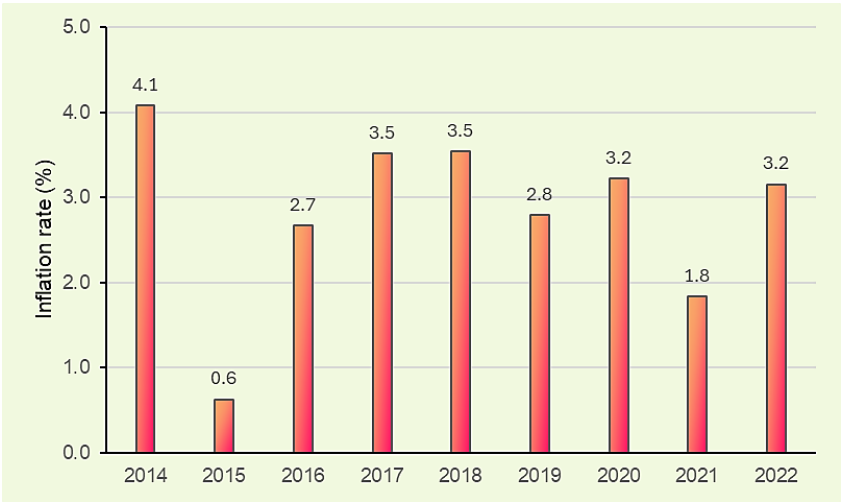

Fig. 5. The inflation rate in Vietnam from 2014 to 2022. (Source: International Monetary Fund, 2024)

To account for inflation, the CBA uses updated costs on fuel, fertilizer, herbicide, rice seed and labor (minimum wage). For material costs, this is done by analyzing the difference of average PPI (Producer Price Indices) from 2019 and 2023. This difference reflects the increases in costs and are multiplied with the costs in the tool presenting the costs of farmer surveys in 2019. This way, the input costs of the tool, better presented the current day costs. It should be noted that PPIs from databases outside of Vietnam are used, which limits the accuracy. This is due to a low accessibility of data for PPIs of Vietnam. However, by comparing the values from the database to newspaper articles, the values seemed to reflect the same dynamics as the market in Vietnam. For labor costs, updates on the Vietnamese minimum wage costs have been used as a reference for increase in labor costs (Vietnam Briefing, 2024).

Apart from fluctuations in costs of rice production, rice prices have also changed. With inflation, rice prices have increased (Fig. 6). These increases will cause a larger revenue for rice sold by the farmers and trade companies. In the CBA, we have accounted for the rice price, by using values that are representative of 2023. Thus, both for income and costs, prices have been adapted to represent the current state of the market.

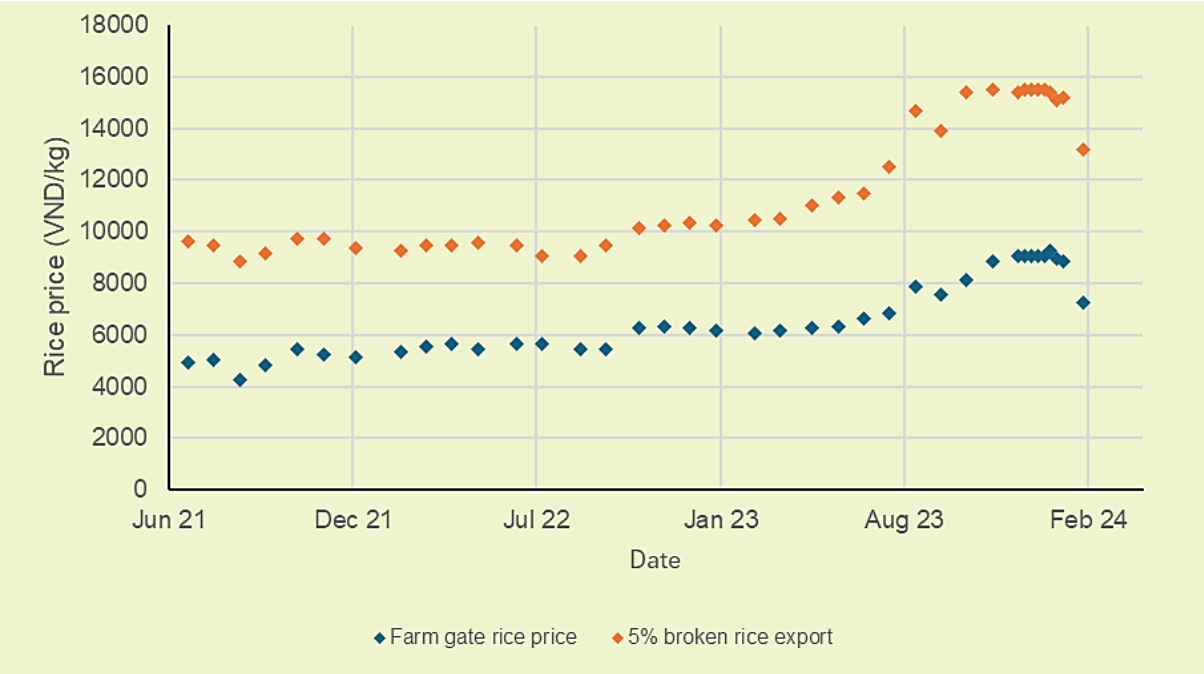

Fig. 6. The evolution of Farm gate and 5% broken rice export prices from June 2021 until April 2024 (Source: Vietnam Food Association, 2024)

4.2 Land-use change: 1MHa project

In the CBA analysis, 4 categories of land-use were identified: Traditional, Straw, 1M5R and 1M5R + Straw. These categories can be described as follows:

1. *Traditional:* prescribes traditional farming (continuous drainage; no change in pesticide, herbicide etc. use).
2. *Straw package:* prescribes traditional farming with the collection and selling of straw.
3. *1M5R:* prescribes the 1M5R farming method without straw collection and selling.
4. *1M5R + Straw:* prescribes the 1M5R farming method with straw collection and selling.

By the end of the 1MHa project, one million hectares of the MRD should be farmed using sustainable farming practices, according to 1MHa project guidelines (according to Decision No. 1490, dated November 27, 2023). At the start of the project, approximately 180.000 hectares were farmed mostly using 1M5R, in compliance with the VnSAT project (CGIAR Research Program on Rice, 2021). Of all farming land in the MRD, approximately 30 % performs straw selling and collection (DCP, 2023). According to the government, this will have increased up to 100% by the end of the 1MHa project. With this information, the scenario for the 1MHa project was created, following these guidelines as follows:

Initial state

The land from VnSAT is assumed to be farmed using the 1M5R method. From this land, 30% is performing straw selling and collection and thus attributed to the 1M5R+Straw package. The rest of the one million hectares is assumed to be farmed traditionally. From this land, 30 % is performing straw selling and collection and thus attributed to the Straw package.

Conversion

For 8 years, a complete conversion from traditional farming to 1M5R was implemented in the CBA. Simultaneously, a growing fraction of both traditional and 1M5R is said to perform straw selling and collection, up to 100% at the end. Thus, at the end, all land is said to be converted to the 1M5R+Straw package (Fig. 7, Fig. 8). To account for carbon credits, the project timeline runs for 21 years (TCAF, 2020). During the Autumn-Winter season (Fig. 7), the total project area is reduced due to a smaller fraction of farmers practicing rice cultivation during this season due to flooding as a result of the rainy season.

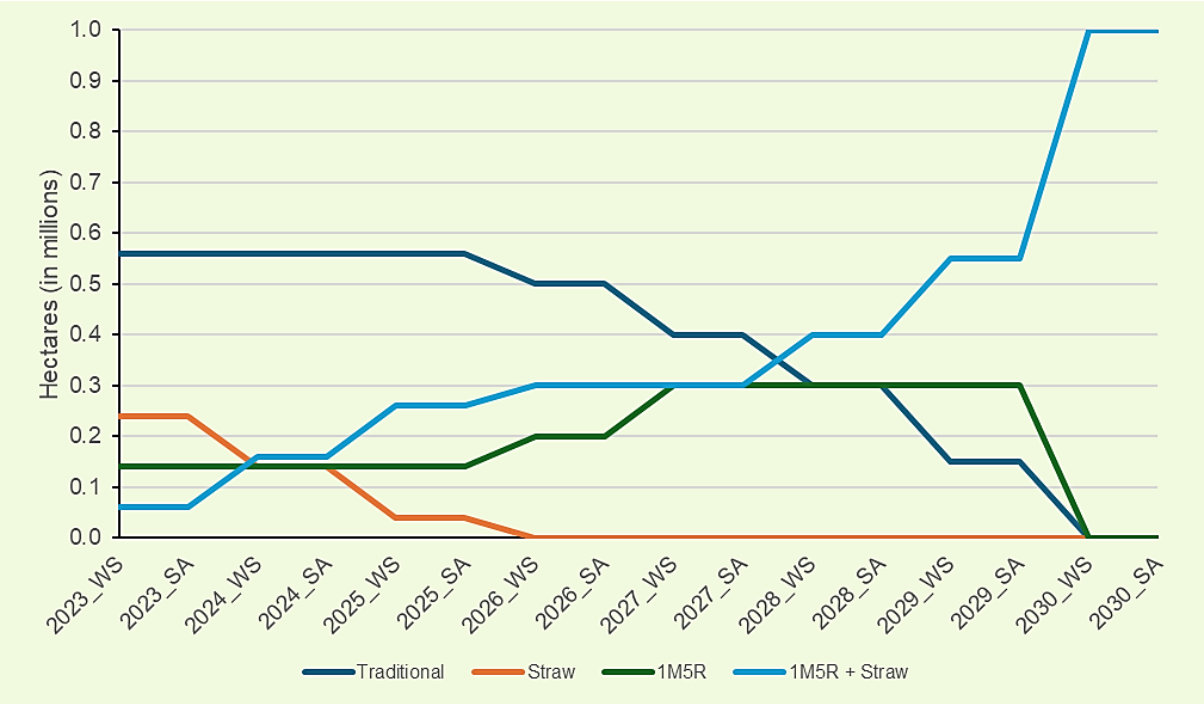

Fig. 7. Land-use changes projected for the 1MHa project for the Summer-Autumn and Winter-Spring season for a total of 1,000,0000 Hectares

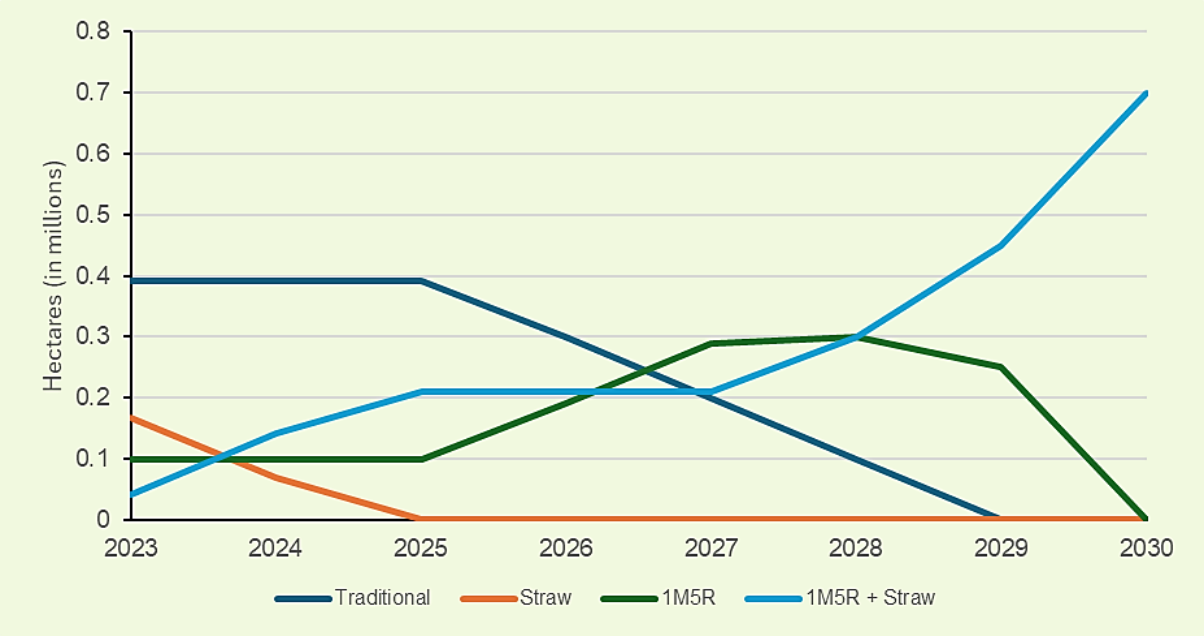

Fig. 8. Land-use changes projected for the 1MHa project for the Autumn-Winter season for a total of 700,000 Hectares

4.3 Cost-Benefit Analysis: 1Mha project

This section explores the possible outcomes of the 1MhHa project. The cultivation of rice with improved agronomic packages led to the reduction of carbon emissions (Figure 9). 1M5R practice often has AWD as the irrigation management practice, hence the reduction is identical. A practice of 1M5R along with straw management results in the promising practice for carbon emission reduction and realistic, given the guidelines of the 1Mha project.

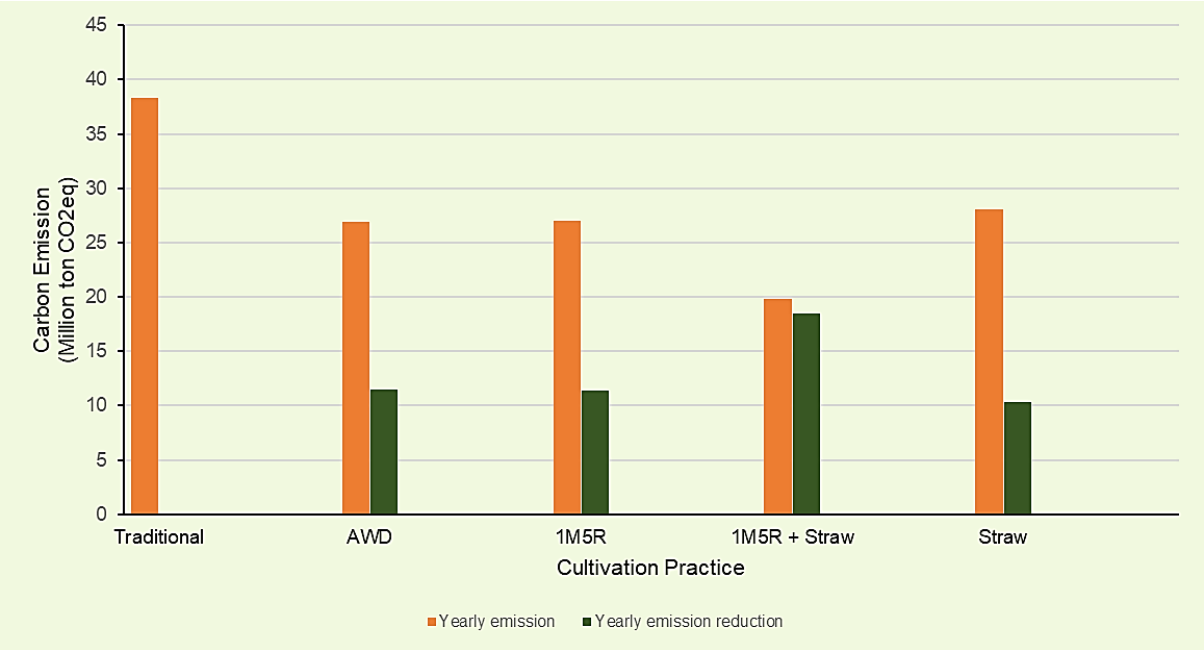

Fig. 9 . Yearly emissions reduction potential if cultivation practice is applied to the total area of 1 Million Hectares project, from a baseline of traditional cultivation. This analysis conveys the emission reduction potential of different cultivation practices on the scale of the Mekong River Delta, but it does not consider fragmented farmer-level application of different practices simultaneously.

In both versions of the tool, the net-annual revenue was higher for the project scenario as compared to the Business As Usual (BAU) (Fig. 10). For the original (o.g.) version of the tool (without accounting for inflation) the project had a higher annual net revenue of 8.6 %. This is comparable to the new tool output; here the project annual net revenue was 8.4 % higher than the BAU. For the new version, the net-annual revenues were significantly higher as compared to the old version. For the proposed project scenario this caused an increase in net-annual revenue of 53.5% in the new tool as compared to the original.

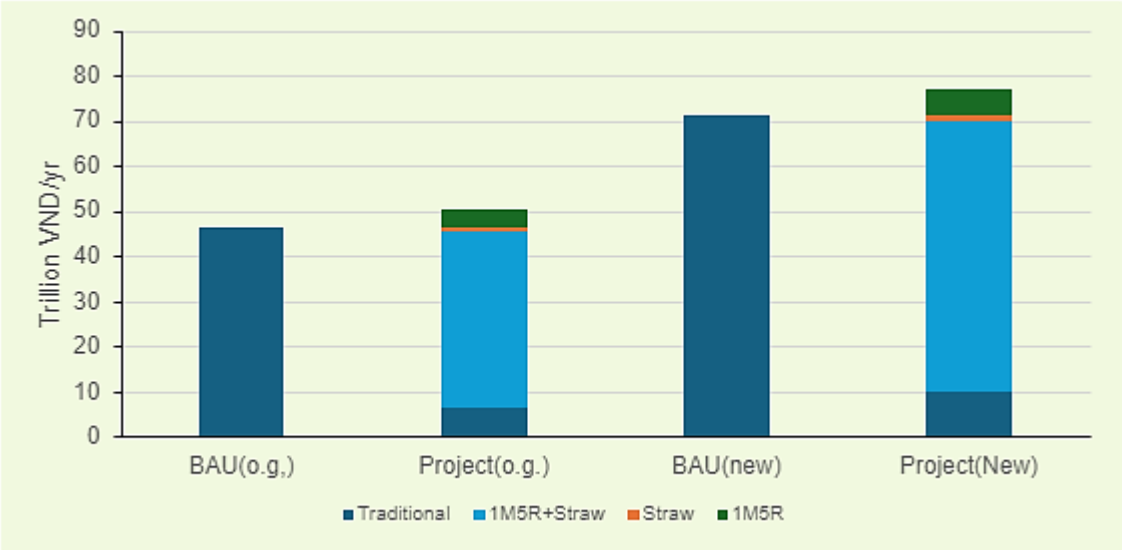

Fig. 10. Total net revenue output of the CBA of the original (o.g.) tool and the new tool.

The CBA accounts for costs outside farmers' costs (such as e.g. training costs, implementing MRV) through implementing timelines of Capital and Operational expenses (CAPEX and OPEX respectively). The CAPEX describes costs only having to be established once, e.g. setting up the MRV and training farmers. OPEX describes the costs that are continuous, in this case the maintenance of MRV-systems. In figure 11, the timelines of the CAPEX and OPEX are plotted for the scenario. The costs are based on the financial information that was presented in the Investment guide for low-emission rice from CGIAR (Tran VT et al, 2019).

We estimate that the total project costs will be 440 million USD, of which 86 million USD is in capital expenditures (CAPEX) until 2030, and 360 million USD is in operational expenditures (OPEX) lasting 21 years for the lifetime of the project. Estimated CAPEX costs include registration of the project, capacity building for the required for the training programs, assessment of the current baseline of AWD application, further development of the MRV systems, certification standard and protocol, initial verification, and validation of the application of the MRV system. OPEX costs cover the seasonal verification that is required for registration of smallholder farmer carbon emissions reductions.

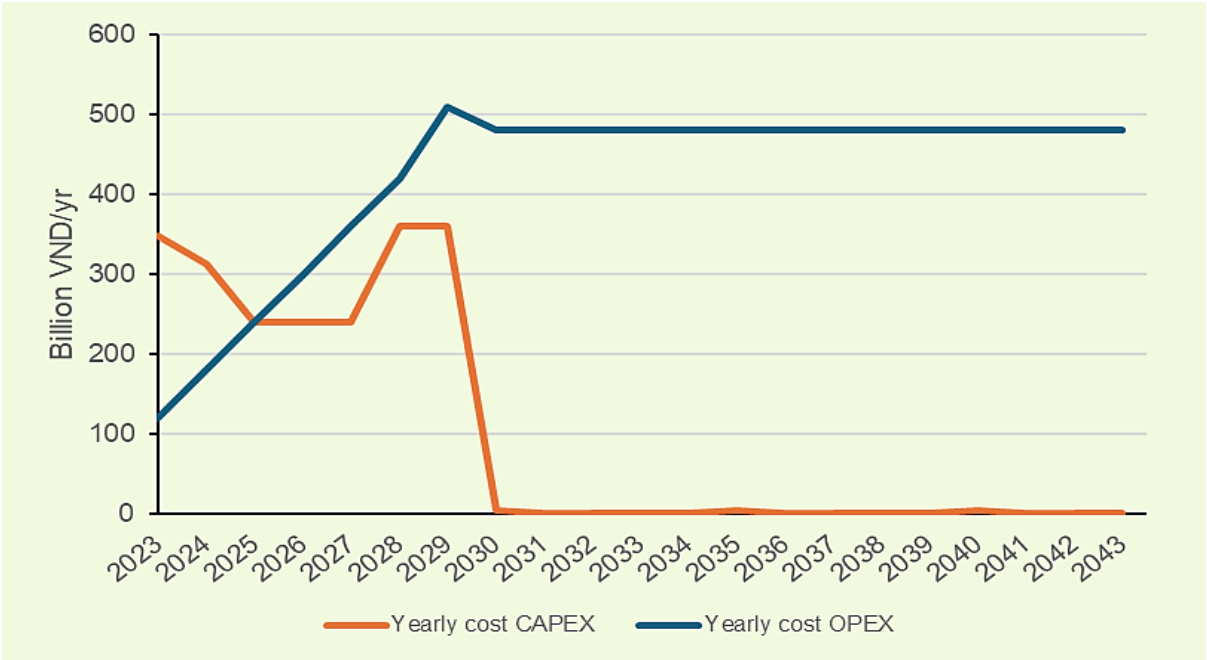

Fig. 11. Evolution of CAPEX and OPEX costs during the timeline of the project.

The project scenario showed a significant decrease in emissions compared to the BAU (Fig. 12). In total, during the project, 318.6 million tons of $CO_{2\ equivalents}$ have been abated. This equals an annual reduction of 15.2 million tons of $CO_{2\ equivalents}$, which amounts to a reduction of 38.1 percent. Per hectare of farmland, the emission reduction comes to 5.6 tons of $CO_{2\ equivalents}$ per hectare per year.

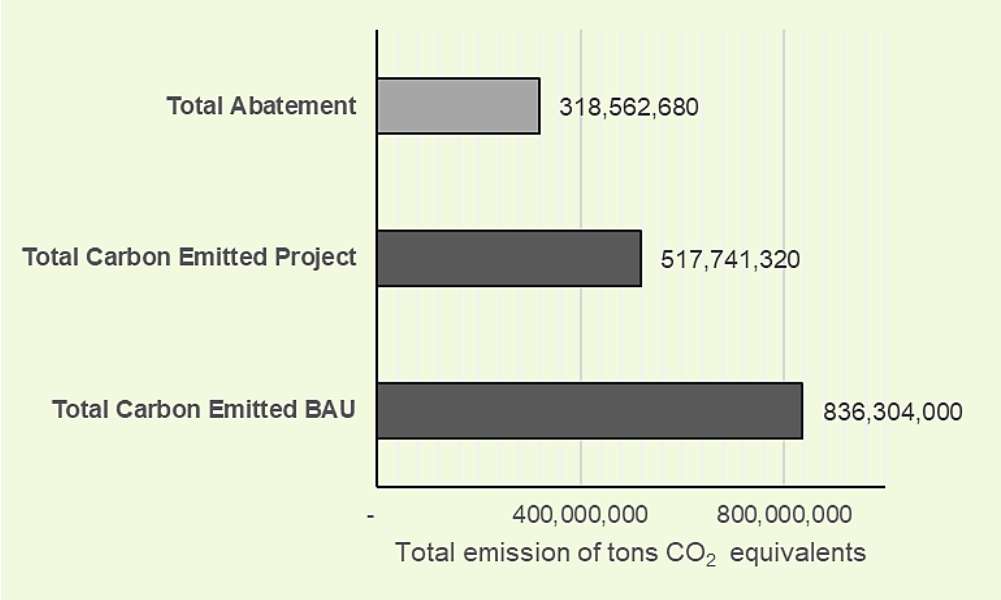

Fig. 12. Differences of GHG emission between the BAU and project scenario for 21 years.

The evolution of carbon emissions reductions over the 21-year lifetime of the project allows for the generation of carbon credits. There is a large amount of uncertainty with respect to the revenue that can be generated from these carbon credits because it remains unclear what the expected contribution of carbon emission reductions from rice cultivation will be used to meet the NDC targets. In Figure 13, it is assumed that all of the emissions reductions will be saleable, which is not realistic, but serves to indicate a maximum revenue that can be achieved. As further transparency is provided with respect to Vietnamese negotiations of their NDC agreements and TCAF policy, this will be adjusted to improve the validity of potential carbon credit revenues that can be distributed to farmers and other stakeholders in the rice carbon credit value chain.

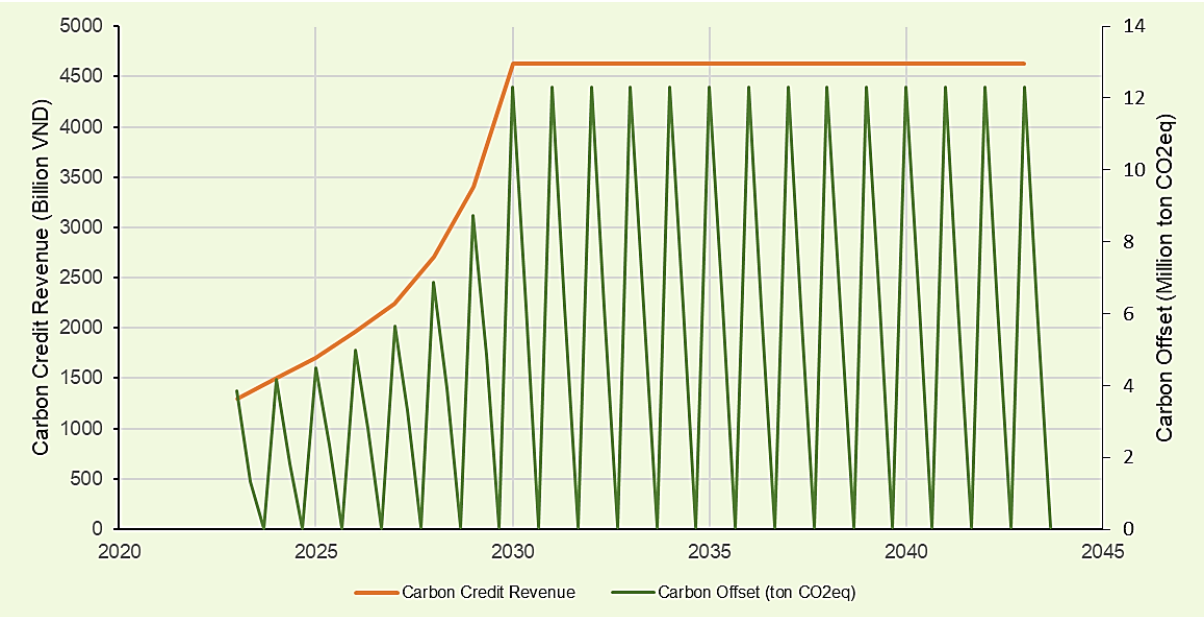

Fig. 13. Seasonal carbon offsets of the 1MHa project and the carbon credit revenue that is returned from this carbon credit generation. Note that the NDC contributions are not considered in this diagram.

In fact, according to our calculations, we estimate that it is not possible to reach the 27% emissions reductions (with international support) that has been targeted for the NDC of Vietnam by 2030. The 2030 goal could only be achieved by 2031 as shown in Figure 14. That being said, yearly reductions will be reduced by 27% of the baseline level by 2028. It may be important to consider long-term reduction goals when solidifying the goals of the 1MHa project.

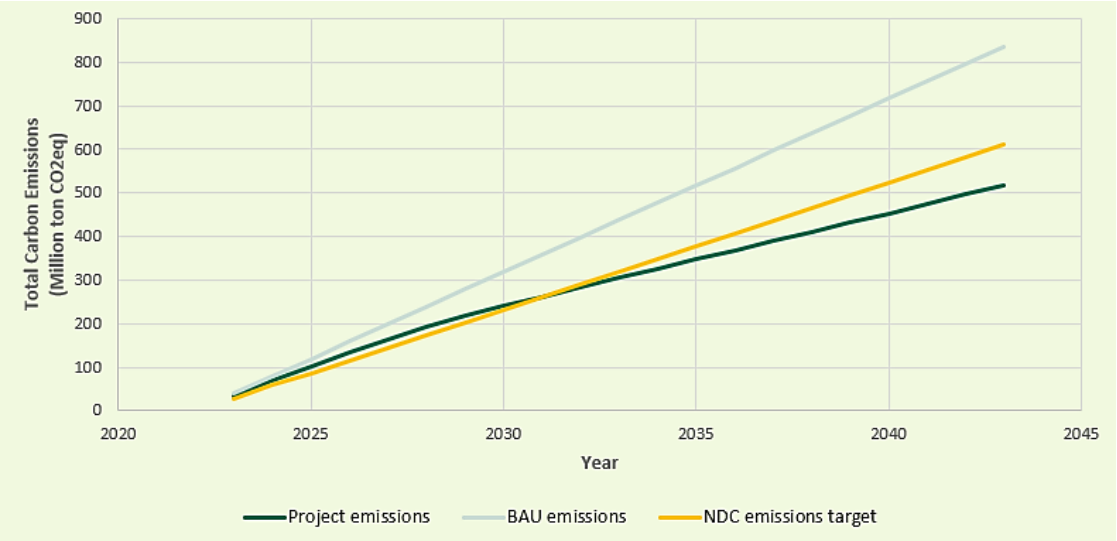

Fig. 14. Cumulative carbon emissions from 2030 for emissions from 1 million hectares of rice cultivation land in the Mekong River Delta under business-as-usual management, the 27% reduction NDC target, assuming international support, and the predicted emissions under the 1MHa project.

4.4 Valuation of Irrigation

Water management policy has played an important role in supporting the highly productive cultivation of rice in the Mekong River Delta (Tran, D. D., & Weger, J., 2018). The Vietnamese Government has invested heavily in irrigation infrastructure in this region to reduce the costs of rice production and promote farmers' incomes. Since 2008, irrigation fees have been waived by the government, promoting water-intensive cultivation management. A consequence of this policy mechanism has been a much lower water use efficiency in rice production than neighboring countries (World Bank Group, 2016). Simultaneously Vietnam is incredibly vulnerable to impacts of climate change, exacerbating flooding, droughts, and heatwaves, which threaten rice production (van Dijk et al., 2013). Furthermore, saltwater intrusion, which has shown the capacity to jeopardize entire rice paddies, is increasingly occurring. This is especially critical in coastal regions of the Mekong River Delta during the Winter-Spring rice cultivation season, which has historically offered the highest profits to farmers (van Aalst et al., 2023).

Restructuring the valuation of irrigation water is a potential option to concurrently reduce regional water use and incentivize farmers to practice improved rice management strategies which reduce greenhouse gas emissions. Estimates of the value of irrigation in Vietnam range from approximately 250 VND/m3 to nearly 20,000 VND/m3, depending on the crop, region and method of estimation (Phu, 2023). Indeed, we calculated that if the flat rate (per hectare) irrigation costs (including water pumping costs) were replaced by a volumetric water price, the break-even price of irrigation water range from 240 to 400 VND/m3, depending on how irrigation water requirements are quantified (seen in Figure 15) as the intersection of Traditional and Traditional: non-volumetric cost curves). Depending on the management practice, which is utilized, and the hypothetical valuation of irrigation water, important differences in farmers' profits can be realized.

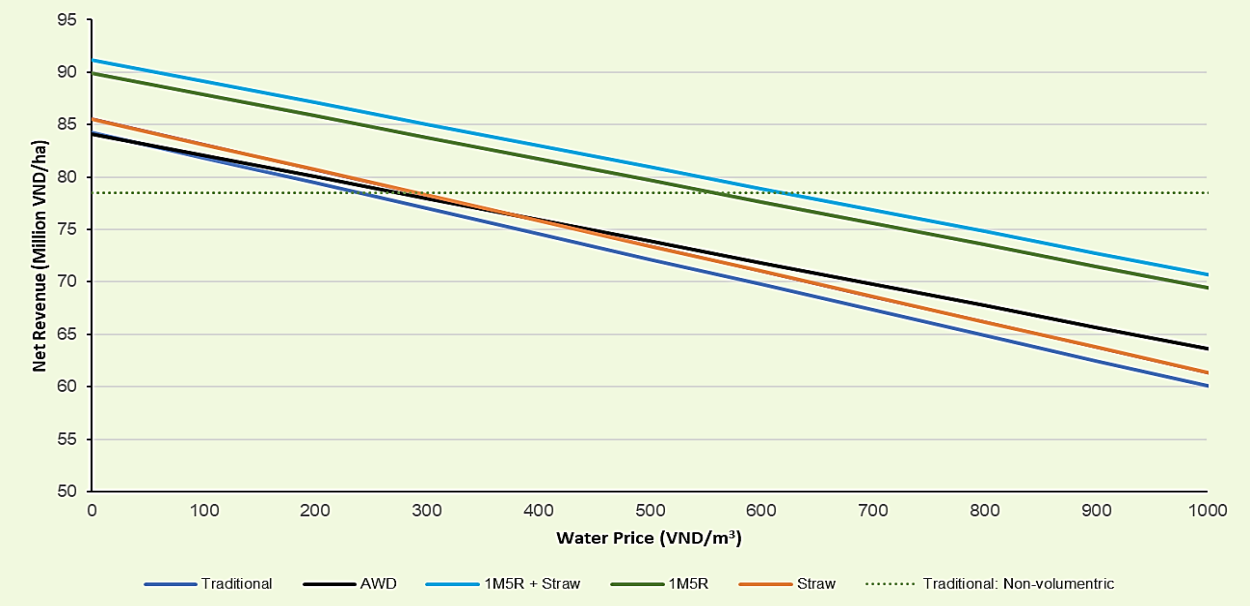

Fig. 15. Net revenue that is returned from volumetric water price for various rice cultivation packages compared to the current conventional system of traditional cultivation with a non-volumetric water price.

4.5 Premium Rice Pricing

Rice labeled as sustainably produced offers the potential to be sold to consumers at a higher price point, especially if it is certified by recognized standards, such as that of the Sustainable Rice Platform (SRP, 2024). Notably, demand for food quality labels in Vietnam is growing, and it has been estimated that domestic rice consumers may be willing to pay a 9-33% premium, depending on the level of knowledge of the certification standard (My et al., 2018). Research on the potential for international export of premium sustainably produced rice, in addition to the domestic market, is limited and requires further attention, but if it is pursued it may generate higher incomes for farmers and post-harvest processors and traders (as shown in Fig. 16). It will be important to consider how this additional revenue is distributed across stakeholders in the rice value chain. Our analysis allocates this additional revenue entirely to farmers, which is an oversimplification performed due to limited availability of and access to market research. Nonetheless, an additional revenue of 15-45 million VND may be generated per hectare.

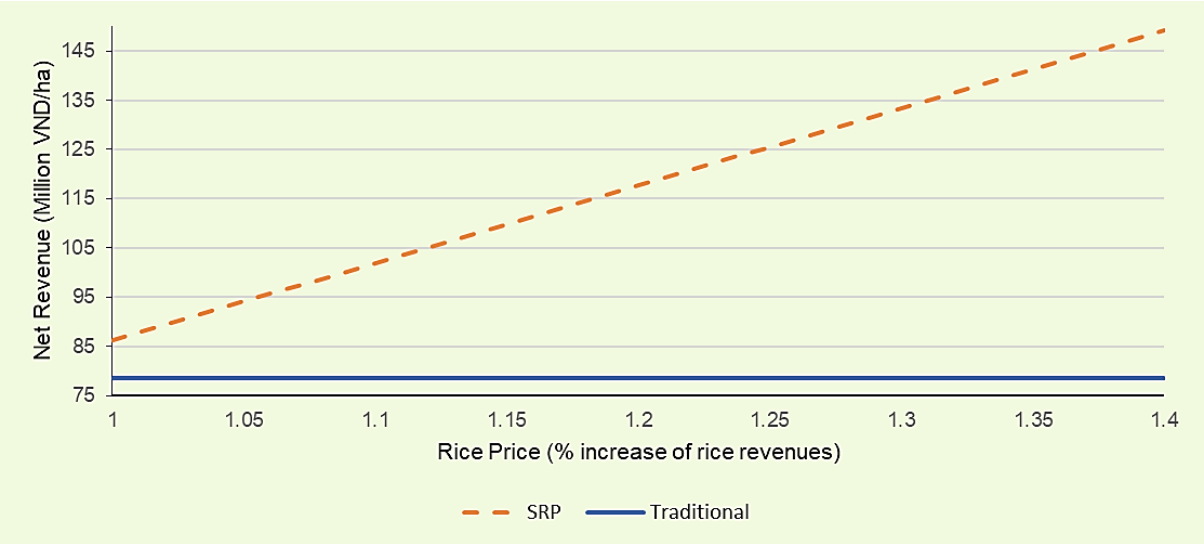

Fig. 16. Net revenue that is returned with increasing rice price for rice certified to be sustainably produced with low emissions, such as with the Sustainable Rice Platform (SRP) certification. Note that additional revenue from increased rice price will require distribution along the premium rice value chain and will not be returned entirely to farmers.

4.6 Carbon Credit Pricing

One of the main objectives of the Vietnamese 1MHa project is to establish and promote carbon credit trading systems for the emissions reductions associated with improved cultivation practices. This will generate increased financial incentives for farmers to transition away from conventional rice cultivation. That being said, establishing carbon credit is associated with many challenges, especially in agriculture, and the prices at which certified emissions reductions, or carbon credits, are sold, depend on the market schemes which are accessed: compliance markets such as Emissions Trading Systems (ETS) or voluntary carbon markets. 10 USD/ton CO2eq is often used as a benchmark reference point in discussions surrounding the price of carbon (World Bank, 2023). Vietnamese news sources have reported that the World Bank has agreed to purchase carbon emission reductions at this price through programs such as TCAF, but even through this program prices are variable (TCAF, 2020). Indeed, internationally the valuation and taxation of carbon emissions has an incredibly large range (Figure 17).

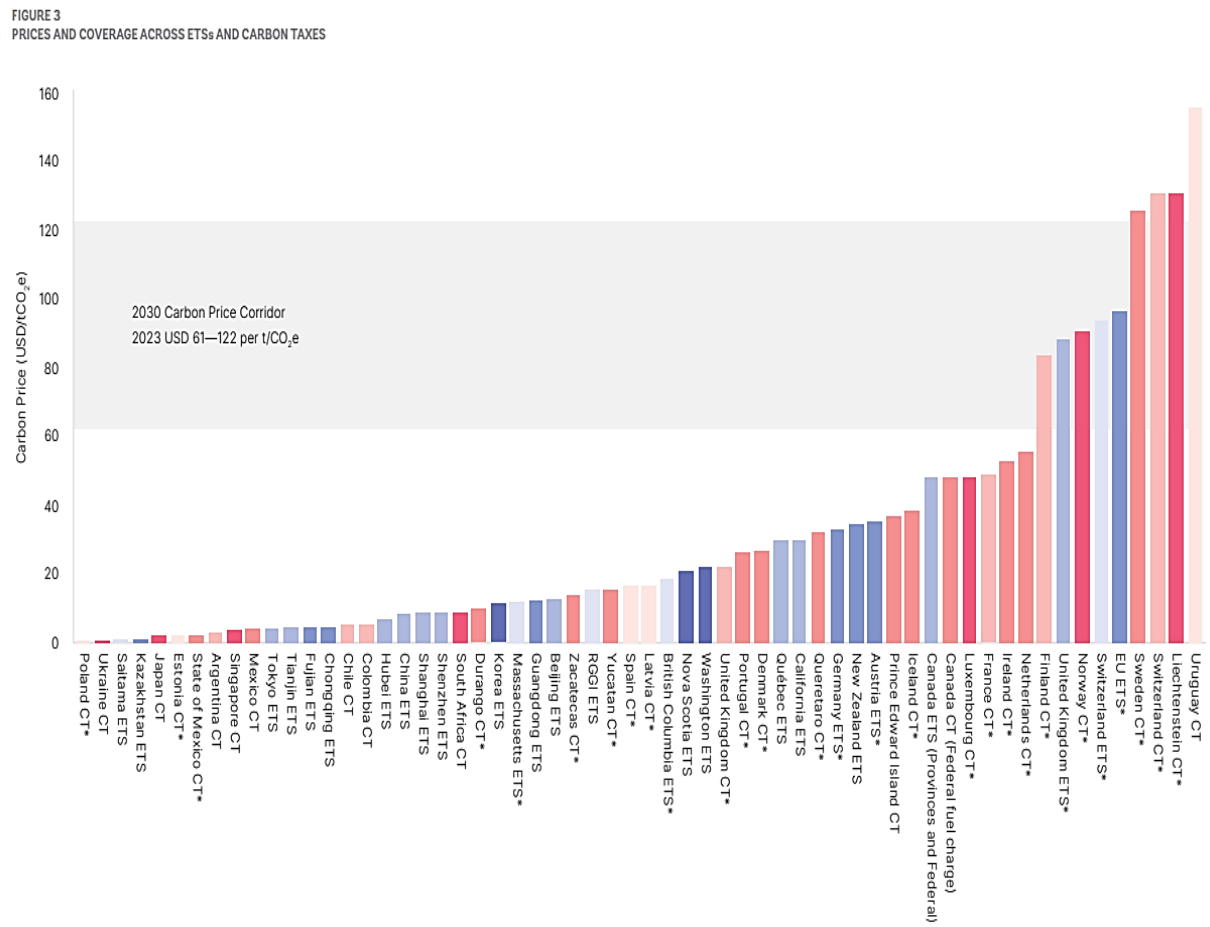

Fig. 17. Carbon price (USD/ton CO2eq) in 2023 for a range of carbon markets. Source: World Bank, 2023.

For our scenario analysis (Section 4.3), a price of 10 USD/ton CO2eq was used. Here we present potential revenue increases dependent on the carbon emissions price accessed. Notably, Vietnam is strengthening its domestic carbon mitigation schemes to aid in achieving the ambitious NDC mitigation goals that have been set. Clean Development Mechanism (CDM) projects have been implemented and a domestic emissions trading system (ETS) market is in development. Connecting agricultural producers to this market may provide a framework for rice emission reductions to be used to offset emissions of other industries which are either more difficult to reduce or unavoidable, such as those of mining, textile, and electrical manufacturing industries. Domestic prices would likely be much lower than purchase prices set by the World Bank, or those used in the European ETS, for example, which reached above 100 USD/ton in 2023. A recent study suggests that an initial carbon price around 2-4 USD/ton CO2eq would be a realistic carbon price to contribute to emission goals, with a 10% annual price growth rate. After 10 years this would realize a carbon price of around 4-8 USD/ton (Do & Burke, 2021). These price ranges more closely align with carbon prices and taxes in East and

Southeast Asian countries.

In Figure 18, we present an analysis of the potential revenue increases associated with increasing carbon credit valuation. The largest marginal benefits are realized by farmers performing 1M5R with straw management, as emission reduction per hectare of rice is the highest under this strategy. Other non-traditional cultivation strategies also benefit from increasing prices of carbon. The additional revenue realized per hectare must be distributed appropriately among stakeholders in the carbon credit value chain through royalties and transaction fees, such as third-party MRV companies and organizations and carbon credit traders.

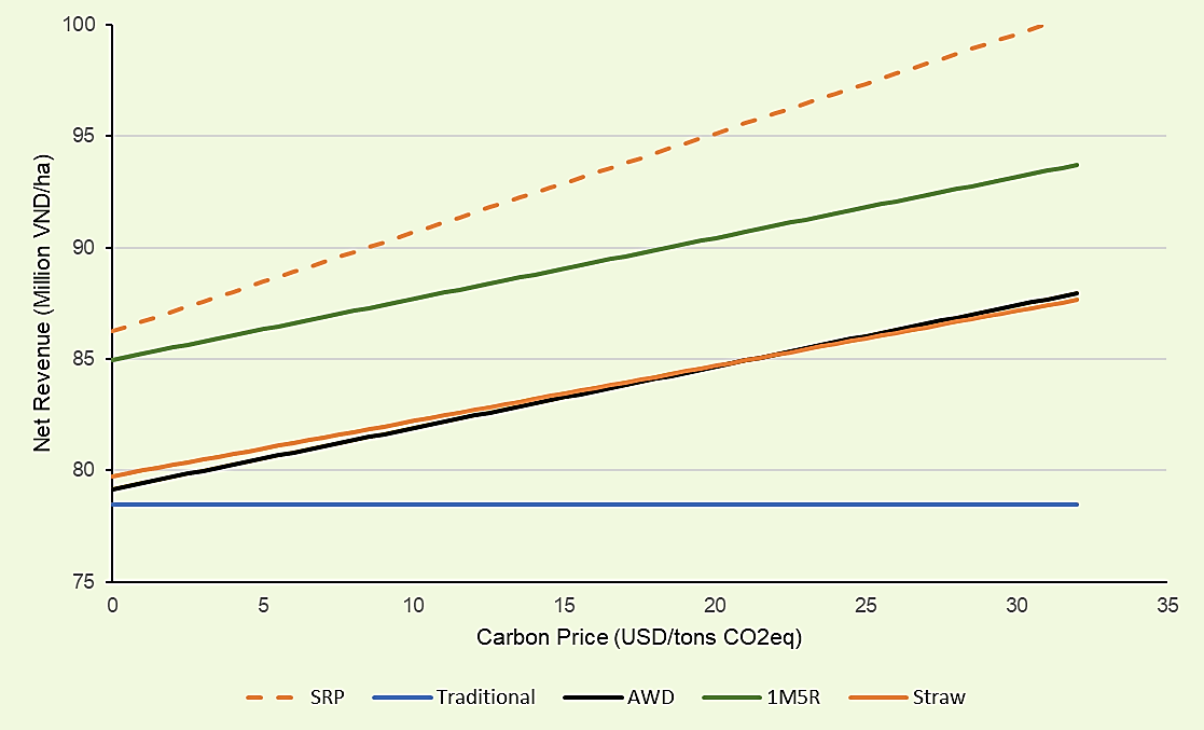

Fig. 18. Net revenue that is returned with increasing carbon price compared to the traditional baseline which does not generate carbon emissions reductions for carbon credits. Note that the profits will be distributed along the carbon credit value chain, and that NDC contributions are not considered.

5. Recommendations

We propose the following recommendations to our commissioner, Katherine Nelson, on behalf of IRRI to enhance the effort of reforming the agricultural landscape the Mekong River Delta of Vietnam to lower carbon emissions of rice cultivation and support smallholder farmers in accessing carbon credit markets.

These recommendations aim to address key challenges and capitalize on opportunities identified during our stakeholder, risk and cost-benefit analyses:

- Prioritize carbon emissions baseline assessment.
- Support the development of the Vietnamese ETS to include agriculture.
- Support the development of a domestic certification label for low emission.
- Promote composting of rice straw and re-application to rice paddies.
- Consider supporting the development of biogas production from rice straw.
- Research opportunities to re-structure irrigation water management.
- Maintain up-to-date tools for cost-benefit analysis.

Prioritize carbon emissions baseline assessment.

It has been found that AWD practices are already being performed to a certain extent by many farmers across the Mekong River Delta, although there are inconsistencies with how this technique is applied that may lead to different levels of carbon emissions reductions that can still be achieved. That being said, this threatens the potential for carbon credit projects which depend on the principle of additionality, which necessitates that the practices which reduce carbon emissions depend on the financing from the project for implementation. If AWD is already being performed, even to a certain extent, this may invalidate the carbon credits generated through the project. To overcome this, it must be clear to what extent AWD, or alternative techniques such as mid-season drainage, are already practiced in the region. Remote sensing presents an opportunity to gauge this baseline, but it nonetheless requires intensive collaboration with farmers and cooperatives due to the complex and fragmented landscape of Vietnamese rice cultivation.

Support the development of the Vietnamese ETS to include agriculture.

Advocating for the inclusion of the agricultural sector in the Vietnamese Emissions Trading System (ETS) would allow for the domestic trading of carbon emission reductions achieved through practicing improved rice cultivation. Industries, such as textile and electrical manufacturing or mining, which have a lower capacity of reducing emissions (in the short-term) would be able to offset their emissions by investing in emissions reductions of farmers. Providing capacity building to the Vietnamese government to link rice farmers to the domestic markets would be an opportunity to manage these emissions reductions on a smaller scale with lowered risk of unwillingness from private international investors.

Investigate investment alternatives to carbon credit projects for practicing AWD.

Carbon credit projects are threatened by a lack of baseline characterization which generates uncertainty as to the rewards that can be received. If instead of relying on carbon credit financing, transition is the rice sector is driven by increased valuation of low-emissions rice, increased profits for farmers can be used as an incentive for improved practices. Furthermore, if the Vietnamese government pursues procurement purchase agreements with international rice buyers for low-emissions rice, investments can be made with higher security to finance the transition to reduce emissions.

Promote composting of rice straw and re-application to rice paddies.

Burning straw releases a high amount of carbon dioxide and pollution into the air and is currently the standard practice of straw management. During this process, nutrients are lost, and air quality is deteriorated. By harvesting straw and composting it, farmers can reap financial benefits from a byproduct that would otherwise be lost, by reducing fertilizer inputs that are required for rice production. Composting the straw allows for some of the carbon pool in straw to be released as carbon dioxide, instead of methane, while preserving important nutrients that may be lost through burning. Furthermore, compost application has several added benefits such as improving the health of the soil and limiting the effect of salinization. This is a relatively easy solution which is applicable by individual farmers on-location at a small scale, with a high potential impact.

Consider supporting the development of biogas production from rice straw.

Straw is a byproduct which is reliably produced from rice production, in addition to byproducts such as rice husks and bran. While the value of these byproducts is lower than that of rice grains, they still have potential value, and should not be regarded merely as waste. In neighboring countries, especially China, the use of rice straw is higher than in Vietnam. In China, the use of rice straw for biogas production is a significant downstream use of a byproduct which allows for the offset of carbon emissions from straw decomposition in the field, and additionally provides alternatives to fossil fuel consumption. This would benefit farmers by adding value to straw, allowing for its sale for post-harvest processing. Furthermore, carbon credit projects can be developed for biogas production facilities, providing investment for the capital expenditures that would be required for the development of this sector. That being said, this strategy will still require significant research and consideration of management to ensure storage of straw for consistent supply of biogas inputs and factors such as moisture and quality requirements.

Research opportunities to re-structure irrigation water management.

Drought and saltwater intrusion, accelerated by climate change, threaten the future of agriculture in the Mekong River Delta. Farmers in the region have benefitted from a water policy that underestimates the added value of irrigation. In the long-term, the government of Vietnam should re-structure this policy to promote farmers practicing water-saving techniques such as AWD, which are associated with carbon emission reductions. This policy will have the added benefit of reducing regional water use for rice production to buffer periods with lower water availability. Furthermore, crops may be more drought resistant when they are grown with water-saving practices, and the effects of increased water salinity will be reduced.

Maintain up-to-date tools for cost-benefit analysis.

For realistic, up-to-date analyses, it is critical that farmers input costs, yields, and output prices are current and accurate. Currently, it is difficult to assess the benefit to farmers through a carbon credit project because of the large variability in estimates of a farmer's costs and revenues. Furthermore, the range of estimates of carbon emissions from land use practices is large, which further complicates the assessment of the added benefit of carbon emissions reducing practices as it is difficult to assess the gains that can be made, which are available for NDC targets or sale to carbon markets. Thus, it is also advisable to consider these targets within the formulation of the tool.

6. Conclusion

The cost-benefit analysis shows a significant decrease in GHG-emissions of 38.1%. In the context of the NDCs of Vietnam, the project will not meet its targets by 2030, but the project will generate additional emission reductions after 2031. The 1MHa project was determined to generate a net annual revenue approximately 8% higher than the business-as-usual (BAU) scenario. The analysis included a revision of input and output costs and prices of the COMPARE tool which generated a large increase in net annual revenue compared to the original version, but differences between 1MHa and BAU scenario revenues remained relatively consistent. It is recommended to maintain an up-to-date version of the tool for future analyses, and to consider integration of NDC targets into the tool in its future iterations. Additional recommendations were made based on stakeholder interviews and literature review as part of the stakeholder and risk analyses.

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Appendix I - The list of Interviewees

Stakeholder	Contact Person	Remarks
Vietnam Academy of Agricultural Sciences	Dr. Dao The Anh, Deputy Director (daotheanh@gmail.com)	Rice Research
Rikolto	Tuan Le (tuan.le@rikolto.org)	Implementing Low Emission Production for Carbon Credit Project
SouthPole	Russ Cullinane (r.cullinane@southpole.com)	Project Implementers
Carbon Farm	Aparna Raturi (aparna@carbonfarm.tech)	Remote Sensing MRV process in Vietnam rice agriculture
Agrig8	David Chen CY and Ramthan, I. (contact@agrig8.com)	MRV- Through predictive forecasts for loan origination and credit assurance, and by adding sustainability metrics alongside financial returns, lenders can break the vicious cycle of farmers being both victims and contributors to climate change.

Appendix II - The list of risks

Category	Description	Solution/ recommendation received	Source
Financial	Lack of investment in infrastructure (irrigation)	The Government is incentivizing the creation of cooperatives to share infrastructure and to make the project more accessible to smallholder farmers that are not yet linked to a cooperative.	VAAS
Financial	Lack of investment in machinery	The Government is incentivizing the creation of cooperatives where machinery can be collectively acquired and shared	VAAS
Financial	Lack of access to Agricultural credit for small farmers	There has been an incentive for the creation of "effective cooperatives" with the help from a Dutch Bank and Companies to help with this.	VAAS
Financial	Lack of access to financial resources (financial investors)		Agrig8
Financial	Perceived financial mismanagement (e.g. abandoned roads, bridges, and water wells)	Working together with locals/cooperatives to invest in ways it serves the public interest.	China Dialogue
Socio-economic (Human factor)	Lack of transparency, lack of human trust in collecting data		Agrig8 /CarbonFarm
Socio-economic (Human factor)	Uncertainty regarding farmers' willingness to adopt new sustainable agricultural practices or technologies.	▪ Increasing financial input by ensuring a large-scale consumption of new rice varieties (good quality rice of the 1MHP) ▪ Implementing a certification process so farmers can sell rice at higher price ▪ Making large deals with trading companies ensuring the rice gets sold in large amounts.	Rikolto/China Dialogue
Technology (Infrastructure)	There is no infrastructure for irrigation, which makes it hard for farmers/cooperatives to implement the AWD. The water regime has been reduced.		VAAS
Technology (Operational)	Monitoring system has not been identified.	Carbon credit is long-term. To reduce the production costs, investment in the infrastructure and selling price must be increased first.	VAAS
Technology (Infrastructure)	Lack of infrastructure or techniques of straw collection, transportation, storage in a cooperative level.		VAAS

	Ex: Transportation is typically by a boat but need to be combined (water + road)		
Technology (Infrastructure)	Poor resolution satellite data	Investment in high quality satellite data with lesser revisit time	Agrig8/ Carbon farm
Technology (Infrastructure)	Internet connection - collection of data from farmers used for MRV process		Rikolto
Market	No carbon market has been established in Vietnam yet		Agrig8/ Carbon farm/ IRRI
Market	Insecurity of the market. Since there aren't regulations yet, it is hard to predict how the carbon credit market will be. It is unclear how much the credits will cost and who is going to buy them.		Agrig8
Technology (Operational)	Uncertainty regarding the existence of domestic buyers for carbon credits		South Pole
Market	Lack of trust in carbon credit validity in rice cultivation (related to failure of Shell Oil rice carbon credits project)		Climate Home news
Technology (Operational)	Lack of labor to implement AWD		VAAS
Technology (Operational)	There is a significant number of farmers who are not yet in a cooperative which makes it harder to disseminate information, training and also makes it harder to get investment, compromising the adoption of sustainable practices	Make contact through Extension services, water systems and innovative farmers who are not yet in a cooperative.	VAAS
Technology (Operational)	Collaboration between many parties required to accomplish 1 Million Ha project Thousands of farmers need to be trained Cooperation of many organizations will be necessary	Vietnamese government will be expected to mobilize extension services and other projects	IRRI/VAAS

Financial	World Bank TCAF carbon credit program lacks transparency so it is unclear how many carbon credits remain available after NDC and TCAF prerequisites		South Pole
Technology (Operational)	Lack of knowledge about the current status of AWD application (or partial water reduction) for carbon credit baseline in the Mekong River Delta region		South Pole/Carbon Farm
Market	World Bank Carbon credit MRV standards are not strict enough for private international carbon trading standards (ICROA)		South Pole
Market	Volatility of rice price		VAAS
Market	Uncertainty related to the ability of getting a Premium price for rice		IRRI/ Agrig8
Market	Volatility and Variability of carbon price		South Pole